Namibia's Water–Energy–Food Nexus: National Development in Uncertain Times

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Numerical Conventions

one	1 or 1.0
one thousand	1,000
one million	1,000,000
one billion	1,000,000,000

Abbreviations

AfDB	African Development Bank
AGRIBUSDEV	Agricultural Business Development Agency
CCWSS	Cabinet Committee on Water Supply Security
COP27	27th Conference of Parties of the UNFCCC
DRFN	Desert Research Foundation of Namibia
DWA	Department of Water Affairs, in the MAWLR
DWAF	Directorate of Water Affairs and Forestry (in the former Ministry of Agriculture, Water and Forestry)
ECB	Electricity Control Board
EU	European Union
FAO	Food and Agriculture Organization
FIA	feasibility and implementation agreement
FY	financial year
GDP	gross domestic product
GH2	green hydrogen
GHG	greenhouse gas
GRN	Government of the Republic of Namibia
GWh	gigawatt-hour; energy unit
HPP	Harambee Prosperity Plan
HPSZ	high-pressure subtropical zone
ICCAT	International Commission for the Conservation of Atlantic Tunas
ILO	International Labour Organization
ITCZ	intertropical convergence zone
IPP	independent power producer
IPPP	National Independent Power Producer Policy
ITA	International Trade Administration

IWRMP	Integrated Water Resources Management Plan
KAZA	Kavango-Zambezi Regions
kg	kilogram
km^3	cubic kilometres, i.e., one billion litres
kW	kilowatt; unit of electrical generation capacity
kWh	kilowatt-hour; energy unit
LA	local authority
LAC	Legal Assistance Centre
LCFoN	Living Culture Foundation of Namibia
LPG	liquid petroleum gas
LPTZ	low-pressure temperate zone
m^3	cubic metre, i.e., one thousand litres
MAWLR	Ministry of Agriculture, Water and Land Reform
Meatco	Meat Corporation of Namibia
MFMR	Ministry of Fisheries and Marine Resources
Mm^3	million cubic metres
Mm^3/a	million cubic metres per year
Mt/a	mega-tonnes per year
MME	Ministry of Mines and Energy
MW	megawatt; unit of electrical generation capacity
MWh	megawatt-hour; energy unit, 1 MWh = 1,000 kWh
N$	Namibia Dollar
NAB	Namibian Agronomic Board
NGHDS	Namibia Green Hydrogen and Derivatives Strategy
NAMCOR	National Petroleum Corporation of Namibia
NamPower	Namibia Power Corporation (Pty) Ltd, national electricity utility
NDP	National Development Plan
NEP	National Energy Policy
NELFP	National Electrification Funding Portfolio
NELP	National Electrification Policy
NERA	Namibia Energy Regulatory Authority
NFCPT	Namibia Fish Consumption Promotion Trust
NIDA	Namibia Industrial Development Agency
NSA	Namibia Statistics Agency

ORASECOM	Orange-Senqu River Basin Commission
PEL	Petroleum Exploration Licence
PPP	public-private partnership
PtX	power-to-X
PV	photovoltaic; technology converting sunlight to electricity
SADC	Southern African Development Community
SCDI	Southern Corridor Development Initiative
t	tonne (metric ton), i.e., one thousand kg
TWh	terawatt-hour; energy unit; 1 TWh = 1 billion kWh
TWh/a	terawatt-hour per year
UNAM	University of Namibia
UNFCCC	United Nations Framework Convention on Climate Change
WRMA	Water Resources Management Act, 2023, (No. 11 of 2023)

Foreword

In the face of growing environmental challenges, Namibia as a semi-arid country has emerged as a pioneer in addressing the interconnected issues of water, energy, and food. This book provides a comprehensive and timely exploration of the nexus between these critical resources, offering valuable insights into the complex interplay of social, economic, and environmental factors and the potential to develop smart solutions.

Natalie Russmann

As we navigate an era of rapid urbanisation, climate change, and resource scarcity, it is essential to understand the intricate relationships between water, energy, and food. Thus, addressing such intricacies is a critical area of action in the global fight against climate change. This requires creative solutions that can react to threats and are suited to local circumstances.

The Konrad Adenauer Stiftung Namibia-Angola Office prides itself in its mission to generate and publish relevant knowledge in this regard, expressly considering the value of access to resources, processes, and strategies to promote peace, justice, and solidarity within a participatory democracy.

This publication essentially allows us to witness the interaction between our essential resources and society. Namibia's approach to the water–energy–food nexus could serve to foster and support a national sustainable development model, whilst emphasizing the importance of integrated resource management and innovative solutions in uncertain times.

In these pages, readers will find a wealth of knowledge from leading experts and practitioners dedicated to advancing the understanding and management of Namibia's water, energy, and food systems. The collective wisdom and experiences of Dr. Detlof von Oertzen, Dr. Martin Schneider and

Piet Heyns promise to offer invaluable insights for policymakers, scholars, and stakeholders seeking to address the complex challenges of resource sustainability and resilience.

I commend the authors for their dedication and contribution toward advancing the conversation around the water–energy–food nexus in Namibia. It is my hope that this book will inspire meaningful collaboration and action, thereby fostering a brighter and more sustainable future for the people and ecosystems of Namibia and beyond.

Natalie Russmann

Resident Representative

Konrad-Adenauer-Stiftung, Namibia-Angola Country Office

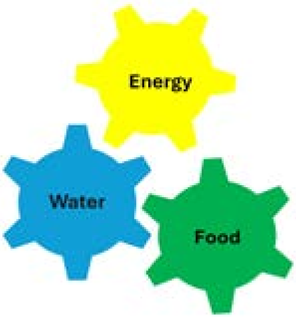
1. Introduction – Namibia's Water–Energy–Food Nexus

Our survival on planet Earth depends most fundamentally on the availability of water, energy, and food. If these necessities are met, we have the luxury of focusing on the many other aspects of importance to us. However, if these prerequisites are constrained or their supply is threatened, the building blocks of the very foundation of modern civilisation are at risk.

Numerous scenarios could lead to interruptions of our water, energy, and food supplies. The spectres of potential risk and constant change include severe drought, national and international conflicts, a breakdown of essential supply routes, interruptions due to civil unrest, and health pandemics. In a highly interconnected world, disruptions of critical supply chains in one country may cause shortages on the other side of the globe (UNESCO, 2021).

The supplies of water, energy, and food are highly interrelated, as illustrated in Figure 1. Energy is essential for extracting, treating, distributing, and supplying water, processing wastewater, and food production. Water is essential to produce food, and, to some extent, energy. Only if water and energy are available, can food be grown. Producing adequate and affordable food, therefore, depends on the availability, adequacy and affordability of both water and energy.

Figure 1: The interconnectedness of water, energy, and food [Source: D von Oertzen]



The interrelation between water, energy and food is known as the water–energy–food nexus. The individual nexus elements are connected and mutually dependent. This mutual dependency implies that it is important to focus on the nexus holistically, rather than on its individual pillars. The choices made in one sector often affect other nexus elements as well.

In a world of more than 8 billion people, the demand for water, energy, and food is massive, and rapidly expanding. Demand is fuelled by population growth, improving living conditions, and our insatiable appetites. Water, energy, and food supplies are directly affected by global trends, while they are constrained by planetary realities, boundaries, and tipping points.

The Earth's ecosystems have a finite ability to produce food, potable water is finite, too, and energy sources are often unevenly distributed. In addition, a changing climate introduces new stresses and limitations on resources, including on the availability and accessibility of the nexus elements. Meeting the ever-growing demand for water, energy, and food, without overexploiting our planet's finite resources, is a global challenge. The adequacy of how we manage water, energy, and food determines whether the security of supplies is achieved.

Namibia faces a multitude of development challenges. Primary among them are water, energy, and food. This text therefore introduces Namibia's water, energy, and food sectors and their interrelationships, while exploring how the country's development prospects can be enhanced by strengthening the interactions between and among the nexus pillars.

2. Namibia's Water Sector

Water is life's matter and matrix, mother and medium.
There is no life without water.

Albert Szent-Gyorgyi

2.1. Introduction

Matters relating to water availability are provided to foster a better understanding of the key role of water in the water–energy–food nexus. This includes water-related uncertainties and water scarcity that may limit national development, the main causes of such uncertainties, and the possible measures to enhance the security of water supplies. Such measures are critical for providing the growing population with adequate water, energy, and food, particularly in an environment undergoing rapid transformation due to a changing climate and increasing environmental degradation.

Namibia is the most arid country in sub-Saharan Africa due to the dramatic difference between precipitation and evaporation. The availability of water for human consumption, livestock and food production, dryland farming, irrigation, electricity generation, mining, industry, and socioeconomic development is, therefore, a permanent challenge, and not every rainy season adequately blessed, as shown in Figure 2.

Figure 2: Dryland farming during the rainy season [Source: G Schneider]

Less than 5% of the country has arable land for producing staple food. This restriction is due to the unreliable, variable, and low rainfall that is only available during summer. Irrigation is a remedy, but it is limited by the availability of water from Namibia's perennial rivers, which occur only along the country's borders, i.e. the Kunene, the Okavango and Zambezi in the north, and the Orange in the south. As regards irrigation from Namibia's ephemeral rivers, several large dams at Hardap (see Figure 35 and Figure 36) and Naute (see Figure 40) serve this purpose, with another 2,000 ha project planned for Neckartal. Irrigation is also possible from major groundwater sources such as the karst area in north-central Namibia, the Stampriet artesian basin in southern Namibia, and possibly the recently discovered Ohangwena aquifer south of the Namibia–Angola border. Although groundwater from smaller aquifers is limited, most commercial farms as well as farms in communal areas obtain enough water from these sources to sustain stock farming.

Although the Namibian Government (GRN 2012) has reached the target of its Fourth National Development Plan (NDP4) of providing 95% of the population with sustainable access to safe water, sound, and sustained water management to ensure social, economic, and environmental benefits remains highly relevant. Water resources need to be shared by all – the growing population, increasing agricultural production and an expanding industry – while accommodating environmental requirements and preventing pollution.

Water supply in the rural areas remains difficult, see Figure 3. Often, water needs to be transported over long distances from its source to consumers. Furthermore, capital investments for new water supply infrastructure are high, and recovering the cost of supplying water to a predominantly poor population in these – as well as in urban – environments is a major challenge.

Figure 3: The daily line-up for water in rural Namibia [Source: W Nghaanekwa]

Nonetheless, existing water supply infrastructure must be maintained, additional infrastructure must be established, water purification and sewage facilities must be operated, and fees must be collected to recover the capital and operating costs associated with water infrastructure. The same operation, maintenance, extension, and fee recovery requirements apply to sanitation services and wastewater disposal. Appropriate water policy, legislation, and regulations are in place, but timely water infrastructure planning and development are vital for achieving national water security objectives.

2.2. The Hydroclimate

2.2.1. Introduction

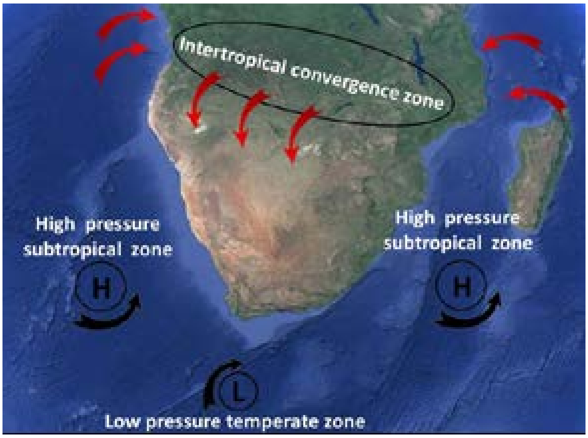
The climate of a country is determined by how the atmosphere behaves over a lengthy period, while its weather is what the conditions in the atmosphere are over short periods.

Namibia's climate is characterised by a rainy season in summer and a winter season without rain, except for scant winter rainfall far south. The country's weather is characterised by the daily variations in the atmospheric regime, including the movement and strength of weather systems, and by short-term changes in the temperature, humidity, clouds, precipitation, wind direction and wind velocity.

2.2.2. Climate Systems

Three major climate systems drive the movement of air masses with sufficient moisture to cause rainfall over Namibia. These are the intertropical convergence zone (ITCZ) north of Namibia, the *high-pressure subtropical zone* (HPSZ) west of Namibia over the Atlantic Ocean, and the *low-pressure temperate zone* (LPTZ) south of Namibia between the southern tip of Africa and Antarctica, as shown in Figure 4.

Figure 4: Summer air pressure systems over Southern Africa [Source: DWA]



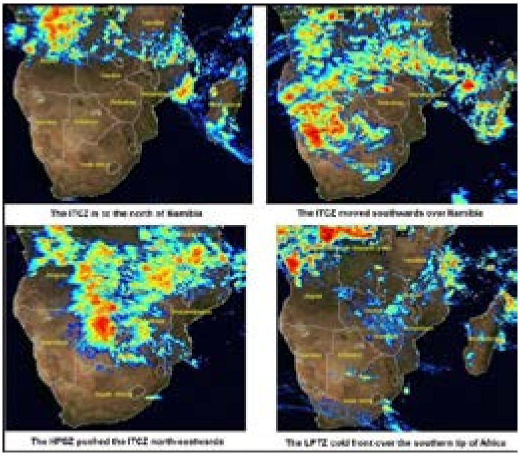
In summer in the southern hemisphere, moist air moves into the ITCZ from the Atlantic and Indian Oceans. At the same time, the HPSZ west of Namibia and the LPTZ move to the south. This allows the ITCZ to move southward itself, introducing moist air over the southern African land mass and allowing rain to fall across Namibia. The HPSZ remains a strong system, however, and it pushes the moist air mass to the southeast across southern Africa. This process – the ITCZ bringing in moist air over Namibia and the HPSZ pushing the air mass eastwards – is continuous. For this reason, southern Namibia receives much less rain than the north. The LPTZ, on the other hand, has little influence in bringing moist air to the southern part of the African continent during summer.

In winter, the air pressure systems move to the north. Thus, the LPTZ brings cold fronts with moist air and winter rainfall to South Africa and southern Namibia. Because the latter is on the northern edge of the cold fronts, the precipitation is far lower than that associated with the southern tip of Africa. The LPTZ's influence, albeit weak, is the main reason that southern Namibia has such low rainfall in summer and winter.

Namibia's summer rainfall season extends from October to early May, while its dry season is in winter, between May and late September. In summer, the country is generally hot and dry. This is because the moisture content or relative humidity of the air masses over the country is normally highly variable and causes erratic rainfall which is unevenly distributed from the north to the south across the country. During the winter months, occasional rainfall events may occur in the southern regions, but such precipitation is mostly low.

Satellite imagery is useful in depicting typical southern African weather systems and rainfall accumulation. The top two and bottom left images in Figure 5 show the summer rainfall system, while the bottom right image in Figure 5 shows its winter counterpart.

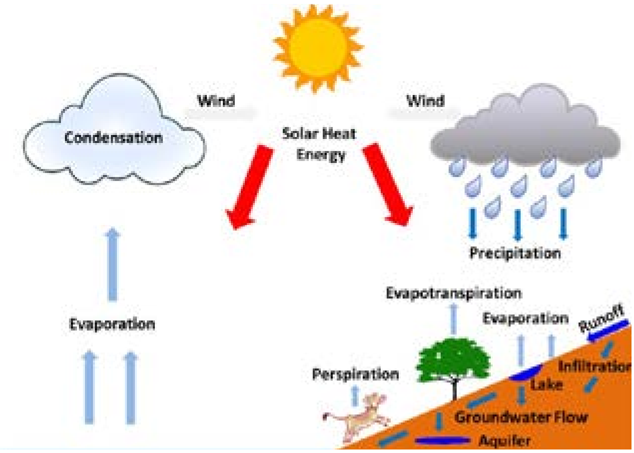
Figure 5: Southern African weather systems [Source: DWA]



2.2.3. The Water Cycle

The weather systems described in section 2.2.2 and Figure 5 are part of the water cycle that is driven by the sun's energy, as illustrated in Figure 6.

Figure 6: The Water Cycle [Source: P Heyns]



The heat of the sun evaporates water from the surface of the ocean; this invisible water vapour cools as it rises. The rising water vapour may remain invisible or condense into clouds at altitude. At the same time, the sun also heats the land, which heats the air above it – and hot air rises. The cold air over the ocean is at a higher pressure than the hot air over the land. This difference in air pressure causes the wind to blow from the high- to the low-pressure area and moves the air mass over the ocean to the land, where the moisture in the air is precipitated as rain, fog, hail, or snow.

Once the precipitation reaches the ground, the force of gravity takes over and the water may run off from where it landed on the surface, or it may infiltrate the soil. Some water may also evaporate back into the atmosphere.

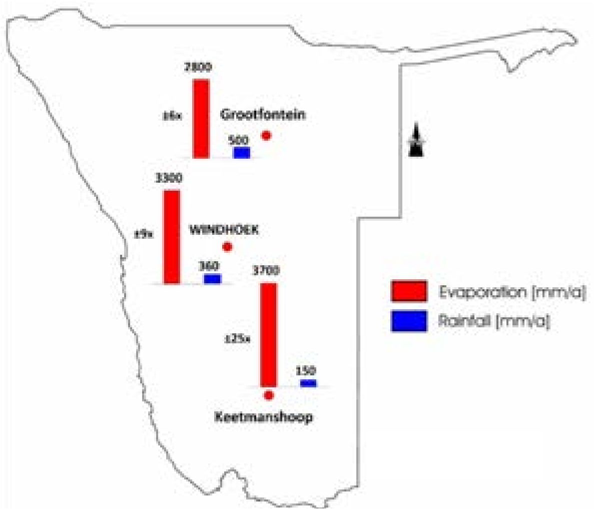
Surface runoff flows downhill. It usually accumulates either in rivers flowing into the ocean or in surface water bodies such as lakes, wetlands, or dams. Water that infiltrates the soil either percolates back to the sea under gravity or accumulates in aquifers. In the latter case, it becomes available as groundwater or remains as soil moisture which is used by vegetation. When vegetation uses soil moisture, water is released back into the atmosphere through evapotranspiration.

2.2.4. Rainfall and Evaporation

Namibia's mean annual rainfall varies between near-zero along the Atlantic Ocean to about 700 mm in the Zambezi Region in the northeast. The annual average mean rainfall over the whole country amounts to 250 mm. Theoretically, the average total precipitation is estimated to amount to approx. 200 km^3/a.

In arid countries like Namibia, most of the precipitation occurs via scattered thunderstorms. These can be very intense but are normally of short duration. The potential for evaporation is also much higher than the actual rainfall, as illustrated in Figure 7.

Figure 7: Deficit between annual rainfall and evaporation [Source: P Heyns]



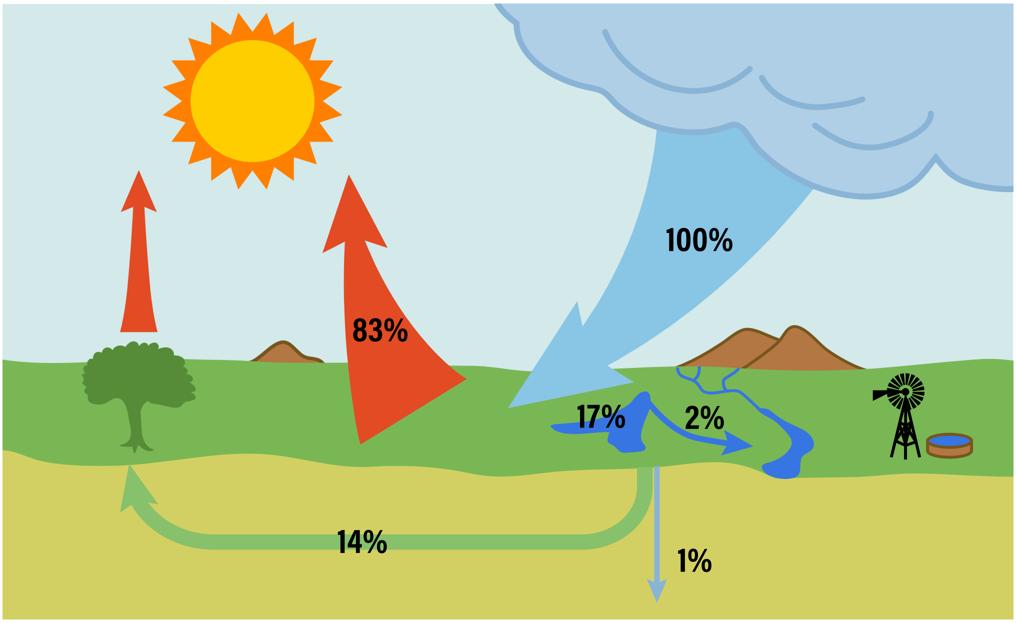
Rainfall is normally low, variable, and unreliable. It is also extremely difficult to predict with any accuracy. In some cases, the actual variability of rainfall in a good rainy season can be twice the long-term average or half of the average in a poor rainy season. Furthermore, when rainfall does occur, it is usually unevenly distributed across the land. Thus, there may be a high-intensity rainstorm in one place and no rain at all a mere kilometre away. These conditions make the occurrence of rainfall unreliable, making it difficult to predict the rainfall conditions that will prevail during a rainy season. This causes uncertainty about the expected availability of water after a rainy season for agricultural purposes such as dryland crop production and stock farming as well as for domestic, industrial, and mining use.

Evaporation varies between 3,700 mm/a in the south to 2,600 mm/a in the north. Over most of the country, the potential evaporation is at least five times greater than the average rainfall. This is the cause of Namibia's aridity – and explains why Namibia is the most arid country south of the Sahara. From a hydrological perspective, Namibia is dry and water-deficient, as illustrated in Figure 7.

2.2.5. The Water Balance

To illustrate the effect of low rainfall, aridity and water scarcity in Namibia, the mean annual rainfall information has been translated into a water balance model, as illustrated in Figure 8.

Figure 8: Water Balance in Namibia [Source: DWA]



It is estimated that, after a rainfall event, an average of 83% of the precipitation on the ground is immediately lost due to evaporation. Only 2% of the total rainfall ends up as surface runoff in rivers, while 1% filters into groundwater aquifers. The 14% balance of the rainfall infiltrates the soil and is available to vegetation for producing biomass; this water is productively returned to the atmosphere through evapotranspiration. Theoretically, this means that, for every 100 drops of rain, only 17 drops are available as surface water to be impounded in dams, or as groundwater that can accumulate in aquifers or as soil moisture for plants. This 17% of all rainfall water may not be much, but it is socioeconomically critical: it is used as a water supply for domestic, animal husbandry, industrial and mining purposes; for irrigation; for power generation; and several types of recreation. Table 1 provides a summary of Namibia's water balance.

Table 1: Water balance in Namibia [Source: DWA]

Event	Percentage [%]	Volume [km^3]
Direct evaporation	83	166
Evapotranspiration by vegetation	14	28
Runoff in rivers	2	4
Recharge to groundwater	1	2
Total	**100**	**200**

2.3. Water Sources and the Availability of Water

2.3.1. Water Sources

Water resources are classified as perennial surface waters, ephemeral surface waters, groundwater, and unconventional water sources, such as reused wastewater and desalinated seawater.

Some perennial water is available from groundwater via natural fountains, springs, and seeps as well as from hand-dug wells in the dry riverbeds. These water sources have enabled the indigenous people in the interior of Namibia to survive for thousands of years during the dry seasons. The water was mainly used for domestic consumption, but also for stock and wildlife. The water was probably not what would today be considered fit for human consumption, but it was all they had.

People living next to the perennial rivers that form some of Namibia's borders today had access to much safer and more reliable water because the rivers were more pristine then. All interior rivers in the country are ephemeral, meaning that they only flow during the rainy season. Their existence is contingent on the rainfall intensity in their respective catchments being high enough to cause runoff. This is because, sometimes, a rainfall event is too short and/or its intensity is too low to result in the runoff on the land surface, and therefore in a dry riverbed itself. Depending on the volume of runoff, such rivers may only flow for a short distance before all the water has filtered into the sandy riverbed.

Due to population growth and socioeconomic development in the intervening years, water demand increased. It therefore became imperative to impound the ephemeral runoff during the rainy season, to be used during the dry season. Studies undertaken by the Department of Water Affairs estimated that the 95% assured safe yield that can be obtained from possible dams in the ephemeral rivers amounts to about 200 Mm^3 per annum. Similarly, it was established that the potential of the groundwater sources amounts to some 300 Mm^3/a. It is also possible to recover about 30% of used water for reuse; the existing reclamation infrastructure enables about 25 Mm^3/a to be repurposed. Thus, the total potential of Namibia's internal water sources is only 525 Mm^3/a, as summarised in Table 2.

Table 2: Namibian national water sources [Source: DWA]

National water sources	Volume [Mm^3/a]
Groundwater (estimated sustainable safe yield)	300
Ephemeral rivers (95% assured yield from dams)	200
Unconventional water sources	25
Total	**525**

Although Namibia has no significant perennial water sources in its interior, it has access to the perennial runoff from the rivers on its borders. These include the Orange River in the south (see Figure 9), the Kunene in the northwest (see Figure 10), the Okavango in the north, and the Zambezi in the northeast.

All watercourses feeding the perennial rivers along the borders of Namibia originate upstream in neighbouring countries (see Table 3). These rivers are the Kunene, and Okavango in Angola, the Orange in Lesotho and South Africa, and the Zambezi in Angola, and Zambia. The Cuvelai River comprises an ephemeral drainage system originating in southern Angola, crossing the Namibian border, and ending in the Etosha Pan in Namibia. All these rivers are therefore transboundary watercourse systems, and access to their water is governed by international water law and associated water treaties.

Table 3: Shared transboundary watercourse systems [Source: P Heyns, based on DWA data]

Perennial river	Countries sharing the water	Measuring station	Mean annual runoff [Mm^3/a]	Present abstraction [Mm^3/a]
Kunene	Angola and Namibia	Ruacana	5,500	75
Okavango	Angola, Botswana, and Namibia	Mukwe	10,000	40

Perennial river	Countries sharing the water	Measuring station	Mean annual runoff [Mm³/a]	Present abstraction [Mm³/a]
Orange	Botswana, Lesotho, Namibia, and South Africa	Noordoewer	11,000	45
Zambezi	Angola, Botswana, Malawi, Mozambique, Tanzania, Zambia, Zimbabwe, and Tanzania	Katima Mulilo	40,000	5
Total				**165**

Figure 9: An aerial view of the mouth of the Orange River [Source: P Heyns]

2.3.2. Water Scarcity

Water scarcity can broadly be understood as the lack of access to adequate quantities of water for human and environmental uses. According to what is commonly referred to as the Falkenmark indicator or Water Stress Index, water scarcity is measured in terms of the total water resources available to a country's population in comparison with the quantity of renewable freshwater available to every person each year (Falkenmark, 1989). For example, if the amount of renewable water in a country is below 1,700 m^3 per person per year, the country is said to be experiencing water scarcity (see Table 4). A country faces absolute water stress if the availability of water is less than 500 m^3 per person per year.

Table 4: Water Stress Index [Source: Falkenmark, 1989]

Water stress category	Water stress index [m^3/person/a]	Namibian consumption [m^3/person/a]
No water stress	more than 1,700	not applicable
Water scarcity	1,700 to 1,000	not applicable
Water stress	1,000 to 500	not applicable
Absolute water stress	less than 500	175

The natural, internal availability of water in Namibia amounts to approximately 525 Mm^3/a. Therefore, for its population of just over 3 million, the availability of water amounts to some 175 m^3/person/a, which indicates Namibia experiences absolute water stress.

The situation is remedied by abstracting water that originates in higher rainfall areas beyond Namibia and flows into the perennial rivers on the country's borders, from where it is extracted and pumped where it is needed. The same principle can be applied by using desalinated seawater, where required. In all cases, importing water is expensive, but if climate change reduces rainfall events even more, then the desalination of seawater and the importation of freshwater are the only options for ensuring there is enough bulk water in future. These water supply projects will stretch over long distances and need to be developed well in advance of when they are required. Failure to connect the final section of the Eastern National Carrier to the Okavango River is one of the causes of the present challenges in meeting the demand for water in the Central Area of Namibia.

2.3.3. Water Demand

In 2015, the total water demand in Namibia was about 427 Mm^3/a. This is estimated to increase to 770 Mm^3/a by 2030 (see Table 5). However, the availability of water from internal water sources amounts to 525 Mm^3/a at most.

Table 5: Past, present, and future water demand in Namibia [Source: DWA]

Consumer group	Demand [Mm^3/a]			
	2015	**2020**	**2025**	**2030**
Urban domestic	80.0	91.1	103.5	117.2
Rural domestic	10.6	10.9	11.1	11.4
Tourism	27.5	31.9	35.2	38.9
Livestock	86.8	86.8	86.8	86.8
Mining	17.2	18.1	19.1	20.3
Irrigation	204.6	344.6	379.8	497.2
Total	**426.7**	**583.4**	**635.6**	**771.7**

The difference will have to be made up by developing additional water sources, i.e. using the perennial boundary rivers or desalinating seawater. As Table 5 shows, the total estimated water consumption in 2020 by the different consumer groups was 584 Mm^3/a. The total domestic water demand (using rounded numbers) was 134 Mm^3/a (23% of the total), comprising 91 Mm^3/a in urban areas, 11 Mm^3/a in rural areas, and 32 Mm^3/a by the tourism industry. The water demand for livestock was 87 Mm^3/a (15%), for mining it was 18 Mm^3/a (3%) and for irrigation 345 Mm^3/a (59%).

Table 5 also reveals that irrigation remains by far the largest consumer of water in Namibia, owing to high evaporation losses while fields are being watered. To illustrate, the irrigation of a hectare of land in Namibia requires between 12,000 and 20,000 m^3/a, depending on the rainfall, soil type and irrigation method. The total water demand for livestock and irrigation purposes in 2020 amounted to 432 Mm^3/a, or about 74% of the total demand in that year. This demand is expected to increase to around 75% by 2030. In respect of the nexus under discussion, the quantity of water required to produce food in Namibia is expected to increase to about 580 Mm^3/a by 2030.

Figure 10: Near the mouth of the Kunene River [Source: G Schneider]

2.3.4. Water Conservation

Due to Namibia's arid environment, the loss of water from water bodies through evaporation is extremely high. Several conservation measures have therefore been put in place to reduce evaporation from canals and large dams. The depletion of groundwater resources by overuse has also received attention by applying innovative aquifer management.

Some of the many water conservation measures in use are discussed below:

A. Reusing water

This entails the reclamation of domestic wastewater for various purposes. Some is treated to produce potable water conforming to quality standards, while some is treated to the extent that it is aesthetically acceptable, disinfected, and suitable for the watering of landscape gardens and sports fields. Industrial wastewater can also be recycled within the industry without improving the chemical quality of the water.

A water reclamation plant is a complex facility (see Figure 11) to treat and purify the effluent received from a sewerage treatment plant, to meet potable water quality standards.

Figure 11: Windhoek's water reclamation plant [Source: P Heyns]

B. Augmentation of water sources

Water imported from the perennial border rivers can be used to augment the internal water resources of Namibia. These rivers are the Kunene, Okavango, Orange, and Zambezi. Water from the Kunene is already imported to the central northern regions, i.e., Ohangwena, Omusati, Oshana, and Oshikoto. Water from the Zambezi is abstracted for domestic use and irrigation projects in the Zambezi Region. Water from the Orange is used for domestic purposes, irrigation, and mining. And lastly, water from the Okavango is used for irrigation and domestic end-users.

According to the Water Masterplan for Namibia, it is planned that water is imported from the Okavango to the Central Area of Namibia. In water supply terminology, the Central Area of Namibia is broadly defined as the area to the north of Windhoek, stretching westwards to Usakos, eastwards to Gobabis, and northwards up to Grootfontein and the Okavango River.

C. Conjunctive water uses

This method of water conservation is applied when water can be supplied from either a dam or a borehole. The principle of conjunctive use is to use the surface water in a dam first because it will evaporate and save groundwater for later use as it will not evaporate.

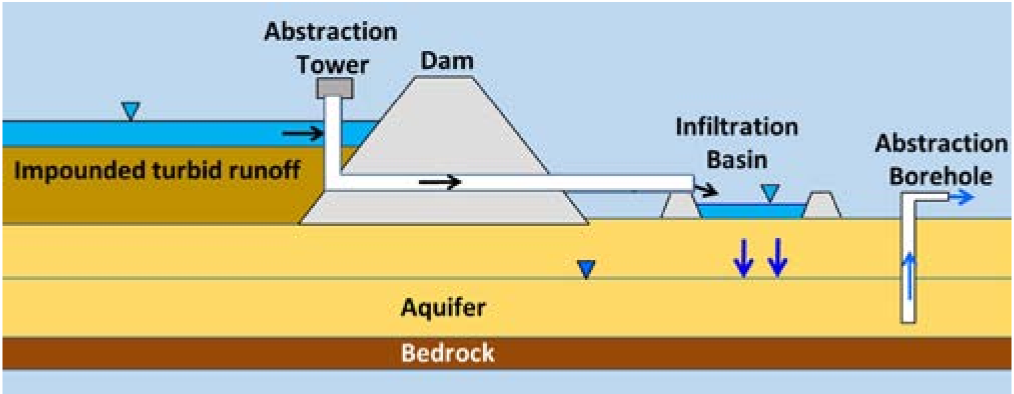
D. Integrated water uses

There are three interlinked main dams in the Central Area, namely the Von Bach, Swakoppoort, and Omatako. They are all interconnected and it is possible to transfer water from a dam with a larger water surface area (which has higher evaporation losses) to a dam with a smaller water surface, to reduce evaporation losses.

E. Artificial aquifer recharge

The Omdel Dam in the Omaruru River lies about 40 km from the coast and the water in the dam is used to recharge the groundwater in the aquifer under the riverbed. Turbid runoff in the river is impounded by the dam, allowing for muddy material in the water to settle out and making the top layer of water clear, as illustrated in Figure 12.

Figure 12: The artificial recharge of an aquifer [Source: P Heyns]



The clear water is decanted from the top and diverted from the dam to infiltration ponds located above the aquifer, downstream of the dam. The water in the ponds then infiltrates the riverbed, thereby recharging the groundwater. This not only reduces evaporative losses from the dam but conserves water in the aquifer, for later use.

F. Desalination of seawater

Water sources for domestic and mining use in the central Namib area are augmented by desalinating seawater (see Figure 13). Although such water is expensive, it is often affordable for mining purposes, whereas the available groundwater ought to be mainly used for domestic purposes because it is less expensive.

Figure 13: The Erongo Desalination Plant's reverse osmosis assemblies [Source: G von Oertzen]

G. Water banking

Water that would have evaporated from the Von Bach Dam at Okahandja is treated at the dam for domestic use and pumped to Windhoek. Some of this water is transferred into the Windhoek aquifer, where it is 'banked' for later use. Figure 14 depicts such an aquifer recharge station which is located south of Windhoek. Water that would have evaporated from the Von Bach Dam at Okahandja is treated at the dam for domestic use and pumped to Windhoek. Some of this water is transferred into the Windhoek aquifer, for later use.

Figure 14: Artificial aquifer recharge station [Source: P Heyns]

2.3.5. Water Demand Management

Water demand management can be defined as a less technical and more participatory way of using water. Practising effective water demand management is key to ensuring the efficient use of water resources.

The most crucial element in managing demand is to inform the public continuously about the quantity of water available, and about practical measures they can take to reduce demand and water losses. Managing demand is vital when sources are running dry due to a lack of rainfall and runoff to recharge dams and aquifers. The aim is to prevent the wasteful use of water or the loss of water from the water supply reticulation systems in cities and towns.

Also vital to water demand management is the maintenance of water supply infrastructure in public areas by the municipality, and by households at home, because the loss of water due to leakage can be an extremely expensive lesson to learn. The excessive use of water can also be managed by introducing a block tariff system which dictates a reasonable cost for reasonable usage. If usage exceeds certain levels, the tariff becomes increasingly expensive – and effectively becomes punitive.

Important water demand management measures include the following:

H. Raising Awareness

People are made aware of the scarcity and value of water as well as methods to save water. They are informed of water restrictions due to a water shortage, the consequences of overuse and the shortage in supply, the expected duration of the shortage, and how to reduce their water consumption at the household level.

I. Reducing Water Loss

Domestic and industrial water supply is measured to enable the respective consumers to pay for the service of receiving their water on tap (see Figure 14). In this way, the cost of treating and supplying water can be recovered and water provision can be sustained. Water leaks from reticulation pipelines to households, industries and mines must be avoided at all costs. This calls for continuously monitoring and maintaining the supply system to reduce unaccounted-for water, which infers the loss of water and lost revenue for supplying it.

J. Imposing Punitive Measures

Consumers in the more affluent residential areas are known for using more water than they require domestically because they may have big gardens, water features, swimming pools or several cars to wash. In Windhoek, it is compulsory to have a cover over a swimming pool to reduce evaporation.

When there is a water shortage, the rich could argue not only that they need to continue their level of consumption, but also that they are willing and able to pay any increased levy. However, if the water ran out, it would not matter how much money one had – there would simply be no water to buy.

Some municipalities therefore introduced a so-called block tariff system where the basic unit cost for water increases according to a scale of consumption. High levels of consumption attract a punitive tariff, which aims to encourage a reduction of water use. Any resident of a town would be subject to the same punitive measures if their domestic consumption exceeded certain conservative levels.

2.3.6. Managing Drought

Namibia is extremely vulnerable to variations in the hydroclimate. To manage the effects of scarce rainfall, it is vital to understand the prevailing conditions and to predict what to expect from them.

