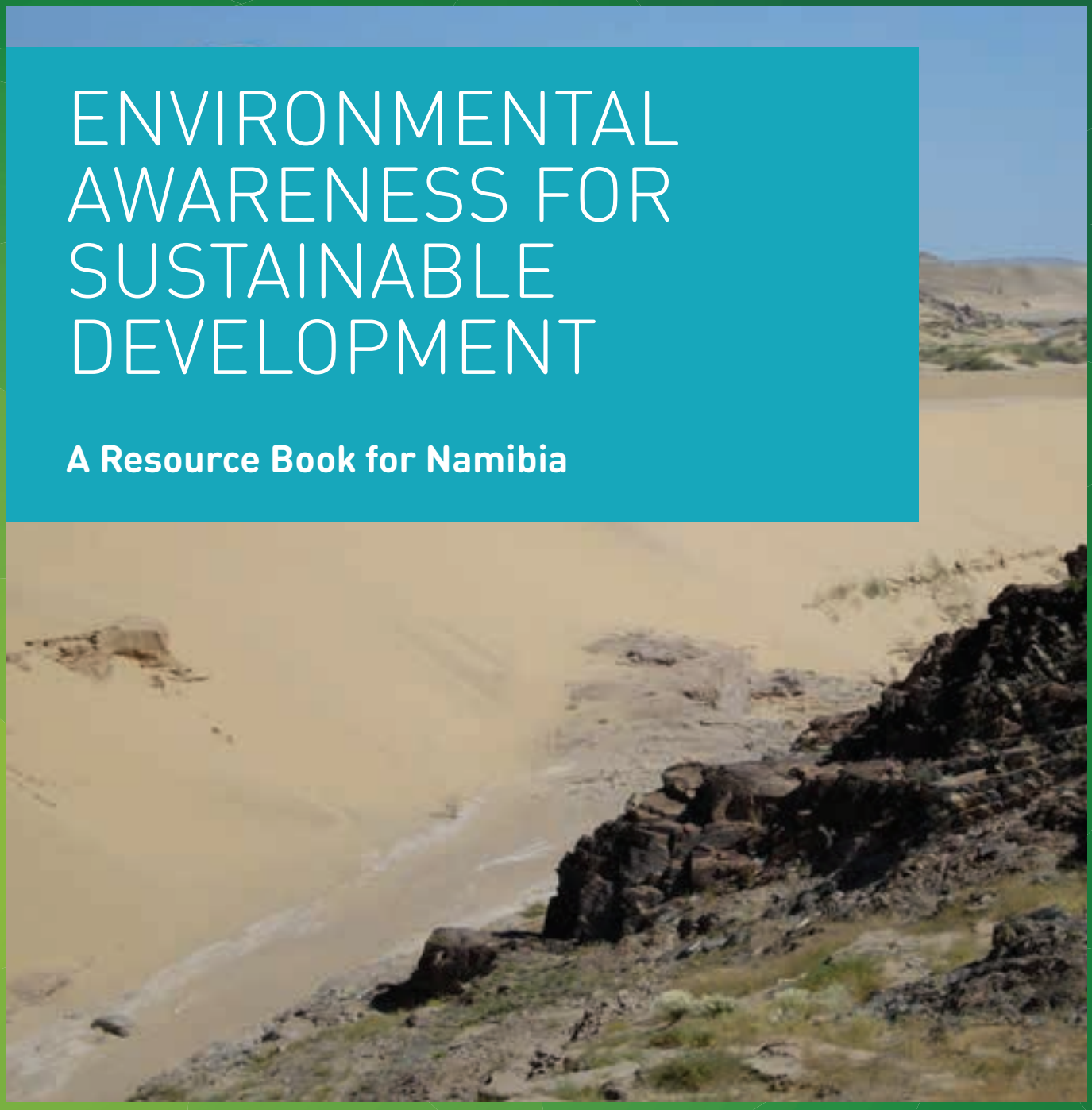
ENVIRONMENTAL AWARENESS FOR SUSTAINABLE DEVELOPMENT

A Resource Book for Namibia



Svenja Garrard · Piet Heyns · Michelle Pfaffenthaler · Gabi Schneider

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Disclaimer
There is wealth of environmental information on the internet and in publications. In this book the authors strove to pull some of this important and fascinating information together. To this end we have referenced other authors extensively. Whilst we have endeavoured to use our own words as far as possible, there are times when others have said it so well that we have included the text directly. This is especially true when using information from policy documents and strategies, which we know have been edited extensively and have adopted specific words and phrases. Please note that the views expressed herein are not necessarily those of the publisher, its employees or affiliates.

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The need for awareness-raising for environmental protection has become increasingly urgent over recent years with consequences of human activities manifesting in our natural world with increasing frequency and intensity. Man-made climate change and environmental destruction are being felt across national and international boundaries.

The concept of sustainability, including the environmental dimension, alongside and on the same footing as economic and social concerns, has characterised this new thinking. The Global Goals for Sustainable Development, and the Agenda 2030 to realise these global aspirations, also speak of the commitment to realise integrated and sustainable development.

Namibia, as one of the first countries in the world to constitutionally make inseparable the well-being of its citizens and the maintenance of its natural environment, sets a standard for others as a global citizen. Yet, numerous and compounded challenges remain for the country such as environmental degradation, the impacts of a rapidly changing climate and low awareness of how to individually and collectively address these challenges.

The main focus of the Hanns Seidel Foundation's Environmental Awareness work in Namibia is to work in dynamic partnerships to tackle awareness-raising in a comprehensive way, drawing attention to key linkages across all sectors, including water, energy and agriculture. Potable water is the most valuable resource worldwide and its sustainable utilisation is of particular importance in Namibia, as it is the driest country in Africa south of the Sahara Desert. Renewable energy, another important topic with Namibia's unequalled amounts of sunshine, can also contribute to a responsible and mitigating environmental and economic policy in Namibia. Our programme focuses on these and many other themes and attempts to contribute to a deeper understanding among Namibians of the close interdependence between sustainably utilised natural environment and a healthy economy to contribute to Namibians being increasingly mindful about their environment, and to support the development of a new consciousness that warrants an unharmed environment for the benefit of Namibia's future generations.

Protection of the environment as one element of the broader sustainable development agenda means collaborative initiatives must be at the heart of our development. Therefore, civil society organisations, government, political parties, traditional authorities, private sector, faith based organisations, media, schools and farmers are called upon to disseminate and create environmental awareness for sustainable development within their respective communities and the broader public.

I wish to thank the authors, coordinators and all who have contributed to this publication for their valuable insights and hard work in service of the Namibian nation. Let all of us make sustainable development a reality for today and future generations!

Dr Susanne Luther
Director of the Institute for International Cooperation (IIZ)
Hanns Seidel Foundation
Munich, September 2017

PREFACE

The main purpose of this book is to create awareness for environmental sustainability amongst young people in Namibia. The book is thus directed at students, learners and teachers in particular. Because there is a lack of easily accessible educational material on environmental awareness in Namibia, particularly for teachers operating in remote parts of the country, it is envisioned that this book will provide a good foundation for the preparation of lessons.

But the book has also been written with other users in mind, e.g. tour guides and government officials, as the intent is to distribute it widely and in doing so encourage as many people as possible to become more environmentally aware. In compiling this book the authors focused on the following:

- Provide a current, clearly written book that describes the environment, with particular emphasis on the Namibian context;
- Remind Namibians what natural resources are available to them and how they are being utilised;
- Outline the roles different members in society can play to contribute towards the responsible use and management of these natural resources;
- Encourage people to find out more about sustainability issues and ways to integrate sustainable practices into their workplaces and homes; and
- Challenge individuals to accept their responsibility in looking after Namibia's natural resources and inspire them to develop an environmental ethic, which they are willing to follow throughout their life, and in doing so make them live more considerately within their environment.

The book has been divided into four main chapters. Chapter 1 sets out the environmental context and introduces concepts like environmental ethic and sustainable development goals. Chapter 2 represents details on the 4 spheres of the natural environment, namely lithosphere, biosphere, hydrosphere and atmosphere. Chapter 3 examines in detail how the resources listed under lithosphere, biosphere, hydrosphere and atmosphere are being used by Namibians and what impact they are having. Issues associated with resource unpredictability, scarcity and fragility are explored. The book concludes with a chapter on environmental management and the actions that are being carried out by different levels of society to cause change, i.e. government through policy making and regulatory framework; industry through corporate governance and responsibilities towards communities; as well as all individuals through their daily decisions and actions. Within each chapter, green textboxes provide definitions and blue textboxes provide interesting case studies and additional information. The aim of the textboxes is to provide additional clarity and stimulate further discussion. Furthermore, certain words within the text are presented in bold to promote ease of reading, introduce new concepts as well as to highlight items that are defined in adjacent boxes.

It is with great excitement that I introduce this book to the intended audiences and the broader Namibian public and commend the authors for a comprehensive, well-structured and dynamic approach taken to environmental awareness for people of all walks of life to become more ecologically mindful in order to care for Namibia's diverse natural wealth.

Dr Martin Schneider
Executive Director
Desert Research Foundation of Namibia (DRFN)
Windhoek, September 2017

^0C	degrees Celsius
a	annum
BA	Botswana anticyclone
BCC	Benguela Current Convention
BCLME	Benguela Current Large Marine Ecosystem
CA	Conservation Agriculture
CAN	Conservation Agriculture Namibia
CBNRM	Community Based Natural Resource Management
CBRLM	Community Based Rangeland Management
CFCs	Chlorofluorocarbons
CCF	Cheetah Conservation Fund
cm	Centimeter
CO	Carbon monoxide
CO_2	Carbon dioxide
DEA	Directorate of Environmental Affairs
DeSeRT	Desert Science and Research Training
DRFN	Desert Research Foundation of Namibia
EIA	Environmental Impact Assessment
ECC	Environmental Clearance Certificate
EMP	Environmental Management Plan
ENWC	Eastern National Water Carrier
ECB	Electricity Control Board
EEC	Exclusive Economic Zone
e.g.	for example
EPL	Exclusive Prospecting License
EQOs	Environmental Quality Objectives
ESD	Education For Sustainable Development
etc.	et cetera
EU	European Union
FFI	Fauna and Flora International
g	Gram
GDP	Gross Domestic Product
GIS	Geographical Information System
GWh	Gigawatt Hours
HFCs	Hydrofluorocarbons
HPSZ	High Pressure Subtropical Zone
HSF	Hanns Seidel Foundation
ICCAT	International Commission for the Conservation of Atlantic Tunas
i.e.	That Is
INPs	Indigenous Natural Products
IRDNC	Integrated Rural Development and Nature Conservation
ISO	International Standards Organisation
ITCZ	Intertropical Convergence Zone
kg	Kilogram
km	Kilometre
km/hr	Kilometres per hour
km^2	Square kilometers
km^3	Cubic kilometers
km^3/a	Cubic kilometres per annum
kV	Kilovolt
kW	Kilowatt
KCINPT	Kunene Conservancies Indigenous Natural Products Trust
LAC	Legal Assistance Centre
LED	Light-Emitting Diode
LLA	Landscape Level Assessment
LPG	Liquid Petroleum Gas
LPTZ	Low Pressure Temperate Zone
m	Meter
mm	Millimetre
mm/a	Millimetres per annum
Mm^3	Million cubic meter
Mm^3/a	Million cubic meter per annum
MEAs	Multilateral environmental agreements
MET	Ministry of Environment and Tourism
MAWF	Ministry of Agriculture, Water and

LIST OF ABBREVIATIONS

	Forestry
MFMR	Ministry of Fisheries and Marine Resources
MME	Ministry of Mines and Energy
MRF	Material Recovery Facility
MoU	Memorandum of Understanding
mSv	Milli Sieverts
MW	Megawatt
N$	Namibian Dollar
N_2	Nitrogen
NaBiD	Namibia Biodiversity Database
NACOMA	Namibia Coast Conservation and Management Project
NaDEET	Namib Desert Environmental Education Trust
Namcor	National Petroleum Corporation of Namibia
NamPower	National Power Utility Company of Namibia
NamWater	Namibia Water Corporation Ltd
NAPHA	Namibia Professional Hunting Association
NASA	National Aeronautics and Space Administration
NBII	Namibia Business Innovation Institute
NBL	Namibia Breweries Limited
NCE	Namibia Chamber of Environment
NDP	National Development Plan
NDTC	Namibian Diamond Trading Company
NGOs	Non-Governmental Organisations
NIRP	National Integrated Resource Plan
NNF	Namibia Nature Foundation
NNFU	Namibia National Farmers Union
NORAD	Norwegian Aid Agency
NO_x	Nitrogen oxides
NUA	Namibian Uranium Association
NUST	Namibian University of Science, and Technology
O_2	Oxygen
O_3	Ozone
PM_{10}	Particulate Matter 10 micrometers or less in diameter,
PV	Photovoltaic
REDs	Regional Electricity Distributors
REFIT	Renewable Energy Feed-In Tariff Project
RNF	Recycle Namibia Forum
SAA	South Atlantic anticyclone
SABIO	South African Bee Keepers Industry Organisation
SADC	Southern African Development Community
SASSCAL	Southern African Science Service Centre for Climate Change and Adaptive Land Management
SAPP	Southern African Power Pool
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SEMP	Strategic Environmental Management Plan
SID	Swedish aid agency
SO_2	Sulphur dioxide
SRF	Solar Revolving Fund
SWA	South West Africa
t	Tonne
TAC	Total Allowable Catch
U-SEA	Strategic Environmental Assessment for the Uranium Province
UN	United Nations
UNDP	United Nations Development Programme
USA	United States of America
US$	United States of America Dollars
USSR	Union of Soviet Socialist Republics
UV	Ultraviolet
WDM	Water Demand Management