Figure 15: Water supply infrastructure in central-northern Namibia [Source: G Schneider]

Some 14% of the rainfall that infiltrates the parched soil after the dry season is used by the natural vegetation. Rain is therefore critically important for sustaining stock farming, cultivating dryland crops, and preserving biodiversity. Thus, when overgrazing has denuded the landscape of grass, there is no vegetation that can use the rainfall to generate biomass. So, the water just runs off unused, or it evaporates.

Namibia has a mean annual rainfall of only 250 mm. Rainfall is difficult to predict in an arid climate because, by its very nature, local precipitation varies hugely. When a weather forecast is made, the probability or chance that it may rain at a certain place in the country is normally given as a percentage. If, for example, a 40% probability of rainfall over Okahandja is predicted, one could also argue that there is a 60% probability of no rainfall. Furthermore, even if there is a 40% probability of a rainstorm occurring, one cannot realistically predict where or when it will occur, what the intensity of the rain will be, or how much rain will precipitate.

Attempts are also made to predict the rainfall conditions in Namibia by observing global-scale phenomena such as sea surface temperatures in the equatorial Pacific Ocean close to the South American continent. When these temperatures decline, a phenomenon referred to as a 'La Niña' event occurs and better possibilities for rainfall are predicted for Namibia. When those temperatures increase, an 'El Niño' event may occur, bringing drought conditions to Namibia.

Namibia is in a continuous low-rainfall condition. It is also a confirmed phenomenon that seasons of high and low rainfall occur in a periodic cycle over time. However, when below-average rainfall seasons prevail continuously over an extended period, a drought can be declared. In other words, a major drought is not the result of a one- or two-year span of below-average rainfall.

Droughts in Namibia can be classified into two main types: hydrological and agricultural. A hydrological drought occurs when the total precipitation during the rainy season is much less than the expected long-term annual mean precipitation and when such conditions persist over several years of below-average rainfall. The occurrence of a hydrological drought is critical in arid areas, but it is often not well understood that a drought and desiccated landscape is something worse than normally dry conditions, as illustrated in Figure 16.

Figure 16: Parched landscape due to drought [Source: Marion, Pixabay]

A hydrological drought can also be subdivided into a *rainfall drought* and a *runoff drought*. A *rainfall drought* can be defined as a lack of adequate rainfall in comparison to the expected long-term average annual rainfall. Conversely, a *runoff drought* occurs when there is not enough rainfall to cause sufficient runoff in the river catchments feeding major dams. This happens when too little (or no) rainfall precipitates in the catchments of those dams, or when the average (or better-than-average) rainfall falls in the catchments, but the intensity of the rains is so low that there is either little or no runoff. A runoff drought can also be caused by antecedent factors. This happens when the vegetation in a catchment has started to recover significantly after initial light rains at the beginning of the rainy season and by the time the heavier showers start to fall, the established vegetation cover reduces the runoff. A runoff drought in the catchments that yield water for the major dams in Namibia can lead to a water crisis, which has multiple disastrous impacts on the country.

An *agricultural drought*, on the other hand, happens when rain-fed crops fail due to a lack of rain or when the natural vegetation available for grazing is in poor condition due to generally low rainfall during a rainy season, or if there was not enough rainfall, as illustrated in Figure 17, when plants critically needed water, resulting in a lower yield and mass in the case of staple food like maize, wheat, or millet.

An *agricultural drought* can be subdivided into a *grazing drought* and a *rain-fed crop drought*. *Grazing droughts* are when grass for grazing has not grown or responded well to rainfall. This might be due to a hydrological drought (too little or no rainfall), for example. Alternatively, there may be average (or even better-than-average) rainfall, but the rain falls either too early or too late to be of any value during the natural vegetation's optimal growing season.

A *rain-fed crop drought* occurs when crops receive no rain or when the rain falls at the wrong time during the rainy season. This rainfall may even be higher than the expected average, but if a farmer starts planting after the first rains of the rainy season have fallen and the follow-up rains stay away, the crops will yield less – or even fail completely.

Figure 17: Farmland under water [Source: G Schneider]

The first significant rains may also fall so late in the planting season that a farmer finds it impossible to plant and harvest a crop in the remaining time when rain can be expected. This is because arid countries may have less than four months with more than 50 mm of rainfall. Thus, not only the length of the rainy season but also the spread of rainfall events during that season in relation to the growing season are critical for successful crop production. The rainfall frequency is also important for crop production because most arid countries have only between 20 to 60 days a year when rainfall occurs, see Figure 17.

The prediction of crop yield is seriously affected by these erratic climatic conditions and has a major influence on staple food production under rain-fed conditions. Even if good rains fall at the beginning of the rainy season, it is too early to predict if a good rainy season will ensue and yield adequate crops. Therefore, perhaps the best approach for farmers is to use their experience and intuition, but they will always have to take these risks into account. It is usually better to prepare the land and to plant after the first rains, instead of waiting to see what will happen. Without further follow-up rains, the Government should consider assisting farmers to recover their production losses.

Similarly, a government is ill-advised to take risks with the national food supply. Governments are responsible for making contingency plans even long before the onset of a rainy season to ensure that a secure supply of staple food will be available in case crops fail. The same applies to the availability of fodder.

If the rains fall before or after the natural vegetation's growing season, there may be severe grazing shortages in the period leading up to the following rainy season. Thus, erratic rainfall has a serious and significant effect on the productivity and economy of farming activities, both in the subsistence and commercial farming sectors.

An unfortunate aspect of an arid climate is that it is virtually impossible to predict the outcome of a rainy season. Whenever someone has reason to expect the worst-case scenario, there is always a good chance that the actual rainfall may prove the person wrong. The only way to predict the behaviour of a rainy season in an arid area is to wait until the end of the rainy season and then confirm what has happened! Some seasons are indeed good, as is, for example, shown in Figure 18.

Figure 18: The Swakop River reaching the Atlantic Ocean [Source: G Schneider]

2.4. The Cost of Water

There is a considerable lack of understanding about the use of the term cost of water. Water in Namibia is free of charge, but it costs money to supply water from its source to the user's tap. This cost does not include any cost for the water itself. Namibia's aridity is the main cause of expensive water because the water must be supplied over long distances from the source to the consumer and the construction of dams to impound the rainfall runoff and to treat the water to make it acceptable for human consumption make the cost to supply water exceedingly high. Water is, therefore, an expensive commodity, but it is essential that it is commonly understood why water is a free commodity, while it has a cost, why the cost of water is high, and how this unavoidably high cost can be adjusted to make water more affordable for end-users. The bottom line is that supplying water to consumers has a cost – and consumers are obliged to cover that cost. If they do not, the water service provider would go bankrupt, and the service would have to be terminated unless the provider is bailed out somehow.

Why do people think that water is – and should be – free? All sources of water originate from rainfall. Therefore, many people believe that water is a 'gift from God', and that it is – or should be – free for all to use. This belief is of special significance in Namibia where the mean annual rainfall is less than 250 mm as well as being unreliable, unpredictable, and limited to a short rainy season. Often, the rainfall is extremely low, or it stays away completely due to a period of drought conditions. It is especially at such times that appeals are made to various supernatural forces to bring relief to the parched landscape, dying animals and thirsty people by sending copious rains.

One might even argue that, when people have access to naturally occurring water sources which are inherently unreliable or unsafe for use, the water could be regarded as free. However, this argument does not hold when it comes to formal or permanent water schemes, which are required to supply properly treated water to an industrialised society.

Over the years, the formal supply of water has become a necessity in Namibia. This is because water demand has increased, owing to a growing population, economic development, and an improved quality of life. Namibia has a huge surface area (about 825,000 km^2), a small population (just over 3 million people) and an exceptionally low average population density (about 3 persons per square kilometre). Communities are small, isolated, and remotely located from high-yielding water sources, but there are also areas where the population density is much higher, such as in central Namibia, in the coastal towns, and the north. Because local water sources were inadequate to provide for all inhabitants' needs, Namibia had to establish long-term, sustainable water supply schemes.

Huge capital investments in infrastructure are required to capture and store water in reservoirs during the rainy season and to convey water over long distances by pipeline from source to consumer. Due to these high costs and the low quantity of water used, the unit cost of the water is high. This makes the water even more expensive. Usually, the intervention of government is necessary to facilitate investments in the development of water sources, and water supply infrastructure and recover the costs of doing so, see Figure 19).

The main actors responsible for water supply in Namibia are the Namibia Water Corporation (NamWater) for bulk water supply; government institutions such as the Department of Water Affairs (DWA) in the Ministry of Agriculture, Water and Land Reform in charge of rural water supply; local and regional authorities for small-scale water supply, water reticulation and effluent treatment; and the private sector, or self-suppliers, such as mines, and farmers.

Figure 19: Ultra-filtration at Windhoek's water reclamation plant [Source: G Schneider]

2.5. Policy and Regulatory Framework for Water Management

The administration of water affairs in Namibia is based on several pillars. These are the Namibian Constitution; national water policy and legislation; regional water policies and protocols; and international water laws, treaties, and conventions. In this context, *regional* refers to the Southern African Development Community (SADC). The task of formulating the regulations for implementing national water legislation and of developing the procedures for administrating such regulations rests with the DWA.

2.5.1. The Constitution of the Republic of Namibia

Three Articles in the Constitution have a direct bearing on the management of water resources. Articles 95 and 100 of Chapter 11 respectively address the principles of state policy regarding the environmental management of water resources and the ownership of water. Article 144 of Chapter 21 on final provisions addresses, among other things, the legal status of international water agreements. The said Articles are:

- **Article 95,** which deals with the promotion of the welfare of the people by, among other things, adopting policies aimed at the following, for example:

    ... [the] maintenance of ecosystems, essential ecological processes and biological diversity of Namibia and utilization of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future.

- **Article 100,** which deals with the sovereign ownership of natural resources, as follows (emphasis added):

    Land, water and natural resources below and above the surface of the land and in the continental shelf and within the territorial waters and the exclusive economic zone of Namibia shall belong to the State if they are not otherwise lawfully owned.

The ambiguity of Article 100 entails a conundrum. It appears to suggest that, as far as water resources are concerned, it applies solely to commercial farmers on privately owned land. This appears to conflict with the spirit of the Article, which is intended to protect all sources of water, among other things, irrespective of where they are located. The present land tenure system provides for private ownership of land, such as commercial farms or residential erven (plots) in urban areas. Large tracts of state-owned land are either official nature parks or communal land held in trust by the state for the community concerned. Technically, therefore, all water resources are owned by the state, and the state is thus duly entitled to allocate water to any user, whether formally requested to do so or not.

The land and the water resources on or below the surface of privately owned land are theoretically part of the privately owned property. After all, who would want to own a farm with the objective of farming commercially, and on business principles, if the water belonged to someone else? The notion that if one owns something (like water in an arid country), one will take good care of it, is totally defeated if water belongs to the state.

A commercial farmer will not invest money in water abstraction facilities or waste pumped water because he has paid for the water supply infrastructure and the operating cost of the service, which is therefore not free of cost in any case. He will also not pollute his water sources or use them in an unsustainable way because that will ruin his farming activities.

Water and property should clearly both be part of the ownership package. If the argument holds that water on privately owned land belongs to the State, then it can be argued that the State has an obligation to supply water to the farmer, which is widespread practice on resettlement farms. Such support is at the expense of the taxpayer, while commercial farmers who previously provided the same services themselves did not become a burden to the taxpayer.

A comparable situation exists on communal land where not only the water but also the land belongs to the State (see Figure 20). The capital cost of rural water supply infrastructure is, directly or indirectly, funded with taxpayers' money. The operating cost to supply the water is also heavily subsidised because rural communities often find it difficult to pay the full economic cost of supply of water (see Figure 21). The supply of potable water in urban areas is expensive, due to the considerable infrastructure requirements, as illustrated in Figure 22 and Figure 23, as is borne by end-users. Commercial farmers bear the full responsibility and cost to provide water on their farms.

Figure 20: Securing daily water needs from an open water canal [Source: I Kunamwene]

It would also be inequitable to serve some communities with water from sources that do not belong to them, while it is expected from a private landowner to protect the property (water) of the State on his land, but he is not assisted with the supply of water. The best the State can do is to monitor the sustainable abstraction of water on commercial farms through a permit system that may require information about the quantity of water abstracted, but many successful commercial farmers do that in any case because, by doing that, one can plan stock numbers, based on the availability of water and grass after a rainy season, thus enabling the farmer to reduce stock numbers when boreholes are yielding less water after a poor rainy season.

- **Article 144, which states the following:**

> *Unless otherwise provided by this Constitution or Act of Parliament, the general rules of public international law and international agreements binding upon Namibia under this Constitution shall form part of the law of Namibia.*

Figure 21: Water collection at a water point in rural Namibia [Source: namibiadailynews.info]

2.5.2. Water-related Policies

Water policies have both a formal and an informal side. The formal side entails the framework of an official, generic policy statement and subsequent legislation formalising the practical implementation of such policy. Informally, there are many internal water management policies which are not enforced by law but are practised in the general administration of water matters. Some of these policies are contained in the regulations promulgated in terms of the law, while others may be based on Cabinet decisions. Yet others may be part of daily management decisions.

Historically, three key policy documents relate to Namibia's water resources:

- **The Water Supply and Sanitation Sector Policy of 1993;**
- **The National Water Policy of 2000; and**
- **The Water Supply and Sanitation Policy of 2008.**

While laws compel or prohibit behaviours (e.g. a law prescribes that a permit is required for driving a car), a policy merely guides the actions to achieve a desired outcome such as the promulgation of an Act by Parliament to implement a policy.

Figure 22: Water reclamation plant at the Goreangab Dam in Windhoek [Source: WINGOC]

2.5.3. The Water Resources Management Act

The Water Resources Management Act, 2023 (No. 11 of 2023) (WRMA) was promulgated by Parliament on 2 December 2013, but it was only brought into force on 29 August 2023. This delay was because of the absence of associated Regulations, which were only prepared in 2022.

The WRMA provides for the management and conservation of all of Namibia's water resources. These include the whole or any part of a watercourse or an aquifer, the sea, and meteoric water. According to section 2 of the Act, its objects are to ensure that –

> *... water resources of Namibia are managed, developed, used, conserved, and protected in a manner consistent with, or conducive to, the fundamental principles set out in section 3 [of the Act].*

Furthermore, section 4 of the Act dictates the following state obligation:

> *The State, in its capacity as owner of the water resources of Namibia by virtue of Article 100 of the Namibian Constitution has the responsibility to ensure that water resources are managed and used to the benefit of all people in furtherance of the objects of this Act.*

2.5.4. Regulations

The technical regulations that prescribe how to implement the WRMA are drafted by the Ministry responsible for the administration of the Act and published in the *Government Gazette*. This implies that the Regulations do not have to be re-promulgated by Parliament but can be adjusted by the Minister as and when required.

2.5.5. Procedures

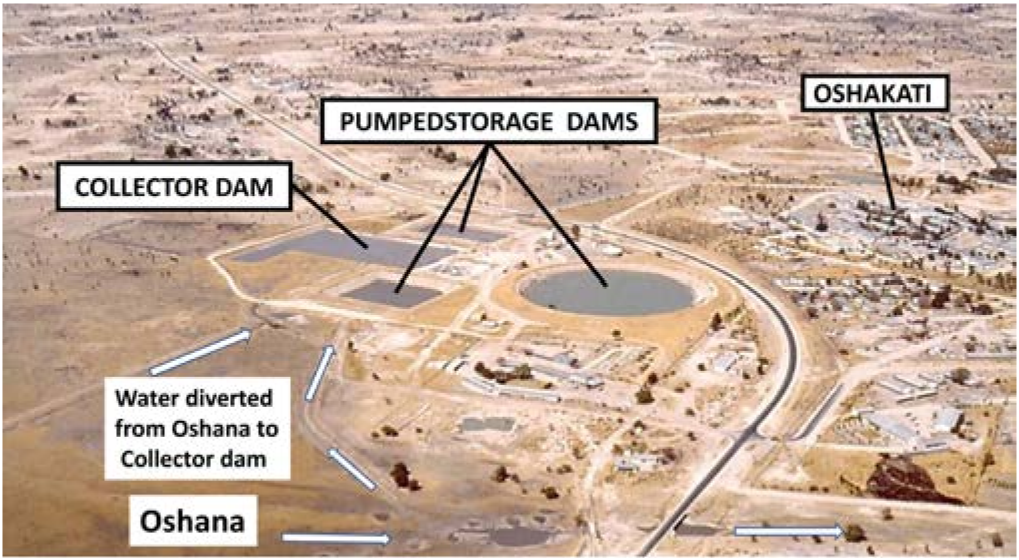
The last step in the WRMA's administration is the formulation of internal ministerial and departmental procedures. These procedures determine and clarify for both the state and the public how the Act should be executed and who is responsible for what.

2.5.6. Other Legislation Relevant to Water

Other legislation of relevance to the water sector includes the following:

- **The Soil Conservation Act, 1969 (No. 76 of 1969)**
- **The Namibia Water Corporation Act, 1997 (No. 12 of 1997), and**
- **The Environmental Management Act, 2007 (No. 7 of 2007).**

Figure 23: Oshakati Water Treatment Works [Source: P Heyns]



2.6. Institutional Framework for Water Resource Development

2.6.1. The Water Development Objective

Since Namibia is the most arid country in sub-Saharan Africa and water resources are scarce, the chemical quality of its groundwater is often poor, and the sustainability of the water sources is compromised by the inherent unreliability of the extremely variable climate, low rainfall, and high evaporation. The main objectives of a water supply scheme, therefore, are to deliver water of acceptable quality in sufficient quantity from the available sources on a sustainable basis, by using affordable means to meet reasonable demand.

2.6.2. Master Water Planning

The planning and development of water supply infrastructure in Namibia require a long-term planning perspective and broad master planning to be implemented over time as the country progresses socioeconomically. The primary objective is to have adequate water schemes in place when required despite any conceivable constraint, such as prolonged periods of drought conditions. Poor planning, bad management and a lack of implementation are, therefore, not an option.

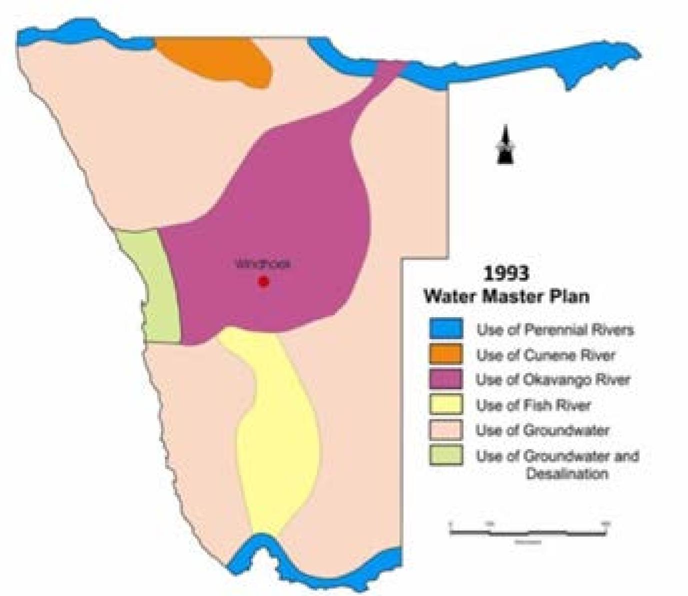
Since 1973, water development in Namibia has been guided by a Water Master Plan. The original plan had a 30-year horizon, but it has been updated every 20 years since then and is currently under review again. Figure 24 depicts the latest version, last updated in 1993.

The main directives of the 1993 Water Master Plan are as follows:

- In principle, the use of water from the perennial rivers – i.e. the Kunene, Okavango, Orange, and Zambezi – for domestic purposes and irrigation should occur as close to the rivers as possible to reduce pumping costs and energy demand (see Figure 25).
- Water from the Kunene should be diverted into the ephemeral Cuvelai basin in the north, where most of Namibia's population lives.
- Water from the Okavango should be imported to the Central Area of the country to augment the surface water resources which are currently unable

to meet future demand. This project is the so-called Eastern National Water Carrier and has been developed in phases. The final phase that still needs to be completed is the link to the Okavango River. The imported water should be used in conjunction with available groundwater as well as unconventional water resources, such as the resources from water banking, water reclamation, interbasin water transfers, and desalination.

Figure 24: The 1993 Master Water Plan [Source: DWA]



- Water from the ephemeral Fish River should be reserved for domestic use and irrigation. Several dams storing runoff in the river during the rainy season could potentially be used to augment the supply for domestic use and stock husbandry purposes when local groundwater resources in small towns or in the agricultural sector cannot meet the demand.
- The groundwater resources in the alluvium of the Kuiseb and Omdel aquifers supplying the central Namib area need to be used sustainably and can be augmented by desalinated seawater. The groundwater should be reserved for domestic use because it is less expensive than desalinated water, while desalinated water should be used mainly for industrial and mining applications.
- The rest of the country would have to rely on groundwater resources provided their quality and quantity adequately meet prevailing demand.

Figure 25: Permanent rivers only occur along Namibia's borders [Source: borgenmagazine.com]

2.6.3. Major Water Schemes

The development of water schemes is organised in a broadly defined National Water Master Plan. This plan determines where Regional Water Schemes are to be located for supplying water over long distances to places where it is required. The plan also determines the location of Local Water Schemes, where towns and villages are supplied from water sources over short distances in the immediate area.

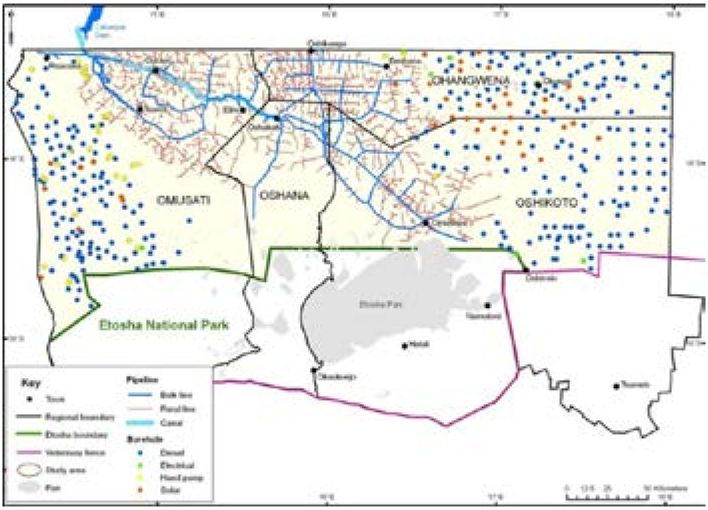
The largest regional schemes are the Cuvelai Water Supply Scheme, the Eastern National Water Carrier, and the Central Namib Water Supply Scheme. These are each discussed in more detail below.

(a) The Cuvelai Water Supply Scheme

Over half of Namibia's inhabitants live in the central Cuvelai drainage basin, in the north of the country. The Cuvelai drainage system originates in southern Angola and terminates in the Etosha Pan. Surface runoff during the rainy season is ephemeral and unreliable, but the deeper-lying groundwater is generally too saline for human or animal consumption. Although shallow wells can provide potable water, it is often polluted and unsafe to use. The water also dries up from time to time due to the arid climatic conditions. The only way to augment these rather unreliable water supplies is to import water from the perennial Kunene River (see Figure 26).

Namibia draws water from the Calueque Dam in Angola, about 18 km north of their shared border. The water is pumped via a pipeline across the watershed between the Kunene and the Cuvelai river systems, into a canal that runs across the border into Namibia. The transfer capacity of the pump station at Calueque amounts to 170 Mm^3/a.

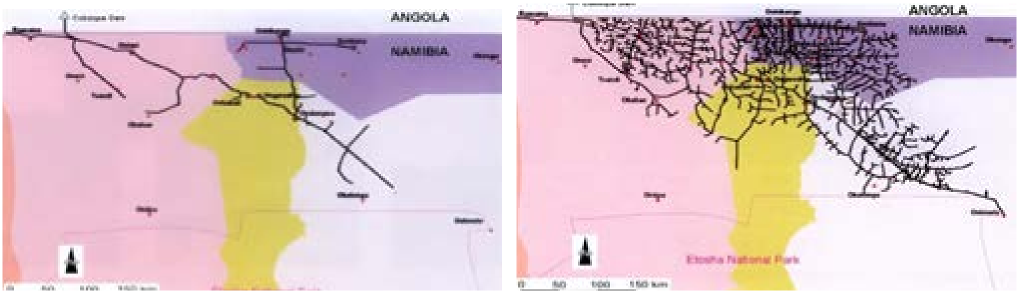
Figure 26: Layout of the water supply infrastructure in the Cuvelai basin [Source: DWA]



The canal from Calueque continues southwards to the Olushandja Dam, where it turns southeast via Ombalantu and Ogongo to Oshakati. The canal system is more than 100 km long. Water treatment plants occur at each of the larger towns (see Figure 26 and Figure 27), enabling potable water to be supplied to the local population through an extensive network of primary, secondary, and tertiary pipelines throughout the Cuvelai basin. The primary pipeline system extends from Oshakati to Ondangwa and then to the southeast in the direction of Oshivelo, to the northeast in the direction of Okongo, and to the north in the direction of Oshikango, which lies at the border with Angola.

The development of the primary bulk water supply system to the main towns in the Cuvelai basin started in the early 1960s. After Namibia's Independence in 1990, the rural water supply network was vastly extended. The canals and dense network of primary, secondary, and tertiary water reticulation pipelines total several thousand kilometres in length and supply safe, potable water to more than 90% of the people in the northern Cuvelai basin. Figure 27 shows a comparison between the status of water development in 1990 and 2010, respectively.

Figure 27: Water scheme coverage by 1990 (left) and by 2010 (right) [Source: DWA]



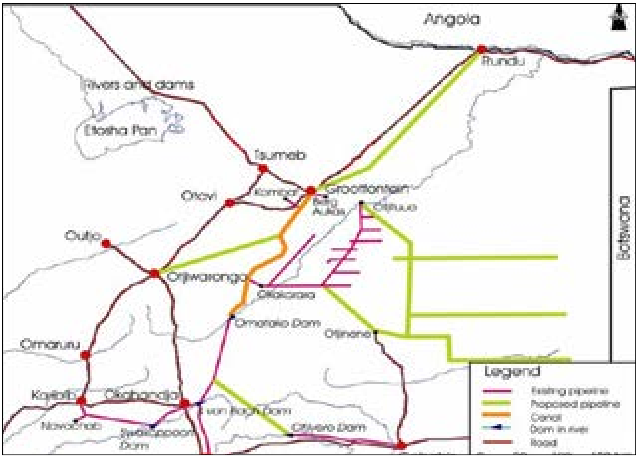
(b) The Eastern National Water Carrier

The single largest water project in Namibia is the Eastern National Water Carrier. Once completed, the carrier will import water from the Okavango River on Namibia's northeastern border to augment water supplies in the central, eastern, and western areas of the country.

The project is being conducted in phases according to the water demand, the potential of the internal water sources to meet that demand, and the availability of capital. The carrier has three main components. The first component entails three dams, namely the Von Bach, Swakoppoort (see Figure 28) and Omatako, in central Namibia. These dams are linked to each other and can be operated on an integrated basis to optimise their yield (see Figure 29).

Figure 28: Swakoppoort Dam [Source: W Ravenscroft]

Figure 29: The Eastern National Water Carrier [Source: DWA]



The next component is a link between the dams and groundwater resources in the Karst area in the Tsumeb–Otavi–Grootfontein triangle. This link comprises a 260 km open canal and inverted syphons between the Omatako Dam and Grootfontein (see Figure 30). The canal has a parabolic shape to reduce evaporation losses from the canal under both low- and high-flow conditions. The canal's full supply capacity is 60 Mm^3/a.

Figure 30: The Grootfontein-Omatako canal [Source: P Heyns]

The third component is a proposed pumping main (a pipeline in which the flow is maintained by pumping) between Grootfontein and Rundu, which lies at the Okavango River. However, this development has been delayed since 1990 due to the success of groundwater resource investigations, innovative water resource management practices, and the water demand management programme in central Namibia.

(c) The Central Namib Water Supply Scheme

The main centres of economic activity in the central Namib Desert are the central coastal towns of Namibia, Walvis Bay, Swakopmund and Henties Bay, along with the town of Arandis outside Swakopmund; and the Rössing/Husab and Langer Heinrich uranium mines, respectively some 60 km northeast and southeast of Swakopmund.

In the past, before the operation of the Erongo Desalination Plant, which has a supply capacity of some 20 Mm^3/a, the towns and mining development in central Namib were all supplied with water from alluvial aquifers in the ephemeral Omaruru River, which lies north of Henties Bay and the Kuiseb which lies south of Walvis Bay. The Kuiseb aquifer constitutes three compartments, namely Swartbank, Rooibank, and Dorop.

The well fields in these aquifers are linked to the supply centres using a network of more than 200 km of pipelines, pump stations and reservoirs. The Omdel Dam was built to artificially recharge the Omdel aquifer, as illustrated in Figure 31.

Figure 31: The central Namib water supply scheme [Source: P Heyns]

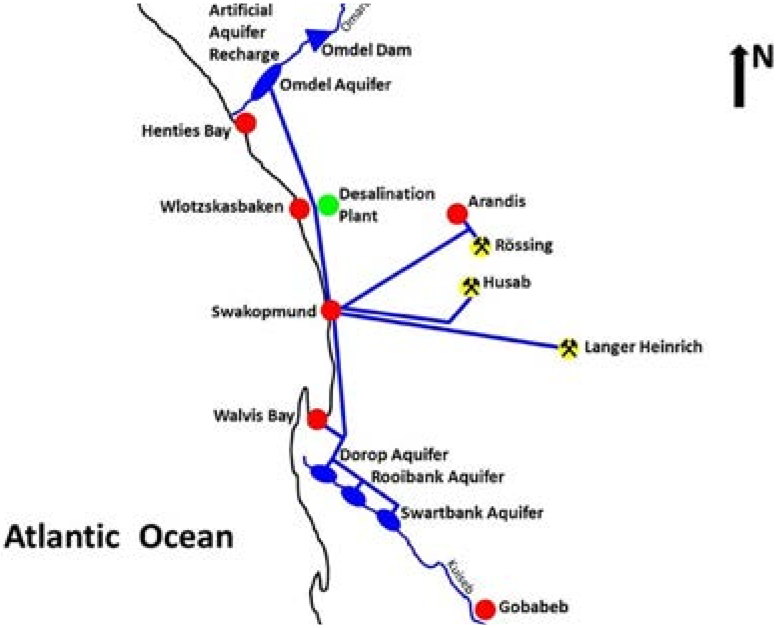


Table 6 shows the water demand and safe yield of water resources in the central Namib.

Table 6: Water demand and water resources in 2016 [Source: DWA]

Main consumer	Demand [Mm³/a]	Source	Sustainable yield [Mm³/a]
Arandis	0.40	Kuiseb aquifer	7
Henties Bay	0.56	Omdel aquifer	3
Swakopmund	11.80	Erongo Desalination Plant	20
Walvis Bay	6.42	Kuiseb aquifers	
Small consumers	0.82	Omdel and Kuiseb aquifers	
Mines	8.00	Erongo Desalination Plant and Kuiseb aquifers	
Total	**28.20**	**Total**	**30**

Table 6 also shows that the total water demand at the coast is 28.20 Mm^3/a, but the safe yield of the groundwater resources (Kuiseb and Omdel combined) is only 10 Mm^3/a. NamWater obtains 11.80 Mm^3/a from the Erongo Desalination Plant, which makes it possible to allow the depleted groundwater resources to recover. An additional 8 Mm^3/a is also sold to the mines in the Erongo Region.

Studies by the DWA in the early 1990s advised that the water in the Central Namib Area would be unable to meet the anticipated growth. The only remedy they foresaw was to desalinate seawater. Further research confirmed that membrane technology should be considered for desalination, provided that the nutrient-rich seawater was pre-treated before being desalinated. New membrane technologies and enhanced operational efficiency have made desalination an excellent proposition today. In addition, to meet the increased demand for water at a reasonable cost, such facilities should be operated using renewable sources of energy.

Notably, uranium mining activities require considerable quantities of freshwater each day. These needs need to be met along with those for all other purposes in the Erongo Region. Numerous studies are therefore currently assessing the construction of an additional desalination plant, which could supply some 25 Mm^3/a or more, to meet the growing water demand by coastal towns, mines, and local industries. The additional resource would also enhance water security in the region.

Consideration should also be given to developing the proposed desalination plant via a public–private partnership (PPP), as advocated in the Harambee Prosperity Plan. This could potentially free up the limited financial resources of the state to provide critical water supply infrastructure in other parts of the country as well. A pertinent case in point is the water crisis looming in central Namibia, and the rural areas (see Figure 32).

Figure 32: The raw water supply canal in central-northern Namibia [Source: G Schneider]

2.6.4. Dams and their Development in Namibia

Large dams are capital-intensive structures that are normally used to supply water for domestic use, industry, mining, irrigation, and hydropower generation or a combination of those uses. Such dams will normally not be built unless they are economically viable, of strategic importance, or ensure a reliable supply of water for socioeconomic development under arid conditions. Due to the scarcity of water in the arid interior of Namibia, there is no possibility of building dams for generating hydropower. However, the proposed Baynes dam on the Kunene River has the potential to generate 600 MW, while the Okavango River has the potential for a small (20 MW) hydropower plant at the Popa Falls in Namibia. Hydropower can also be generated at the Hardap Dam (460 kW) and the Neckartal Dam (3 MW), but the output is negligible.

The eventual selection of a dam site is determined by several natural factors. These include the hydrology, topography, and geology of the area, as well as the location of the intended consumers of the water. If the water will be used for irrigation, then the dam needs to be upstream of land with irrigable soil to facilitate irrigation under gravity. If the dam is envisioned to supply domestic and industrial needs, then it needs to be as near as possible to these potential consumers. If the dam is used to recharge borehole water sources, then it should be situated near to, and upstream of, a suitable aquifer.

Selecting a dam site is determined not only by the most optimal location in relation to the envisaged consumers but also with respect to the dam wall itself, which needs to be built in a deep and narrow part of a river valley. Such an ideal location would contain the cost of the dam structure and reduce evaporation losses. Furthermore, the geological features of the site need to provide a stable foundation for the embankment and spillway. A dam basin in arid areas is required not only to have enough storage capacity to impound large floods which occur intermittently but also to be able to bridge years with less or no runoff. The dam basin characteristics – i.e., the relationship between the water depth and a dam's surface area – also need to be as favourable as possible so that evaporation losses are minimised (see Figure 33).

Figure 33: The Neckartal Dam is Namibia's newest and largest dam [Source: NamWater]

Due to erratic rainfall conditions, the flow of rivers in the interior of Namibia is ephemeral in nature, and therefore irregular and unreliable. Consequently, the potential of these surface water sources is extremely limited (see Figure 34). The only way the water can be made available for use is to impound it in dams during runoff events in the rainy season.

Namibia has 11 major dams, refer to Table 7. A feasibility study is currently underway for another dam on the lower Orange River, some 6 km upstream from Noordoewer. The combined storage capacity of the existing dams is about 1,520 Mm^3, but due to high evaporation losses, the 95% assured safe yield from the dams is only about 200 Mm^3/a which is, on average, only 13% of the storage capacity of each dam. This is a clear indication of the low efficiency of surface water storage facilities in the arid environment that characterises Namibia.

In 2020, when the construction of the Neckartal Dam in southern Namibia was completed, it increased the yield of the Fish River system by 115 Mm^3/a. This latest dam will improve water supply and food security by providing drinking water for domestic use and raw water for irrigation. The irrigation potential is in the order of 4,000 ha, comprising 35 farms covering 100 ha each, and 10 farms covering 50 ha each. However, the irony is that the anticipated irrigation development to make use of the water has not yet started, even though the construction of the dam started in 2013.

Table 7: Major dams in Namibia [Source: DWA]

Dam	Main purpose	Structure type	Height [m]	Capacity [Mm^3]	95% safe yield [Mm^3/a]
Hardap	Irrigation	Rockfill	30	300.2	50.0
Naute	Irrigation	Concrete arch	37	83.6	12.0
Neckartal	Irrigation	Concrete gravity	71	857.0	115.0
Swakoppoort	Water supply	Concrete arch	33	69.0	4.7
Von Bach	Water supply	Rockfill	35	50.0	6.9
Omatako	Water supply	Embankment	12	45.1	2.1
Omdel	Aquifer recharge	Embankment	36	42.0	5.2
Oanob	Water supply	Concrete arch	55	35.0	4.5
Otjivero	Water supply	Concrete gravity	21	17.6	1.4
Dreihuk	Water supply	Rockfill	21	15.5	
Friedenau	Mining water	Concrete gravity	23	6.7	0.5
Total				**1,521.7**	**202.3**

Figure 34: Watering and washing point in central-northern Namibia [Source: G Schneider]

2.6.5. The Integrated Water Resources Management Plan

The main objective of an Integrated Water Resources Management Plan (IWRMP) is to achieve a sustainable regime for managing water and to ensure the infrastructure to do so is adequate. Achieving this objective will contribute to social equity, economic efficiency, and environmental sustainability.

An IWRMP is not a plan to develop a specific water project. Rather, it is a means of implementing a comprehensive solution to address all the relevant activities that will ensure water resource use is managed sustainably, which includes maintaining water supply services, disposing of effluent appropriately, and addressing capacity-building activities and funding requirements. The water resources in question encompass all water used for personal hygiene, sanitation, stock and wildlife drinking, industry, mining, and irrigated agriculture.