1

ENVIRONMENTAL CONTEXT AND CONCEPTS

1.1 ENVIRONMENTAL CONTEXT

For thousands of years humans have been developing their world without taking nature into account. This has resulted in the loss of vital natural resources, the increase in pollution of air, water and soil and the loss of wilderness. Namibia is a young nation, with a growing population that is, in general, aspiring to achieve a higher standard of living with a comfortable lifestyle. The side effects of this development are the same that are seen the world over, and include environmental degradation and alienation of people from the natural environment. It is rarely intentional but as people's interests and needs shift to things more urban and technological, the time spent outdoors diminishes and people simply lose touch with what the environment is all about.

Calls have gone out for people to change the way they behave in order to conserve the environment. And whilst some people have risen to the challenge, the majority have not. The result is the ongoing erosion of our **natural capital**. There are very convincing arguments, underpinned by evidence that the way humanity behaves needs to change. The environment on Earth is becoming increasingly degraded. The reasons for this are:

- **Over exploitation of natural resources** for short term economic gain, e.g. over fishing, poaching and the illegal trade in wildlife;
- **Destruction of habitat** for large scale economic developments such as mining, deforestation for timber, monoculture (agriculture and commercial plantations), stock farming, and urban settlements; and
- **Pollution** of water, land and air from a multitude of industrial, agricultural, urban and rural activities.

The main reason that environmental degradation is spiralling out of control is overpopulation. This is exacerbated by the current economic paradigms which focus on increased consumption, the aspirations of millions to achieve a higher standard of living, powerful and unscrupulous monopolies/industries, ineffective and/or corrupt governments, escalating poverty and apathetic societies.

Every country in the world is wrestling with the need for poverty alleviation and economic development but the big question is whether they are going to try and do that sustainably, i.e. within the constraints of functioning ecosystems, or whether they will further degrade their natural capital to meet the short term needs of the current generation.

On one hand Namibia is fortunate. It is a big country with a small population. On the other hand, it is one of the most arid places on Earth, which means that its ecosystems are vulnerable and easily degraded by large scale impacts especially those which continue for extended periods of time.

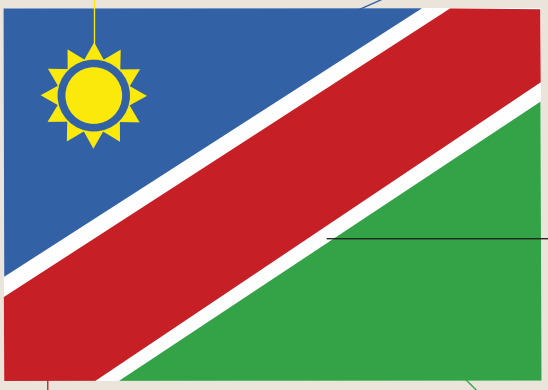
Namibia is faced with a number of serious environmental challenges that threaten the long term prosperity of its people and the ongoing integrity of its ecosystems. Yet it also boasts some of the most innovative and successful approaches to the conservation and management of natural resources.

Whether or not Namibia succeeds in developing an environmentally conscious society depends to a large extent on the will of the people. Whilst there is evidence that many Namibians living in urban areas, especially the youth, are disconnected from the natural environment, the vast, arid landscapes that define this country are deeply engrained in most of us at some level. Even if we are not always aware of it, our environment plays a part in defining who **we** are as Namibians.

The **name Namibia** is derived from a Nama/Damara word meaning "shield" or "vast place" – that was used to refer to the large coastal desert. The **symbolism in the Namibian flag and coat of arms** is strongly linked, not only to its people but to the natural environment and the value of Namibia's natural resources as well as our responsibility to protect it as enshrined in the Constitution. The symbolism in both the Namibian flag and coat of arms is outlined on the next page.

THE SYMBOLISM IN THE NAMIBIAN FLAG

The **golden sun** represents life and energy, the grassy plains and the Namib Desert.



Blue represents Namibia's clear skies, the Atlantic Ocean, precious water resources and reminds one of the importance of rain.

White represents peace and unity.

Red represents one of Namibia's most important resources – its people. The colour symbolises the determination for which they fought for independence.

Green represents Namibia's precious vegetation on which both pastoral and agricultural activities depend.

THE SYMBOLISM IN THE NAMIBIAN COAT OF ARMS

The **fish eagle** represents the north of the country and Namibia's water resources.

The **welwitschia** is a unique desert plant that fights for survival in the harsh desert. It is a symbol of Namibia's fortitude and tenacity.

The **diamonds** represent the mineral wealth of the country.

The **two oryx** represent the semi-arid parts of the country and symbolise courage, elegance and pride.

The flag is firmly anchored in the **sands of the ancient Namib Desert**.

1.2 UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS (UN SDGs)

Utilising natural resources more sustainably and managing environmental degradation has by now been high on the global agenda for many years. Nations have come together to try and find consensus on ways to interlink environmental, social and economic development that meets the needs of the present without compromising the ability of future generations to meet their own needs. On 25 September 2015, the UN General Assembly adopted the **2030 Agenda for Sustainable Development**, a framework that follows the Millenium Development Goals that took 3 years to develop, with input from all UN member states (of which Namibia is one) and millions of people from across the world. The core of this agenda are 17 Sustainable Development Goals (SDGs).The importance of these goals can be well summarised by a quote from the former United Nations Secretary-General Ban Ki-moon:

"We don't have plan B, because there is no planet B".

The SDGs outline global challenges that must be tackled if humanity is to have a chance of a sustainable, peaceful, prosperous and equitable society moving into the future. They set environmental limits and critical thresholds for the use of natural resources whilst recognising the needs for poverty alleviation and economic development. They address key systemic barriers to sustainable development such as inequality, unsustainable consumption patterns, weak institutional capacity and environmental degradation. Overall, the SDGs are a valuable set of goals.

Whilst it is inevitable that such a document will have gaps, such as downplaying the issue of overpopulation, if adopted, countries will make changes towards a more sustainable society.

The 2030 Agenda for Sustainable Development provides a roadmap for all countries. Each sovereign state has to figure out how best to implement these new international commitments in their own country through the development of national laws, policies and strategic plans.

Namibia is in the process of mainstreaming the SDGs throughout national strategic plans, including the latest National Development Plan 5. The critical step is moving from policy and strategic plan to actual implementation. Implementation requires commitment on all levels from economic incentives for investments in sustainable technologies, social investment to reduce inequality, to enforcing environmental laws.

Many people who are committed to making a change do not know how to deal with such huge issues as climate change, whilst others have not heard about the problems or do not understand them sufficiently to be able to help.

If mankind is truly committed to the issues outlined in the SDGs, then everyone requires the knowledge, skills, values and attitudes to **empower them to make meaningful change and contribute to sustainable development**.

Education is therefore crucial for the achievement of sustainable development. Education for sustainable development (ESD) lays a platform for all people to engage with sustainability issues as it recognises the importance of lifelong learning in all contexts. Integrating ESD into all learning spheres including the formal sector such as schools, higher education as well as government institutes and the private sector is much easier said than done, because fundamental changes to the way teaching is done need to take place. Yet it is one of the most important tasks of our time and it is hoped that the call for ESD will be heeded.

Why do we need education for sustainable development?

The extent to which environmental education has been integrated in mainstream education varies but is generally low.

Education for sustainable development (ESD) is all about integrating key sustainable development issues into teaching and learning. Successful integration of sustainability issues into learning curricula and workplans would allow people to:

- **Envision,** because if we know where we want to go, we will be better able to work out how to get there;
- **Develop critical thinking and reflection skills,** as learning to question our current belief systems and to recognize the assumptions underlying our knowledge, perspective and opinions is critical for fundamental change;
- **Develop systemic thinking skills,** which help in acknowledging complexities and looking for links and synergies when trying to find solutions to problems;
- **Build partnerships,** so as to promote dialogue and negotiation, and in doing so teach people to work together and
- **Participate in decision-making,** thereby empowering people.

1.3 ENVIRONMENTAL ETHICS

Most societies have moral principles that guide the way they behave. These principles are dependent on their ethics. **Ethics** delve into the 'best way' that people should live and strive to solve what is right and wrong.

Establishing an ethic is not that simple because it is influenced by culture, family, gender and age. For this reason different people have slightly different ethics, which may change during the course of their lives. Typically ethics revolve around how we should treat ourselves and other people within a society. Some cultures have much stronger principles relating to how they should treat the environment than others, and because many cultures believe they have dominion over the rest of creation, many environmental ethics are focused on how the environment should benefit man.

Unfortunately this inherent belief has allowed humans to undermine the very resources they need for survival. Although ethics and morals help to define a culture or society, they are not static. There is a pressing need for most societies' ethics and morals to be reviewed and adapted to include an environmental ethic that apportions rights to the rest of the environment. If societies cannot evolve more environmentally conscious principles, they will struggle to find sustainable solutions to the challenges they face today.

One of the main reasons that people's ethics no longer 'fit' is that they were founded by much smaller societies living in a world that was considerably less populated than today. Whilst there are cases of civilizations that have gone extinct due to a variety of reasons including over exploitation and degradation of their environment (e.g. Majans and Norse Greenlanders); in general, natural resources were much more abundant in the past. Humans were able to migrate from problem areas, and ecosystems were given a chance to recover from the impacts of human exploitation. But with the onset of the industrial revolution and with more than seven billion people living on the planet, this is no longer the case. Regardless of religion, economic disposition or political inclinations there are some environmental issues that should be reconsidered.

What do you attach to nature and the experiences it offers?

(Source: M Pfaffenthaler)

Some of the questions to explore when reconsidering your environmental ethic:

- What is our place in the natural world?
- Do all organisms have the right to life?
- What should our relationship be between nature and technology?
- How do we respond to the issues of resource loss and pollution?
- What value do we attach to environmental experiences?
- What are the best forms of conservation?

Ethical conduct is to do the right thing when nobody is looking. For example; will you leave your rubbish on the beach or will you take it home and dispose of it properly?

All creatures have a right to live in a healthy environment for which they have adapted
(Source: M Pfaffenthaler)

For some people access to open spaces and natural environments are very important
(Source: M Pfaffenthaler)

The outcomes of such deliberation and discussion will help to form one's environmental ethic and will define your environmental values.

Whilst everyone's ethic will vary, there are a few fundamental truths which need to be accepted. Everyone needs to start taking responsibility no matter how inconvenient the reality. They are:

- The planet's resources are **finite** and even those resources which people have always seen as renewable will become depleted and disappear, if people do not take personal responsibility in looking after them.
- As human numbers grow, the amount of resources available for each person and other species on the planet will decrease because people have to share with more. Not everyone will want to share. People will start fighting for these resources and our standard of living will decrease.

One of the challenges with looking after the environment is that some natural resources such as water belong to everyone. It is referred to as a public good. Everyone has the right to use a **public good**, but everyone has a responsibility to look after it too. Unfortunately the tendency is to assign the responsibility to someone else, which means that the resource degrades due to insufficient care.

For many people the natural environment has an intrinsic value, which means that it is worth protecting regardless of its value to humans, i.e. life should be conserved because it exists. They see people as being part of nature, thus in damaging nature, we damage the very processes that created us, ultimately damaging ourselves. Because human activities are the source of so much environmental destruction, people should be taking the responsibility to conserve what remains. Whilst many people struggle to support this view wholly, it is impossible to ignore the fact that although many people now live removed from nature, they cannot live without it. This is apparent across all cultures, globally and testament is given to this in literature, music and art, and in the success of the global ecotourism industry.

A different approach (although not necessarily contradictory) is that the natural environment performs a number of services for humankind that have economic, recreational or aesthetic value. This is the **anthropocentric approach**. Although the intrinsic approach to conserving biodiversity is persuasive, it is the anthropocentric one that has gained more traction, because people can relate to it more easily.

In this book the authors have taken a more anthropocentric approach to viewing the environment, because there are so many convincing case studies demonstrating how Namibians benefit from a healthy environment and these are much easier to understand,

Nature offers recreational, spiritual values and well-being to many
(Source: M Pfaffenthaler)

than the ones about **intrinsic value** or the inherent rights of future generations. However, an approach based purely on a fiscal value is flawed because people are unpredictable, their values change over time and they are selfish. If the environment merits conservation solely because it has economic value, what happens when the demand for that commodity changes and it no longer has a value?

Even though this book presents many examples of why it makes sense to manage the environment from a socio-economic perspective, it also advocates that, fundamentally, conservation of the environment is a morally good thing to do and that the human race should be striving towards a more harmonious relationship, not solely for their own benefit but for the millions of other species too.

The non-monetary aspect of environmental conservation

That strong sense of belonging that you feel when you smell the air after a rainstorm, when you sit on the banks of a river and watch the moon rise, or when you watch the water filling up the dry river beds – these are things that do not have a monetary value but without which a part of you might be incomplete. Many people want a clean, intact environment because it increases their sense of well-being.