In 2004, the Global Water Partnership in Southern Africa hosted a workshop at a Symposium in Windhoek, introducing the concept and implementation of an IWRMP for each southern African country. As a result, in early 2006, a Namibian delegation who had attended a meeting of the African Ministers' Council on Water, had discussions with representatives of the African

Development Bank (AfDB) to obtain assistance for Namibia to develop an IWRMP. In April of that year, after AfDB funding had been secured, the Namibia Water Partnership hosted a planning workshop to discuss implementing an IWRMP. A proposal was prepared to develop an IWRMP on behalf of the then Department of Water Affairs and Forestry (DWAF) in the then Ministry of Agriculture, Water and Forestry.

The DWAF submitted the proposal document to the AfDB for consideration, and in May 2007, the AfDB signed an agreement with the Namibian government to fund the preparation of the IWRMP. This funding enabled the DWAF to retain a consortium of consultants led by Windhoek Consulting Engineers, who cooperated closely with the Ministry for Agriculture and Water and the Namibia Water Partnership to prepare the IWRMP.

The compilation of the IWRMP took all water policies and water development plans of service providers such as NamWater, the Directorate of Rural Water Supply in the DWAF, and the Local and Regional Authorities into account, along with the plans of the various basin management committees. The preparation phase also entailed reviewing the Water and Sanitation Sector Policy (published in 1993, and updated in 2000, and again in 2008), the existing Water Act, and the promulgated WRMA of 2004. These reviews aimed at determining the extent to which policy and legislation supported the IWRMP concept.

Figure 35: The Hardap Dam, and water spilling from the dam [Source: P Heyns]

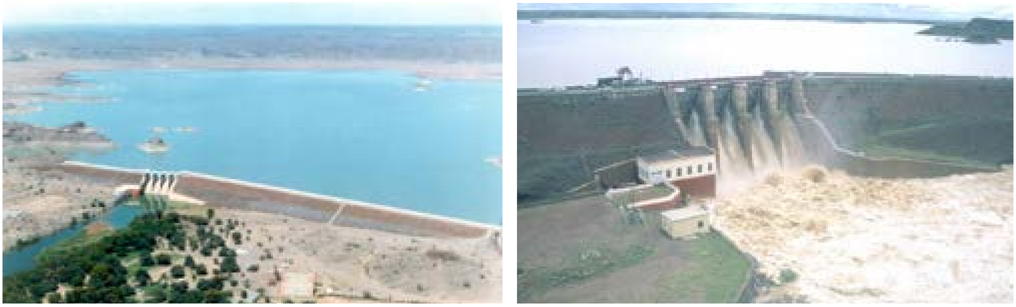


Figure 36: Hardap irrigation schemes *(left), and Mariental's flood in 2006 [Source: P Heyns]*

The IWRMP was completed in 2010 and was formally adopted in 2012. The new national plan addressed all aspects of water resource management using themes. The new national IWRMP also called for the implementation of an IWRMP for each region in the country. To date, each of the Ohangwena, Omusati, Oshana and Oshikoto Regions – where half of the Namibian population lives – have a Regional IWRMP in place.

The overall goal in addressing water resources management is sustainability. Planning and implementing water resources management in an integrated manner is not a linear exercise: it is cyclical. Thus, it needs to be accompanied by regular evaluation, progress assessments, and further planning.

To date, Namibia has been able to meet the growing demand for water to sustain development through innovation and exceptional ingenuity. There is no reason to believe that the continued provision of potable water cannot be maintained provided that the proper development of human resources continues, and adequate financial investments are made.

A wealth of knowledge already exists about Namibia's climate, rainfall, runoff, surface water and groundwater resources, thanks to data gathered over more than 100 years. The data includes measurements as well as research by scientists and engineers. The country also has a huge body of experience in the planning, design, construction, operation, and maintenance of water supply infrastructure, as shown in Figure 35 to Figure 41. Water awareness training, water demand management, community participation and an acute knowledge of the need to be on top of technological developments to maintain access to adequate supplies of water of acceptable quality for various kinds of uses are well embedded in the institutions responsible for water management.

Figure 37: Von Bach Dam (left), and the Von Bach Dam spilling (right) [Source: DWA]

How the new IWRMP is implemented in practice will depend on the organisational efficiency of the water sector institutions in place, the capacity of the human resources employed in those institutions, and the financial resources made available to achieve the plan's objectives. However, for the national IWRMP to succeed, priority attention needs to be focused on implementing water management activities at the community level.

Moreover, responsibility for integrated water resources management in Namibia is held by all stakeholders in the water sector, i.e. all water service providers, water-service-related management and governance entities, and all water users. Therefore, effective stakeholder participation at all levels is required in all decisions concerning water resource allocation and management. This participation needs to focus on capacitating stakeholders to manage specific water resource management activities – thus ensuring ownership of, and overall responsibility for, such resources.

Water demand management is a fundamental part of an integrated approach to the sustainable management of any water sector. In Namibia, such management contributed significantly to avoiding the potentially disastrous consequences of a lack of water availability in 1980, 1997, 2014 and 2019. The current water demand management strategy in the country aims at improving cost recovery, managing, and maintaining infrastructure, and reducing inefficient consumer demand. If the strategy succeeds, the pressure and reliance on conventional water resources will be reduced, as will the cost of operating and maintaining the associated infrastructure. This, in turn, would result in a net financial benefit to the supplier as well as its customers, while serving to protect the water environment.

Capacity-building and institutional development are also essential for implementing integrated water resource management successfully in Namibia. Such training and development should target all stakeholders to ensure not only effective and balanced water use but also water resource conservation and water security.

Figure 38: The Oanob Dam [Source: P Heyns (left), Lake Oanob Resort (right)]

Funding is another crucial component of a successfully implemented IWRMP. For this, a funding strategy is required. Several domestic and international approaches and instruments are available to Namibia for developing such a strategy. Moreover, Namibia has come a long way in creating the enabling environment necessary for ensuring that the investments to be made in the water supply sector can be mobilised. However, The current underperformance of service providers in terms of fiscal management and water infrastructure maintenance needs to be addressed as Namibia is wasting scarce resources through financial mismanagement. For example, funds from the central government that could be used to finance water supply and sanitation programmes and projects are being used to finance bad debt. Future planning needs to address these fiscal management shortcomings. The overall goal in addressing water resources management is sustainability.

Figure 39: Otjivero Dam (left), dam spilling (right) [Sources: P Heyns (left), G Schneider (right)]

The objectives of the water and sanitation sectors are specifically aligned with the nation's Poverty Reduction Strategy and its National Poverty Reduction Action Programme. Based on integrated water resource management principles, these policy documents provide overall guidance to the sector. The overarching goals for this sector are also aligned with the United Nations' Millennium Development Goals as well as goals articulated for the region in the Revised Protocol on Shared Watercourses in the Southern African Development Community (SADC, 2000) and the Regional Water Policy (SADC, 2005).

Figure 40: Naute Dam (left), dam spilling (right) [Source: P Heyns]

The key challenges in the water sector are to operationalise and implement the relevant policies, legislation, and plans. The IWRMP is vital in this context because it addresses the technical, institutional, financial, socio-economic, and other issues required to achieve the Namibian Vision 2030 with respect to water development within the next several years.

Namibia will also increasingly need to use the maximum potential offered by transboundary water resources. The government has already taken steps in this regard to ensure sustainable cooperation with Namibia's neighbouring sovereign states within the existing international water treaty frameworks and the SADC Revised Protocol on Shared Watercourses. Transboundary cooperation on the beneficial use of shared water resources will be greatly enhanced by these regional and international agreements and can lead to joint project implementation and operational management.

Figure 41: Omdel Dam [Source: P Heyns]

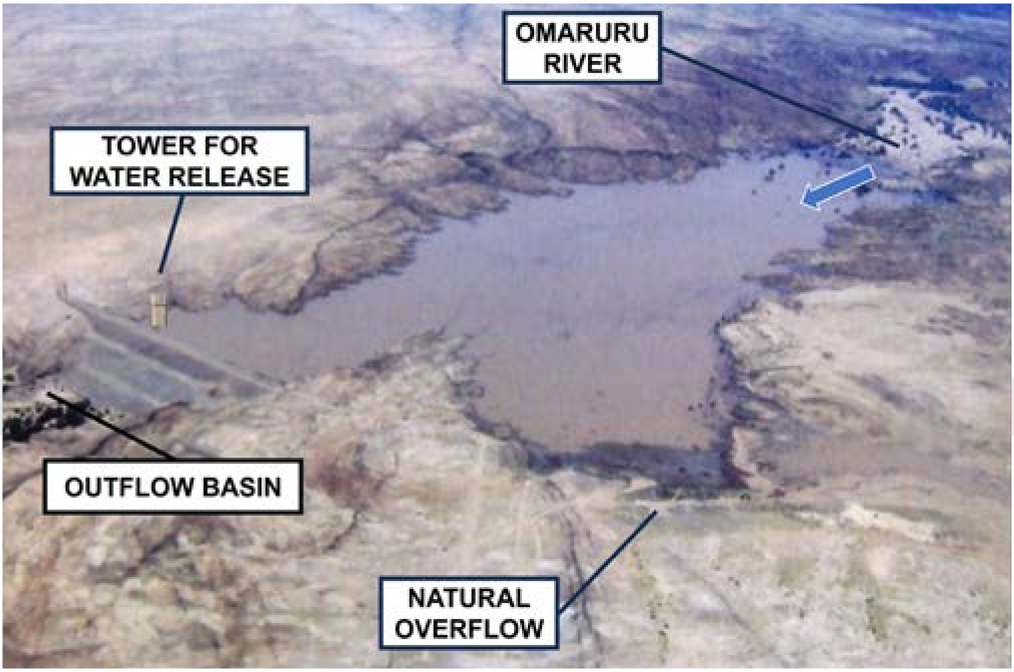


Figure 42: Confluence of the Orange and Fish Rivers [Sources: P Heyns (left), G Schneider (right)]

2.6.6. Institutional Arrangements

The Namibian Constitution provides for the establishment of a dedicated Ministry responsible for water affairs, policy implementation and the administration of the water sector. These responsibilities are shouldered and given effect on the government's behalf by a competent body – the DWA. The WRMA gives the Minister responsible for water affairs the power to take all steps considered necessary for the investigation, development, control, and utilisation of water resources, as well as the regulations for giving effect to the provisions in the Act.

The functions of overall water planning and development management, together with the broad division of responsibilities within the water supply and sanitation sector, are vital in managing water successfully. Table 8 identifies the main Namibian actors responsible for water management, water supply and the disposal of domestic effluent.

Table 8: Roles and responsibilities in the Water Sector [Source: P Heyns]

Institution	Roles and responsibilities
Ministry of Agriculture, Water and Land Reform, DWA: • Directorate: Resource Management • Directorate: Water Supply and Sanitation Coordination	• Irrigation water supply to Green Schemes • Integrated management of the rural water supply sector • Coordination of the development of rural sanitation services
Namibia Water Corporation (NamWater)	Bulk water supply on business principles
Regional Authorities	Water supply and sanitation to small communities
Local Authorities	• Water supply, reticulation, sewage treatment, reclamation, and reuse (e.g. Windhoek) • Water supply, reticulation, and sewage treatment (e.g., Outjo) • Reticulation and sewage treatment (e.g. Rehoboth)

Institution	Roles and responsibilities
Private sector: • Commercial farmers • Mines • Tourism establishments	• Self-supply of domestic water • Self-treatment of domestic sewage • Recycling and reuse of water used by the mines

2.6.7. Joint Water Commissions

Every transboundary river basin has upstream and downstream states. All those states have their expectations about using the water sources in their territories in the basin. The downstream states have similar objectives but are concerned about the magnitude of the water consumption for existing and future development by the upstream neighbours and that can become a reason for conflict. These expectations and concerns are to be addressed by establishing a joint water commission for each river basin. The main purpose of the commission is to advise its member states on the sustainable development of water resources in their portions of a shared river basin according to the results of joint studies on behalf of the member states to determine the yield of the water sources available as well as the most probable water-related development needs in each state. Such commissions do not implement water infrastructure development, because the member states do that according to the agreements reached between them and with contractors.

Namibia is a member of the water commissions established for the Kunene, Cuvelai, Okavango, Zambezi, and the Orange River, which are all rivers shared with other states. The terms of reference of those commissions are guided by the principles of international water law, as well as the policies, legislation, protocols, and conventions governing water issues in the respective basin states. The requirements of regional integration bodies such as the Water Sector Division in the SADC, the SADC Protocol on Shared Watercourses, the African Ministers' Council on Water, and the United Nations Water Convention, are respected by the water commissions.

According to Article 144 of the Namibian Constitution, all international water agreements ratified by Parliament become part of the law in Namibia.

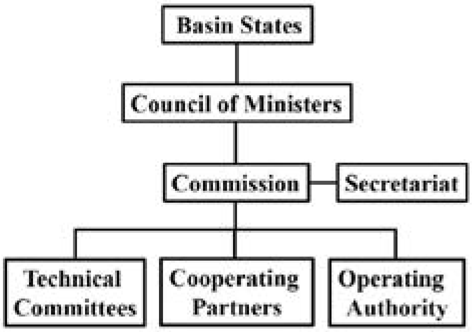
One of the most important activities of a water commission is to mobilize resources to conduct a diagnostic assessment of the development potential of a shared watercourse system. This can be achieved by the joint participation of the basin states in the studies required to analyse information collected over time and to evaluate the development potential of the basin. This will enable the implementation of a strategic action plan to develop the basin for the benefit of the population in each basin state.

Such diagnostic assessments are followed up by a strategic action plan for the river basin. The plan would provide a framework within which each basin state could perform its conservation duties and anticipated water developments, of which the other member states would be fully aware. The water commission's duty would then be to monitor these developments and report on progress to their member states' respective governments.

The number of states represented in a water commission varies according to the number of states in the catchment of a particular river. To illustrate: there are two states involved in the Kunene River and the ephemeral Cuvelai drainage system, namely Angola, and Namibia, three on the Okavango (Angola, Botswana, and Namibia), four on the Orange (Botswana, Lesotho, Namibia, and South Africa), and eight on the Zambezi (Angola, Botswana, Malawi, Mozambique, Namibia, South Africa, Zambia, Zimbabwe, and Tanzania).

The organisational structure of a water commission varies according to the number of states involved and the activities required. Figure 43 shows an example of the generic structure of a water commission.

Figure 43: *Generic structure of a water commission [Source: P Heyns]*



As mentioned, in the case of the Okavango, there are three basin states involved, namely Angola, Botswana, and Namibia. The Commission comprises three delegations, one from each state. Each delegation has three commissioners, of which one is the Leader of Delegation. The chairperson at each meeting is the leader of the delegation of the country hosting the meeting. The Council of Ministers are the three ministers responsible for water in each state. The leader of each delegation normally reports to the respective water minister following a commission meeting. The ministers must also jointly attend at least one commission meeting per year to enable them to meet each other and to be presented with a joint, annual report by the chairperson of the commission about the achievements of the commission, the work done and consensus about decisions proposed.

The members of the Council can discuss the proposals, obtain answers to questions, and make proposals for further consideration by their colleagues, or agree with the proposals. After all contributions have been considered and a proposal is accepted it is technically a joint proposal adopted by consensus by all the basin states.

The commission has a permanent secretariat which is responsible for the administration, management, logistics, organisation, and monitoring of the activities of the commission, including meetings and site visits.

2.7. Development and Maintenance of Water Supply Infrastructure

Water supply infrastructure is required to support the socioeconomic development that enables an acceptable standard of living and is the basis of prosperity for all. Establishing and operating a water supply scheme, in turn, requires capital investments. However, such investments negatively impact consumers, as recovering the costs of building and maintaining water supply infrastructure affects all end-users of the resource.

Water schemes do not last forever, see Figure 44. Thus, if maintenance is not properly done, facilities will deteriorate to the extent that the lifetime of the works is reduced, thereby requiring premature replacement – often at a higher cost than would otherwise be necessary.

Figure 44: Dilapidated water infrastructure in north-central Namibia [Source: G Schneider]

The administration, resource investigations, planning, design, construction, and operation of water supply facilities were done under one roof at the DWA, until NamWater was officially registered as a company on 9 December 1997. NamWater is a state-owned commercial entity that supplies water in bulk to its customers, who then reticulate such water to their customers. Ironically, although the water supply infrastructure and key personnel (such as technicians, hydrologists, scientists, and engineers) were transferred from the DWA to NamWater to continue water supply operations, top management was sourced from elsewhere. This arrangement inhibited the progression of staff careers through the ranks and led to the gradual attrition of critical human capacity to what was left of the DWA and NamWater. This development also largely contributed to existing water supply infrastructure being poorly maintained, while additional requirements were delayed. Moreover, the failure to undertake the necessary maintenance of existing, deteriorating waterworks and procure additional water infrastructure took place against the background of poor rainfall seasons.

The situation reached a critical point in 2016, prompting the President to appoint a Cabinet Committee on Water Supply Security (CCWSS) to address the looming water scarcity, especially in the central and northern regions of the country. The CCWSS not only had to fast-track solutions to address the water supply crisis, but it also had to conduct planning and cost the water needed (refer to Table 9). The Committee's work resulted in 27 priority projects with a total estimated cost of N$ 8.374 billion.

Table 9: Water-related priority projects considered for implementation [Source: CCWSS]

Number	Project	Cost [million N$]
1	Master water plan study Central Northern Regions	42.0
2	Calueque Permanent Pumping Station	6.5
3	Omahenene to Olushandja Dam Canal Refurbishment	89.0
4	Olushandja Pump Station and Syphon I Refurbishment	2.0
5	Olushandja to Ogongo Canal Refurbishment	173.0
6	Ogongo to Oshakati Canal Refurbishment	210.2
7	Oshakati Water Treatment Plant Upgrading	772.1
8	Rundu Treatment Plant Upgrading	748.0
9	Ohangwena Aquifer development for Oshandi – Eenhana Area	296.0
10	Katima Mulilo Treatment Plant Upgrading	437.0
11	Omundaungilo-Omutsegwonime Water Supply Scheme	724.5
12	Ogongo – Oshakati Pipeline Replacement	287.5
13	Replace Ondangwa–Oshali–Omuthia–Omutsegwonime Pipeline	467.8
14	Katima Mulilo Distribution Network Extension	341.5

Number	Project	Cost [million N$]
15	Reclamation Plant Extension and Upgrading Sewage Works	1,917.2
16	Berg Aukas Power Supply Upgrade	150.0
17	Rehabilitation of Karibib Boreholes	8.5
18	Central Area Water Supply Alternatives Study	2.0
19	Abenab – ENWC Pipeline Link	1,476.1
20	Berg Aukas Deep Installation and Capacity Upgrade	43.0
21	Central Coast Master Plan and link to Central Area Study	28.0
22	Kuiseb boreholes Replacement	5.0
23	New Kuiseb Delta Borehole Scheme	153.0
24	Kuiseb Aquifer Capacity Upgrade	16.0
25	Kuiseb to Swakopmund Pipeline Replacement	557.0
26	Omdel Wlotzkasbaken Pipeline Replacement	95.0
27	Orano Desalination Plant alternatives study and negotiations	15.9
	Total	**8,374**

2.8. Conclusions – The Water Sector

The purpose of this discussion about water issues is to create a better understanding of the importance of managing the relationships and interactions among water, energy, and food. Understanding how best to manage this nexus will ensure that the development of the Namibian people and their resources continues despite the uncertainties posed by, for example, a changing climate and its impacts on the availability of water.

Water, energy, and food for the nation are essential for sustainable development and attaining an acceptable standard of living for the population. Projections indicate that the global demand for freshwater, energy and food will increase significantly over time, mainly due to population growth, urbanisation, economic development, international trade, and other factors. Today, agriculture alone accounts for some 70% of total freshwater withdrawals in Namibia, rendering this sector the largest water user. Such water is mainly used for irrigating crops, watering livestock, and other agricultural production along the entire agri-food supply chain.

Energy is required to produce, transport, and distribute food, as well as to abstract, pump, lift, transport and treat water as well as wastewater. Human consumption, industry and a multitude of other uses demand more water than ever before, while the demand for energy and land resources continues to rise as well. This has resulted in resource scarcity and is compromising environmental sustainability.

Namibia is a developing country, which also implies that the demand for water, energy and food should be met most economically. There is no point in producing food to be self-sufficient when the cost per unit of production is higher than imported equivalents. Such a scenario sacrifices the opportunity cost to the detriment of the economy as well as the Namibian people.

The required policy, legislative framework and institutional arrangements are already in place for the efficient and effective provision of water supply infrastructure and services to meet current demand and cater for future development. Future planning needs to consider that climate change unfolds over time. Thus, Namibia's harsh climate and arid conditions will systemically impact the yield of water sources, how we generate energy, and how we produce the food we need. Any detrimental effects must be identified early and managed in an innovative way to meet the threats they pose.

Before NamWater was established in 1997, the DWA had a dedicated Division that did the planning of all the large-scale bulk water supply schemes in the country. This planning had to be based on the best possible information on the location of surface water and groundwater resources, the availability of suitable water sources, and an assessment of their assured yield to supply the demand generated by the growing economy over time. These assessments were undertaken and kept up to date by hydrologists, hydrogeologists, other scientists, surveyors, and technical support staff. The information they obtained was used for planning and development by the engineers, technicians, and artisans, as well as the construction labour force. After NamWater was established, the main planning activities that remained at the DWA were conducted for small-scale rural water supply schemes, while the large projects became the responsibility of NamWater.

The establishment of NamWater caused huge delays in the development of additional bulk water supply schemes and further led to a lack of rigorous maintenance of existing infrastructure. In 2016, some 18 years after the commercial entity was established, appropriate action was needed to save the day. This led to the creation of the Cabinet Committee on Water Supply Security, whose planning will be executed over several years to come so that water security in Namibia can once again reach acceptable levels.

The sustainability of the economy of Namibia relies heavily on the availability of water for development. The recent challenges related to the lack of water have mobilised financial and technical resources to ensure the availability of water. Planning undertaken since 1973 indicated that water would have to be imported from the perennial border rivers to meet the water demand of a growing nation. This could only be realised after Namibia's independence in 1990 when an agreement was reached with Angola to abstract 170 Mm^3/a from the Kunene River (see Figure 45) at the Calueque Dam in Angola.

Namibia also has an agreement with its southern neighbour, South Africa, to abstract 9 Mm^3/a for the Noordoewer irrigation project at the Orange River. However, the present abstraction of water from the river at other irrigation schemes, towns and mining activities located along the Orange River on the southern border of Namibia already amounts to more than 160 Mm^3/a. In 2014, Namibia and South Africa commenced a joint study to build a dam on the lower Orange River. Namibia planned to obtain a share of at least 300 to 400 Mm^3/a in the yield of the dam, but South Africa has put the construction of the dam on hold, which implies a huge lost opportunity for Namibia.

No water use agreement currently exists between the Okavango River basin states (Angola, Botswana, and Namibia) regarding access to water from the Okavango, although a joint study has been conducted to determine the future water demand of each state in the basin. The planned measures, as far as the abstraction of water from the Okavango is concerned, indicate that the future water requirements will be at least 200 Mm^3/a within the next 20 years.

The other Okavango basin states are aware of this resolve, which is also well-documented in a report on the transboundary diagnostic analysis that was done under the auspices of the Permanent Okavango River Basin Water Commission (OKACOM). However, an environmental lobby in Botswana has been objecting since 1995 against the abstraction of water from the Okavango, insisting that the Okavango Delta "must get all the water it can get".

OKACOM's report offers a more reasonable perspective on this issue, considering that water availability is the key to enabling an economy and contributing to the welfare of the population, noting the context of the water and food components of the nexus as is the topic of this text.

Figure 45: Epupa falls in the Kunene River [Source: P Heyns]

3. Namibia's Energy Sector

A nation that can't control its energy sources can't control its future.

Barack Obama

3.1. Introduction

Energy is an integral requirement of any economy. The provision of water, food, health services, education, and resources to accomplish most other human endeavours, all depend on the availability, accessibility, affordability, and adequacy of a country's energy supplies.

Energy manifests itself in a variety of forms, including, for example, kinetic energy, heat energy, gravitational energy, electrical energy, chemical energy, nuclear energy, and others. For this book, which revolves around the interdependencies between water, energy, and food in Namibia, it is important to note that different forms of energy are used and contribute to meeting the country's energy needs, as well as energy sources that are exported.

Securing national energy supplies necessitates a thorough understanding of the options, costs and impediments associated with individual energy supplies. In the recent past, Namibia's energy sector has witnessed exciting oil and gas discoveries. Others suggest that green hydrogen will reignite the country's stagnant economy. This chapter includes reflections on how new energy sources, i.e., those that have not been part of the country's past energy mix, may contribute to meeting Namibia's future energy needs, and be synthesised to be exported.

Namibia is generously endowed with a variety of energy resources. These include the country's renewable energy riches, such as solar, wind and biomass resources, as well as a variety of non-renewable deposits of fossil fuels and natural gas, as well as minerals used in the international nuclear energy industry. Generally, Namibia's renewable resources are abundant, readily accessible, available, safe, and clean, and will remain so in future. Non-renewables are finite, and their use is associated with a multitude of social and environmental impacts.

The deliberate exploitation of Namibia's mineral and fossil resources will boost national development. However, realism and a grasp of science are necessary when deciding on future energy resource development, and its uses. Unfortunately, many a public discussion centres around plainly surreal notions on the role of different energy forms, which energies are to be developed to secure our energy needs, and their costs and impacts. Conceptual misinterpretations imply expensive mistakes that will burden society. This chapter will attempt to provide a sober perspective on Namibian energy sources and their applications.

International trends and initiatives are increasingly focusing on the deployment of cleaner, more sustainable, and climate-friendly energy options. Developing the uptake of less impactful energy sources can be achieved by switching from fossil fuels to renewable energy technologies. Namibia, which is rich in renewable energy resources, displacing fossil-powered technologies with renewables also enhances the social, environmental, and economic benefits associated with the use of local resources and local value creation (von Oertzen, 2018c).

Essential bridgeheads for Namibia's energy future can be built by maximising the benefits from the country's fossil and nuclear mineral endowments, while dramatically upscaling the deployment and use of renewables. Deliberations on Namibia's energy future should steer clear of irrational beliefs in hyped-up promises, wishful thinking and ideological rhetoric, as these create misleading expectations that will not address Namibia's development needs.

3.2. Energy Sources

Namibia is abundantly endowed with a large variety of indigenous energy resources (von Oertzen, 2012; von Oertzen, 2015).

Primary energy sources refer to those natural energy forms that have not been altered by one or several conversion processes. Primary energy sources include, among others, biomass, crude oil, geothermal energy, natural gas, solar radiation, wind energy, and energy released in nuclear fission. As such, primary energy forms can be renewable or non-renewable and often serve as input to a system that is engineered to provide energy for human use.

Secondary energy sources are those obtained via the conversion of one or several primary energy sources. For example, petrol and diesel are liquid fuels that are derived through a refinement process of crude oil, which renders them secondary energy sources. Other examples of secondary energy sources include electricity generated in power stations, such as in a solar photovoltaic power plant, a coal-fired power station, or a hydroelectric generation plant.

The next sections provide a snapshot of Namibia's primary and secondary energy sources.

3.2.1. Biomass

More than one-half of all Namibian households continue to use wood as a fuel source for both cooking and space heating. Biomass therefore continues to be a significant energy source and important contributor to Namibia's total energy mix. In past deliberations on the country's energy sources and their uses, biomass resources enjoyed little attention (von Oertzen, 2020).

Figure 46 illustrates the distribution of encroacher bush biomass, covering an estimated 45 million hectares of commercial and communal lands (SAIEA, 2015). Biomass can be a renewable energy fuel, which can be used in the electricity sector, commerce, and industry. In addition to the thermal uses by households and the displacement of coal and liquid fuels in industry, bush biomass also serves as a primary feedstock to the country's charcoal industry and for animal feed, and it is used to produce composite building materials (von Oertzen, 2015).

Figure 46: Encroacher bush (left) and its distribution as grey blocks (right) [Source: SAIEA, 2015]

3.2.2. Coal

Although some local coal deposits exist in Namibia, none are currently considered suitable for commercial development.

3.2.3. Geothermal sources

Some evidence of geothermal potential exists, for example in southern, central, and north-western Namibia, and hot springs are found (amongst others) at /Ai-/Ais, Windhoek, Gross Barmen, near Kamanjab, and at Warmquelle near Sesfontein. However, the country's geothermal potential has not been explored nor quantified systematically, and none of the known resource fields can be considered ready for commercial use.

3.2.4. Hydropower

Water flowing in the perennial rivers on the borders of Namibia and in the ephemeral rivers in the country can be used to generate hydropower. However, Namibia's hydropower potential is limited by the volume of the flowing water, the gradient of the rivers, and suitable sites where dams can be built to store water during the rainy seasons, for it to be available during the whole year to generate electricity.

3.2.4.1. The Fish River

In 1963, Namibia's first hydropower plant was completed at the Hardap Dam, which is fed by the ephemeral Fish River, near Mariental, see Figure 47 (left). Water released for irrigation at the Hardap irrigation scheme can be passed through two installed turbines, with a generating capacity of 47 kW, and 289 kW, respectively, which is shown in Figure 47 (right). These installations are no longer used but are included in this discussion because of their historic role.

Figure 47: Hardap Dam (left) with hydropower turbines and generators [Source: P Heyns]

3.2.4.2. The Kunene River

In the 1960s, the hydropower potential of the Kunene River was investigated. With a mean annual runoff of some 5,000 Mm³/a, a steep gradient, and narrow valleys in the upper reaches of Angola, the Kunene River offers multiple important hydropower locations. For Namibia, the River's lower reaches on the border between Angola and Namibia are of strategic relevance, both in terms of the hydro-potentials as well as the sharing of scarce water resources.

The hydropower development potential along the common border is estimated at 2,100 MW. On the lower Kunene River, the difference in elevation between the top of the Ruacana Falls (which itself has a drop of some 120 m) and the Atlantic Ocean amounts to more than one kilometre over the distance of some 325 km. It is therefore entirely possible to construct a cascade of dams along the Kunene to generate hydropower.

Angola's Gove Dam was built to impound summer rainfall and to release the water to supply a constant flow of water for downstream uses. This is important for Namibia, as it ultimately determines Ruacana's electricity generation capacity. As shown in Figure 48 (left), the weir upstream of the Ruacana Falls diverts water from the Kunene River to the power station through a tunnel into a head bay, which serves to maintain the water level in the weir and the head bay at the same level. Water is diverted down the penstocks to the turbines and generators in the Ruacana power station, see Figure 48 (right). After passing the turbines, water is channelled via the tailrace back into the Kunene River, from where it proceeds to flow downstream.

Figure 48: Ruacana hydropower station (left) and generator hall (right) [Source: NamPower]

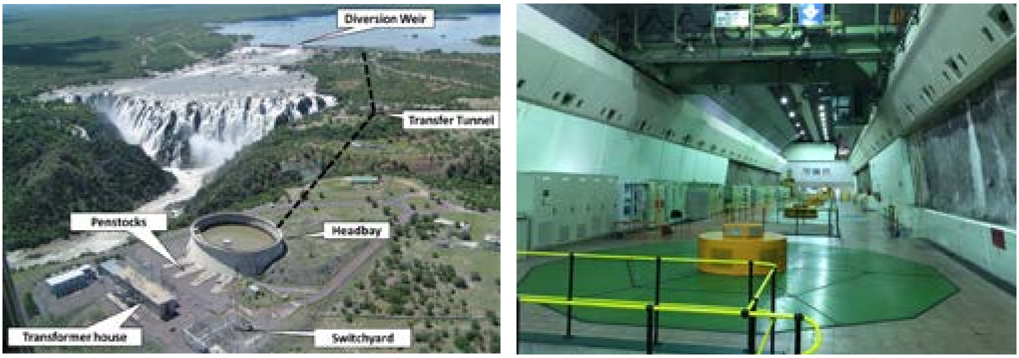
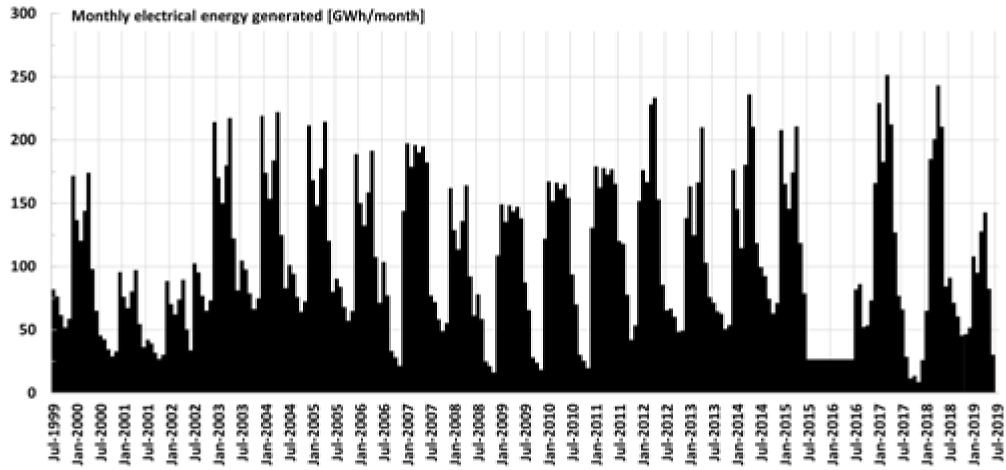


Figure 49 shows the electrical energy generated at Ruacana, in GWh per month, between July 1999 and July 2019. The plant's output is highly variable. Without large-scale storage and noting that there is only a small reservoir to manage water levels over 24 hours, Ruacana's output is rainfall-dependent (von Oertzen, 2018a).

Figure 49: Ruacana's electrical energy output between 1999 and 2019 [Source: D von Oertzen]



Changes in the regional climate are likely to further pronounce the current variability of water flows at Ruacana. In addition, the many new agricultural projects and industrial developments that are initiated in southwestern Angola are expected to negatively affect the reliability of the Kunene River's flows further, thereby substantially influencing the future output of this critically important national electricity-generating asset.

Further hydropower assessments have been undertaken since Namibia's independence in 1990, to investigate the requirements and viability of additional hydropower plants on the lower Kunene River, at both the Epupa and Baynes dam sites. While the Epupa site was found to be technically preferable, as it offers greater storage capacity, the Baynes site would be less disruptive to the life of the Himba people and would also have a smaller overall environmental impact.

The Baynes site, which is some 200 km downstream of Ruacana, would necessitate a dam wall of 200 metres in height, creating a water head on the turbines of 187 m. The dam can hold some 2,650 Mm^3, be some 43 km long, and have a maximum width of up to 4 km. The area inundated by the reservoir would amount to some 57 km^2.

Baynes is envisaged to have a generating capacity of 600 MW, which is to be shared between Angola and Namibia. Operations during the wet season will allow the station to operate at full capacity, while generators will only be used during mid-merit/peak periods in the dry season. Like the Ruacana power station, Baynes would be mainly used as an intermittent station, which would enable NamPower to minimise importing expensive electricity in peak demand periods.

3.2.4.3. The Okavango River

The hydropower potential of the Okavango River in Angola and Namibia would allow for the development of four separate dams with a total generating capacity of some 166 MW on the Cubango River, and a further 12 MW on the Cuito River.

Downstream of the confluence of the Cubango and the Cuito rivers, a hydropower plant with a generating capacity of between 20 to 30 MW could be built at the Popa Falls. Popa is in Namibia, where the Okavango River crosses the Caprivi on its way to the Okavango Delta in Botswana.

A small off-the-river hydropower plant with a generating capacity of 50 kW is located at Andara, refer to Figure 50. Water is being diverted on the Namibian side of the Okavango River into the power station, where electricity is generated to supply the hospital at Andara.

Figure 50: Andara power station, Okavango River (left) with 50kW generator [Source: P Heyns]

3.2.4.4. The Orange River

The hydropower potential of the Orange River is limited, with hydropower stations at Muela in Lesotho (80 MW), at Gariep (360 MW) as well as at Vanderkloof (240 MW) in South Africa. These dams cause significant fluctuations in the downstream flow and associated water levels when water is released for power generation, according to the demand for power at certain times during the day. The modifications to the environmental flows in the river have impacts, resulting from a loss of small flood events that stimulate fish breeding, the stabilisation of the temperature regime in the water, detectable up to an estimated 180 km downstream, and reduced turbidity because dams capture and reduce sediment transport further downstream.

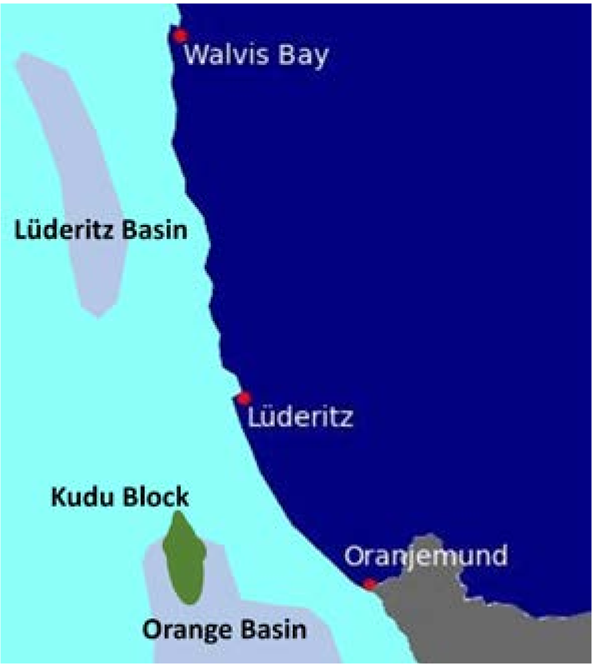
The Lower Orange River holds options for the development of smaller hydropower plants, i.e., the Lower Orange hydroelectric power scheme. This scheme entails the development of up to nine hydropower stations, ranging from 6 MW to 12 MW, along the lower Orange River, with an estimated total power generation potential of between 80 MW and 120 MW.