2

THE NATURAL ENVIRONMENT

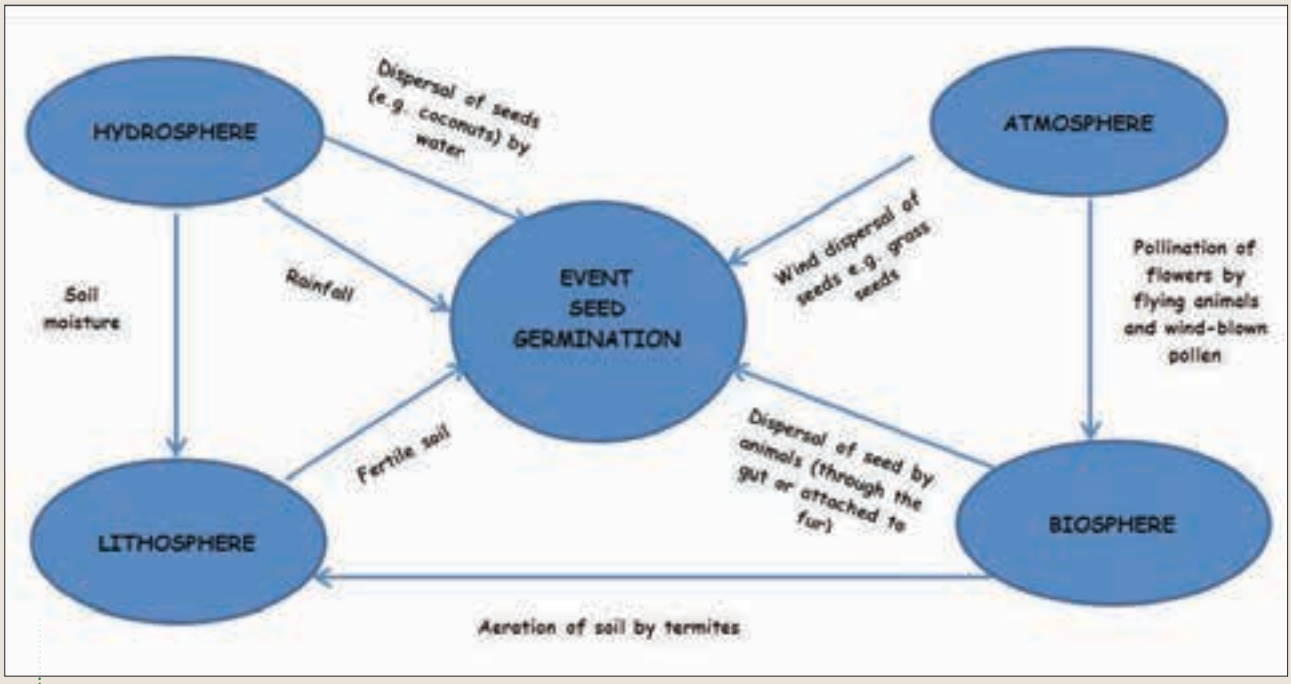
2.1 INTRODUCTION TO EARTH'S SPHERES

Planet Earth is unique from the other planets in our solar system because it houses life – a complex and spectacular array of life that can be found from the deepest ocean trenches to the highest mountains, from the driest deserts to the wettest jungles.

To appreciate how Earth can support such diversity of life, it is important to understand how the planet works. Earth is divided into four broad areas or spheres, namely the **lithosphere** (land), the **hydrosphere** (water), the **atmosphere** (air) and the **biosphere** (living things). The spheres get their energy from the Sun and from Earth's internal heat, deep down in its core.

There are **no defined boundaries** between the spheres and each of them interacts with the other to create the fully functioning system that is our planet Earth.

An example is **seed germination**. For seeds to germinate successfully and grow into adult plants all of the spheres must interact, as is shown in the diagram. Another example is soil erosion, which occurs when weather patterns (atmosphere) cause rain to fall on the land. The runoff picks up loose sand and soil (lithosphere) and carries it into streams and rivers (hydrosphere). The rivers transport the silt downstream and when they run out of energy the silt is deposited. This is the reason flood plains are so fertile and are home to many plants and animals (biosphere).



The spheres interact to create a life event: Seed dispersal and germination

(Source: M Pfaffenthaler)

This book examines the four spheres within the context of Namibia. It is one of the driest countries in the world, yet despite this, it is able to support an amazing variety of life. Plants, animals and people that live here have adapted to deal with the heat and unpredictable water availability and have learnt to utilize the resources at their disposal. Namibians have all benefitted from one of the most unpolluted skies in the world and the variety of minerals and striking landscapes that this country has to offer. However, semi-arid and arid places are **fragile** systems, characterized by high climatic variability, **unpredictable** rainfall patterns, **variable** temperatures, water and poor soils. If not looked after carefully the environment can become unbalanced and deteriorate into unproductive wastelands that struggle to support life.

What does a fragile environment mean? Life has existed on Earth for 3.8 billion years. Despite some dramatic events such as meteor impacts and bitterly cold ice ages, life has persisted. Ecosystems have adapted, but in the process species went extinct and new ones evolved. When people talk about 'a fragile environment,' they are looking at it from an anthropocentric (human centered) perspective, because humans need an environment that supports humans. Fragile environments are those that can be easily damaged, are difficult to restore once they are disturbed because they take a long time to get back to the state they were in, or because the environmental conditions that created the environment no longer exist. Many of our environments have become more fragile because of the negative impacts that humans have placed on them. For example some of Namibia's best agricultural areas have become fragile, due to poor farming practices, which have resulted in soil erosion and bush encroachments. A far more strategic approach to land use is needed in Namibia if we are to minimize impacts on our fragile environment.

By better understanding Earth's four spheres, this book should assist to:

- Develop a greater appreciation of how Namibia's environment 'works';
- appreciate what is needed to look after the environment;
- have more clarity as to the role that every individual should take to ensure that resources for a healthy life are managed now and in the future.

Dead Camethorn tree at Dead Pan with living camelthorns in the back

(Source: G Schneider, 2012)

Ancient Camelthorns – true icons of the desert

One of the reasons that deserts are considered fragile is because change occurs very slowly and often only periodically. The iconic camel thorn trees that are scattered through the Namib Desert require higher than average rainfall to germinate and grow. Radiocarbon dating of trees has shown that the trees established during warmer and wetter periods (i.e. about 900, 870 and 570 years ago). If all of the camel thorn trees were chopped down or the groundwater was lowered to such an extent that they could not access water, then these old trees will die and without any young ones around, the species will go extinct in the desert.

2.2 LITHOSPHERE

2.2.1 LITHOSPHERE – GEOLOGY

Geology underlies everything. This wise statement not only refers to the fact that wherever we are, rocks are beneath our feet, or beneath the buildings, vehicles or structures in which we find ourselves. If it was not for geological processes, life as we know it, would not have developed.

Our planet Earth is a complex system, and so far unique in the universe we know. Why is it so unique? It is because geological processes that have shaped the Earth have also allowed for an oxygen-rich atmosphere and liquid water, which are essential ingredients for life to flourish. To give you only one example: geological processes allow for carbon capturing, and thereby reduce carbon dioxide in our atmosphere. If this was not the case, the atmosphere would have heated up long ago, which would have caused water to leave its liquid state to become vapour, and make our planet unliveable. So geology indeed underlies everything.

The **lithosphere** comprises the rocks and soils on which we walk and which we use for various purposes, such as building materials, ores for the extraction of metals and soils for agricultural use, to name but a few.

Earth as such is subdivided into the **crust**, which is the skin of rock on the outer layer of the planet, the **mantle**, which separates the crust from the core, and the hot core. The lithosphere includes the rigid, solid crust and upper mantle, and is of the order of 100 km in thickness, but varies greatly as the crust underlying the oceans is much thinner than the so-called continental crust. It represents the part of Earth that is involved in so-called Plate Tectonic processes.

The theory of **plate tectonics** explains "how the Earth works". The lithosphere is broken into seven large, rigid pieces called the African, North American, South American, Eurasian, Australian, Antarctic and Pacific Plates. Several smaller plates also exist. The plates are moving in different directions relative to each other, at a speed between 2 and 10 cm per year, which is about the speed fingernails grow. There are three different types of plate boundaries (the border between two plates), depending on how the plates are moving relative to each other: **convergent**, **divergent** and **transform** plate boundaries.

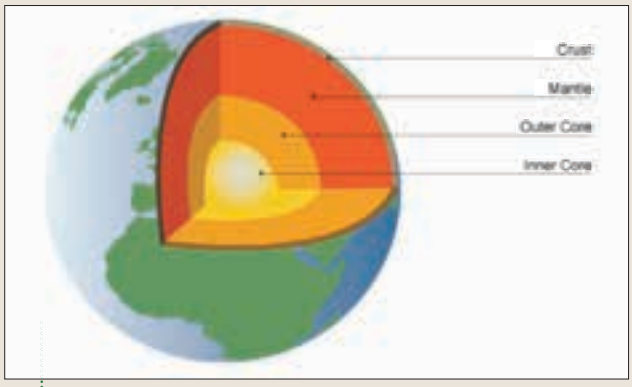
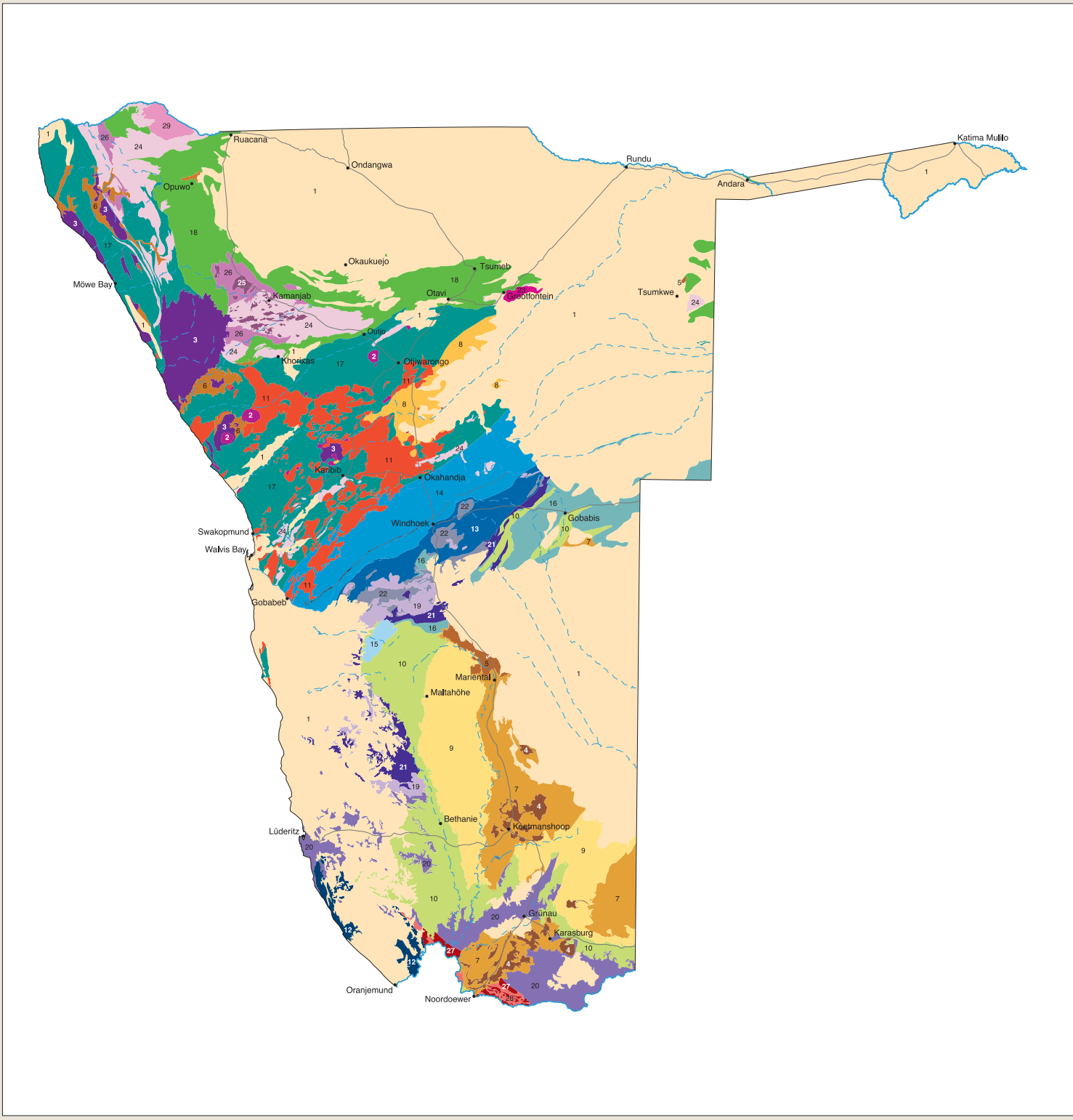


Diagram showing the structure of Earth
(Source: bbc.co.uk/schools)

At the edge of the over-riding plate of a **convergent plate** huge mountain ranges can be formed, while the other plate is moving deep into the earth. The folding and bending results in earthquakes, and as the rocks of the under-riding plate get hotter and hotter, melting can occur, which in turn gives rise to volcanoes. This way the South American Andes with their spectacular volcanoes have formed.