The combined hydropower potential of such plants is estimated at 100 MW. However, the development of the hydropower plants is complicated by the fact that the Orange River is already a highly regulated river system that is close to reaching its optimal development potential. Among the pertinent issues to address is that the diversion works to convey water into the hydropower plants would have to be located across the river. However, the boundary between Namibia and South Africa lies officially on the northern bank of the river. While the South African and Namibian governments agreed to move the border to the centre of the river in 1991, this has not yet been implemented. Until the border issue is finally resolved, developments along the Orange River will likely remain stifled.

3.2.5. Natural Gas

Namibia's Kudu gas field is in the northern Orange subbasin, some 130 km off the southwestern coast, as shown in Figure 51. Discovered in 1974, the field has proven and potentially exploitable natural gas reserves amounting to some 1.3 trillion cubic feet, at a water depth of some 170 metres. To date, the gas field has been extensively explored, including the drilling of exploration wells, and 3-dimensional seismic surveys undertaken in 1993 and 1996.

Figure 51: Indicative location of the off-shore Kudu gas field [Source: G von Oertzen]



Despite decades of exploration and development work and hundreds of millions of Namibia Dollars in investments, the commercial development of the field remains elusive. In 2017, the commercial developer BW Energy entered into a farm-in agreement for a 56% operated interest, with the

National Petroleum Corporation of Namibia (NAMCOR) holding a 44% joint venture interest (NAMCOR). In 2021, BW Energy signed a farm-up agreement that saw the company increase its interest to 95% in the license (BW Energy).

BW Energy is progressing a revised development plan for a gas-to-power project, utilising a repurposed semi-submersible drilling rig as a floating production unit. In the first quarter of 2022, the semi-submersible drilling rig West Leo was procured for targeted use in the gas field.

The development of the Kudu gas field could create opportunities to supply one or several on-shore power stations along Namibia's coast, either supplying a plant owned and operated by NamPower or in partnership with others, for example as an Independent Power Producer, for local use as well as for export to regional off-takers.

3.2.6. Ocean and Wave Energy Sources

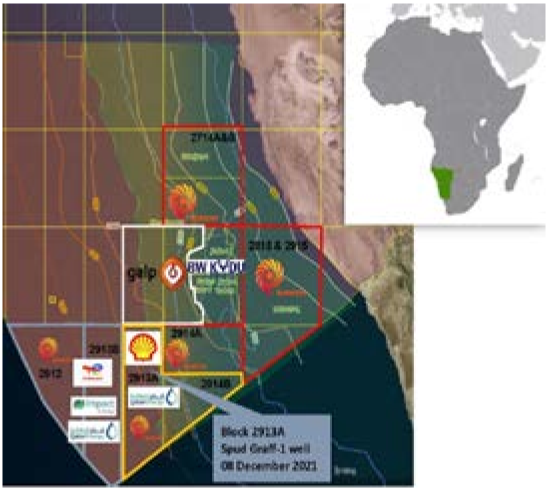
Namibia has a long coastline that offers the likely potential to harvest energy from waves and the ocean. This resource potential, however, awaits to be properly investigated and quantified.

3.2.7. Oil

Over the past 15 years, exploration activities in Namibian off-shore areas have yielded valuable geological data, providing evidence that potentially exploitable hydrocarbon resources exist.

Shell Namibia Upstream BV (Shell) is an oil and gas exploration entity active in Namibian waters. It has a 45% participating interest in Petroleum Exploration Licence 39 (PEL 39), located in the country's southwestern offshore waters, as shown in Figure 52. The other partners holding an interest are Qatar Energy, holding a 45% interest, and NAMCOR at 10%.

Figure 52: Off-shore oil and gas exploration areas and main active entities [Source: NAMCOR]



Shell completed three seismic surveys of PEL 39 between 2014 and 2019, to identify geological structures below the seabed which might contain oil or gas. In early February 2022, Shell completed drilling its first exploration well (Graff-1) in PEL 39, establishing that the off-shore exploration site Graff-1 was a working petroleum system, and confirming the presence of light oil. Further evaluation of the well results is necessary, complemented by additional exploration activities, to determine the size and recoverable potential of the hydrocarbons.

In early 2023, Shell announced their fourth discovery, confirming that the Lesedi-1X well confirmed the presence of hydrocarbons.

TotalEnergies EP Namibia BV is another active oil and gas exploration entity. It is the operator at PEL 56 (40%), with Qatar Energy (30%), Impact Oil & Gas Namibia (20%), and NAMCOR (10%).

In February 2022, TotalEnergies drilled the Venus-1X exploration well in Block 2913B within PEL 56 to a depth of 6,296 m, discovering light, sweet oil as well as natural gas. Their Deepsea Mira semi-submersible drilling rig re-entered the Venus-1X discovery in June 2023. Initial flow tests show positive results and are to be further firmed up at Venus-1A towards the end of 2023.

To date, Namibia has not produced any oil or gas. However, given the favourable results of recent exploration activities, further appraisal tests are being undertaken. These will provide evidence of whether the current finds contain adequate volumes and flow properties that lend themselves to commercial development. The scale of potentially exploitable resources will also determine how production is best to be undertaken.

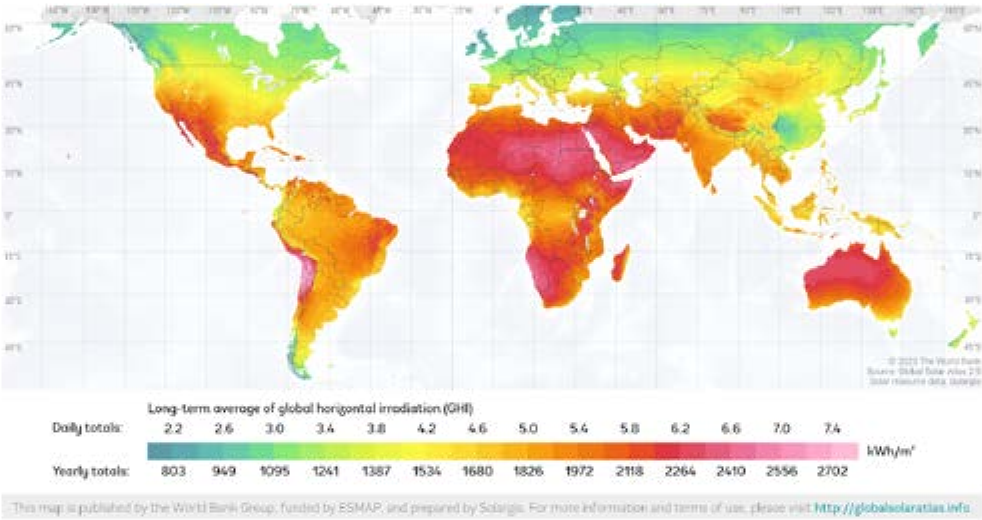
The complexity of the marine production environment, noting that Jonker-1X is some 270 km offshore, at 2.2 km water depth, with a well of more than

6 km deep, may favour a floating production storage and offloading platform. This would allow the transfer of crude oil from the production fields onto tankers, for shipment to refineries, and necessitate investments of between US$15 billion and US$20 billion before starting production.

3.2.8. Solar Energy

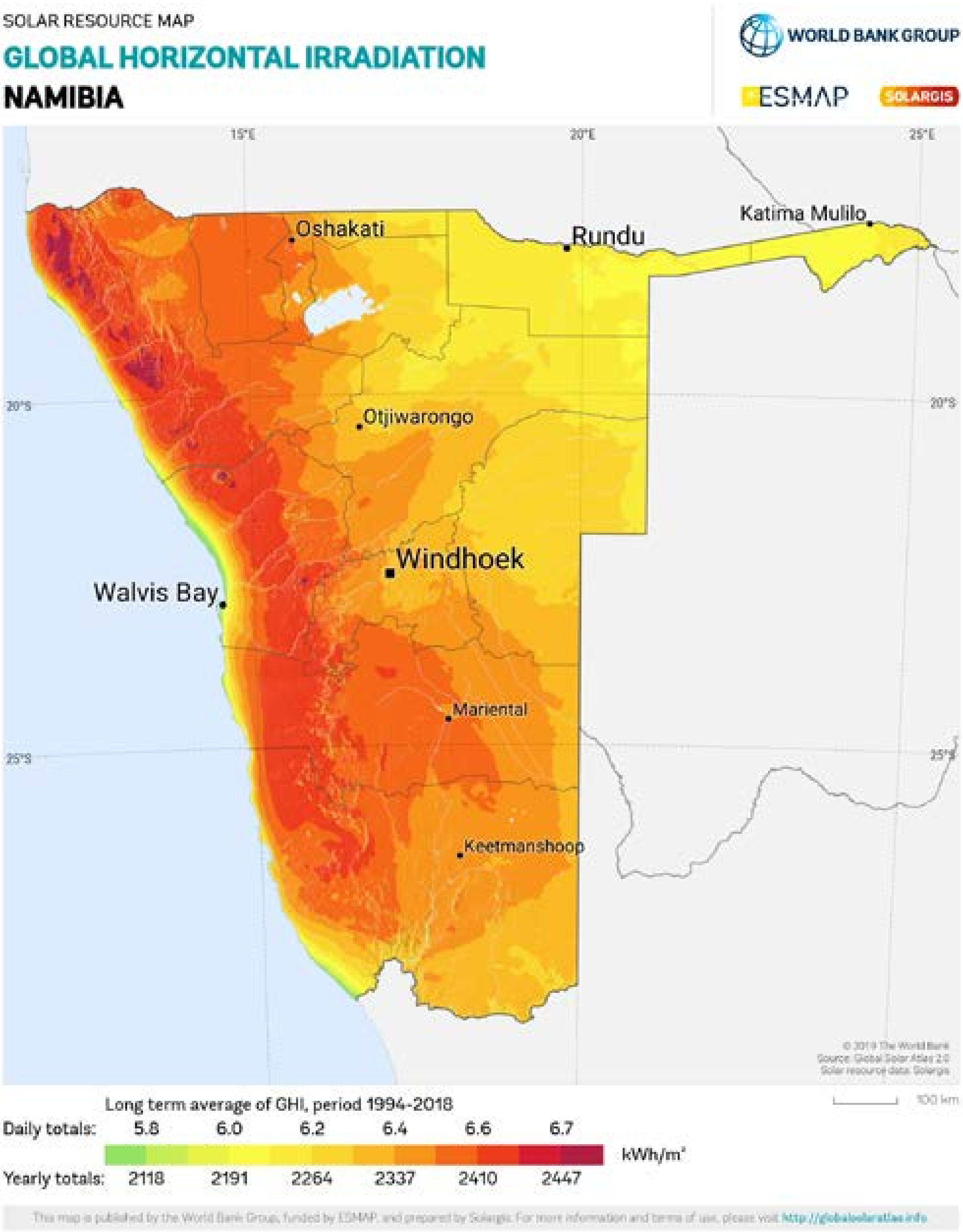
Figure 53 and Figure 54 show that Namibia is endowed with one of the best solar energy regimes worldwide (IRENA, 2014; von Oertzen, 2015).

Figure 53: Long-term average global horizontal irradiance, in kWh/m² [Source: World Bank]



Solar resources are most suitable to generate electricity, for example in a solar photovoltaic plant or concentrated solar plant, as well as for solar thermal applications. The commercial exploitation of Namibia's solar resource is increasing rapidly, most notably because of solar PV (electricity generation) and thermal energy uses, for example, to heat water.

Figure 54: Namibia's world-class solar resource, in kWh/m² [Source: World Bank]



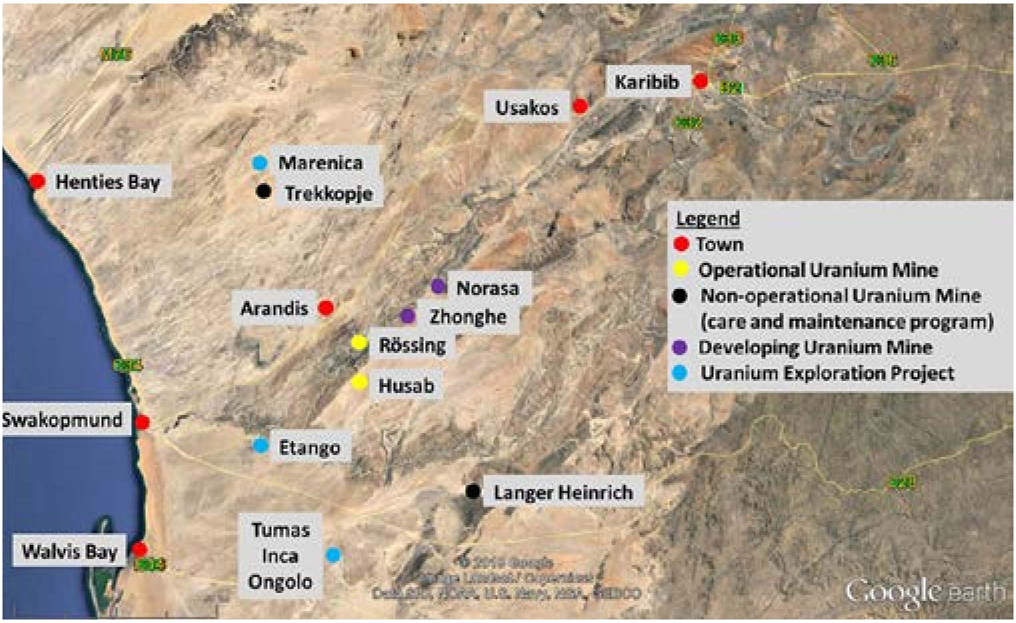
In Namibia, solar energy is already widely used in photovoltaic electricity generation units. Many a homeowner, manufacturers, and shopping malls benefit from augmenting their existing electricity supplies with solar-supplied electricity, as is illustrated in Figure 55. The future will tell whether and when Namibian vehicle owners will decide to adopt electric vehicles at scale, to derive further benefits from Namibia's outstanding solar resource.

Figure 55: Fossil-fuelled vehicles at Windhoek's solar-powered Grove Mall [Source: A Scholle]

3.2.9. Uranium

Namibia's Erongo Region is the country's premier uranium production province, see Figure 56.

Figure 56: The Erongo Region is Namibia's premier uranium province [Source: D von Oertzen]

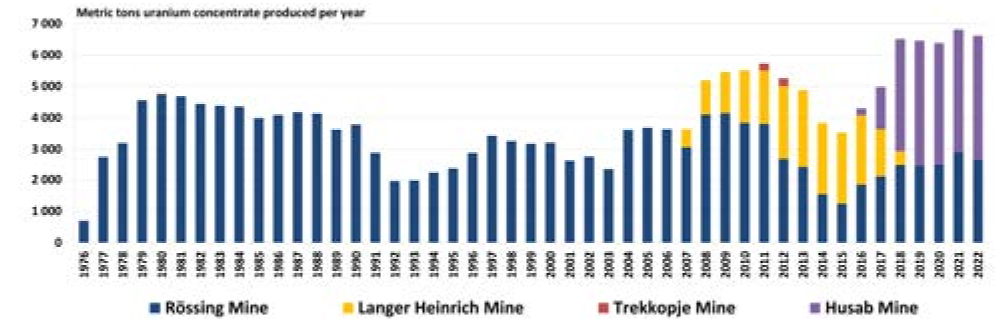


Production of uranium concentrate commenced at the Rössing Uranium Mine in 1976. Other mining operations, i.e., Paladin's Langer Heinrich Mine, Orano's (formerly Areva's) Trekkopje Mine, and Swakop Uranium's Husab Mine (see Figure 57) have started operations since. In 2023, Swakop Uranium and Rössing Uranium were the only two operating facilities, while the Langer Heinrich Mine is to re-start production in 2024.

Figure 57: Part of the Husab Mine's pit [Source: D von Oertzen]

Figure 58 shows Namibia's annual uranium concentrate production figures since the start of production in 1976, in metric tonnes per year.

Figure 58: Namibian uranium concentrate production since 1976, in [t/a] [Source: D von Oertzen]



Between 1976 and 2022, the country produced a total of some 189 kilo-tonnes of uranium concentrate, which is an export-only product. In 2022, the country contributed some 11.4% of global uranium supplies.

Comparing Namibia's total energy use to the country's uranium exports, expressed as the potential electricity generated from this resource, renders the country a significant net energy exporter (von Oertzen, 2015).

3.2.10. Wind Energy

Along the country's coastline, as well as in select inland locations, Namibia boasts some good to significant wind energy potential suitable to generate electricity. Figure 59 depicts the typical average wind speeds at 100 metres above ground level, illustrating the wind resource potential across the country, while Innosun's Ombepo wind farm at Lüderitz is shown in Figure 60.

Figure 59: Mean wind speed at 100 metres above ground level, in m/s [Source: World Bank]

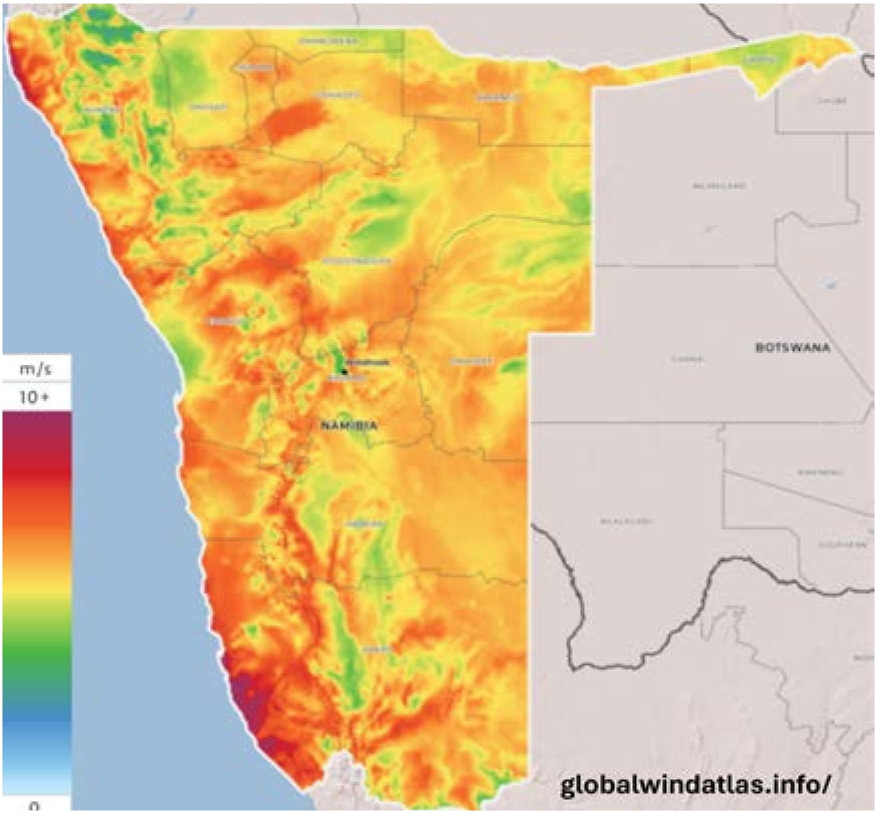


Figure 60: Part of Innosun's Ombepo wind farm at Lüderitz [Source: D von Oertzen]

3.2.11. Waste

Namibia has several municipal waste disposal sites as well as other sources of waste that could potentially be utilised for the generation of heat and electricity. Prime candidates for future development include the main waste disposal sites located near Windhoek, Walvis Bay and Swakopmund.

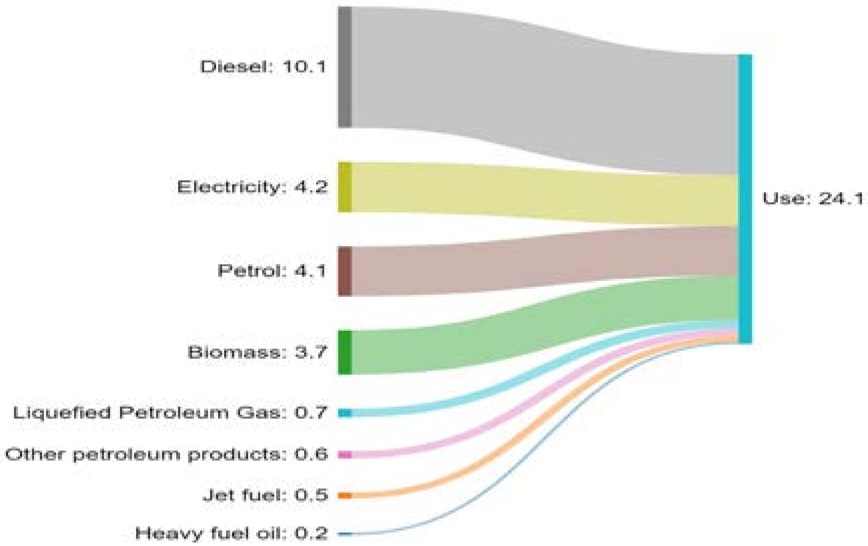
3.3. Energy Uses

Namibia remains fully dependent on the import of all liquid fuels, while also continuing to import a sizeable fraction of the country's electricity requirements (von Oertzen, 2019).

The composition and total contribution of different energy forms, expressed in TWh/a, to the country's total energy mix is shown in Figure 61, while Figure 62 shows the percentage contribution to the country's total energy use.

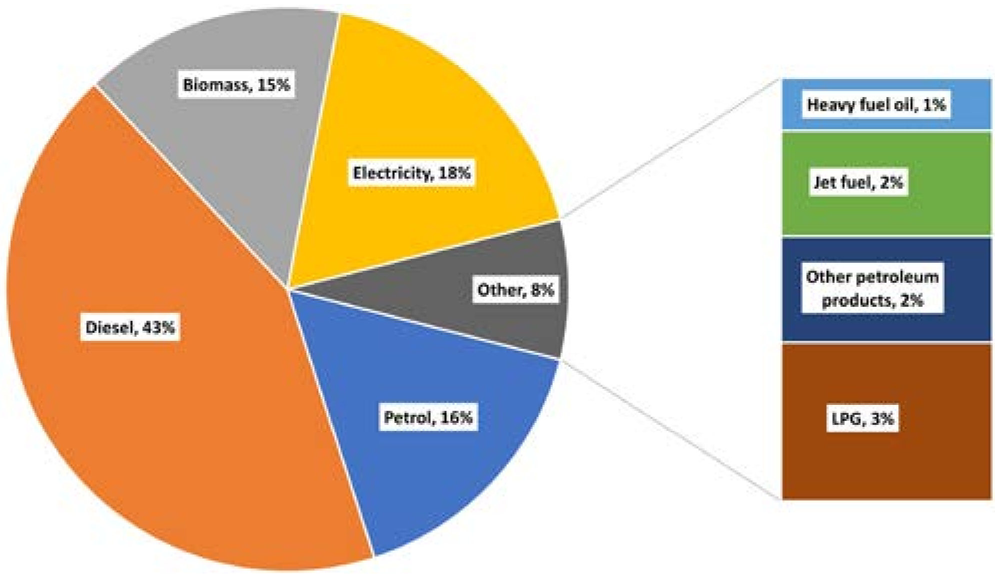
Liquid fossil fuels are the principal energy contributors, while electricity and biomass (mainly for domestic use) are important energy sources meeting local demand too. Minor contributions are from liquefied petroleum gas, jet fuel and heavy fuel oil.

Figure 61: Namibia's total energy use mix by type in 2022, in TWh/a [Source: D von Oertzen]



Contributions by the country's uranium and charcoal industry are excluded from the energy uses as these commodities do not contribute to meeting local energy needs.

Figure 62: Namibia's total energy mix by type in 2022, in % [Source: D von Oertzen]



3.4. Namibia's Energy Industry

Namibia's energy industry comprises formal downstream liquid fuels and electricity sectors, as well as the upstream oil and gas subsectors (MME, 2017a). Less structured and developed are the bush biomass, downstream gas, and thermal energy sectors.

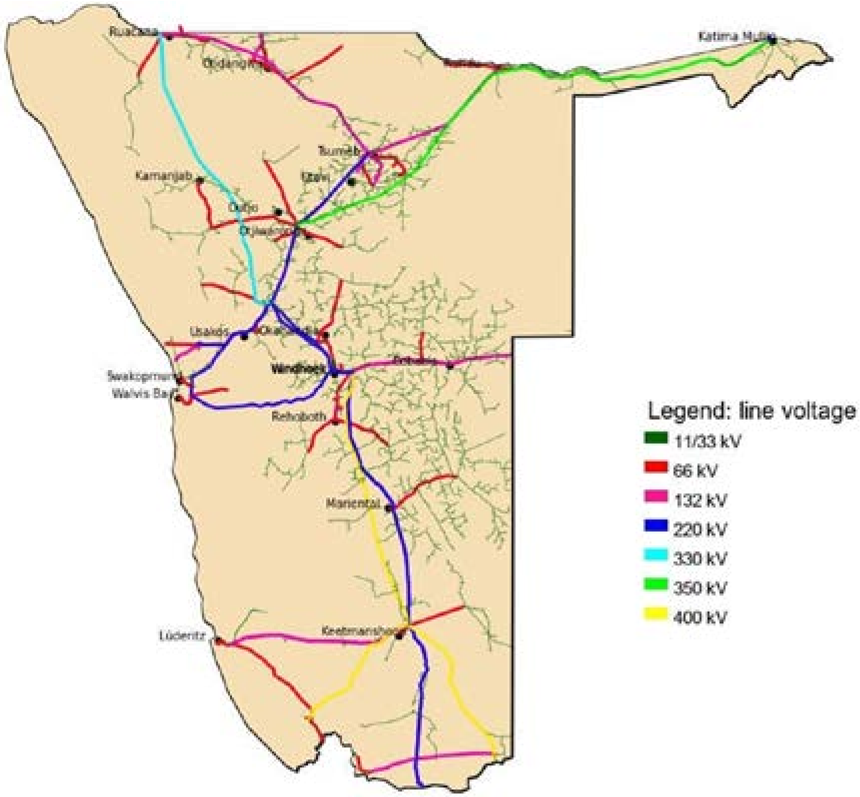
The petroleum liquid fuels sector consists of upstream (exploration and production), midstream (storage, refining and transportation), and downstream (supply and distribution) subsectors. On the upstream oil and gas side, various exploration activities have been undertaken over the past decades. Evidence of a working petroleum system exists for the Orange Basin in the off-shore area adjacent to Namibia's southwestern coast. While the commercially exploitable Kudu gas field was discovered in the mid-1970s, significant discoveries were recently made.

The downstream liquid fuels sector imports all fuel products consumed in Namibia. To improve the security of supplies and reduce reliance on private oil suppliers, a 73,000 m^3 national strategic liquid fuels storage facility was built in Walvis Bay.

The electricity sector is characterised by a well-developed regulatory framework, under the aegis of the Electricity Control Board (ECB). The state-owned electricity utility Namibia Power Corporation (Pty) Ltd (NamPower) owns and operates the country's transmission network, see Figure 63. This network connects southern African markets to Namibia, thereby enabling the import and export of electricity.

In late 2023, NamPower owns and operates electricity-generating assets with a total installed electricity generation capacity of 509.5 MW. Several Independent Power Producers are operational; additional entrants are expected via the Modified Single Buyer market in future.

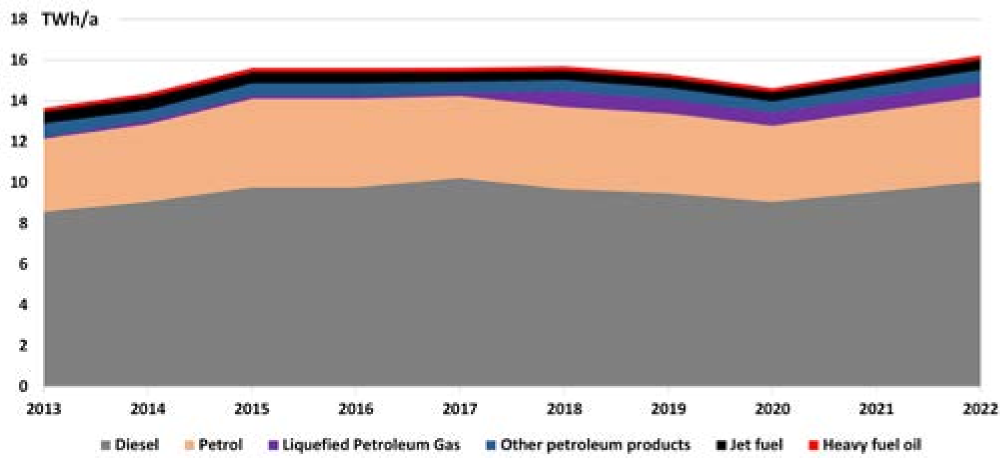
Figure 63: NamPower's transmission and distribution infrastructure [Source: NamPower]



3.4.1. The Liquid Fuels Sector

The liquid fuels sector comprises three subsectors, i.e., upstream (exploration), midstream (storage and transportation) and downstream (distribution and supply). The downstream liquid fuels sector is responsible for the import of all liquid fuels used in the country. The sector is dominated by multi-national entities, while state-owned NAMCOR gradually increases its share as well. Figure 64 illustrates Namibia's liquid fuels consumption between 2013 and 2022.

Figure 64: Annual liquid fuels consumption, 2013 to 2022, in TWh/a [Source: D von Oertzen]



3.4.2. The Electricity Sector

Electricity is a most versatile energy form that is indispensable for the provision of most goods and services that modern life depends on. Access to reliable and affordable electricity is a prerequisite for Namibia's socioeconomic development and a key enabler of national development.

Locally, electricity supplies originate at the state-owned utility NamPower, as illustrated in Figure 65, showing NamPower's four electricity generation assets with a nominal capacity of 509.5 MW in late 2023. NamPower imports electricity from South Africa, Zambia, Zimbabwe, and the Southern African Power Pool, to cover the gap between what is locally produced, and the actual local demand for electricity.

Figure 65: NamPower's electricity generation assets in 2023, in MW [Source: G von Oertzen]

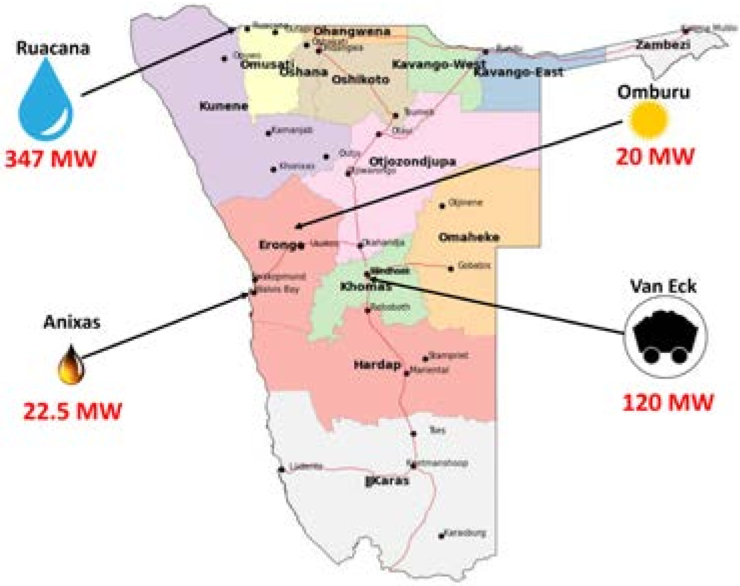


Figure 66 shows the active Independent Power Producers operating in Namibia in 2023.

Figure 66: Independent Power Producers operating in Namibia, in MW [Source: G von Oertzen]

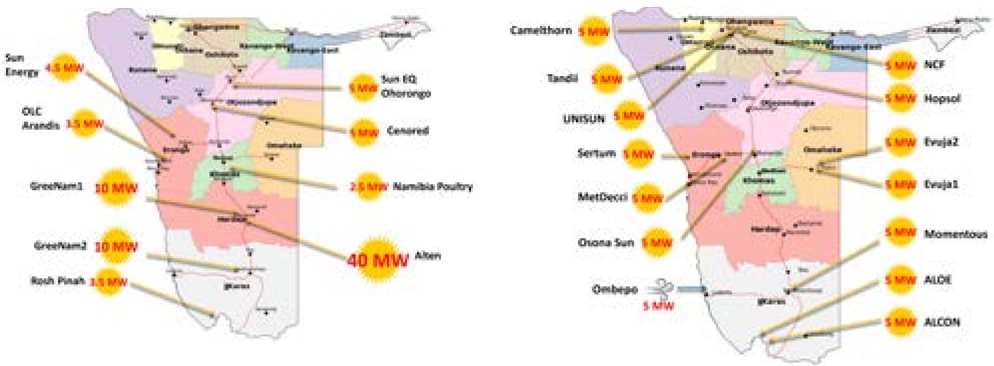


Figure 67 identifies the different entities that contributed to Namibia's electricity mix between 2012/2013 (which is abbreviated as 2013), and 2021/2022 (which is abbreviated as 2022).

Figure 67: Percentage contribution by main electricity sources [Source: D von Oertzen]

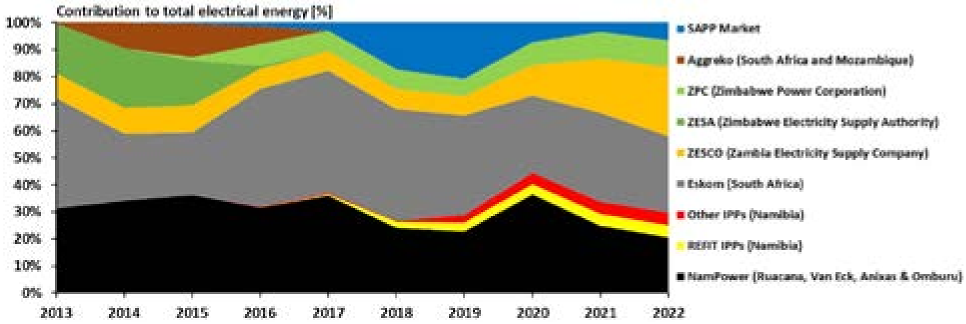


Figure 68 depicts the various technologies used to generate electricity, and their corresponding contribution in 2022, noting that this includes all imports.

Figure 68: Electricity sources by generation type in 2022, in TWh/a [Source: D von Oertzen]

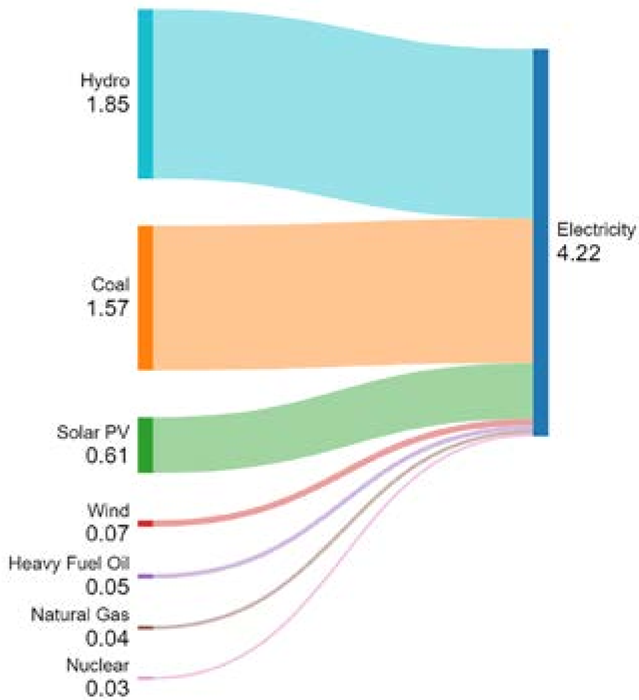
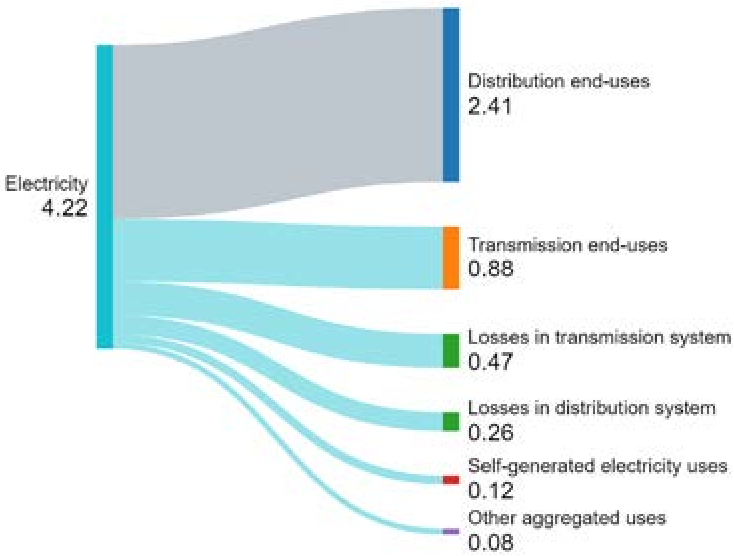


Figure 69 shows the main uses of electrical energy in Namibia in 2022.

Figure 69: Namibian electricity uses in 2022, in TWh/a [Source: D von Oertzen]



3.4.3. The Biomass Sector

Namibia's biomass sector is dominated by the domestic end-user market, the charcoal industry, as well as the export of firewood (von Oertzen, 2020).

Table 10 summarises the most important energy-related biomass uses, both for local consumption as well as for export. Biomass for non-energy uses is not considered here, although such uses constitute an important consumption category for this renewable resource.

Table 10: Energy-related biomass consumption in 2022, in [TWh/a] [Source: D von Oertzen]

Energy-related biomass consumption by type	**Local use [TWh/a]**	**Export [TWh/a]**
Fuelwood	3.0	0.2
Charcoal	<< 0.1	1.4
Wood chips	0.7	-
Total	3.7	1.6

An estimated 45 million hectares are affected by bush encroachment. Namibia's current demand for bush biomass for energy-related uses amounted to some 5.3 TWh in 2022. This is a tiny fraction of the total available bush biomass, which far exceeds 1,000 TWh in total (von Oertzen, 2020).

3.5. Policies, Legal, and Regulatory Frameworks

This section provides a brief overview of the main policies, legal provisions, and regulatory frameworks of relevance to Namibia's energy industry.

3.5.1. Development-related Policies

Namibia's main development-related policies relating to the energy sector include Vision 2030; the National Development Plans; and Harambee Prosperity Plans I and II.

3.5.2. Vision 2030

Namibia's national development goals and ambitions are guided by Vision 2030, as was adopted in 2004. Regarding energy, Vision 2030 envisages Namibia to be *"largely self-sufficient with reliable and competitively priced energy, meeting industry demands, plus some export of energy"* by 2030.

Vision 2030 also foresees the provision of secure and affordable energy to the country's developing economy and its people. Regarding national electrification, Vision 2030 foresees a "*master plan for electricity distribution, which includes a substantial national budget, provides for almost full coverage by a decade before 2030*".

With access to electricity remaining below 50% in 2023, Vision 2030's electrification goals have not been achieved, not even those pertaining to the electrification of schools, i.e., providing "... *electricity, where the necessary infrastructure will be supplied by 2006*", see Figure 70.

Figure 70: Will Vision 2030 bring development to Namibians? [Source: M Courtney-Clarke]

3.5.3. National Development Plans

Namibia's 5th National Development Plan (NDP 5) is the country's national development plan for the period 2017/18 to 2021/22. The topic of energy is introduced under the header "*expansion and modernisation of physical infrastructure*" and focuses on electricity-related aspects only. Specifically, NDP 5 envisages that "*by 2022, Namibia has a sustainable mix of locally generated energy capacity of 755 MW to support household and industry development*".

Regarding Namibia's national electrification rate, NDP 5 suggests that it is to be increased from the baseline value of 34% (in 2015) to 50% by 2021/22. Evidently, with access to electricity remaining below 50% in late 2023, NDP 5's electrification goal was not met. Rural areas remain significantly under-served, and most of the electrification undertakings, as per the Rural Electricity Distribution Master Plan of 2010, were not implemented (MME, 2010).

3.5.4. Harambee Prosperity Plan I

The Harambee Prosperity Plan I (HPP I) is the late President Geingob's plan for prosperity for all. The Plan was meant to accelerate development in select priority areas, thereby complementing the 5-yearly National Development Plans and Vision 2030.

It is important to note that none of HPP I's electricity-related goals were met, i.e.,

- increasing the local electricity generating capacity from 400 MW to 600 MW;
- providing electricity to all schools and health facilities by 2020; and
- increasing the rural electrification rate from 34% in 2015 to 50% by 2020.

Evidently, the Government's implementation efforts must be improved if development-related undertakings are to advance Namibia, as illustrated in Figure 70 and Figure 71. Among others, this implies that the personal performance of key staff who are entrusted with the implementation of national projects must be significantly improved. Non-delivery of all main state actors has, for far too long, been tolerated, to the detriment of Namibia's development and her people.

Figure 71: Electrification is essential for the upliftment of informal areas [Source: PicturesWild]

3.5.5. Harambee Prosperity Plan II

For the period 2021-2025, thus following HPP I, the Harambee Prosperity Plan II (HPP II) was launched. The Plan seeks to prioritise the implementation of targeted policies, enhance service delivery, support economic recovery, and promote growth.

Under HPP II, economic advancement is, among others, premised to be achieved through three goals and sixteen activities, which "*will be executed to strike a balance between pursuing inclusive socio-economic growth and the requisite economic transformation to achieve the industrialisation goals enshrined in Vision 2030*".

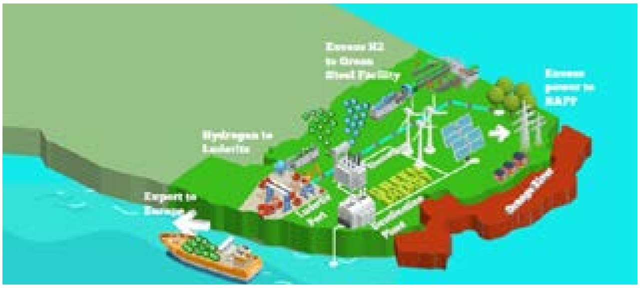
Noting that agriculture, forestry, and fishing represent some 10% of the country's gross domestic product in 2021, and approximately 30% of employment, activity 1 under pillar 2 envisages to identify and prioritise investments into projects with high employment creation opportunities. Activity 3 is to "promote and facilitate the infusion of private strategic investments into the agricultural sector, through a thorough review of the possibility of applying the PPP approach to all green schemes in the various regions of the country".

The HPP II's third goal, i.e., developing complementary engines of economic growth, includes activities to attract private investments into the so-called green and blue economies (activity 1), and investigating the feasibility of green hydrogen and ammonia as a transformative strategic industry (activity 2). To this end, HPP II introduces the "Southern Corridor Development Initiative" (SCDI), consisting of complementary projects and infrastructure to synthesise green hydrogen and ammonia, as illustrated in Figure 72.

How the SCDI is to create hundreds of thousands of much-needed new jobs, how much the Namibian taxpayer will end up paying for creating infrastructure used for export products, and the long-term benefits to the water–energy–food imperatives and the well-being of the people of this country, remains to be elaborated.

The SCDI revolves around creating wind and solar electricity generating assets which are to feed a desalination plant, and the electrolysis of water to make hydrogen and ammonia. A new deep-water port at Lüderitz, a wind blade manufacturing plant, a green steel plant and fertilizer plant, ammonia supply to the green scheme near Neckartal dam, and transmission assets are mentioned as well. Each of these would, provided that rational decision-making is applied, necessitate their own risk and viability assessments. Unfortunately, the ideals espoused in both HPP I & II lack a sense of realism of what is required and achievable given Namibia's realities.

Figure 72: The Southern Corridor Development Initiative as per the HPP II [Source: NIPDB, 2021]



While the mega-scale development of a local hydrogen industry will have massive repercussions for Namibia, this and other HPP II ambitions await to be implemented. It is too early to speculate if and how specific initiatives will affect the country's water–energy–food nexus, except to say that large-scale investments in infrastructure will exert significant further pressures on Namibia's scarce water, energy, and food resources unless significant mitigation actions are initiated immediately. There is no tangible evidence that such actions will commence shortly.

3.5.6. National Energy Policy

As part of its mandate, the Ministry of Mines and Energy (MME) is responsible for the development of the principal policies and plans that shape Namibia's energy sector. The National Energy Policy of 2017 (NEP) defines the Government's strategic intent relating to the country's energy industry (MME, 2017a). The NEP recognises the pivotal role that energy plays in national development, and its role as a driver and lubricant of continued socio-economic upliftment.

The NEP emphasises the all-important contribution that the discovery, development, and beneficial use of Namibia's plentiful indigenous energy resources can play. It differentiates the energy sector into the more formalised electricity, upstream oil and gas and downstream liquid fuels subsectors as well as the less formalised downstream gas and thermal energy subsectors, which is the same approach as taken in this text.

As an expression of the Government's energy-related intent, the NEP is *"to ensure the development of Namibia's natural capital and its sustainable use for the benefit of the country's social, economic and environmental wellbeing"*. The Policy's principal goals, in relation to all forms of energy, are to a) ensure the security of all relevant energy supplies to the country; b) create cost-effective, affordable, reliable, and equitable access to energy for all Namibians; c) promote the efficient use of all forms of energy; and d) incentivise the discovery, development and productive use of … diverse energy resources.

3.5.7. National Renewable Energy Policy

The National Renewable Energy Policy (NREP) of 2017 guides the Government on the development of the country's renewable energy sector (MME, 2017b). Central to the NREP is the scale-up of contributions from local renewable energy sources.

Among others, the NREP aims "*to enable access to modern, clean, environmentally sustainable, and affordable energy services for all Namibian inhabitants*", and "*to meet short-term and long-term national development goals, and to assist Namibians climb the development ladder, empowered by access to energy at levels that facilitate engagement in productive activity*".

The NREP applies to both on- and off-grid energy supplies in both urban and rural areas. It recognises the Renewable Energy Procurement Mechanism, differentiating electricity supply systems based on generating capacity, including the application of the Net Metering Rules for installations with a generating capacity smaller or equal to 500 kW while not exceeding the circuit breaker rating of the electricity supply.

The NREP suggests the use of renewable energy feed-in tariffs for supplies above 500 kW and smaller than 5 MW, including from solar photovoltaic, wind, biomass and concentrating solar power plants as well as competitive auctions for electricity projects with generating capacities exceeding 5 MW.

The NREP stipulates that projects resulting in grid-connected generation assets are to be governed by the provisions of the National Independent Power Producer Policy (refer to section 3.5.8), while off-grid projects are to be undertaken based on the framework included in the National Electrification Policy (refer to section 3.5.9).

Figure 73: Namibia's first commercial solar photovoltaic IPP at Omaruru [Source: C Roedern]

3.5.8. National Independent Power Producer Policy

The National Independent Power Producer Policy (IPPP) of 2018 expresses the Government's commitment to broaden private-sector participation in the electricity sector (MME, 2018a). Its departure point is the realisation that even modest economic growth necessitates significant additional electricity-related investments, which cannot be funded by the Government alone.

Private investors are the Policy's target group for both grid-connected and off-grid projects (MME, 2007b). The Policy classifies IPP projects into small below-5 MW projects, medium-sized undertakings of greater than 5 MW, and up to 100 MW, and those with a capacity exceeding 100 MW. Figure 73 shows Namibia's first commercial solar photovoltaic IPP near Omaruru, while Figure 74 shows the country's largest IPP, i.e., the 37 MW Alten solar PV plant east of Mariental (status: early 2023). IPPs are connected to the national transmission grid infrastructure that spans the country, which is owned and operated by NamPower, refer to Figure 63.

Figure 74: The 37 MW Alten solar PV plant east of Mariental [Source: C Roedern]

3.5.9. National Electrification Policy

The to-be-promulgated National Electrification Policy (NELP) renews the Government's commitment to actively lead, support, and promote electrification in Namibia, aiming to achieve universal access to electricity by 2040 (MME, 2022).

The Policy recognises that continued electrification efforts must follow a principle-centred approach, which is to be underpinned by holistic planning, broadened funding and rigorous (and accountable) implementation. The Policy emphasises the importance of further electrification efforts in realising the country's multiple national development aspirations.

The NELP also recognises that electrification efforts need to be appropriate and meet minimum service standards at the lowest possible life-cycle cost. Unfortunately, the Policy does not address how smart grid applications could benefit the country's electricity industry, noting that demand management potentials exist that could be further strengthened (von Oertzen, 2018b).

The Policy recognises that cost recovery plays a vital role in determining the best possible electrification funding option and supporting low-income consumers as well as productive uses of electricity. It also states that cross-subsidisation needs to be economically justified and prioritised to maximise the economic benefits associated with electrification.

A National Electrification Funding Portfolio (NELFP) was developed in parallel to the Policy, to broaden the potential avenues to fund future national electrification efforts.

3.5.10. Electricity-related Legal and Regulatory Framework

Under its mandate as the regulatory authority of the country's electricity sector, the Electricity Control Board (ECB) has developed numerous rules, regulations, codes, standards, charters, procedures, and related instruments (ECB). These provide the guiding framework for most activities taking place in the electricity supply, transmission, and distribution industry today. Policies and plans relating to Namibia's electricity sector are summarised in Figure 75.

Figure 75: Government's main electricity-related policies and plans [Source: D von Oertzen]

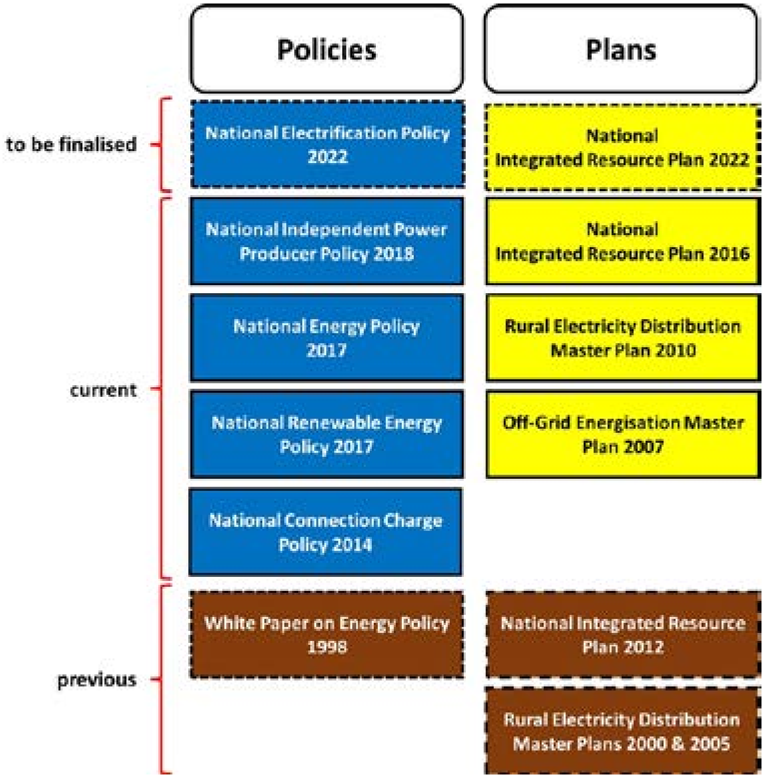
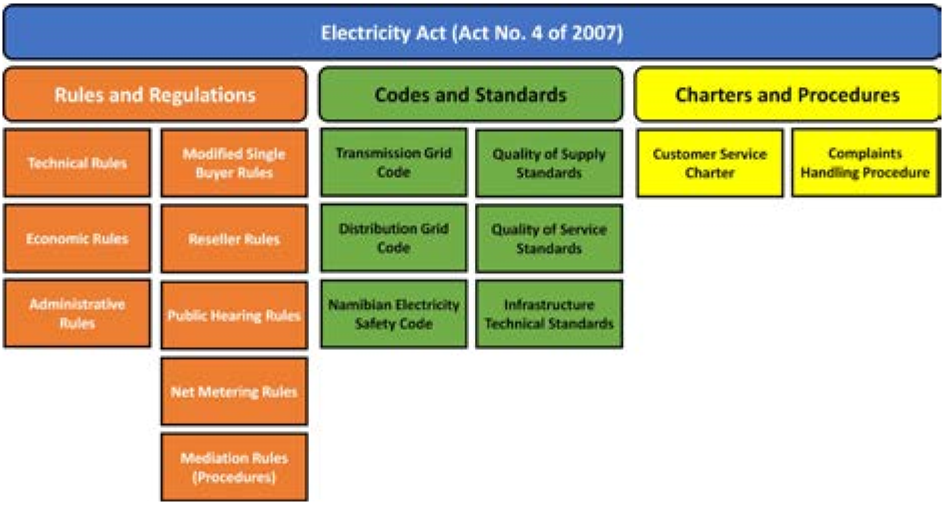


Figure 76 summarises the main instruments underpinning the country's electricity-related legal and regulatory framework.

Figure 76: The electricity sector's legal and regulatory framework [Source: D von Oertzen]



3.5.11. Electricity Act

The Electricity Act, (Act No. 2 of 2000), established the Electricity Control Board and described its key mandate and functions. This Act has since been repealed and replaced by the Electricity Act, 2007 (Act No. 4 of 2007), which details the ECB's roles and responsibilities, and the conditions and requirements for licenced activities in the electricity sector (MME, 2007a).

The Electricity Act of 2007 establishes the ECB as a juristic person and the country's regulatory authority for the electricity industry, with the following main responsibilities:

1. to control and regulate the provisions, use and consumption of electricity;
2. to oversee the functioning and development of the electricity industry and security of supply;
3. to ensure the efficient provision of electricity;
4. to ensure a competitive environment in the country's electricity industry with such restrictions as may be necessary for the security of supply and public interest; and
5. to promote private sector investments in the electricity industry.

The Act stipulates that the ECB's activities are to be undertaken in accordance with Government policy. It lays the foundation for the licensing of electricity-related activities, including for generation, trading, transmission, supply, distribution, import and export of electricity, which necessitate separate licences. Certain exemptions apply for plants smaller than 500 kVA, standby supply for own use, and the distribution of electricity for own use, provided such demand is less than 500 kVA.

Of critical importance are the ECB's responsibilities vis-à-vis recommending the issue, transfer, amendment, renewal, suspension and cancellation of licences, and the approval of the conditions on which electricity may be provided by licensees, for consideration and the ultimate approval or their rejection by the Minister of the Ministry Mines and Energy (MME).

The ECB, with prior approval by the Minister of MME, may develop rules/ codes relating to the establishment, operation, and administration of the electricity market, and those of licensed entities. These include, among others, safety and grid codes, system security and network connection rules and those governing the pricing and metering of electricity.

Once the Namibia Energy Regulatory Authority Act, as discussed below, is promulgated, the Electricity Act is expected to be repealed.

3.5.12. Namibia Green Hydrogen and Derivatives Strategy

The Namibia Green Hydrogen and Derivatives Strategy (NGHDS) was launched at the 27th Conference of Parties (COP27) in Sharm El-Sheikh, Egypt, in November 2022 (NIPDB; UNCC, 2022). The Strategy states that green hydrogen plays a crucial role in global decarbonisation efforts, especially in hard-to-abate sectors. These sectors include the steel, cement, petrochemical, and chemical industries, each of which produces massive amounts of carbon dioxide, accounting for some 30% of the world's greenhouse gas emissions.

The NGHDS suggests that "*Namibia will be able to produce hydrogen and its derivatives at highly competitive costs*", mainly because of the country's world-class renewable energy resources. The Strategy aims to see Namibia export hydrogen-based products, such as "*ammonia, methanol, synthetic kerosene and hot-briquetted iron*", observing that the country "*is well placed to serve markets in Europe, China, Japan and South Korea and other parts of the world*".

The Strategy envisages the creation of an "*at-scale green fuels industry with a production target of 10 to 12 Mt/a* [mega-tonnes per year] *hydrogen-equivalent by 2050*". Production capacities would be established in three so-called hydrogen valleys, namely in the "*southern region of Karas, the central region including Walvis Bay port and the capital Windhoek, and the northern region of Kunene*". In May 2023, Namibia signed a feasibility and implementation agreement (FIA) with Hyphen Hydrogen Energy, which sets out the governance provisions underpinning Hyphen's US$ 10 billion green hydrogen project in Namibia, as illustrated in Figure 77.

Figure 77: Hyphen Hydrogen Energy's planned plant in the Tsau /Khaeb park [Source: Hyphen]

The Strategy views hydrogen as an agent to accelerate Namibia's socio-economic development. Specifically, the Strategy suggests that "*the hydrogen industry could contribute up to US$6 billion to GDP, 30% more than 2030 GDP estimates with no hydrogen industry development*", thereby boosting "*labour demand by generating up to 80,000 additional jobs by 2030, and up to 600,000 by 2040*".

Namibia's severely limited technical skills base is to be addressed through a "*comprehensive skill development strategy based on domestic talent sourcing and attractive immigration policies will ensure sufficient labour supply*". The absence of the regulatory regime and system of governance is thought to be addressed by a "*fit-for-purpose regulatory and institutional framework will create the right enabling environment*", which is to be supported by an "*Implementation Authority Office and a dedicated concierge service*", to "*create *a transparent, streamlined and user-friendly process for all stakeholders in prospective hydrogen projects*".

The Strategy also envisions the use of "*strategic economic diplomacy*", by which "*Namibia plans to forge relationships with international partners dedicated to building its hydrogen economy*", mentioning existing memoranda of understanding with "*Germany, Belgium, the Netherlands and Japanese companies and another is in the pipeline with the European Union*".

3.5.13. Electricity Bill

In early 2024, the Electricity Bill (2018) remains a draft, albeit close to finalisation and subsequent promulgation (MME, 2018b). Namibia's current Electricity Act, i.e., Act No. 4 of 2007, deals with the establishment and functions of the ECB and the regulation of the country's electricity supply industry. The policymaker decided to split the Electricity Act into two new parts, namely

a) an update of the Electricity Act, which is to replace the Electricity Act of 2007, and

b) the development of the Namibia Energy Regulatory Authority (NERA) Act, which is to transform the ECB into Namibia's national energy regulatory authority.

Among others, the Electricity Bill stipulates that the Minister of MME, in consultation with the regulatory authority, is responsible for the preparation and implementation of the National Integrated Resource Plan (NIRP) (MME, 2016). The NIRP is the Government's long-term plan to spell out the optimal resource mix that balances the country's electricity supply and demand in an efficient, cost-effective, and secure manner.

The Bill also states that the Minister may, under the NEP, the NREP and the NIRP, determine the manner and procedures in which new generation capacity, including ancillary services, are to be sourced and allocated to supply entities, such as the state-owned power utility NamPower, as well as current and future IPPs, as illustrated in Figure 78.

The Electricity Bill stipulates that separate licences are required to generate, transmit, distribute, and supply electricity, for trading, storage, import and export of electricity, as well as for the role of system or market operator. Also, the Bill relates to the transfer of assets and liabilities between licensees, in the event of changes of a licensee or through restructuring, and local government charges (i.e., surcharges) on the sale of electricity. In addition, support levies, as well as Ministerial oversight of decisions taken by the regulator, are addressed.

Figure 78: Namibia's first wind farm, Ombepo, at Lüderitz [Source: Innosun]

3.5.14. Namibia Energy Regulatory Authority Bill

In early 2024, the Namibia Energy Regulatory Authority (NERA) Bill of 2018 remains a draft, albeit being close to finalisation and the subsequent promulgation (MME, 2018c). The NERA Bill is the draft version of the to-be-promulgated NERA Act. The Bill's main purpose is the establishment of the Namibia Energy Regulatory Authority (NERA). This to-be-established entity is to be a juristic person and the country's independent national energy sector regulatory authority. In addition, the NERA Bill describes the regulator's functions and duties and makes provision for related incidental matters.

The NERA Bill extends the ECB's mandate beyond the electricity sector, to include downstream gas and petroleum, including pipelines and storage facilities, renewable energies, and energy efficiency. In addition to defining

NERA's constitution, mandate, functions and related administrative matters, the Bill also

- authorises NERA to impose a regulatory levy;
- details an enforcement regime that includes directives, enforceable undertakings, and administrative penalties;
- provides the basis for the establishment of an energy tribunal; and
- endows NERA with effective powers to initiate and execute investigations.

3.6. Institutions and their Main Energy-related Roles and Responsibilities

Table 11 summarises the key institutional actors and their responsibilities in the energy sector.

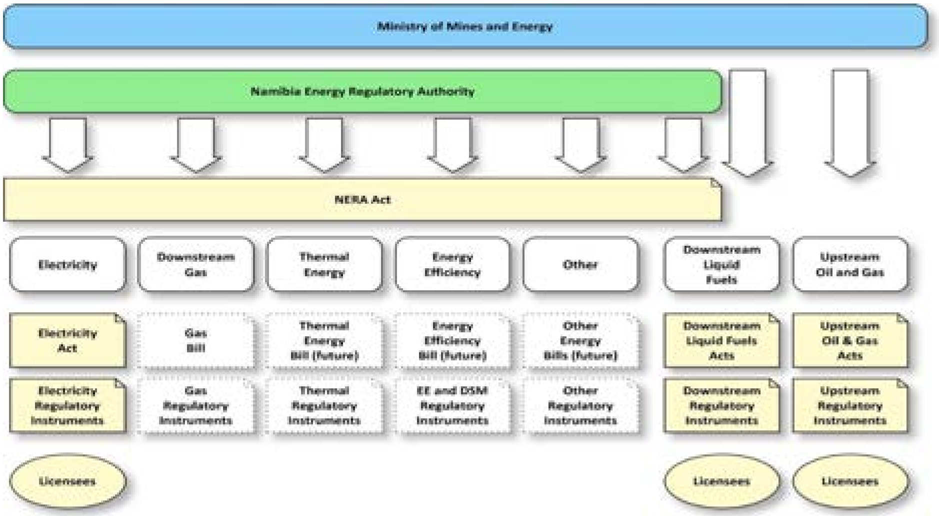
Table 11: Key institutional energy sector actors and their main roles and responsibilities

Institution	Main Roles and Responsibilities
Ministry of Mines and Energy (MME)	The MME is Namibia's energy sector custodian and principal policy maker, and the sector's overall institutional anchor.
Ministry of Environment, Forestry and Tourism (MEFT)	The MEFT ensures that legislation and regulations facilitate environmentally responsible implementation of activities.
Ministry of Finance (MoF)	The MoF manages the Government's finances. It allocates regular and once-off budgets for project implementation.
National Planning Commission (NPC)	The NPC ensures that policies meet national requirements and manages and monitors their implementation.
Electricity Control Board (ECB)	The ECB is the regulatory authority for the electricity sector and is responsible for its mandate under the Electricity Act.
Electricity suppliers and distributors	Electricity suppliers and distributors are licensed entities that supply and distribute electricity to end consumers.

Institution	Main Roles and Responsibilities
NAMCOR	NAMCOR is a state-owned enterprise and national oil company. By partnering with external parties, it is involved in oil and gas exploration and is also retailing liquid fuels.
Namibian Standards Institution (NSI)	The NSI adopts and publishes standards and technical regulations, including those relevant to the energy industry.
NamPower	NamPower is a state-owned enterprise and national electricity utility. It generates, transmits, distributes, supplies, and trades electricity, including across the borders.

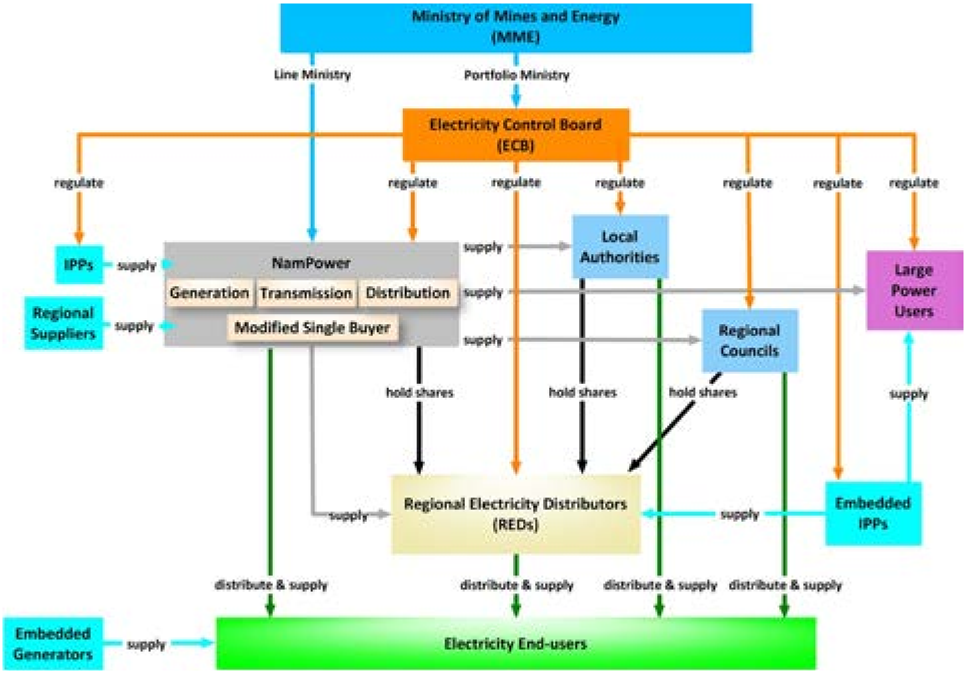
Table 12 depicts Namibia's energy-related future legal, statutory and regulatory framework, assuming that the NERA and Electricity Bills, as introduced in 3.5.12 and 3.5.14, are promulgated, and supported by additional laws that activate NERA's envisaged regulatory responsibilities and functions. Legal frameworks for upstream oil and gas are under review. In early 2024, all provisions for a hydrogen and derivatives sector remain to be developed, and an institutional home for hydrogen and associated derivatives sector remains to be identified.

Table 12: Energy-related legal, statutory, and regulatory framework [Source: MME, 2017a]



The institutional underpinnings of the electricity sector are shown in Table 13.

Table 13: Institutional underpinnings of Namibia's electricity sector [Source: D von Oertzen]



3.7. Energy for Water and Food

In most energy production processes, water is an essential and indispensable input. To illustrate, coal-fired power stations typically consume between one and three litres of water per kWh of electricity. The water use of other electricity-generating systems varies, with hydro-power and biomass being substantial water consumers. Most thermal power plants also require water for cooling, while water also remains an important factor in the extraction of fossil fuels.

Water use for energy production is a critical consideration of the water–energy–food nexus. Today's energy systems continue to be dominated by oil, coal, and natural gas, all of which require copious amounts of water for operations. In addition, which is an often-neglected aspect, water is a necessity in the extraction of fuels, and their processing, transport, transformation, distribution as well as the end-use. This renders fossil-fuelled production a most formidable water consumer, with electricity generation being the largest energy-related water consumption factor. Water also remains a critically important input to the mining sector, in the production of fuels, as well as for cleaning purposes and cooling in most power plants.

Wind and solar power have a relatively small water footprint. However, technologies relying on renewable energy resources also rely on other natural resources, for example, mineral resources, which in turn require water for mining and production. Even if the worldwide fleet of fossil-fuelled energy production systems were to be rapidly replaced by renewable energy technologies, many of the current assets would remain operational for decades, thereby exerting a water demand. It is concluded that the availability of water will continue to play a critically important role in most energy-related uses.

The production of food ranks as one of the most impactful activities on the natural environment. This is illustrated by considering the European food production industry alone implies the consumption of some 5 m^3 of water per person per day. Livestock production, especially beef, sheep, goat, and pork production, is well-recognised as being associated with significant environmental impacts, including on water resources, soils, and air quality. In contrast to the livestock industry, the production of most fruits and vegetables is generally exerting a smaller global environmental footprint. Overall, food production for human and animal consumption has a massive water footprint, in addition to other environmental service requirements. Also, food transport, processing and distribution all necessitate considerable quantities of energy, thereby often remaining highly dependent on the availability of fossil fuels.

Figure 79: Elements of the water–energy–food nexus in Namibia [Source: G von Oertzen]

To ensure the availability of most water resources, energy is necessary. Most water-related processing activities, including the pumping, treatment, wastewater processing and desalination of seawater, are all energy-intensive. These processes cannot be undertaken without adequate amounts of reasonably priced energy. For most contemporary water utilities, energy is a key cost driver. Many water processing applications are powered by electricity, for example, to pump, process, pipe and distribute water and wastewater.

This section dealt with the crucial role of energy in a country's water–energy–food nexus, see Figure 79. Energy is a prerequisite to enable the production and use of water and food. Demand for one often affects the demand for the other nexus topics. Energy is required to extract, process, and treat water, and for wastewater processing, transport, and treatment. In the food sector, energy is an essential prerequisite to food production, ranging across the entire food value chain, from the production of agricultural inputs to storage, transport, distribution of food, and the disposal of food products associated waste. Modern agriculture is the single largest water user. Figure 80 illustrates how food and electricity production could be undertaken in future, using approaches developed in the field of agrivoltaics.

Today, more than a quarter of the global energy is expended to produce, store and supply food. At the same time, most of the world's energy uses rely on the provision of adequate water. As renewable energy technologies are often less resource-intensive than fossil-fuelled alternatives, the former can enhance water and food security, while contributing to the accessibility, affordability, and reliability of energy supplies.

Figure 80: Agrivoltaics produces food while also generating electricity [Source: metsolar.eu]

3.8. Green Hydrogen and Power-to-X

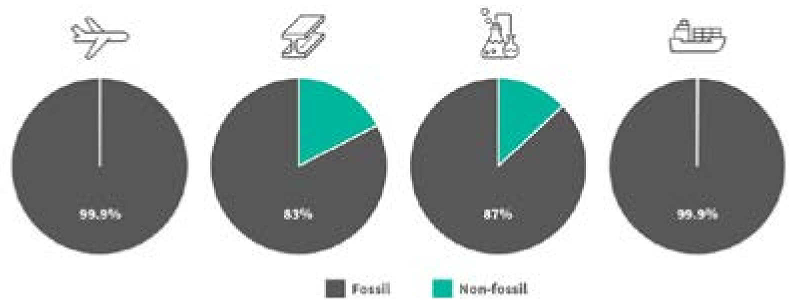
Anthropogenic greenhouse gas (GHG) emissions are a global challenge, as they drive climate change (UNFCCC, 2015). Today, the lifestyles of billions of people around the globe are based on the regular direct and indirect use of fossil fuels, thereby producing copious GHG emissions. While industrialised countries have been the main contributors of atmospheric GHGs attributable to human endeavours, developing countries are often particularly affected by the resulting changes in the global climate (IRENA, 2018; IRENA, 2019). Generally, GHG reduction strategies are best applied where they are cheapest. This implies that industrialised as well as developing nations should act if these can be shown to be cost-effective (IRENA, 2020).

Most developing nations also face important development-related challenges other than those brought about by climate change. Investments in cost-effective GHG mitigation actions may therefore burden the already strained financial resources, as is the case for Namibia. While remaining a net sink of GHGs, Namibia is particularly affected by the impacts of global climate change, without having contributed to it, and without having the financial resources to effectively deal with the multiple impacts related to climate change.

The latest reports by the International Panel on Climate Change (IPCC) are clear about the necessity to drastically reduce global GHG emissions. A critically important measure to reduce GHG emissions is to displace carbon emitters by carbon-neutral sources, where such switching is possible. This practice is known as decarbonisation and is based on the systematic phase-out of fossil fuels, and their successive displacement by zero- or low-carbon energy carriers.

Often, electrification is a viable approach to effectively displace fossil fuels (IEA, 2019). Such electrification implies that energy needs are successively met by electrical energy rather than from fossil fuels, if this is technically and financially viable, see Figure 81. The rationale for large-scale adoption of electricity is based on the realisation that electrical energy generated from renewable energy sources is not significantly contributing to GHGs but is also increasingly price competitive. However, some sectors are more readily electrified than others. For the so-called "hard to abate sectors", which include the steel, chemical, and cement industries, as well as aviation and shipping, electrification remains difficult and often prohibitively expensive. These sectors therefore require alternative GHG reduction approaches.

Figure 81: Fossil fuel dependency of key global industries [Source: PtX Hub]



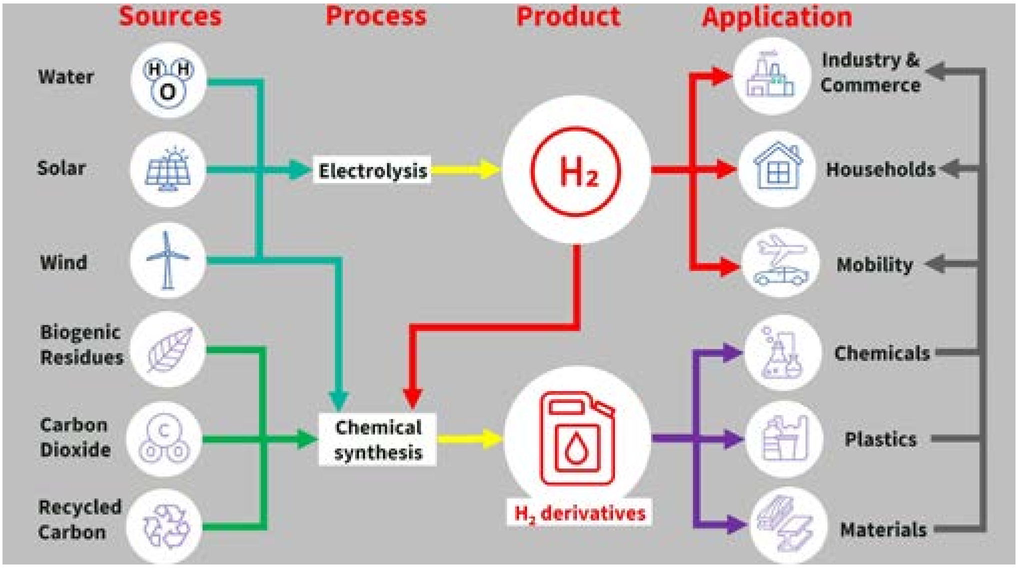
Hydrogen has long been recognised as a fuel that could play a more prominent role in a clean(er) energy future (USDOE, 2002; COAG, 2019; EC, 2020; Hydrogen Council, 2020; Hydrogen Council, 2021). While hydrogen has been an important input to the chemical, fertiliser, and oil industries, it is still mostly produced from fossil fuels, such as natural gas and methane. For example, steam-reforming natural gas is often used to produce so-called "grey hydrogen", thereby resulting in atmospheric carbon emissions. Also, most other conventional hydrogen production processes are associated with GHG releases, mainly in the form of carbon dioxide.

Alternative and cleaner production methods are therefore required to produce hydrogen, without the commonly associated GHG emissions. This can, for example, be achieved by splitting water and using electricity from renewable energy sources to power electrolysers to produce "green hydrogen" (GH2). There is no physical or chemical difference in hydrogen produced from fossil fuels or renewable energy sources. On the other hand, the GHG emissions associated with hydrogen produced from renewables are substantially lower than those produced when using fossil fuels.

Of special note is that the cost of electricity produced from renewable energy sources, specifically solar and wind energy, has dramatically decreased in the past decades. Hydrogen produced using renewable sources can, in future, become cost-competitive with hydrogen produced from fossil fuels, as penalty payments for carbon emissions are implemented, for example, in the form of a carbon emissions tax.