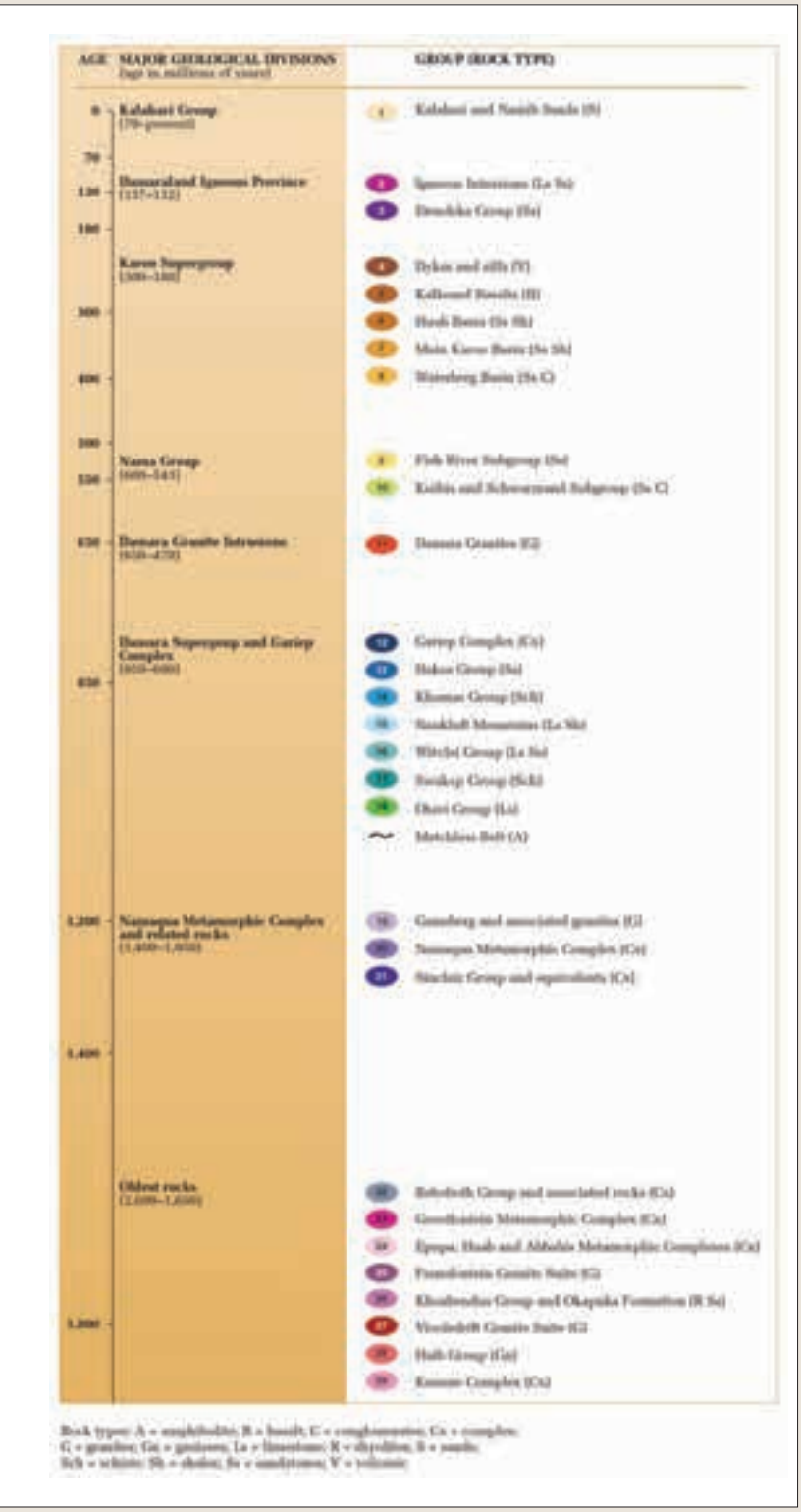
At the boundary where two plates are separating (**divergent plates**) you will find a rift valley. This can cause milder earthquakes and volcanism. As the plates continue to move apart, the rift valley widens, and eventually a complete ocean takes its place, as is the case with the Atlantic Ocean separating Africa and South America. Sediments are deposited in both, the rift valley and the ocean.

Transform plate boundaries do no create mountain ranges or valleys. However, substantial pressure can build up between the plates and eventually result in violent earthquakes, such as the famous one that destroyed San Francisco in 1906. It was caused by the Pacific and North American plates sliding past each other.



Geology of Namibia

(Source: Ministry of Environment and Tourism, 2002)



Folded Metasediments

(Source: G Schneider, 2015)

Bogenfels

(Source: G Schneider, 2017)

Tsondab Sandstone underlying the Namib Sand Sea

(Source: P van Schalkwyk)

As the plates move, oceans are opening at divergent plate boundaries, while they are eventually closing again at convergent plate boundaries, a process that is referred to as a complete **Plate Tectonic Cycle**. Many geological phenomena are related to what is happening at the boundaries of the various plates. The theory of Plate Tectonics further provides good explanations for issues related to the composition of the atmosphere and hydrosphere, and ultimately the biosphere.

The **geology of Namibia** must be seen in the larger context of the geological evolution of southern Africa, which spans a long period of 3 500 million years. It began with the formation of the first stable parts of the early Earth's crust, so-called **cratons**, surrounded by tectonically active areas. In time these surrounding areas became stable, and formed larger cratons. During the course of plate tectonic movements these areas combined to form large continents, only to disperse again later and eventually form new continents. The development of the southern African lithosphere is closely linked to these processes.

In southern Africa, the development of cratonic areas was followed by the assembly of the large continent Rodinia some 1 000 million years ago. The subsequent dispersion of Rodinia preceded the assembly of the huge continent Gondwana about 550 million years ago. Gondwana comprised of modern Australia, India, Antarctica, Africa and South America. Southern Africa remained part of Gondwana until its break-up some 180 – 130 million years ago. Since then stable geological conditions have prevailed as southern Africa developed further as part of the African continent.

Important geological definitions

Geology
Geology is the science concerned with the solid earth, the rocks of which it is composed, and the processes by which these rocks formed and change over time.

Lithosphere
The lithosphere consists of the earth's two topmost layers, the crust and the uppermost mantle.

Plate tectonics
Plate tectonics describe the movement of plates of the earth's lithosphere, over millions of years of Earth's existence.