As discussed in section 3.2.8, Namibia has world-class solar energy resources, while some regions also have good to excellent wind resources (see section 3.2.10). Given these endowments, renewable energies such as solar and wind energy can – in principle – be used to produce green hydrogen and many derivative products, in a process referred to as power-to-X (PtX), which is illustrated in Figure 82.

Figure 82: Summary overview of green hydrogen and synthetic fuels production [Source: D von Oertzen]



Producing green hydrogen and PtX derivative products necessitates the establishment of most significant new electricity generation capacities, in addition to electrolysers, as well as water, storage, processing, transport and other infrastructure elements. The key building blocks necessary for green hydrogen and ammonia production are all highly capital-intensive. Their realisation depends on the availability of low-cost funding and therefore hinges on access to plentiful, long-term cheap capital (von Oertzen, 2021).

In early 2024, many a green hydrogen project around the world remains financially non-viable. This challenge is often addressed by governments and equity partners making available liberal grant funding to assist developers in reducing capital cost, operational cost, or both, thereby improving their financial feasibility.

In Namibia too, grant funding has allowed the commencement of various small-scale pilot projects, including Cleanergy Solutions Namibia (a joint venture of the Namibian O&L Group, and the Belgian CMB.Tech), see Figure 83, HyIron Namibia (see Figure 84), HDF Energy's Renewstable Swakopmund (see Figure 85), TransNamib's hybrid locomotives project with CMB.Tech (see Figure 86), the Daures Green Hydrogen Village (see Figure 87), and others.

Figure 83: Cleanergy Solutions Namibia's planned project near Walvis Bay [Source: O&L, 2024]

Figure 84: HyIron's direct reduction pilot plant in Lingen, Germany [Source: HyIron, 2024]

Grants can enable ventures that would not have happened using commercial considerations only. Grant funding does, however, also encourage the commencement of flawed project ideas, and a high risk of resulting in white elephants, causing costs to affected third-party stakeholders. The origins of grant funding may also reveal ideological motives, and blunt attempts by foreign governments or other actors to gain traction and exercise their influence, as is readily evident in Namibia today.

Figure 85: HDF Energy's vision of the Renewstable Swakopmund plant [Source: HDF Energy]

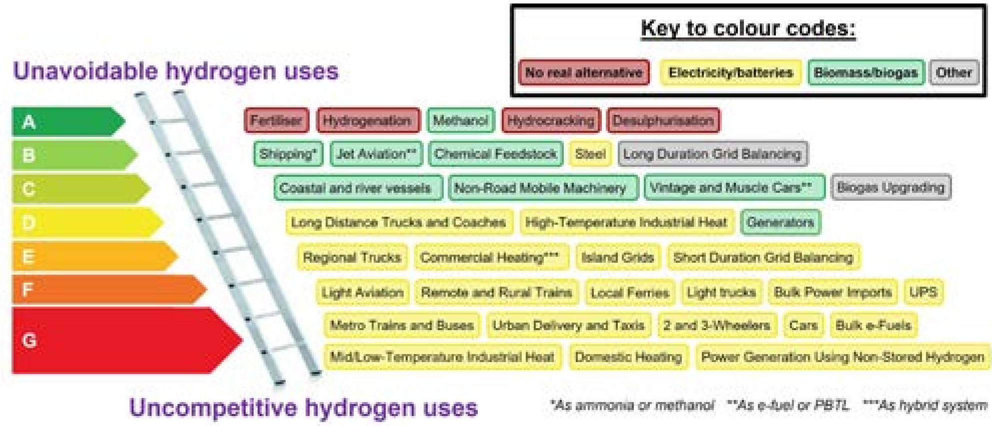
Figure 86: CMB.Tech's hybrid locomotives project with Transnamib [Source: CMB. Tech]

Figure 87: Daures Green Hydrogen Village [Source: Daures, 2024]

Namibia's Green Hydrogen and Derivatives Strategy (section 3.5.12) envisages the production of 10 to 12 Mt/a of hydrogen or its equivalents by 2050. The details, of how this is to be achieved, i.e., the '*who will do what, when, and where*', and '*who will pay for it all*', however, remain entirely unclear. Possibly, they hinge on *strategic economic diplomacy*, or maybe, there is another mantra to be introduced here?

Liebreich's clean hydrogen ladder, as shown in Figure 88, is a reminder of the many attractive and unavoidable uses of hydrogen (Liebreich, 2023). At the same time, green hydrogen will remain an expensive commodity for at least another decade or two. This implies that numerous hydrogen uses that are already technically possible will remain uncompetitive. The hydrogen ladder is not static, and changes as innovation, research and development, and economies of scale are achieved.

Figure 88: Liebreich's clean hydrogen ladder [Source: Liebreich, 2023]



Despite the many uses for clean(er) hydrogen, many power-to-X derivatives, as illustrated in Figure 82, are likely to remain uncompetitive, even if carbon taxes are rapidly escalated in future. As Liebreich's ladder shows, such constraints also apply to bulk e-fuels, which form part of the future ambitions in Namibia's green hydrogen and derivatives strategy (NIPDB, 2022).

Establishing hydrogen production hubs in the //Kharas Region, the central region, and the Kunene Region, necessitates astronomical financial resources, ignoring the multitude of other prerequisites for the moment, including most considerable human, technical and others.

While various international estimates indicate that Namibia could produce green hydrogen at US$1.5/kg by 2030, these figures are questionable and unsubstantiated when viewed from a local techno-economic perspective (von Oertzen, 2021). Namibia's ultra-limited financial capabilities, minimal technical and manufacturing expertise, and the non-existence of targeted policies and subsidies remain to be overcome. In addition, regulatory provisions, standards, and certification regimes for exports remain further challenges that demand to be addressed soonest. The absence of even basic infrastructure in the south-western //Kharas Region, and the north-western Kunene Region, are certainly not the only or the most important impediments that need to be addressed to enable the construction of green hydrogen hubs.

The challenges described above are not to be viewed as prophecies of doom, or to throttle investments in Namibian renewable energy projects in general, or green hydrogen, and PtX projects. Namibia's economy is in a most urgent need of substantive invigoration, to create new and meaningful jobs, broaden and deepen the small national income base, and enhance the country's prospects for development. Well-chosen hydrogen projects could therefore play a role in addressing the country's key needs. However, whether a hydrogen project's benefits outweigh its societal and environmental costs remains highly project-specific. Notably, the label "green" does not guarantee a project's actual sustainability or indicate its desirability.

Today, countries around the globe invest massively in various decarbonisation initiatives. This will begin to transform the global energy industry, causing systemic impacts around the world. An economy-wide decarbonisation drive is a daunting challenge, even for industrialised countries, with ready access to global finances, cutting-edge technical, engineering and manufacturing capacities, solid institutions, and a track record of industrialisation capabilities.

Bootstrapping Namibia's development in the green hydrogen space necessitates that the country derives benefits from global clean energy advances. However, global climate and energy topics are part of global geo-political agendas that Namibia has no influence over. Consequently, pursuing local development options may be smarter, as they can result in tangible social and economic advancement at home, without harming our brittle environment.

Decarbonisation requires a long-term political commitment to the cause. As it is most costly, such an agenda also diverts funds from many other endeavours. Whether Namibia should immediately embark on a clean energy transition, or should first focus on securing the water, energy and food for its citizens and draw benefits from its hydrocarbon resources is a debate that is yet to happen. Namibia's means and development imperatives are materially different from those of industrial countries. Our development must therefore not merely follow those whose agenda revolves around securing their country's needs, rather than advancing Namibia.

Developing Namibia's energy resources is critical for national development. Such development initiatives include those benefitting from the recent offshore oil and gas discoveries. At the same time, Namibia's renewable energy potentials are spectacularly significant and ready for use. Offering more opportunities than can realistically be developed necessitates a dual and pragmatic focus. This could encompass the prioritised strengthening of the country's water–energy–food nexus elements, while at the same time, advancing no-regrets investments and initiatives that enable Namibia to derive local benefits arising from the global clean energy transition.

3.9. Conclusions – The Energy Sector

Humans depend on the sun as a primary energy source: solar energy drives the flow of wind and water across the biosphere and enables the photosynthetic production of most foods we consume. Modern societies also depend on the fossilised stores of past solar energy, mainly in the form of hydrocarbons such as coal, oil, and natural gas, and their derivatives, such as petrol, diesel, and kerosene, as well as on electricity, which is also often generated using fossil fuels.

Traditionally, societies derived their food, heat, and mechanical power requirements from sources that were almost direct transformations of solar radiation, or harnessed these from biomass, food crops and livestock. Today, all economies are substantially dependent on fossil fuels. Unlike solar and wind energy, fossil fuels are concentrated forms of energy that can readily be transported, stored, and made available on demand, at prices we take for granted.

Since the beginning of the industrial revolution in the mid-1700s, global energy consumption has risen exponentially. Technical advances have improved energy conversion processes and their efficiencies, enabling the prolific supply of cheap fossil fuels that power the world's economies. Today, mass production of most goods is common; logistics revolutionised their cost-effective transport from one side of the world to the other. In this way, fossil fuels have fundamentally shaped the modern world, and there is no credible indication that this will stop anytime soon.

Readily available and cheap energy has dramatically influenced the structure and dynamics of global trade, and the advances of modern societies.

Among others, key impacts of the accessibility of energy include that abundant food has become available to many, often at levels far above the bare minimum required for survival. Advances in the transport sector mean that many goods and services are globally available, including those required to enhance productivity in the water and food sectors. In parallel, with the improvement of agricultural production practices, health care has often dramatically expanded, even to far-away rural communities, thereby extending average life expectancies, including of people in developing nations.

Technical advances powered by readily available, accessible, and cheap energies have enabled rapid urbanisation and increased agricultural productivity, enhancing the choices available for personal mobility, and broadening access to services. Advances in electronics enable the ubiquitous availability of information, including in otherwise underserved areas.

None of the deep changes mentioned above would have taken place without the global adoption and use of the most significant quantities of fossil fuels. While fossil fuels have markedly decreased global poverty levels, they have also further accentuated the gap between industrialised and developing nations. Fossil-derived energies have enabled a period of unprecedented growth and human development. At the same time, the world's insatiable consumption of fossil fuels is a key contributor to human-induced global climate and many of the associated environmental changes that are increasingly becoming evident these days.

To avoid uncontrollable global temperature increases, the use of fossil fuels needs to be reduced, long before they are depleted. This necessitates that fossil fuels need to be rapidly replaced by energy sources that do not further degrade the environment, which are urgent and important efforts that require unprecedented global changes affecting most human endeavours.

Strengthening Namibia's water–energy–food nexus needs to be significantly advanced while, at the same time, the country's energy riches need to be effectively and rapidly developed. Such a multi-pronged approach implies diverse local development growth centres that create jobs, improve livelihoods, while enabling the country to benefit from the global clean energy transition. In this way, Namibia's adaptive capacities and its resilience are improved, which are critical necessities for national development to take place in uncertain times.

4. Namibia's Food Sector

Food is national security. Food is economy. It is employment, energy, history.

Food is everything.

Chef José Andrés, founder of World Central Kitchen

4.1. Introduction

Namibia's arid climatic conditions pose various constraints on food production. These constraints concern the availability of adequate water resources, as well as the increasing electricity demand. In addition, urgent steps need to be considered to more rigorously initiate actions to adapt to climate change, to ensure a more sustainable and resilient future.

On average, agriculture's contribution to Namibian GDP over the last five years has been just over 4%, although it reached 6.6% in 2019. Notably, the agricultural sector consumes around 75% of all water (DRFN, 2009). With a population of just over 3 million and an annual population growth rate of around 3% in recent years, food security remains increasingly important.

Numerous factors affect Namibia's food security, including the country's arid environment, unemployment, and a lack of education about nutrition. Of importance to food security are the availability of, access to, and use of food, all of which remain major challenges. The predominant use of land in Namibia is agricultural, entailing mainly livestock production. The crop production is limited and contributes only 48% of the domestic demand.

Table 14: Average food commodity and fuel prices as of February 2024 [Source: Market Watch, 2024]

Commodity	Zone 1	Zone 2	Zone 3
Brown Bread (each)	N$ 13.82	N$ 14.33	N$ 13.91
Frozen Chicken (1.5kg)	N$ 83.56	N$ 85.76	N$ 82.23
Eggs (6)	N$ 19.94	N$ 22.49	N$ 21.65

Commodity	Zone 1	Zone 2	Zone 3
Loose oranges (per kg)	N$ 39.37	N$ 41.82	N$ 37.70
Sunflower oil (750ml)	N$ 32.52	N$ 31.81	N$ 30.99
Brown sugar (1kg)	N$ 21.49	N$ 21.49	N$ 20.83
Stewing beef (per kg)	N$ 95.12	N$ 90.35	N$ 93.97
Local beer (330 mk)	N$ 13.69	N$ 13.98	N$ 13.35
Petrol (per litre)	N$ 21.28	N$ 21.20	N$ 21.20
Diesel (per litre)	N$ 21.56	N$ 21.48	N$ 21.47
Zone 1: Kavango East, Kavango West, Kunene, Ohangwena, Omusati, Oshana, Oshikoto, Otjozondjupa and Zambezi Zone 2: Khomas Zone 3: //Kharas, Erongo, Hardap and Omaheke			

More than 62% of Namibians live in rural areas and have a small subsistence field on communal land held in trust for their community by the state. Normally, these fields provide a family with enough food to avoid hunger but are not always able to provide the right mix of nutrients.

Today, more than 80% of food products available in Namibia are imported from South Africa. The imports cause high food prices, because of trade tariffs and long-distance transport. Most dairy products are imported from South Africa, and other food imports from this source include fresh produce, meat, beverages, and canned food products (NSA, 2022).

Agricultural production is mainly based on livestock and crop farming and is dominated by subsistence farmers. Commercial farmers produce staple cereal crops such as maize, wheat, and potatoes for domestic consumption. Livestock is produced for domestic and international markets, with Namibia being a net exporter of livestock and livestock products.

Table 15: Inflation of select food commodities and fuel prices 2020-2023 [Source: NSA, 2023a]

Product	2020	2021	2022	2023
Bread	0.6%	7.5%	13.0%	12.3%
Maize	0.0%	-3.5%	14.8%	8.4%
Rice	13.2%	2.0%	0.8%	13.3%
Beef	13.2%	13.0%	6.7%	6.0%
Chicken	5.7%	15.9%	8.2%	12.3%
Fish	9.0%	1.6%	3.9%	16.9%
Milk	5.3%	-0.5%	6.4%	5.3%
Cheese	3.3%	2.9%	1.7%	12.4%
Eggs	4.8%	7.8%	6.6%	9.6%
Cooking Oil	7.0%	26.7%	36.1%	-12.7%
Potatoes	9.6%	7.9%	11.4%	25.8%
Sugar	5.9%	0.8%	10.2%	12.3%
Jam	5.5%	7.1%	6.7%	10.2%
Petrol/Diesel	-11.1%	18.0%	52.4%	-3.3%

The Government recently announced that "the number of people expected to experience food insecurity from October 2023 to March 2024 would rise to 695,000 (26% of the population)" (IPC, 2023). Notably, most households lack food reserves. In a recent survey (IPC, 2023), most respondents indicated that their food supplies would last for less than a month; even those who initially had reserves lasting between one and three months had already exhausted their stocks. This meant households were encountering considerable difficulties in affording food due to a combination of insufficient income and high rates of unemployment.

A myriad of challenges relating to climate, soil, technology, institutional support, and socioeconomic factors constrain Namibia's agricultural production and productivity. Those with which smallholding farmers grapple include inadequate market access, financing, land ownership, machinery, and equipment, agro-inputs, and water and equipment for irrigation. Although smallholder farmers contribute only 6 to 7% to GDP, and given that agriculture is constrained and underperforms, the sector nevertheless is and will remain a crucial one for Namibia.

Figure 89: Rice farming at Kalimbeza, Zambezi Region [Source: M Schneider]

Climate change poses significant challenges to Namibia's food sector as well, rendering the country particularly vulnerable to its effects on food security as a result. Some of the key impacts of a changing climate include erratic rainfall patterns, water scarcity, crop failure, livestock vulnerability, land degradation and loss of biodiversity.

Addressing climate-related challenges necessitates a multi-faceted approach. Such an approach would entail, among other things, the introduction of climate-resilient farming, technical innovation, advancing adaptation strategies, and pragmatic policy support. Today, climate change poses a complex and serious threat to Namibia's food sector and necessitates a concerted effort from the Government, communities, and international organisations to implement strategies to make the food system more resilient and enhance the population's food security.

4.2. Legislative Underpinnings

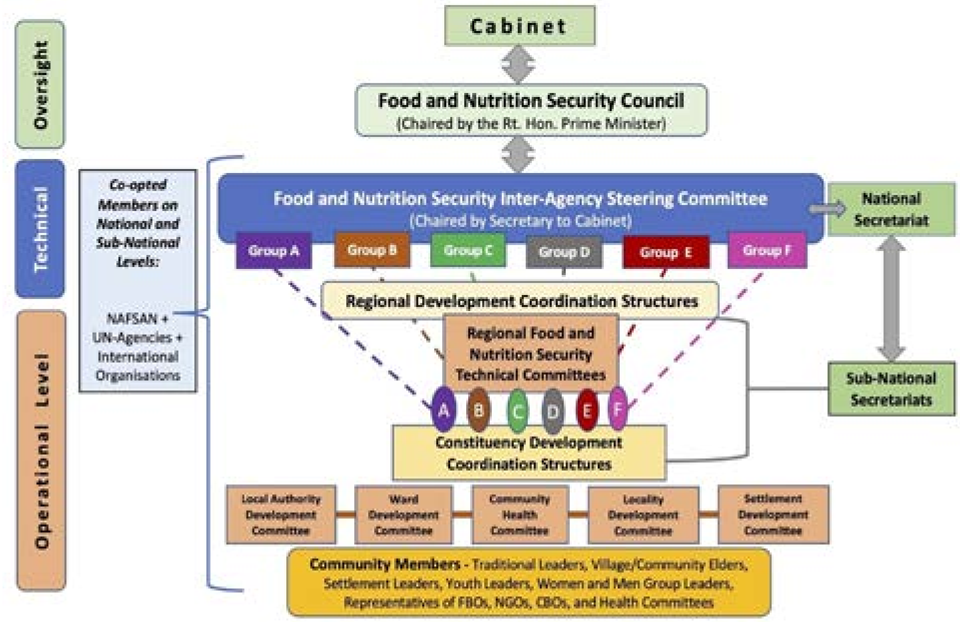
The Government places significant emphasis on ensuring food security. This aligns with the primary objective of the United Nations Millennium Development Goals (MDGs), where achieving self-sufficiency in food production is crucial to eliminate hunger, alleviate poverty and support agricultural efforts.

In 2021, the Namibian Government implemented its Revised National Food and Nutrition Security Policy (GRN, 2021a), along with an associated Implementation Action Plan that describes the role of the Nutrition and Food Security Alliance of Namibia (GRN, 2021b). The mission of both these instruments is to provide integrated, affordable, accessible, equitable and quality food and nutrition security services that are responsive to the needs of the population. Established coordination structures on national and subnational level aim to include all levels within Government, the private sector and civil society, to strengthen the food security and nutrition situation for all Namibians.

Within the context of food security, the critical matter of food safety in consumption often does not receive the attention it deserves. Food business operators are responsible for guaranteeing the safety of the food they sell. This entails implementing fundamental hygiene initiatives by food business operators, such as Good Manufacturing Practices, Prerequisite Programmes, Good Hygienic Practices and Good Agricultural Practices. By integrating food safety standards into their daily practice, these operators can effectively minimise the risk of food contamination and ensure they provide safe, wholesome products.

Currently, only food business operators, i.e., abattoirs, dairies, poultry producers and fishing companies, implement food safety and quality standards. These standards include Hazard Analysis Critical Control Point standards, the British Retail Consortium Global Standards, and the International Organization for Standardization's ISO 9001 and ISO 22000. Export-oriented businesses are obliged to adhere to stringent food safety regulations for the countries importing products from Namibia. However, such safety and quality measures are not enforced for food products intended for local consumption, due to the absence of robust food safety laws and regulations. This leaves Namibians potentially exposed to unsafe food products.

Figure 90: Proposed Food and Nutrition Security Coordination Structure [Source: GRN, 2021a]



The food safety policy framework in Namibia designates the Ministry of Agriculture, Water and Forestry (now Ministry of Agriculture, Water and Land Reform) as the primary authority responsible for food production. This Ministry oversees the enforcement of food safety regulations at various stages of production and primary handling, such as silos, packhouses and slaughterhouses.

The Ministry of Health and Social Services also plays a crucial role in the food safety landscape, assuming responsibility for all matters related to food safety. It acts as a hub of information for foreign governments engaged in food trade with Namibia, ensuring compliance with Codex Alimentarius International Food Standards.

The Namibian Standards Institution, which falls under the Ministry of Industrialisation and Trade, bears the responsibility of implementing the Standards Act, 2005 (No. 18 of 2005). This Act governs aspects such as food additives, food processing aids and all traded food products within Namibia.

Within the domain of fisheries, the Ministry of Fisheries and Marine Resources oversees food safety issues related to fish and fishery products up to the point of catch and landing. Standards for traded fish, whether processed or not, fall under the auspices of the Ministry of Industrialisation and Trade. On the other hand, the responsibility for maintaining food safety standards for plant and animal products exported from Namibia lies with the Ministry of Agriculture, Water and Land Reform.

At the regional and local level, the regional and local authorities concerned are tasked with overseeing food business operators within their respective jurisdictions. This approach reinforces the collective effort required to ensure the safety and quality of food products throughout Namibia.

The Namibian Agronomic Board and the Livestock and Livestock Products Board of Namibia are Government institutions entrusted with the task of "promoting the agronomic sector and facilitating the production, processing, storage, and marketing of regulated commodities within Namibia" (NAB, 2020). The primary objective of these institutions is to invigorate local production and diminish reliance on imported goods. Additionally, Government entities such as the Agro-Marketing and Trade Agency and the Agricultural Business Development Agency (AGRIBUSDEV) have been established with an oversight function that includes managing Fresh Produce Business Hubs, maintaining the National Strategic Food Reserve infrastructure, and supervising Namibia's Green Scheme Programme.

Food systems encompass a comprehensive spectrum of activities. These involve the creation, processing, distribution, marketing, preparation, consumption, and disposal of items derived from agriculture, forestry, or fisheries. The food system framework also considers societal, ecological, and economic interactions along the value chain. The system addresses food security and the broader array of other systems within which food functions, including traditional and informal markets.

The stakeholders in Namibia's food system are multifaceted and diverse, ranging from subsistence smallholding farmers and commercial agriculturalists to farmers' associations, specialised agricultural agencies, governmental bodies, and private enterprises. Each participant contributes significantly to the optimal functioning of the system. It is vital, therefore, for all these players to understand the existing state of the food system so that the system's dietary, economic, social, and developmental goals can be met sustainably.

4.3. Resources for Food Production

Critically important resources for food production include water, land, an effective legal framework, and an environment that is conducive to investment. Additionally, producing food demands a proficient workforce and the support of extension services provided both by Government and private entities. The availability of support services to access machinery, equipment, seeds, and fertilisers across the entire nation is equally pivotal.

Only some 2% of Namibia's land surface area receives adequate rainfall for crop cultivation without irrigation. The challenges of minimal and erratic rainfall, coupled with inherently poor soil quality, are significant impediments to achieving optimal agricultural output. Inland rivers being ephemeral, irrigation is most feasible along the border rivers, namely the Kunene, Okavango, Orange, and Zambezi. The utilisation of water for irrigation beyond these rivers relies on groundwater sources (at Otavi, Stampriet, and Windhoek) or reservoirs (such as the Hardap and Naute Dams).

Farming in communal areas is constrained by a shortage of land, which is exacerbated by an inadequate placement of water points and a lack of fencing where and if required. This results in significant migration of youth away from agriculture. However, there is also a trend among the youth towards commercialised farming practices on communal land (Nangolo & Alweendo, 2020).

Freehold land is privately owned. Communal land, on the other hand, is held in trust for traditional communities by the state. Nonetheless, members of such communities possess customary rights to occupy and use the land allocated to them.

Approximately 105,000 out of a total of 170,000 traditional agricultural holders/communal farmers exclusively engage in crop and livestock farming. Some 50,000 other holders combine crop, livestock, and forestry holdings, while approximately 8,500 focus solely on crop production and some 6,450 engage solely in livestock farming (NSA 2015). Most agricultural holders reside on communal lands.

Investing in food production in Namibia necessitates a robust financial framework. The country enjoys notable financial stability as well as an investor-friendly environment, being part of the Common Monetary Area alongside Lesotho, South Africa, and Swaziland. The development of food production facilities and infrastructure requires government involvement, be it for environmental impact studies, clearances, or water abstraction permits. Investments in irrigation schemes generally demand long-term leaseholds to ensure a reliable return on investment. This is particularly important when PPPs are considered, such as under the Green Scheme Project or the schemes at the Hardap and Neckartal Dams.

Food production also relies equally heavily on dependable trade relations. Long-term marketing opportunities – especially concerning potentially lucrative exports to other countries – ensure consistent investment in infrastructure and human resources.

4.4. Crop Production – Staples, Vegetables and Fruit

Namibia produces a variety of crops, ranging from cereals and fruits to vegetables cultivated through irrigation. Fresh agricultural products cover tomatoes, potatoes, carrots, cabbage, butternuts, beans, groundnuts, dates, grapes, watermelons, melons, and citrus.

Figure 91: Advertising food commodities produced and sold in Namibia [Source: M Schneider]

Cereals include maize, pearl millet (mahangu), wheat, sorghum, and sunflowers. The most productive vegetable exported to South Africa and Angola is the onion. Although the crop production subsector has expanded significantly over the past decade, Namibia produces only 35% of its vegetables, while less than 4% of the annual demand of 730 t of fruit is produced locally.

Table 16: Crops planted and harvested in Namibia in 2020 [Source: NSA, 2021]

Crop type	Crop Field Area Planted [ha]		Quantity Harvested [kg]		
	Irrigation	Dry land	Irrigation	Dry land	No of farms
White Maize	4,378	1,567	103,886	44,679	173
Yellow Maize	436	149	31,732	26,732	69
Wheat	2	185		5,811	7
Fodder	1,732	2,037	16,532	16,730	37
Beans	837	8	16,963	25	61
Sunflower	146	2	8,249		11
Olives		1		5	2
Sorghum	410	5	16,146	22	25
Groundnuts	371	19	19,918	7,560	15
Mahangu	28		1,260		8
Total	**9,098**	**6,317**	**219,975**	**140,113**	**289**

Table 17: Horticulture products planted and harvested in Namibia 2020 [Source: NSA, 2021]

Horticultural product	Area Planted [ha]		Quantity harvested [kg]		No of farms
	Dry land	Irrigation	Dry land	Irrigation	
Onions	37	99	855	807,048	94
Watermelon	38	71	1,343	346,917	72
Sweet Melon	14	11	135	83,336	34
Tomatoes	40	1,131	280	313,936	88
Potatoes	1	25	12	231,813	18
Pumpkin	27	96	913	31,432	79
Butternut	3	30	27	46,944	36
Sweetcorn		1,205	40	910	20
Gem squash	1	6	16	4,122	14
Cabbage	16	1,232	205	439,942	61
Dates		6		741	4
Sweet potatoes	6	10	50	160,068	25
Peppers	1	2,006	37	37,670	29
Chili	1	4	6	193	24

Horticultural product	Area Planted [ha]		Quantity harvested [kg]		No of farms
	Dry land	Irrigation	Dry land	Irrigation	
Cauliflower		607	19	2,654	12
Carrots	15	23	21,157	34,207	70
Broccoli	1	608	10	2,640	10
Cucumber	1,000	6	20,020	119,929	22
Asparagus			6		1
Spinach	2	27	41	7,902	32
Lettuce		6	20	72,738	20
Other	54	35	20	36,247	11
Total	**1,257**	**7245**	**45,212**	**2,781,387**	**147**

4.4.1. Commercial Irrigation

Commercial irrigation has emerged as a crucial pillar of agricultural development in Namibia. With the challenges posed by water scarcity and the need to achieve food security, Namibia's pursuit of effective commercial irrigation techniques has become integral to sustainable agricultural growth. As such, commercial irrigation plays a critical role in enhancing agricultural productivity, securing food supply, and boosting the economy. Such irrigation also enables the cultivation of crops that would not thrive in the natural climate, which contributes to food self-sufficiency and reduces reliance on imports.

While commercial irrigation holds promise, it also presents challenges that require careful consideration. The high upfront costs of establishing and maintaining irrigation infrastructure can be a barrier for small-scale farmers. Proper water management is essential to prevent over-extraction and degradation of the resource. Addressing these challenges requires sustainable practices, efficient water distribution systems, and ongoing investment in research and technology.

The expansion of commercial irrigation in Namibia raises environmental and social concerns. The over-extraction of groundwater can lead to land degradation and salinisation, affecting soil quality. Competition for water resources among various users, including agriculture, industry, and households, necessitates effective water governance and equitable distribution. Additionally, consideration needs to be given to the potential displacement of communities and impacts on local ecosystems.

Figure 92: Rice farming at Ogongo, Omusati Region [Source: M Schneider]

The commercial irrigation of crops and horticulture products is practised along Namibia's perennial Okavango, Orange, and Zambezi Rivers, at the Hardap and Naute Dams, in the Stampriet aquifer, in the Swakop and Omaruru Rivers, in the Maize Triangle constituted by the Grootfontein–Otavi–Tsumeb area, and in the northern communal areas. Irrigation schemes are implemented by both private entities and by the Government's Green Scheme agency (AGRIBUSDEV) under the auspices of the Ministry of Agriculture, Water and Land Reform. The perennial rivers bordering Angola and Zambia in the north and South Africa in the south are currently utilised as shared resources in a sustainable way and to the mutual benefit of all partner countries. Privately-owned small-scale irrigation to sustain private livelihoods, households and communities also occurs countrywide.

At Independence in 1990, approximately 5,000 ha of land were under irrigation. By 2014, approximately 10,300 ha were being irrigated for food production, with plans to extend that area. By 2020, some 16,343 ha were under irrigation (see Table 17). The Government has also expressed its eagerness to continue implementing irrigation projects along the main perennial rivers and dams to ensure food security for the country (NSA, 2021).

Table 18: Irrigation areas in Namibia 2020 [Source: NSA, 2021]

Area/Region	Hectares under irrigation
Orange River Irrigation Project, //Kharas Region	2,400
Hardap Dam environs	2,400
Naute, //Kharas Region	400
Hardap Region Stampriet aquifer	620
Khomas Region, Eastern and Central Namibia	140
Kavango East and Kavango West Region	2,540
Maize Triangle-Otjozondjupa Region	1,200
Etunda-Omusati Region	600
Irrigation on farms and homesteads countrywide to sustain own demand for food	6,043
Total ha under irrigation	**16,343**

4.4.2. Orange River Irrigation Project

Along the Orange River, roughly 100 km inland from its mouth, irrigation projects take advantage of water from the river and soils from the floodplains, turning parts of a normally earth-toned landscape into a lively emerald green. An area of 2,346 ha around Aussenkehr is under irrigation, with grapes being the primary agricultural product. Other major crops include tomatoes, butternut, baby marrows, mango, green beans, dates and pumpkin.

Figure 93: Irrigation on the banks of the Orange River near Aussenkehr [Source: NASA, 2010]

To encourage and ensure optimal use of water from the Orange and to prevent its pollution, a Joint Irrigation Authority was established in 1993. This Authority also provides support to the Orange–Senqu River Commission and its four member countries – Botswana, Lesotho, Namibia, and South Africa – whose mandate includes promoting integrated water resource management in the river basin.

Namibia plans to extend some of the existing irrigation schemes as well as develop a new one. The new scheme will be located at the Neckartal Dam in the Fish River basin.

Table 19: Planned irrigation projects in the Hardap & //Kharas Regions [Source: ORASECOM, 2014]

Scheme	Type	Current size [ha]	Additional size [ha]	Irrigation Demand [m^3/ha/a]	Additional water demand [Mm^3/a]
Neckartal	planned	0	2,000	20,000	100
Hardap	existing	2,400	no plans	20,000	-
Naute	existing	400	250	15,000	3.8
Aussenkehr	existing	1,500	no plans	15,000	-
Noordoewer	existing	286	1,000	15,000	15
Haakiesdoorn	existing	250	450	15,000	6.8
Komsberg	existing	310	no plans	15,000	-
Total		**4,946**			**125.6**

Along the border between Namibia and South Africa, irrigation is mainly for high-value crops that require irrigation throughout the year. The area equipped for irrigation along the Orange River – which includes the Noordoewer and Aussenkehr Schemes – is about 2,300 ha.

The Orange River Irrigation Project (ORIP) is an established Green Scheme Project under the umbrella of Namibia's then Ministry of Agriculture, Water and Forestry in 2010. Since then, ORIP has yielded a substantial volume of seedless grapes for sale to customers in Asia, the EU, and the Middle East. As a Green Scheme Project, ORIP also produces dates and various vegetables (see Figure 94 and Figure 95).

Figure 94: Grape production at Noordoewer in the //Kharas Region [Source: M Schneider]

Figure 95: Date farming along the Orange River, //Kharas Region [Source: Desert Fruit]

4.4.3. Stampriet Transboundary Aquifer System

The Stampriet Transboundary Aquifer System (STAS) consists of three aquifers, i.e., the Auob, the Kalahari, and the Nossob. The STAS covers a large arid region, stretching from Central Namibia into Western Botswana and South Africa's Northern Cape Province (UNESCO, 2016). In the STAS area, 47% of water is used for irrigation, followed by stock watering at 37.5%, and domestic use at 15% (UNESCO, 2016). Figure 96 shows irrigation infrastructure in the greater Stampriet area.

Figure 96: Irrigation in the greater Stampriet area [Source: Roots Development]

STAS crops are dominated by fodder (lucerne) and horticulture (e.g., vegetables, and fruits). Since irrigation needs higher investment, crop production is dominated by commercial farmers who can invest in irrigation systems. Approximately 80 commercial farms irrigate 619 ha of some 1,000 ha of irrigable land.

Drip irrigation is widely applied in the area. Other methods in use are sprinkler and mixed applications (drip, sprinkler, and flood). Few farms apply flood irrigation alone. Lucerne represents approximately 50% of the irrigated area (310 ha) and 38% of crop production (6,200 t/a). The crop is primarily produced for farmers' use as feed for livestock, and consequently may not directly generate income for farmers. However, growing lucerne as fodder reduces expenditure on such inputs for livestock farming. Own production is probably also more cost-effective than obtaining it from the Hardap scheme, for example.

Table 20: Food production in the Namibian segment of STAS in 2016 [Source: UNESCO, 2016]

Product	Area [ha]	Percentage [%]	Production [t]
Vegetables	142	23	8,520
Oats	43	7	49
Fruits	25	4	125
Maize	74	12	348
Lucerne	310	50	620
Hoodia	25	4	100
Total	**619**	**100**	**9762**

Some farmers have started switching to vegetables (e.g., tomatoes, beans, potatoes, pumpkin) and fruits (such as citrus, grapes, and melons). Vegetables and fruit represent 50% and 8% of total crop production, respectively. Potential income from vegetables and fruit is greater than from other crops (e.g., oats and maize). However, these commodities are deemed to have higher labour and initial investment costs and to be riskier in terms of their yield (mainly due to climatic conditions) and value.

4.4.4. Hardap Irrigation Scheme

The Hardap Dam provides water for the irrigation of approximately 2,400 ha using 16 km of concrete-lined canals and pipelines. The main crops cultivated under different irrigation systems are wheat, maize, lucerne, cotton, grapes, and raisins. Crops are sold to local millers, exported to South Africa, or sold for animal feed in the local market.

The irrigation capacity of the Hardap Irrigation Scheme is almost fully utilised, however. Moreover, as the population increases, there will be a demand for more food production, which will in turn require more irrigation areas.

The Ministry of Agriculture, Water and Land Reform plans the future development of a small irrigation area of approximately 200 ha for previously disadvantaged farmers. This effort would be in keeping with Government practice to cater for underrepresented groups and would promote the right to equality concerning state-supported Green Scheme projects.

Table 21: Areas under maize production in Namibia, 2016 to 2018 [ha] [Source: NAB, 2018]

Production Areas	Dryland	Irrigation
	Planted [ha] 2016/17	Planted [ha] 2016/18
Omaheke Region	1,833	140
Hardap Irrigation Scheme and its environs	0	647
Maize Triangle and its environs	7,862	1,223
Kavango and Omusati Regions combined	200	2,395
Total	**9,895**	**4,405**

4.4.5. Irrigation Projects in Kavango East and West and Omusati Regions

These Green Scheme Projects contribute significantly to domestic white maize production. The projects, which are managed on behalf of the Government by AGRIBUSDEV, are Etunda (Omusati Region) and Government irrigation schemes (Kavango East and West Regions – see Table 21). Irrigation is by centre pivot, using a rotating sprinkler that directly administers water to crops.

Wheat, as a winter crop, can only be planted under irrigation in Namibia. The main wheat production areas are the Hardap Irrigation Scheme near Mariental and Government irrigation projects along the Okavango River. Small amounts of wheat are also produced at irrigation farms in the Maize Triangle and the Omusati Region (NAB, 2018).

Table 22: Irrigation in the Kavango East and West Regions [Source: OKACOM, 2009a]

Irrigation Farm	Area [ha]	Irrigation system	Crop type(s)
Musese-Maguni	200	Centre Pivot	Cotton, Maize
Vungu-Vungu	225	Centre Pivot, Sprinkler	Lucerne, Maize, Oats
Ndonga Linena	800	Centre Pivot, micro, drip	Maize, Wheat, vegetables
Sikondo	166	Centre Pivot	Maize, wheat, vegetables
Shitemo	400	Centre Pivot	Cotton, Maize, Wheat
Shadikongoro	400	Centre Pivot	Cotton, Maize, Wheat

Irrigation Farm	Area [ha]	Irrigation system	Crop type(s)
Bagani Research	40	Micro	Fruits
Divundu Prison	110	Centre Pivot	Maize, vegetables
Mashare	140	Centre Pivot, Sprinkler	Maize, Wheat, vegetables
Kaisosi	34	Sprinkler	Cotton, Maize, vegetables
Shankara	20	Sprinkler	vegetables
Total	**2,535**		

4.4.6. Maize Triangle and its Environs

Namibia's Maize Triangle is home to maize farmers operating in the triangular area lying between the towns of Grootfontein, Otavi and Tsumeb in the northern part of the country. The triangle lies within the karst area, which is known for its fertile soils and favourable climate for maize cultivation. However, due to limited and erratic rainfall, irrigation has become essential for consistent agricultural production.

Centre-pivot irrigation is the predominant method employed in the Maize Triangle. Given the area's constrained water resources, the efficiency of water distribution is paramount, making centre-pivot irrigation systems particularly valuable. Farmers within the Maize Triangle have enthusiastically adopted this technology to optimise their yields and guarantee a steady maize output. The collective irrigated land area spans around 1,200 ha.

Despite these achievements, challenges persist. Maintaining a delicate equilibrium between water utilisation and conservation remains vital. Over-extraction of groundwater for irrigation purposes carries the risk of depleting aquifers, thereby raising long-term sustainability concerns. In addition, the changing climate could potentially disrupt rainfall patterns and the accessibility of water resources, necessitating continuous adaptation strategies.

Figure 97: Irrigation at Mashare, Kavango East Region [Source: GoogleEarth]

4.4.7. Other Irrigation Areas

A. Swakop, Omaruru, Okahandja projects: These commercial projects mainly focus on fresh horticultural produce for formal and informal local markets at Okahandja and Windhoek in the Khomas Region, and Omaruru, Swakopmund and Walvis Bay in the Erongo Region. Irrigation in these cases draws from resources in the Okahandja, Omaruru and Swakop riverbeds using flood, drip, or sprinkler systems as well as manual watering.

B. Naute Dam: The Naute Fruit Farm has some 400 ha dedicated to its date plantations, which are currently being irrigated via the Naute Dam. Plans are underway to expand operations on another 250 ha. The dates are primarily destined for export to the EU. The Naute Irrigation Scheme in the //Kharas Region is managed by the Namibia Industrial Development Agency (NIDA), established under the Ministry of Industrialisation and Trade "to foster industrial development, youth empowerment and entrepreneurship development, investment facilitation and attraction, export-oriented industrial growth and import substitution" (NIDA, 2020).

C. Neckartal Dam: Namibia's largest dam is situated in the //Kharas Region. Since its completion in 2018, the dam has filled up to its maximum capacity and now holds 787,45 Mm^3 following good rain in its catchment area. The Government intends to secure PPPs for the irrigation of 2,000 ha downstream and to include the project under its Green Scheme.

D. Omaheke Region: Commercial irrigation and rain-fed agriculture are practised in the Summerdown and Hochfeld areas in this Region. Approximately 1,800 ha are under rain-fed agriculture, while some 140 ha are under irrigation.

Figure 98: Asparagus farm in the lower Swakop River Valley [Source: H Fahrbach]

Figure 99: Horticulture production at Farm Palmenhorst, Erongo Region [Source: G Schneider]

E. Small-scale irrigation: Small-scale irrigation – inclusive of organic farming – is practised countrywide by commercial and subsistence farmers, households and lodges, communities, settlements, and conservancies for self-consumption to sustain livelihoods and pending the availability of sufficient water resources, see Figure 100 and Figure 101. Some of the fresh produce is sold on informal and formal markets throughout the entire country. However, no statistics are available on the total area under small-scale irrigation.

Figure *100: Vegetables from organic farming [Source: SfCF]*

Figure 101: Herbs under irrigation in Khomas Region [Source: M Schneider]

F. Commercial rain-fed agriculture: Commercial rain-fed or dryland agriculture is practised in the Summerdown and Hochfeld areas in the Omaheke Region and the Maize Triangle and its environs in the Oshikoto and Otjozondjupa Regions. A key factor contributing to the success of commercial rain-fed agriculture in Namibia is the adoption of sustainable farming practices. Farmers in the region have embraced techniques such as conservation tillage, agroforestry, and crop rotation to maximise water efficiency and soil health. These practices help to mitigate soil erosion, retain moisture, and enhance the overall resilience of the agricultural ecosystem. Another important aspect of the success of this type of agriculture is the utilisation of drought-resistant crops. Namibian farmers have focused on cultivating drought-tolerant varieties of crops like millet, sorghum, and indigenous vegetables.

G. Subsistence agriculture: Subsistence agriculture plays a crucial role in Namibia's socioeconomic landscape, providing livelihoods for a significant portion of its population. This type of agriculture is predominantly characterised by small-scale farming that prioritises self-sufficiency over commercial production. Most subsistence farmers have limited resources, but they can rely on a treasure of traditional farming methods passed down through generations. Maize, millet, sorghum, and livestock such as goats and cattle are common components of subsistence agriculture, forming the backbone of food security for many rural households. Subsistence agriculture remains a vital aspect of Namibia's rural economy because it serves as a critical source of food security and livelihood for many communities.

Figure 102: Beehives at Neudamm Farm, Khomas Region [Source: M Schneider]

Figure 103: Traditional food storage baskets, used in Omusati Region [Source: G Schneider]

Figure 104: Cabbage under irrigation at Etunda Farm, Omusati Region [Source: M Schneider]

4.4.8. The Green Scheme

Namibia's Green Scheme projects represent a concerted effort by the Government to transform the nation's agricultural sector, enhance food security, and foster economic development in the face of challenging environmental conditions. Green Scheme projects are strategically designed to promote agricultural activities in regions where water is available, either from perennial rivers or groundwater sources. These projects have catalysed the transformation of formerly underutilised areas into productive agricultural zones, showcasing the nation's commitment to harnessing water for both subsistence and commercial farming. The projects are also testimony to Namibia's acknowledgement that sustainable water management practices are essential for addressing the inherent challenges of water scarcity and climate variability.

Key to Green Scheme projects is their emphasis on improving livelihoods and food security. By providing suitable land, access to water and technical support, these initiatives empower local communities, particularly those residing in rural areas, to engage in viable agricultural ventures.

A notable Green Scheme project is the Etunda Irrigation Project. This project exemplifies the integration of modern irrigation technologies and local expertise to cultivate crops such as maize, vegetables and fodder.

The expansion of irrigation capacities through centre-pivot systems and water-efficient practices has not only increased agricultural productivity but also fostered knowledge transfer and skill development among farmers (Agribank, 2023).

Another noteworthy endeavour is the planned Neckartal Dam Green Scheme project. This project intends to harness water from the Fish River for the irrigation of a 2,000 ha area to cultivate crops in southern Namibia.

The success of the Green Scheme projects is not only attributed to their infrastructural advancements but also to their holistic approach to development. These initiatives incorporate capacity-building programmes, technical training, and market linkages, ensuring that farmers are equipped to maximise their yields and profits. The projects also prioritise sustainable practices, including soil conservation and efficient water use, which are crucial for maintaining the long-term viability of the agricultural sector.

Green Scheme projects are not without their challenges, however. Ensuring equitable access to resources such as land and water is critical in preventing marginalisation and conflict among the various stakeholders. In addition, long-term sustainability necessitates continuous investment in infrastructure maintenance, research, and community engagement (Sheehama, 2023).

Presently, the Namibian Government is in the process of evaluating all Green Scheme projects. This assessment has already brought to light persistent hindrances to attaining the Green Scheme's goals. Challenges include inconsistent policies, insufficient political will, limited public awareness, and a lack of technical expertise among those responsible for management. Delayed financial intervention is a contributing factor. The Government bears a financial burden due to the absence of full-time engagement by managers overseeing Green Scheme projects.

To achieve both food security and socioeconomic development through Green Scheme initiatives, policy frameworks need to be enhanced, appropriate technology employed and awareness among farmers must be raised, among other things. The effectiveness of Green Scheme practices also faces barriers such as market-related concerns, inadequate technical proficiency, and a lack of comprehension concerning irrigation practices at the end-user level (NMH, 2023).

As outlined in the Fifth National Development Plan and the Harambee Prosperity Plan, the agriculture sector is expected to put 27,000 ha under irrigation by the year 2030 through the implementation of the Green Scheme programme (Nam Farmer 2018). With only some 16,300 ha achieved by 2021, much still needs to be done to achieve this goal.

4.5. Meat Production

Livestock farming plays an important role in Namibian agriculture and contributes approximately two-thirds to total agricultural production. Livestock farming thrives with breeds that are adapted to arid conditions, such as the Damara sheep and the Nguni cattle. These farming efforts have not only ensured food production, but they have also contributed to the preservation of traditional agricultural knowledge.

Figure 105: Cattle farming in the Erongo Region [Source: M Schneider]

Namibia is a small meat producer in international terms, having about 2.5 million head of cattle as at 2023 (Namibia Economist, 2023). About 85% of production is exported, primarily to South Africa and the EU (premium cuts). There are only limited exports to members of the Tripartite Free Trade Area set up through an agreement between SADC countries and their Common Market for Eastern and Southern Africa (COMESA) and East African Community (EAC) counterparts. Namibia sees potential in increasing exports of cattle, sheep and goats, chilled and frozen beef, and low-priced meat into Angola (depending on infrastructure development). As an arid country, Namibia's options for expanding meat production are limited as most abattoirs work below capacity due to low supplies as a result of drought recovery.

Namibia's beef exports to markets in the United States are still being developed, but they are continuing to China, the EU, Norway, and South Africa. For the month of January 2024 Europe remained Namibia's biggest beef export destination. Besides cattle other livestock sectors such as goat, pig and sheep also witnessed positive development with Europe, South Africa and China remaining increasingly significant markets (The Namibian 2024). Namibia became only the second African country after South Africa to export beef to China and was the first African country to export its well respected free-range and hormone-free beef to the lucrative US market. Regionally, Namibia has strong trade relations with South Africa; in 2020, it exported 96% (44,103 head of livestock) of all domestic live animal exports to its southern neighbour, with the remainder going to Angola. South Africa is also the biggest export destination for Namibia's beef products, followed by Norway (FAO, 2023).

Figure 106: Cattle farming in the Omusati Region [Source: M Schneider]

Table 23 shows the export and import of live animals by type for 2021. It also compares the income generated by both large and small stock exports and imports. The earnings from export of live cattle in the fourth quarter of 2021 stood at N$252.7 million (N$240.6 million: Q4 2020), followed by sheep at

N$70.2 million: Q4 2020 and goats at N$27.8 million: Q4 2020. Live animals destined for South Africa accounted for 96 of all exports; Angola holds a 3.6% share.

With respect to imports, cattle were the main live animal brought into the country in 2021, registering a value of N$11.1 million by the end of the year, followed by chickens (N$9.2 million). The principal sources of imported livestock were Botswana (51.7%), South Africa (32.6%) and Zambia (14.1%) (NSA, 2022). Currently Namibia cannot import all livestock – such as cattle, sheep, goats and pigs from South Africa and Zambia – due to its prevailing foot and mouth disease status.

Table 23: Export and import of live animals by type, 2021 [N$ m] [Source: NSA, 2022a]

Export of live animals	**Q1: 2021 [N$ m]**	**Q2: 2021 [N$ m]**	**Q3: 2021 [N$ m]**	**Q4: 2021 [N$ m]**
Cattle	195.7	243.8	345.6	252.7
Sheep	63.4	138.7	62.1	70.2
Goats	11.4	24.9	24.6	27.8
Other live animals	0.2	3.0	6.6	24.9
Total exports of live animals	270.7	410.4	438.8	375.7
Import of live animals				
Cattle	13.2	15.9	10.7	11.1
Chicken	5.1	4.3	3.0	9.2
Other live animals	1.1	0.3	4.2	2.9
Total import of live animals	**19.4**	**20.5**	**17.9**	**23.1**

4.5.1. Large Stock

Livestock farming remains the dominant force in the meat production sector, contributing roughly two-thirds of this type of agricultural production. The commercial livestock farming realm in Namibia stands out as a well-established, capital-intensive endeavour with a focus on exports. Cattle husbandry dominates the central and northern regions, while sheep and goat farming are concentrated in the more arid southern areas. Subsistence farming primarily takes place in the communal lands of the densely populated northern regions, characterised by roaming cattle herds.

An impediment to livestock movement between northern and southern Namibia is constituted by way of the Veterinary Cordon Fence. This measure bars the export or trade of livestock from north to south to prevent the spread of disease.

Enhancing productivity within the Namibian beef industry demands strategic investments in novel infrastructure, encompassing feedlots, equipment, and drought-restocking programmes. Equally essential is the provision of incentives to empower small-scale beef processors and fortify their operations. Prioritising the improvement of rangelands and augmenting grazing capacity for cattle is another fundamental aspect of enhancing productivity, as is the implementation of initiatives aimed at producing and stockpiling animal feed to mitigate the impact of drought periods (NRMP, 2019).

In late 2023, the Government-controlled Meat Corporation of Namibia (Meatco) abattoir at Windhoek faced severe challenges because of management-related issues and delayed payments to cattle farmers. Another abattoir located in Rundu, is operational but cannot export yet. A new producer-funded abattoir, i.e., Savanna Beef, has secured investment capital to build a new abattoir in 2024, and is likely to become a competitor to existing facilities.

Beef production is the backbone of Namibia's agricultural sector. As such, it requires farming practices to be modernised and the latest agricultural techniques to be adopted, including improved breeding, feed, and herd management. This is the only way the subsector can increase productivity and produce higher-quality beef (Dlamini 2023a).

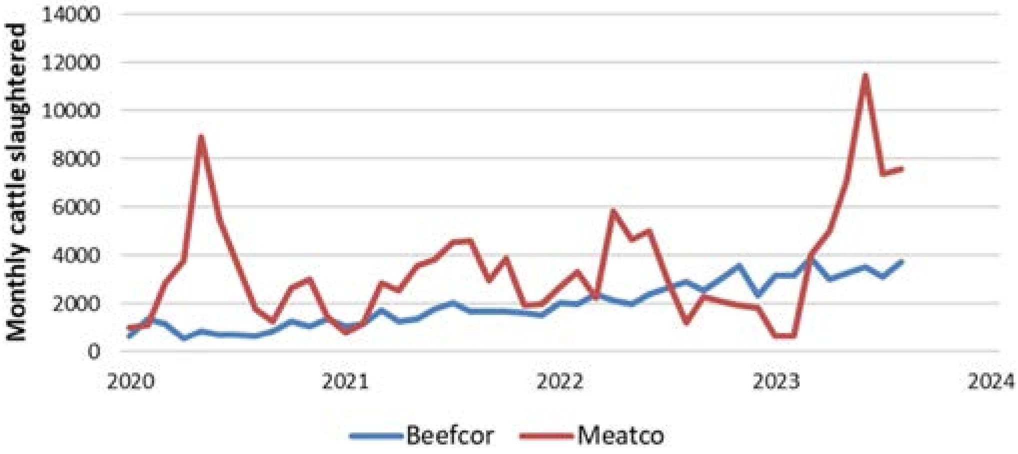
Figure 107: Livestock watering points are sometimes shared with game [Source: M Schneider]

During 2022, Namibia exported a total of 10,020,827 kg of beef. The main export destination for beef was the EU, which accounted for 46% of the total exported, followed by South Africa with 20%. Norway and China accounted for 13% each. The least amount of beef was exported to Tanzania, namely 0.6%. Beef exports increased by 27% between 2021 and 2022. Marketing activities at export-approved abattoirs improved due to attractive prices throughout 2022. Like Botswana, Namibia exports beef duty-free to Norway, with each of the two exporting countries Namibia and Botswana assuming about a 50% share of the allocated 3,200 t.

According to the Livestock and Livestock Products Board, despite a decrease in beef marketing numbers between 2021 and 2022, beef exporters were able to make full use of Namibia's approximately 50% share of the 3,200-t Norwegian beef quota available to the Southern African Customs Union. The countries were approved for export in 1995 under the Generalised System of Preferences quota, and exporters have since then had preferential and duty-free market access to Norway. The Norwegian market is highly lucrative: it has increased the profitability of the local meat industry and generated significant foreign currency for Namibia.

Beefcor at Okahandja is currently Namibia's second largest abattoir, exporting some 400 t of prime beef cuts to Norway. An additional export quota of 1,200 t was allocated to Meatco in 2022. For example, in July 2023, Meatco's slaughtering numbers stood at 7,352 head of cattle; in August the same year, its capacity was 7,550 head (+2.7%). In contrast, Beefcor slaughtered 3,080 cattle in July 2023 and 3,743 in August 2023 (+21.5%) (see Figure 108). The increase in Beefcor's slaughtering capacity – for those months at least – is the result of offering better prices to producers and paying them on time.

Figure 108: Monthly slaughter of cattle by Beefcor and Meatco 2020 to 2023 [Source: R Ritter]



4.5.2. Small Stock

Despite being drought-prone, Namibia has more than 4 million head of small livestock (sheep and goats), and these are concentrated in the Hardap and //Kharas Regions. The two Regions account for 68% of the country's sheep, whereas the northern communal areas including the northern Kunene Region account for 47% of Namibia's goat population (see Figures 109 and 110). Pigs are farmed at various locations around the country.

Namibia ranks third in southern Africa in sheep production after South Africa and Tanzania. The dorper sheep accounts for over 60% of all sheep bred in Namibia. This makes Namibia an excess producer of mutton and therefore a net exporter of it. Another small stock breed associated with meat production, the boergoat, accounts for nearly 50% of total small stock in Namibia (Kahuika et al., 2006).

Namibia has exported about 960,000 live sheep South Africa each year for decades. Namibia also exports some 250,000 live goats on average each year to South Africa. In respect of pork production, local output in 2022, for example, could only meet 40% of local demand. The remainder was imported from South Africa and the EU (Smit, 2023b).

Figure 109: Sheep farming, Hardap Region [Source: M Schneider]

Figure 110: Goat farming, Otjozondjupa Region [Source: M Schneider]

4.5.3. Game

Game farming is the commercial marketing of native and non-native wildlife for a variety of products, including meat, hides, feathers, and horns. This type of farming is practised on over 600 hunting enterprises with over 30 huntable species, including Blue and Black Wildebeest, Cape Eland, Cheetah, Gemsbok, Greater Kudu, Impala, Leopard, Warthog and Zebra (see Figure 111). (Conservation Namibia, 2024).

The game meat industry encompasses the harvesting, processing, and distribution of meat from various wild animals. Besides the huntable species mentioned above, this includes Ostrich. Game meat has grown in popularity both domestically and internationally due to its lean and organic nature as well as its contribution to culinary diversity.

Namibia places great emphasis on the sustainable use and conservation of its wildlife resources. The Government has established strict regulations and guidelines to ensure that game meat production does not endanger the delicate balance of ecosystems or threaten species' survival. Licensing, quotas, and regulated hunting seasons are employed to maintain viable wildlife populations and prevent overexploitation.

The game meat industry generates substantial export earnings, with game meat products finding their way to international markets, particularly in the EU. Game meat production also supports a significant number of jobs, ranging from hunting guides and butchers to logistics and marketing professionals. These jobs benefit local communities, promoting economic growth and social well-being.

Sustainable game meat production also contributes to wildlife conservation efforts, see Figure 111. Revenue generated from regulated hunting permits and fees often goes towards funding conservation initiatives, anti-poaching efforts and habitat preservation.

Figure 111: Game farming, //Kharas Region [Source: M Schneider]

4.5.4. Poultry

The poultry subsector has undergone significant growth in recent years. It secured the position of the second most important subsector in 2019, yielding an annual revenue of N$1.05 billion. Imports of frozen chicken portions are capped at 1,500 t monthly. Of the monthly demand of 3,000 t for broilers, roughly 1,700 t are locally produced by an industrial-size factory near Windhoek, and a large free-range chicken farm in the Khomas Hochland. There is also substantial informal production, both in communal areas and on farms. Opportunities exist for Namibia to grow its poultry sector and move closer to self-sufficiency (Poultry World, 2021).

4.6. Fish

4.6.1. Marine Fish

The fishing industry in Namibia is often grouped with agriculture and forestry due to their combined impact on the economy, although it is considered a distinct sector. The country's marine fisheries sector stands out as a leading player in Africa. The Benguela Current off Namibia's coast supports a range of commercially valuable species. Among them are seven main species that are harvested on a large scale, and various other species are caught in smaller quantities.

Namibia's 200 nautical-mile Exclusive Economic Zone contains about 20 different species. These are small pelagic species (anchovy, horse mackerel, mackerel, and sardine/pilchard) and lobster; large pelagic species (e.g., adult mackerel and demersal hake); and other deep-sea species (e.g., monkfish, sole and crab) in the waters further offshore. Eight of the 20 species are regulated through total allowable catch (TAC) quotas, including hake, monkfish and kingklip.

The principal species harvested for commercial purposes are hake, monk, horse mackerel, sardine/pilchard, deep-sea red crab, and rock lobster. All fish are landed in the two ports of Walvis Bay and Lüderitz, with hake and horse mackerel accounting for 87% of landed catches, 82% of the average annual landed volume, and 60% of the total fisheries export value (ILO, 2022).

Figure 112: Pilchard harvest [Source: A Kreiner]

The ongoing development of commercial fishing, including fish processing, has propelled it to become the fastest-growing segment of Namibia's economy in terms of job creation, export revenues, and contributions to GDP (Haimbala, 2021; ITA, 2022). This industry stands as the third-largest contributor to the country's GDP, ranking only behind mining – the country's largest export earner – and tourism. The fishing industry is also Namibia's third largest employer after mining and agriculture.

The commercial fishing sector is dominated by three species, namely hake, horse mackerel and monkfish. Species with high potential for value addition include hake, horse mackerel, kingklip, monkfish, orange roughy, rock lobster, sardine/pilchard, sole, tuna, swordfish, and large pelagic deep-sea red crab. The focal point of the fishing industry is Walvis Bay, which is responsible for around 90% of the landings, while Lüderitz is the hub for the rock lobster, swordfish, and tuna subsectors. Smaller amounts of hake are also landed at this southern port (GIZ, 2022).

The TAC for hake was 154,000 t for the fishing year from November 2019 to September 2020, with October being a month closed to fishing because of the fish-spawning season (Haimbala, 2021). That TAC remains current, based on the findings of a biomass survey conducted by the Government in 2016 (MFMR, 2017). This research indicated a relative total hake biomass of around 1,000,000 t. The survey also observed a decrease of about 32% in fishable biomass of hake sized less than 35 cm (MFMR, 2017).

Horse mackerel and hake are the most important fish for Namibia in respect of their significant contributions to the economy. According to the 2017 State of Stocks report submitted to the Ministry of Fisheries and Marine Resources (MFMR), the horse mackerel biomass in 2017 was 1.45 Mt, a level considered above the maximum sustainable yield (MFMR, 2022). Put in perspective, the biomass was at its highest in 1961 (3.2 Mt) but had declined to about 1 Mt at Independence in 1990; since then, the biomass has been increasing slowly under Namibian management (Williamson & Japp, 2018).

Figure 113: Crayfish catch [Source: BCLME]

The monkfish TAC was 7,200 t for the fishing period from May 2019 to April 2020. According to the Ministry of Fisheries and Marine Resources' Annual Report (MFMR, 2016), the 2016 biomass survey estimated the monkfish biomass at around 33,000 t, which is an increase of 38% relative to the total biomass from 2015 (Haimbala 2021 and MFMR 2017).

Figure 114: Subsistence angling north of Swakopmund [Source: G Schneider]

After decades of overfishing combined with environmental changes, Namibia's sardine/pilchard population is in critical condition. Falling by 99.5% from an estimated 11 million t in the 1960s to a tiny 50,000 t in 2015, this resource has been severely exhausted. Despite calls for a moratorium on sardine/pilchard fishing by scientists since 1995, a moratorium on sardines was only implemented in 2018, and only for three years, while a moratorium on pilchard, also implemented in 2018, is effective only until 2024.

Figure 115: Fish factory at Walvis Bay [Source: BCLME]

Figure 116: Tuna catches [Source: BCLME]

Sardines – and their more fully developed form as pilchards – are small fish that feed on plankton and provide an important source of food for a large array of other fish, seabirds, marine mammals, and humans. They are considered a high-quality pelagic species in terms of the energy they contain per gram. Sardine/pilchard thus provide most of the energy pathway between plankton and larger fishes (including many commercial species), birds and marine mammals. For humans, canned pilchards are much cheaper than most other protein options. These fish are also used widely to produce fishmeal for agricultural purposes. Fishmeal production was once a thriving industry in Namibia, but it, too, has been hard hit by the decline in resources (NCE, 2021).

Table 24: Total allowable catch per species, 2022/3, in [t] [Source: ICCAT, 2022]

Species	Total Allowable Catch [t]
Hake	154,000
Horse-mackerel	290,000
Monkfish	7,200
Tuna (for 2023 to 2025)	50
Rock Lobster	180
Deep Sea Red Crab	4,200

Namibia's fish exports primarily consist of horse mackerel, which is mostly destined for the Tripartite Free Trade Area. More valuable fish varieties such as hake and monkfish are directed towards the EU and South African markets, where exporters can get better prices. However, horse mackerel competes with lower-priced food items such as chicken pieces; this competition constrains producers' pricing strategies. Namibia's horse mackerel, being the smallest and lowest in fat content among global horse mackerel species, necessitates competitive pricing to contend with products from other regions of the globe.

Table 25: Fisheries landings, 2015 to 2021, in [t/a] [Source: ILO, 2022]

Species	2015	2016	2017	2018	2019	2020	2021
Horse Mackerel	315,972	318,200	304,533	311,892	295,976	182,186	174,951
Hake	137,488	150,219	159,600	152,038	143,574	122,429	139,984
Pilchards	20,379	3,427	3,974	0	0	0	0
Monk	10,105	8,412	8,001	7,702	8,054	6,768	9,119
Crab	2968	3,078	2,964	3,136	4,099	2,772	1,103
Rock Lobster	87	126	164	134	282	80	106
Total	**486,999**	**483,462**	**479,236**	**474,902**	**451,985**	**314,235**	**325,263**

4.6.2. Marine Fisheries Exports

Fish continues to be the country's number one export revenue earner in terms of food items. Exports per species and market are summarised in Table 26.

Table 26: Namibia's main fishery products & market destinations 2018–2021 [Source: MFMR, 2023]

Species	Market	Percentage Market Share		
		2018/19	2019/20	2020/21
Hake	Spain	44%	49%	52%
	Namibia	28%	18%	13%
	South Africa	17%	23%	13%
	France	3%	2%	4%
	Italy	3%	3%	5%
	Germany	2%	2%	3%
	Netherlands	1%	1%	3%
	Australia	1%	1%	1%
	Other	2%	1%	6%
Monkfish	Spain	56%	43%	72%
	Portugal	8%	18%	12%
	Italy	33%	38%	13%
	Holland	2%	1%	-
	Namibia	1%	0%	0%
	France	-	-	2%
	Germany	-	-	1%
Horse Mackerel	DRC	27%	22%	43%
	South Africa	23%	16%	7%
	Namibia	23%	34%	-
	Zambia	10%	15%	21%
	Mozambique	3%	10%	15%
	Other	-	-	14%
Crab	Spain	65%	65%	34%
	South Africa	27%	26%	29%
	Japan	7%	6%	14%
	Namibia	1%	3%	-
	Other	-	-	23%

Species	Market	Percentage Market Share		
Rock Lobster	Japan	77%	69%	81%
	Namibia	20%	4%	6%
	Hong Kong	3%	4%	6%
	China	0%	23%	7%

4.6.3. Mariculture

Mariculture production includes abalone, oyster, and kelp. Both Pacific Oysters and European Oysters are cultivated in Namibia. Oysters and abalone are also the main molluscs with potential for export to the EU. Commercial oyster farms operate at Lüderitz, Swakopmund and Walvis Bay (see Figure 117). The commercial cultivation of endemic black mussels also occurred but was suspended in the early 1990s due to frequent red tides and poor market conditions. Only one company in Lüderitz currently produces kelp and abalone (MFMR, 2023).

Namibia has a master plan for marine aquaculture. Targeted potential species include bigeye tuna, mussels, oysters, and scallops for cultivation in suspended longline culture systems and offshore surface gravity-type cage culture systems. In addition, abalone, kob and turbot are proposed for land-based flow-through aquaculture systems and reticulation aquaculture systems (MFMR, 2017).

Figure 117: Oyster production at Walfish Bay lagoon [Source: BCLME]

4.6.4. Freshwater Fish

A. Freshwater Catches

The Kavango East, Kavango West and Zambezi Regions in Namibia benefit from a more favourable climate and the presence of the northern rivers. A significant portion of the population therefore rely on these inland fish resources for sustenance, income, and informal employment. Seasonal fishing takes place in the Cuvelai system, and minor fishing occurs in the Kunene and Orange Rivers.

Inland fisheries predominantly operate on a subsistence level, characterised by labour-intensive practices yielding a relatively low catch per unit of effort. The catch is primarily consumed by the fishers themselves, their extended families, and local communities. Freshwater fish therefore play a pivotal role in the daily lives of many individuals in these Regions. Crucial, however, is ensuring that the interests of subsistence fishers are protected against unregulated commercialisation. Approximately 60% of households in the Kavango East, Kavango West and Zambezi Regions rely primarily on this fishery subsector for subsistence and income, with the earnings obtained from fishing fulfilling fundamental needs such as other food and clothing.

In terms of production, the annual estimates for the inland fisheries sector in Namibia are around 2,000 t for the Zambezi Region, 800 to 1,000 t for the Kavango East and Kavango West Regions, 250 t for the Cuvelai system, and smaller quantities for the Kunene and Orange Rivers. The catch typically comprises species like bream and catfish. Among the choices, fresh fish holds the highest preference, followed by dried fish, while smoked fish is consumed in smaller quantities. Notably, canned marine fish is also consumed in large quantities throughout the country.

B. Freshwater Aquaculture

Namibia's aquaculture industry has established several freshwater aquaculture enterprises across the country (see Table 27). These efforts mainly focus on fingerling production of tilapia and catfish. Despite these enterprises producing a significant number of fingerlings for further potential operations, the demand from farmers to engage in aquaculture remains relatively low. This can be attributed to factors such as the shortage of suitable ponds with adequate water retention, water availability and individual interests.

Table 27: Freshwater aquaculture enterprises [Source: MFMR, 2023]

Name	Type of Facility	Location
Mzungu Fish Farm	Community-based fish production farm	Nkurenkuru, Kavango Region
Kamutjonga Inland Fisheries Institute (KIFI)	Fingerling and fish production, Research, Training and Information Center	Divundu, Kavango Region
Epalela Fish Farm	Government fish grow out of farm	Omusati Region
Onavivi Inland Aquaculture Center	Fingerling, and fish production, Research, Training	Omusati Region

Name	Type of Facility	Location
Ongwediva IAC	Fingerling and fish production facility	Oshana Region
Hardap IAC	Fingerling, fish production, Research, Training	Hardap Region
Fonteintjie FF Project	Community-based project	//Kharas Region
Leonardville IAC (New)	Fingerling and fish production, training	Omaheke Region

4.7. Dairy and Other Food Products

4.7.1. Dairy

The Namibian dairy sector is battling to survive, with production decreasing and the price-cost squeeze forcing producers to exit the sector. Raw milk production dropped from 21.8 million litres in 2019 to 17.2 million litres in 2021, which is a 21.1% decline in volumes. Most of the animal feed in Namibia is being imported from South Africa, with transport constituting about 20% of the total cost, and increasing production prices accordingly. This disadvantages Namibian producers' competitiveness and makes it virtually impossible to compete with imported milk, noting that milk from Cape Town, South Africa, delivered to Windhoek can be sold for less than locally produced milk.

Namibia Dairies – the largest and longest-serving milk producer in the country – operates across an integrated value chain, ranging from milk farmers to the processing and packaging of dairy products. The industry sources milk exclusively from local farmers instead of importing subsidised milk powder.

The droughts experienced in the past have resulted in low water levels in local dams. Consequently, fodder production in the Hardap Dam area has seen a significant decline. The area is also home to Namibia Dairies' !Aimab Superfarm near Mariental, where close to 80% of the country's raw milk is being produced (see Figure 118 and Figure 119). Namibian dairy producers were consequently forced out of the industry, contributing to drastically reduced local supplies of raw milk. Since the early 2000s, the number of active milk producers in Namibia has declined from 45 to 10.

Figure 118: !Aimab Superfarm, Mariental [Source: namibiadairies]

Figure 119: Fodder harvesting at ! Aimab Superfarm, Mariental [Source: namibiadairies]

Namibia Dairies exports 2–3% of its total production to Angola. Export products are exclusively value-added options, such as yoghurt or milk drinks. Limits of expanding exports: High tariff and non-tariff barriers: most SADC countries (including the Southern African Customs Union members Botswana and Swaziland) have a controlled market for dairy products and strictly control and/or limit dairy imports.

The !Aimab Superfarm currently houses 1,500 cows in milk. The Superfarm is equipped with tested, state-of-the-art technologies from Israel, New Zealand, and the USA. Controlled feeding of cows in large barns provides for a semi-intensive milk production process. Apart from fresh milk, the Superfarm also produces long-life milk and other dairy-based products such as soft cheeses, yoghurts, and fermented traditional drinks (O&L, 2023).

Figure 120: A selection of dairy products produced in Namibia [Source: M Schneider]

4.7.2. Eggs

Namibia's six egg producers located near Windhoek, Okahandja and Swakopmund market some 130 million eggs a year. To date, Namibia is self-sufficient in terms of egg production and even exports to South Africa. The industry still faces challenges, however, such as animal diseases and the high cost of imported feedstock (Poultry World 2021).

To date, dumping by Zambian farmers remains a risk to the sector. Zambian trucks claiming to bring eggs into Namibia for export are only supposed to drive to the port at Walvis Bay, but they end up selling eggs illegally in Namibia.

4.7.3. Traditional Foods

Namibia boasts a rich culinary heritage rooted in its diverse cultural traditions and local ingredients. Traditional cuisine reflects the country's history, geography, and the resourcefulness of its people. Blending indigenous ingredients and cooking methods with influences from others creates a unique and flavourful culinary tapestry that continues to be celebrated and enjoyed across the country.

Examples of some of the well-known traditional Namibian foods include the following:

- **Potjiekos:** From an Afrikaans word literally meaning "pot food", this is a traditional stew cooked in a cast-iron pot. It typically involves meat and vegetables, sometimes even fruit, and is slow cooked on glowing embers.
- **Biltong:** A popular protein-rich snack and staple in many a Namibian's diet, biltong is beef or game meat that is cured and seasoned with certain spices and dried, see Figure 121.

Figure 121: Biltong made from game meat [Source: G Schneider]

- **Kapana:** A popular street food, kapana consists of sliced, grilled pieces of meat (often beef or chicken) seasoned with kapana spice and dried chilli. Kapana is commonly served with a stewed tomato-and-onion sauce and vetkoek (a deep-fried savoury ball of dough).
- **Oshifima:** Also referred to by the Afrikaans word pap ("porridge"), oshifima is a staple food made from maize meal. It has a porridge-like consistency and is often served alongside stews and sauces.

- **Mahangu:** Pearl millet (mahangu in Oshiwambo) is a traditional grain used to make porridge (see Oshifima above) or a thick paste. It is a significant part of the diet in rural areas.
- **Mopane worms:** Considered a delicacy in many parts of Namibia, mopane worms are caterpillars of the emperor moth, as shown in Figure 122. They are usually dried or fried and can be eaten as a crunchy snack or added to stews for extra protein.

Figure 122: Food from Mopane worms [Source: B Coleman]

- **Game meat:** Due to Namibia's wildlife diversity, game meat is commonly consumed. Various types of game meats, including kudu, springbok, oryx and zebra, are prepared as stews, steaks, sausages, and salami.
- **Giant bullfrog:** This is the largest frog species in the country and is considered a delicacy in north-central Namibia, where they breed and are harvested during the annual floods (efundjas) in the area. The frogs breed in the shallow seasonal depressions in the flood plains (oshanas).
- **Melktert:** Afrikaans for "milk tart", melktert is a traditional dessert consisting of a sweet pastry crust filled with a creamy custard filling made from milk, eggs, sugar, and flour, which is traditionally sprinkled with cinnamon sugar.
- **Kalahari truffle (Terfezia pfeilii):** Another sought-after delicacy, desert truffles (//habas in the local Khoekhoe language) are high in nutrients and contain an optimal amount of fats, proteins, fibre, and vitamin B, see Figure 123. Truffles only grow after there has been enough rain. If so, this would be most likely to occur between January and April. The truffles are harvested between April and June, and, after the first frost,

they disappear. Because the conditions required for growth are heavily dependent on atmospheric events, the truffles grow sporadically, usually every four years. They can be identified by small cracks in the terrain, a distinct garlic smell, and their association and collocation with specific plants or herbs of the desert, such as Acacia hebeclada as well as Aristida and Eragrostis species. After harvesting, they require rigorous washing to clear them of fine sand particles in their ironically smooth exteriors.

Figure 123: Kalahari Truffle, Omaheke Region [Source: LCFoN]

- **Omajova:** This sought-after delicacy is a mushroom species that appears on termite mounds in the central part of the country after good rains, see Figure 124. The fungi are harvested informally to supplement local diets and incomes.

Figure 124: Omajova mushrooms [Source: W Ewald]

- **Eembe:** The fruit of the bird plum tree is a wild fruit harvested between March and April. It has a high sugar and vitamin C content and is consumed fresh or dried and stored for later use to be fermented to make ombike – a local traditional beverage. It is also used in an eponymous cream-based liqueur manufactured by the Omaruru Winery and sold worldwide.
- **Samp and beans:** A hearty, nutritious and filling dish made from dried corn kernels (samp) and beans, often flavoured with onions, tomatoes, and spices.
- **Fermented foods and beverages:** These play a major role in the diet as well as certain socioeconomic and cultural activities of Namibia's population. Commonly produced fermented foods and beverages include milk-based products (omaere, omashikwa, mashini ghakushika, mabisi and âudaï), cereal-based beverages (oshikundu, omalodu, otombo – a beer made from marula fruit, epwaka, okatokele, oshafuluka, maxau and |ho ≠goas), vegetable-based fermented food (e.g., mudhika), and fruit-based beverages (e.g., ombike, omagongo and omalunga).
- **Leafy green vegetables:** Various indigenous food plants include akwakwa, mpungu, ombidi, mundambi, mutate, sishungwa, tepe, and the !nara melon, as shown in Figure 125.

Figure 125: !Nara fruit, Hardap Region [Source: G Schneider]

4.7.4. Agro-processed Food Products

Agro-processing falls within the manufacturing sector but is also closely related to the agriculture sector. The industry is divided into upstream and downstream components.

Upstream industries process agricultural raw materials into preliminary products. Major upstream agro-products are derived from the livestock subsector in Namibia. They include processed meat (chilled, frozen, dried, or canned), milk and dairy products, and tanned leather. Crop production constitutes another important source for upstream and downstream agro-processing activities. These activities include the milling of maize, mahangu and wheat, the latter to produce local pasta. In addition, groundnuts are turned into peanut butter, oil is pressed from plant seeds, and fruits are pressed to produce juice, see Figure 126 and Figure 128.

The upstream products made from agricultural materials are processed further by the downstream industries. This is where most of the value addition takes place. Downstream activities include baking bread and biscuits, producing cereals and pasta, and brewing beer. The agro-processing sector is strategically important for employment, income generation and value addition, due to its close links with the agricultural sector. The country is a net exporter of unprocessed agro-products, especially from livestock; however, very few of these products are exported.

Namib Mills produces about 75,000 t of maize meal and 55,000 t of wheat flour per year. This producer's primary focus is on serving the local market. Exports amount to between 5% and 7% of total production, mainly due to limited production capacities, and are destined for South Africa, Botswana, Zambia, and Angola.

Namibia imports about 95% of its fruit to meet the gap in domestic demand. Though Namibia produces fresh fruit, which includes dates, grapes, lemons, mangoes and oranges, the fruit industry faces challenges such as the unavailability of quality and improved fruit tree seedlings, high input costs, pest outbreaks, and a lack of tailor-made and affordable finance.

Namibia also produces agro-processed products such as tomato sauce, chilled vegetables, and juice. On the other hand, imports include mainly juice, frozen vegetables, frozen potato chips, jams, olive oil, spices, and other forms of dried vegetables. South Africa accounts for over 97% of the agro-processed products that Namibia imports.

Figure 126: A selection of food made in Namibia [Source: UNDP]

Namibia recovers salt from seawater in coastal solar evaporation pans and is the largest salt producer in sub-Saharan Africa, refer to Figure 127. About 50% of its production is being exported for use in the chemical industry. Approximately 80,000 t are refined to table salt in Namibia and consumed locally as well as in neighbouring countries.

Locally, salt is used in the food processing industry, in agriculture, mining, as well as in hospitality establishments and private households. In 2022, Namibia produced just over one million tonnes of salt, of which some 650,000 tonnes were being exported in bulk to east- and west-African countries, where it is processed into table salt and used in the chemical and agricultural sectors.

Figure 127: Solar evaporation ponds and salt works at Walvis Bay [Source: NACOMA]

4.7.5. Canned and Bottled Food Products

Meatco produced canned beef products until 2020. Canned fish is produced by fishing companies at Walvis Bay for both the domestic and regional markets. While most canned food products available in Namibia are imported, a variety of bottled condiments are being produced by the local cottage industry, albeit on a limited scale.

4.7.6. Canned and Bottled Beverages

Beverages are produced by Namibia Breweries and under licence for Coca-Cola, both for the domestic and regional markets. As shown in Table 28, South Africa is the primary source of beverages, including alcoholic and non-alcoholic drinks such as mineral water, soft drinks, and juices. Germany and the USA respectively follow South Africa as secondary and tertiary sources. South Africa also remains the principal export destination for beverages, followed by Zambia and then the Democratic Republic of the Congo.

Table 28: Export and import of beverages by country and percentage share [Source: NSA, 2023b]

Export percentage per country	Import percentage per country
81.7 % - South Africa	92.8% - South Africa
6.9% - Zambia	4.2% - Germany
4.7% - Democratic Republic of the Congo	0.9% - USA
4.0% - Tanzania	0.7% - United Kingdom
2.7% - Other	1.4% - Other

A variety of beers, wines and spirits are produced by craft breweries, wineries, and distilleries in the Hardap and //Kharas Regions as well as in or on farms around the towns of Omaruru, Swakopmund, Tsumeb and Walvis Bay, see Figure 128.

Figure 128: Locally produced beverages (left) and spirits (right) [Source: M Schneider]

4.8. Conclusions - The Food Sector

Import and export of agricultural products play an important role in Namibia. While up to 77% of the value produced in the agricultural sector is exported and contributes significantly to the country's national trade balance, only 43% of the food consumed in Namibia is produced locally.

Although Namibia does not produce enough food for its own needs, some 24% of all food grown per year is lost or wasted at farm level. Eliminating or minimising food loss and waste, along the entire value chain from producer to consumer, provides opportunities to further enhance food supplies in Namibia (GRN, 2017).

The development of adequate food security continues to be challenged by long-standing contracts with South African producers, perpetuating Namibia's historical dependency, unfair competition from international trading partners, the paucity of vocational training facilities for agriculture, and ongoing institutional challenges relating to agricultural production. At the same time, several initiatives have been launched to strengthen local food production capacity. These include Government schemes such as the Horticulture Market Share Promotion Scheme aimed at increasing the local sourcing of foods, and the National Horticulture Development Initiative aimed at opening local markets for locally produced horticultural commodities.

Namibian food production is in a wide range of development stages, characterised by dissimilar levels of capacity and efficiency. For example, commercial livestock farming, various irrigation projects – particularly in the Maize Triangle and along the Okavango and Orange Rivers – and the fishing industry all produce substantial outputs, e.g., by way of innovative techniques such as conservation agriculture and integrated pest management. At the same time, long-standing challenges such as the shortage of suitable land, the lack of water, skills shortages, and inadequate financial and technical resources to strengthen the subsistence farming sector remain food-related bottlenecks that negatively affect the food industry's sustainability.

Livestock farming, which is a cornerstone of Namibia's rural economy, contributes significantly to agricultural production. The sector's growth is marked by well-developed commercial livestock farming and a surge in poultry farming. It provides livelihoods for many Namibians and contributes substantially to the national economy. However, land shortages, water availability and veterinary regulations need to be addressed to ensure the sector's sustainability.

Stock theft and poaching are an ever-increasing problem, see Figure 129. They constitute a major contributing factor to the decline of cattle farming in Namibia. Livestock and game farmers have lost millions worth of animals to predation and theft which remain persistent issues. The Government is obliged to address the lack of proper law enforcement and consider the implementation of sufficient penalisation of poaching (The Namibian, 2024a).

Figure 129: Snares used for poaching game in Oshikoto Region [Source: G Schneider]

Since Independence in 1990, Namibia's population has more than doubled to just over 3 million persons at the end of 2023 (Vital Statistics, 2024). Amongst the biggest challenges facing the country is the ever-increasing demand for food. Livelihoods are threatened by food insecurity. As a fundamental underpinning, the availability and affordability of sustainable food is and remains key to dealing with many of the country's development-related problems. Considering the multitude of impacts brought about by climate change, strengthening Namibia's food sector remains of critical importance in the country's development endeavours.

According to the Namibian Government, "*Namibia is facing a starvation crisis with an estimated 600,000 Namibians expected to be food insecure in 2023/24*" (GRN, 2023). Severe acute malnutrition, poverty and inequality amongst vulnerable groups remain problematic, according to the 2023 State of the Nation Address. Urbanisation often implies that traditional means of food production are lost. New urban arrivals are suddenly forced to purchase food, while their rural counterparts are often able to sustain themselves through subsistence farming.

Recently, the International Monetary Fund raised concerns about the excessive Namibian bureaucracy discouraging potential investors. The Fund therefore suggested that the Government streamline administrative processes relating to the investment environment (Matthys & Lazarus, 2023).

To date, most of the population remains unable to sustain their livelihoods through a regular income that covers food expenses. By the end of 2023, the unemployment rate in Namibia was expected to reach 23% (Trading Economics 2023). With limited job opportunities for school leavers and graduates from institutions of higher learning, the Government's priorities vis-à-vis the allocation of resources for infrastructure projects need urgent reconsideration. Enormous losses of public funds over the past few decades for projects that never reached operational status and/or remain dormant to date, such as the commencement of agricultural production at the Neckartal Dam, business parks, fresh produce distribution hubs and Oshakati's abattoir and tannery, underline the need for a fundamental reprioritisation (The Namibian, 2024b).

Namibia's journey towards robust and resilient food production revolves around a dynamic interplay of factors, such as climate, technology, policies, funding, and community engagement. Thus, the nation's commitment to achieving food security, sustainability, and improved nutrition, which are essential for the well-being of its citizens, requires realism, pragmatism, and dedication. Such an approach is needed not only to address current challenges, develop opportunities, and integrate local wisdom with global expertise, but also to develop a more resilient, thriving, and vibrant national food production system. Collaboration between the Government, the private sector and development partners can enhance the availability, affordability and quality of food products made in Namibia.

5. Ideals and Realities in Namibia's Water–Energy–Food Nexus

5.1. Introduction

Namibians are regularly reminded that the country is and remains arid. Water is critically important to keep the economy's cogs turning. Despite this obvious vulnerability, Namibia remains entirely rainfall-dependent, and the country's water–energy–food nexus is perpetually at risk.

In the absence of rain, the country faces water shortages, food shortages, hunger, displacement, and increased urban-to-rural migratory pressures. Given the inherent links between water, energy, and food, Namibians should ask what they intend to do when they once again face dire circumstances owing to a lack of water.

The following subsections introduce some potential development options that can strengthen not only Namibia's adaptive capacities and resilience against a changing climate but also the country's water–energy–food nexus.

5.2. Horticultural Production at Bethanie, //Kharas Region

The //Kharas Region, where Bethanie lies, provides several tourist attractions with ample accommodation facilities along the Keetmanshoop-Aus-Lüderitz corridor. Water facilities at Bethanie have recently been upgraded to provide potable water for a settlement of some 3,000 people. This upgrade was made possible through grant funding from the Adaptation Fund between 2019 and 2022. Further supplies are being made possible via the installation of a new desalination facility operated by solar and wind energy, as shown in Figure 130.

Bethanie could serve as a food production hub for horticulture products for accommodation facilities and school hostels, mining companies and retailers in Keetmanshoop, Aus and Lüderitz. This would, for one, necessitate a suitable training programme to be established at Bethanie, with possible seed funding from a development and/or agricultural bank, and the inclusion of all local stakeholders.

Figure 130: Desalination plant at Bethanie [Source: NamWater]

The availability of adequate and affordable electricity, and sufficient water, would make Bethanie a suitable option for such an initiative and may be made to fit the requirements of a Climate Smart Village in future.

The livelihoods of local communities need to be strengthened. This can be achieved by promoting a participatory approach in which context-specific land management practices and socio-economic aspects are discussed and implemented. Communities need to understand how they can sustainably drive their economic upliftment.

The sustainability of establishing a food production hub at Bethanie requires the community to become co-responsible for its success. This will entail being empowered to handle the envisaged production facility and being trained in associated marketing and logistics.

5.3. Irrigation Projects in the Greater Cuvelai Area

Irrigation projects along the Okavango River can be extended both west and east of Rundu. Private investment initiatives should have preference over Government-operated Green Schemes, due to the management challenges that government entities seem to have.

A notable case in point is one of the first commercial blueberry projects in Namibia, which was started on the banks of the Okavango River, between the Mashare and Mupapama villages in Kavango East, northern Namibia in 2020. Today, this project is an example of a successful operation. The success of the partnership between the Namibian Government Institutions Pensions

Fund and the private firm Koenigstein Capital, to develop productive blueberry farms in the Kavango, has prompted other investors to plan their own productive farms. Among them is Namibia Berries, which is planning to develop a 250 ha blueberry export farming project on the outskirts of Divundu in Kavango East. It will employ nearly 800 people full-time and offer 7,000 seasonal jobs when the berries are harvested.

The blueberry projects focus on export to the EU market as is the case for grapes and dates in the Hardap and //Kharas Regions. All entities are privately owned and operate without interference from the Government or a state-owned enterprise. Energy and water are available, as is the expertise to ensure success in planting and marketing the specific product, creating local employment opportunities in areas that have previously been considered hard to address.

5.4. Irrigation at Stampriet

In the absence of mining activities, the land in the Stampriet area is used for agricultural purposes, as illustrated in Figure 131. This includes large and small stock farming, crop irrigation, and horticultural production for the Namibian market.

Figure 131: Irrigation at Stampriet [Source: Roots Development]

Since irrigation necessitates high upfront investment, the production of crops is dominated by commercial farmers willing and able to make such investments. To illustrate, and according to DWA, the construction of a shallow borehole costs around N$50,000, while a deep borehole costs around N$300,000 today.

Substantial initial investments in equipment for irrigation, including sprinklers, pivot systems and water pumping and piping infrastructure, are required, and can readily exceed N$250,000. The Stampriet area includes an estimated 80 commercial farmers irrigating more than 600 ha, out of a total of some 1,000 ha of potentially irrigable land. Individual irrigated areas on farms usually do not exceed 20 ha, often relying on drip irrigation.

With the required investment, the further upscaling of irrigation projects in the Stampriet area is possible. It would certainly strengthen the country's food security while creating long-term jobs in rural Namibia.

5.5. Water–Energy–Food Development Corridors

5.5.1. Rationale

Today, it is no longer merely a hypothetical scenario that Windhoek may run dry. It *can* happen. A capital city having to operate under severe water restrictions, or being forced to ration water, is most undesirable. It is therefore of strategic importance that viable alternatives are found to effectively de-link Windhoek's water requirements from regular rainfall events. At the same time, new long-term national development initiatives need to be launched to secure the supplies of water, energy, and food.

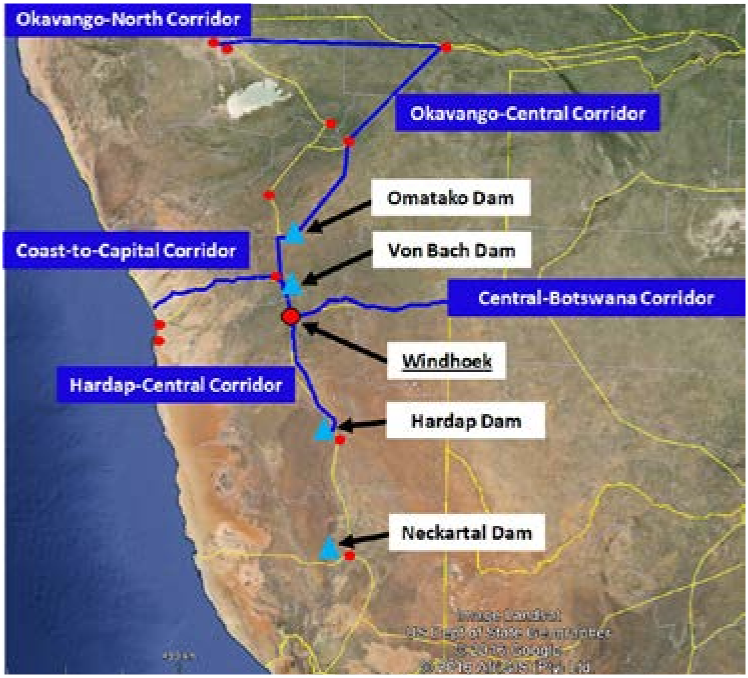
5.5.2. Concept

This section introduces the concept of successively decoupling the country's water supplies from rain-fed sources, by creating water–energy–food corridors to spur decentralised development (von Oertzen, 2016; von Oertzen & Braby, 2019). Such industrial development corridors would create decentralised growth centres, while also safeguarding Windhoek's water supplies, which remain rainfall-dependent. Once access to water, electricity and transport infrastructure has been established, the resulting industrialisation in these is expected to create multiple new opportunities for long-term economic growth.

The concept rests on the premise that the provision of water, electricity and transport infrastructure creates new industrial development initiatives and decentralised growth zones. In each such zone, industrialisation creates multiple new opportunities for long-term economic growth once the availability of water, electricity, and the proximity of logistics is established.

In principle, and as shown in Figure 132, several such industrial development corridors could be created across Namibia. Of strategic importance would be the Coast-to-Capital Corridor, as it would unlock the unlimited water supplies of the Atlantic Ocean, to produce potable water, using seawater desalination, powered by renewable energies. Such water would be piped via Usakos, Karibib and Okahandja, to the Von Bach Dam, to complement Windhoek's other water supplies.

Figure 132: Potential candidates for industrial development corridors [Source: D von Oertzen]



An industrial development corridor from the coast to Windhoek would, for the first time in Namibia's history, supplement the capital city's water supplies with a water source that is and will remain rainfall-independent. Such a lifeline would ensure, firstly, that national development can be successively de-linked from Namibia's highly variable climatic conditions. Secondly, national development would benefit from the almost limitless natural assets that the country is endowed with, including the waters of the Atlantic Ocean, a world-class solar radiation resource, and vast tracts of sparsely populated land that offer untapped development potentials. Usakos, Karibib, Omaruru, Wilhelmstal and Okahandja would be immediate beneficiaries and could be developed to become Climate Smart Villages, further strengthening already established food production industries.

Other industrial development corridors may be possible too. For example, the Okavango-Central Corridor, piping river water to the Omatako Dam north of Okahandja, and from here to the Von Bach Dam, for processing and pumping to Windhoek. An Okavango-North Corridor would pipe water from the Okavango River to the densely populated towns of Oshakati and Ondangwa, and beyond. A third possibility is a Hardap-Central Corridor, linking the Hardap Dam to Windhoek's water supply system, and possibly connecting the Neckartal Dam to the Hardap Dam in future.

Each of the corridors introduced above has unique requirements and dominant drivers. Despite such differences, development corridors share several key characteristics: they make available potable water to where development is to take place, and they deliver energy and logistics infrastructure to underutilised land – all of which are essential prerequisites to jump-start industrialisation and national development.

Piping water for hundreds of kilometres is costly but unavoidable, as our cities and towns cannot provide for their own water needs. Investments in large-scale infrastructure projects, as is necessary to realise one or several industrial development corridors, will create numerous permanent jobs, and invigorate the immediate local and regional economy. Moreover, since such undertakings would draw in additional peripheral investments, a variety of indirect local economic activities are expected to commence, including in places that have not benefitted from past economic growth.

The following subsections present further detail on four of the proposed industrial development corridors, i.e., the Coast-to-Capital Corridor, the Okavango-North and Okavango-Central Corridors, and the Hardap-Central Corridor.

5.5.3. The Coast-to-Capital Corridor

Amongst the development corridors introduced above, the Coast-to-Capital Corridor is special, as it creates access to water resources that are unaffected by Namibia's unreliable rainfalls. This is critically important, especially given the country's climate variability, which is expected to worsen because of a changing global climate.

The Coast-to-Capital Corridor has the Atlantic Ocean as its permanent water source. It is envisaged that seawater desalination, as is already applied at the Erongo Desalination Plant at Wlotzkasbaken, north of Swakopmund, is used to produce potable water, see Figure 133 and Figure 134. Desalination necessitates considerable amounts of electricity, to be provided by a mix of grid electricity sources complemented by decentralised solar electricity plants.

Figure 133: The Erongo Desalination Plant [Source: Orano]

Today, a modern desalination plant producing some 25 million cubic meters of water per year would cost of the order of N$4 billion. The plant should be financed through Namibia Dollar-denominated loan facilities, including local insurance companies, pension funds and development banks. At an interest rate of 8.5% per year over 20 years, water would cost some N$40/$m^3$ when operations commence, increasing to an estimated N$60/$m^3$ by 2030. This compares favourably with today's cost of potable water from established sources, noting that the business water price charged by the City of Windhoek amounts to N$45/m^3 in early 2024.

Solar electricity would be used to reduce the cost of water when compared to the cost incurred when relying only on conventional grid electricity, even if it is readily available. Displacing grid electricity by the output of a solar plant creates operational savings over the life of the desalination plant which are equivalent to almost N$600 million in today's money, i.e., about one-sixth of the total capital cost for a desalination plant of 25 Mm^3/a capacity today.

Piping desalinated water from the coast to the Von Bach Dam close to Okahandja necessitates infrastructure, including a pipeline, pump stations, electricity substations and solar generating plants along the route. Such infrastructure would cost some N$3 billion, thereby adding approx. N$30/m^3 to the cost of desalinated water when delivered at Von Bach Dam.

Figure 134: Effluent water from the Erongo Desalination Plant [Source: G Schneider]

As is the case for desalination, water pumping costs could be significantly reduced by opting for electricity from a solar photovoltaic plant, augmenting the supplies from national electricity supplies. Adding suitably sized solar plants creates significant savings, having a present value equivalent of more than one-fifth of the capital requirements of the pipeline, see Figure 135.

The total cost of desalinated water when reaching the Von Bach Dam from the coast, would amount to approx. N$60/m^3, i.e., will be more expensive than NamWater's bulk water tariffs today. However, when rains have failed, again, and Windhoek is about to run dry, such a cost seems more acceptable than the cost of not having water at all.

Figure 135: Connecting the water source with the distribution centre [Source: D von Oertzen]

5.5.4. Okavango to Windhoek, Okavango to Oshakati, Ondangwa and the Cuvelai Area

In 2013, the Ministry of Agriculture, Water and Forestry commissioned a study to assess alternative water sources which could be developed to secure the long-term provision of water to Namibia's central and Cuvelai areas. The study included an assessment of the requirements to pipe water from the Okavango River.

Some pertinent common issues include the following:

a) Rainfall in the southeastern parts of Angola, where most of the waters of the Okavango River originate, is highly variable. Such rains are also expected to be affected by a changing climate, affecting the availability of water that can be abstracted once it reaches Namibia.

b) South-eastern Angola is likely to see considerable future developments. Large-scale agricultural, industrial and settlement activities will have significant impacts on the availability and quality of water arriving at the border to Namibia.

c) Activities that permanently reduce the waters feeding the Okavango Delta, which is a RAMSAR and World Heritage site, are likely to raise regional and international concerns, thereby likely influencing the financing modalities of an abstraction project and leading to protracted negotiations and challenging trade-offs, with yet uncertain outcomes.

d) While water abstraction from the Okavango is an option, it is not evident that it is best used to augment supplies in Namibia's central and/or Cuvelai areas. When pumped and piped to the Omatako Dam, such water would cost approx. N$35/m^3, which renders it less expensive than bringing desalinated water from the coast, see Figure 136. Okavango water delivered at Oshakati would cost some N$27/m^3, which is likely to be competitive with supply costs by then. However, water abstraction from the Okavango perpetuates our dependence on unreliable rainfalls in Angola, and may, as a result, even strain Namibia's relations with Angola and/or Botswana in future.

Figure 136: The eastern national water carrier near the Waterberg [Source: one-namibia.com]

5.5.5. The Hardap-to-Windhoek Development Corridor

Namibia's Hardap Dam has a useful storage capacity of more than 250 Mm^3. In early 2024, a pipeline connecting Windhoek and the Hardap Dam does not exist, and the transfer of water from the South to the capital is therefore not possible.

At Mariental, the dam's water is mainly used for irrigation purposes, which creates some economic value. Other value-adding activities could be devised by piping a fraction of Hardap's water into a to-be-established Hardap-to-Windhoek development corridor. This would create a southern supply link for Windhoek's supply, which would be an additional safety measure for the capital city, and link directly to existing water infrastructure, see Figure 137.

Figure 137: Carbon filtration at Windhoek's reclamation plant [Source: Veolia]

The cost to establish the required water and power infrastructure along the existing road and railway connections to the South amounts to some N$3 billion. The water delivered to Windhoek in this way would cost about N$30/$m^3$. Operating costs related to electricity could be reduced by using solar power augmented with grid supplies and bring about savings that have a present value exceeding N$0.5 billion. This example illustrates the long-term cost advantage when putting locally abundant, and sustainable energy resources to productive use.

A cost of supply of N$30/$m^3$ is expected to be close to the average domestic end-user cost of water. This emphasises the importance of assessing *all* potential water provision options when seeking supply alternatives for

Windhoek. However, Hardap's main catchment area has similar rainfall characteristics to the Von Bach Dam. This implies that drought conditions affecting one may also readily affect the other, meaning that low inflows may potentially characterise both dams.

5.6. Conclusions – Ideals and Realities in Namibia's Water–Energy–Food Nexus

Access to adequate water, energy, and food is essential for human well-being. At the same time, these elements are prerequisites to national development. However, population growth, an expanding economy, changes in a country's demographics, global trade and many other factors continuously increase the additional demand for water, energy, and food.

Climate change compounds the pressure on the availability of water, and its quality, while giving rise to extreme weather events like floods and droughts, while having profound socio-economic and environmental repercussions.

A vision to future-proof Namibia needs to be underpinned and maximise the benefits derived from the country's natural resource endowments. The provision of adequate, accessible, and reasonably priced water, energy and food is central to all national development efforts. This realisation calls for a national development vision that is centred around the deliberate strengthening of the water–energy–food nexus, thereby also creating additional value from locally abundant resources.

This section offered perspectives on how Namibia could embark on long-term development by successively decoupling its water supplies from rain-fed sources, as illustrated in Figure 138. For example, building on the concept of industrial development that is catered around the water–energy–food nexus, a west-to-east water–energy–food and transport corridor, i.e., the Coast-to-Capital Corridor, incentivises new economic activity by providing reliable water, electricity, and transport infrastructure, enabling food production activities. In this way, industrial development corridors could strengthen the backbone of national development efforts that also future-proof Namibia.

The establishment of an industrial development corridor, such as the Coast-to-Capital Corridor, would safeguard and supplement Windhoek's water supplies while creating long-term decentralised economic stimuli for growth and development. As one of several such development corridors in Namibia, the Coast-to-Capital corridor would likely enhance decentralised economic development, while benefitting from Namibia's clean, sustainable, and locally abundant resources.

Figure 138: Food and energy production while optimising water use [Source: EU Commission]

6. National Development in Uncertain Times

Namibia's water, energy, and food sectors are highly vulnerable and remain underdeveloped. As such, they are strategic risks that may adversely affect the country's potential for further development. As an arid country, Namibia is most vulnerable to the impacts of a changing climate. The manifestations of climate change in Namibia include an increase in the variability of rainfall events, more accentuated and longer drought periods, and occasional flooding events. These and related impacts change the quality and availability of the ecosystem services that are essential for development, which is associated with a loss of soil-penetrating water, increased evaporation, decreasing biodiversity, and triggering the decline of soil productivity and loss of soil fertility.

The interactions between the nexus elements discussed in this text necessitate that each nexus pillar must be further developed and strengthened to meet the needs of the country and its people. Keeping the interlinkages between the nexus pillars in mind, planning for the future is imperative if one is to anticipate and implement measures that enable the timely delivery of outputs from each nexus element. Similarly, financing is essential and necessitates that adequate time is provided to secure the most optimal form of funding as can be secured. Furthermore, the diligent execution of actions is key to translating visions, policies, and plans into tangible realities.

The core activities required to develop each nexus element, while strengthening the water–energy–food nexus as a whole, are both complex and vital for Namibia to ready itself for an uncertain future. Planning, funding, and execution take place in an environment where views and opinions on priorities, the allocation of adequate funding, and the need for – and pace of – implementation are often determined by political motives, and/or persons with vested interests and specific prerogatives, and/or in work environments that are suboptimal in respect of their capacity, dedication, and motivation.

A critically important risk facing Namibia's development is the country's exposure to climate change. The unfolding impacts of a changing climate must be competently managed. The key is to enhance Namibia's resilience, especially in relation to accommodating the effects of having to live with less rainfall, *and* higher average temperatures, *and* longer periods of drought, *and* more accentuated aridity, *or* occasional floods, the outbreak of pests, and additional disasters that may be triggered by an increased climate variability. The magnitude of climate change is not beyond human control. At the same time, however, one is obliged to realise that climate-related changes have already taken place, and that further climate-related impacts are a reality that current and future generations must learn to live with.

Future-proofing Namibia cannot be achieved without directly addressing the security of water, energy, and food supplies, which form an interlinked system of causes and effects. In this regard, it is important to realise that the new national development narrative revolving around creating industrial capacities to produce and export hydrogen, ammonia, and synthetic fuels is rather tight-lipped on matters relating to the importance of securing water, energy, and food for local use. It remains to be seen whether such ventures strengthen the country's water–energy–food nexus, and how they are to result in the hundreds of thousands of low-tech jobs that Namibia so desperately needs.

Instead of focusing on export products, Namibia's core development imperative should instead create the conditions for securing sustainable sources of water, energy, and food for local use. The country's inherent resource blessings, including coastal access to seawater, excellent solar and wind energy resources, and generous land endowment for food production are the resources that form the basis on which to build the nexus, and where massive jobs can be created, and stomachs can be filled.

Strengthening each nexus pillar necessitates the deliberate integration of planning, governance and management across the water, energy, and food sectors, rather than addressing these essential development ingredients on their own, as has often been the practice in the past. The interconnectedness of water, energy, and food with Namibia's ecosystems and the essential services that are derived from it form the natural basis of our life. Constraints in one of the nexus pillars create imbalances in the quantity, quality, and accessibility of the others. Fostering integrated solutions in the water, energy and food sectors is therefore of critical importance, and must guide the country's development vision, plans, and actions.

Namibia's harsh climate and arid conditions render its water resources an exceptionally valuable commodity. The future need for potable water is expected to dramatically increase, not only due to an ever-increasing demand from agriculture, mining, and other economic activities, but also due to population growth, urbanisation, and an increase in living standards.

While Namibia is a net energy exporter on account of its uranium production, the country's local energy security remains highly import-dependent. Fossil fuels supplied more than three-quarters of the country's total energy needs in 2023. Strengthening Namibia's energy sector, therefore, must focus on the deliberate adoption and use of its generous renewable energy endowments, while benefitting from its own hydrocarbon resources, if viable for exploitation. Investments in this sector will spur local development and reduce the country's significant and ongoing dependence on energy imports.

Namibia's food security also depends on imports, noting that only some 43% of the food consumed is produced locally. Food insecurity is not only a threat to livelihoods, but it is also key to addressing many of the country's development-related challenges. To date, local food production costs remain high, and consumer prices of local produce are often uncompetitive. However, subsidising local produce, and imposing import levies on select food imports does not support local producers in achieving lower production costs. At the same time, it renders cost-effective imports impossible and delays the urgent need to improve local competitiveness.

Government control over food exports and/or imports disincentivises investors. Other hurdles, such as extraction permits, environmental clearance certificates and related compliance measures, often complicate matters relating to the provision of adequate water, land, and energy, thereby similarly reducing local and international investor appetites.

SADC has acknowledged that southern Africa faces water, energy, and food insecurity, and is embracing the water–energy–food nexus approach to guide the Community's policies. In doing so, it aims to foster dialogue and establish regional frameworks to create an environment conducive to nurturing regional nexus approaches and enabling the nexus pillars to be funded. SADC also aims to improve institutional coordination and align regional development to effectively promote investments in regional nexus pillars (UNESCO, 2021).

In Namibia, further emphasis and focus on local production, value addition and use of natural resources will spur economic development; however, the converse is more likely if raw materials merely continue to be exported. Promoting decentralised development will be important to slow the migration to urban areas – a dynamic which further strains the capacities of local authorities to provide serviced land, housing, water, electricity, sanitation, and many other essential services. Today, most local, and regional authorities do not deliver adequate and timely services. Yet, persons migrating to urban areas in search of a better life abandon their subsistence agriculture – often without having first secured a job, and they find themselves forced into a system that relies on the sale of food.

Moreover, because the Government's financial resources are severely limited, prioritising the country's budget remains critically important. This necessitates, among other things, that state-owned enterprises must have to deliver or be wound up, and that financial discipline is enforced – including in local authorities. Using services such as water and electricity without paying for them will bankrupt the country. A culture of non-payment has established itself, including from local and regional authorities, which needs to be urgently addressed.

The Government should also not commit public funding to entities that compete with private sector efforts. Namibia's water–energy–food nexus stands to benefit if public spending were to be improved to enhance private sector engagement and participation across the economy. Civil society plays a pivotal role in assisting the Government in reviving the economy.

Tapping into global funds that promote the green economy presupposes that mismanagement and corruption are and will continue to be effectively addressed. Investments in water, energy, food, education, and health will only be stimulated if investors are certain that there is no misuse of public office, that the rule of law applies, and that the justice system is transparent, fully functional and can effectively deliver. Wishful thinking and illusionary development visions are also not helpful in shaping realistic perspectives that will translate the country's challenges into tangible opportunities for growth.

Leveraging Namibia's national endowments to create local value is essential for crafting a liveable future. This entails, among other things, safeguarding our limited water resources, rapidly expanding the use of local energies, and cultivating the brittle ecosystems and soils for enhanced food production. Creating jobs, enhancing livelihoods, and expanding decentralised economic developments will strengthen the country's fabric and reduce its current dependency on imports.

7. Whereto from here?

To revive and strengthen Namibia's economy, urgent and effective Government interventions are essential, including the following:

a) **Creating effective inter-ministerial processes to jointly plan, fund and implement projects strengthening Namibia's water-energy-food nexus;**

b) **Privatising underperforming state-owned enterprises active in the water, energy, and food sectors;**

c) **Enhancing the capacity, performance, and accountability of public service provision in the water, energy, and food sectors;**

d) **Reducing the multiple impediments to direct foreign investments in Namibia's water, energy, and food sectors;**

e) **Diversifying and actively promoting youth training programmes in the water, energy, and food sectors;**

f) **Incentivising entrepreneurship in the water, energy, and food sectors; and**

g) **Enhancing Namibia's business framework conditions to enable and actively support private sector investments and initiatives.**

To be prepared for uncertain times, securing water, energy, and food supplies must become the cornerstone of actions to create Namibia's national development future.

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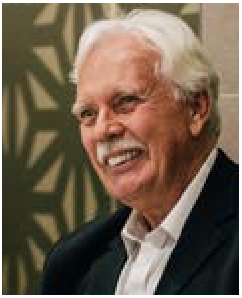

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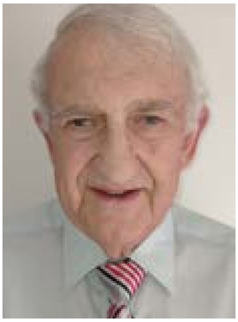

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Annex: Summary of Energy-related Units

A.1: Energy

The *International System of Units*, i.e., the so-called SI units (from the French Système International d'unités), is a metric system of units. The SI unit for energy is the Joule, which is abbreviated as [J].

Electrical energy is typically quantified in multiples of Watt-hours [Wh]. The prefix that is used depends on the quantity to be expressed and includes tera [T], giga [G], mega [M], or kilo [k]. Electrical energy is therefore commonly expressed in units of kilowatt-hours [kWh], megawatt-hours [MWh], gigawatt-hours [GWh] or terawatt-hours [TWh], as shown in Table 29.

Table 29: Common energy units

Unit	In words	Relation to other units	Example
kWh	kilowatt-hour [kWh]	basic unit of energy	1 kWh of electrical energy is needed to change the temperature of 30 litres of water from 20°C to 48°C.
MWh	megawatt-hour [MWh]	1 MWh = 1,000 kWh	A household using an average of 400 kWh of electrical energy per month consumes 12 x 400 kWh = 4,800 kWh or 4.8 MWh of electrical energy per year.
GWh	gigawatt-hour [GWh]	1 GWh = 1,000 MWh = 1,000,000 kWh	In the financial year 2021/22, NamPower's Ruacana hydropower plant contributed 781 GWh of electrical energy to Namibia's electricity mix.
TWh	terawatt-hour [TWh]	1 TWh = 1,000 GWh = 1,000,000 MWh	In 2021/22, NamPower sold 3,701 GWh = 3.701 TWh of electrical energy to its customers, of which 3.405 TWh of electrical energy was sold to Namibian customers.

A.2: Power

Units that quantify the generation capacity of electrical power plants are given in Table 30. Power plant capacities are often expressed as multiples of a kilowatt [kW], or megawatt [MW].

Table 30: Common power units

Unit	In words	Relation to other units	Example
kW	kilowatt [kW]	1 kW = 1,000 Watt	The electrical generation capacity of small mobile petrol- or diesel-powered generators typically ranges between 3 kW and 30 kW.
MW	megawatt [MW]	1 MW = 1,000 kW	In February 2024, NamPower owned and operated four power plants that have a combined generating capacity of 509.5 MW.

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