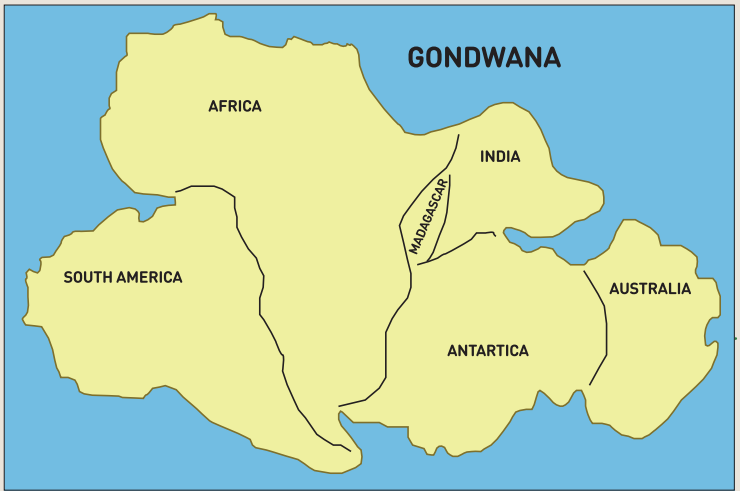
Convergent plate boundary
Convergent plate boundaries are places where two plates crash and one plate is eventually subducted beneath the other.

Divergent plate boundary
Divergent plate boundaries are places where two plates are pulling apart.

Transform plate boundary
Transform plate boundaries are places where plates slide past each other.

Subduction
Subduction is the process of one plate sliding under another.

Craton
A craton is an old and stable part of the continental lithosphere.



Shape of Gondwana
(Source: geo.fu-berlin.de/en/v/geolearning/gondwana)

There are three main types of rocks, namely **magmatic rocks, sedimentary rocks, and metamorphic rocks**.

The melting and formation of **magmatic rocks** is caused by one of the three following processes: an increase in temperature, a decrease in pressure, or a change in composition. If the change into a solid rock occurs beneath the Earth's surface, we talk of **intrusive** rocks; if it occurs on surface, we call them **volcanic** rocks. Prominent Namibian examples of intrusive rocks are the granites of the Brandberg and the Spitzkoppe; volcanic rocks are represented by the basalts of the Etendeka Mountains and the tuff forming major parts of the Erongo.

There are a number of different sediments that make up **sedimentary rocks**. **Clastic sediments** are those, where the minerals and rock fragments are derived from the erosion and weathering of older rocks, and subsequent transport by water and wind to the point of deposition. **Chemical sediments** form when minerals dissolved in water precipitate because the solution is more than saturated. Sometimes the deposited material consists of remnants of organisms, in which case we speak of **organic sediments**. Prominent Namibian examples of sedimentary rocks are the Tsondab Sandstone that forms the prominent cliffs underlying the modern Namib Desert, and the sandstones and shales of the Schwarzrand escarpment.

Rocks at depths are particularly subject to **metamorphic** changes because of the weight of the overlying rocks; and because of heat, pressure and intrusions of magma associated with plate tectonic movements. Prominent examples of metamorphic rocks are the marbles of the Karibib area and the gneisses underlying the town of Lüderitz.

Namibia's geology covers more than 2 600 million years of Earth's history. Many of the old rocks are well exposed, but some 50% of the country is covered by the young sediments of the Kalahari thirst land and the Namib Desert. Namibia has five main **rock-forming periods**.
The **oldest** rocks occur as **metamorphic complexes** with an age of 2 600 to 1 800 million years, and comprise of highly deformed gneisses, amphibolites, metasediments and associated intrusive rocks. The Kunene and Grootfontein Igneous Complexes in the north, the volcanic Orange River Group and the Vioolsdrif Granite Suite in the south, as well as the volcano-sedimentary Khoabendus Group and Rehoboth Sequence belong to this group.

Important rock type definitions

Magmatic rocks
Magmatic rocks form through the cooling and solidification of magma or lava. The magma is derived from the melting of existing rocks in the Earth's mantle and crust.

Sedimentary rocks
Sedimentary rocks form through the deposition and cementation of minerals and rock fragments at the earth's surface and often below water.

Metamorphic rocks
Metamorphic rocks develop from pre-existing rocks through substantial alteration in composition, texture, and/or internal structure by heat, pressure and/or infiltrating material.

These old rocks underlie the rocks of the **next major period**, which include **sedimentary** and **volcanic successions** with an age of 1 800 to 1 000 million years. Their formation is linked to the assembly of the large continent of Rodinia. This period is represented by the Namaqua Metamorphic Complex in the south, comprising of granitic gneisses and metasedimentary and intrusive rocks; and by the volcano-sedimentary Sinclair Sequence of central Namibia, with its associated granites.

The **third main event**, the formation of the **Damara mountain belt**, started with intracontinental rifting (break-up of Rodinia) some 900 million years ago and sedimentation in the widening rift as the continents spread apart. Thereafter the diverging plates changed direction and converged, culminating in continental collision during the Damaran Orogeny between 650 and 450 million years ago. The **Damara Orogen** therefore represents a full plate tectonic cycle. This event coincided with the assembly of Gondwana, and rocks of the Damara mountain belt cover vast areas of Namibia.

In the north, **carbonate sediments** were deposited on a stable platform, while in the central part a variety of metasedimentary rocks point to more variable depositional conditions. Along the south-western coast, the volcano-sedimentary **Gariep Complex** is interpreted as the southern extension of the Damara Orogen. During the later stages of orogenic evolution, the shallow-marine sediments of the Nama Group, which covers much of central southern Namibia, were derived from the erosion of the uplifted Damara and Gariep belts.
The **fourth phase** occurred some 300 to 135 million years ago with the deposition of **sedimentary** and **volcanic** rocks of the **Karoo Sequence**. These rocks can be found in the Aranos, Huab and Waterberg areas in the south-eastern, north-western and north-eastern parts of the country. Extensive volcanism represented by many dolerite intrusions and the predominantly basaltic volcanism of the Etendeka Plateau of north-western Namibia accompanied the break-up of Gondwana at the end of this period.

Young sediments of the **Namib Desert** and the **Kalahari Basin** were deposited after this break-up. They cover some of the older rocks, and constitute the **fifth phase**. However, this youngest phase of the Namibian geology also saw the development of some magmatic complexes which today form inselbergs, such as the Brandberg, the Spitzkoppe and the Erongo Mountains.

The inselberg of Spitzkoppe
(Source: Areva, 2009)

Why are our inselbergs so special?

The iconic inselbergs in the Namib Desert and north-western Namibia are islands of high biodiversity and have attracted humans and wildlife for time immemorial, as documented in a plethora of rock art. They owe their existence to magma that formed when the African Plate moved over a very hot spot in the Earth's mantle. The magmatic rocks forming the inselbergs host the rarest minerals and mineral deposits, and therefore constitute a remarkable and outstanding geological and environmental phenomenon.

Namibia's **varied rock formations** host a number of ore deposits, the development of which is directly related to the geological processes described above. **Ore deposits** are mined to extract metals and other valuable materials that are used to manufacture most of what we use in everyday life. One must remember, everything we consume that cannot be farmed or harvested, needs to be obtained by mining.

2.2.2 LITHOSPHERE - SOILS

Soils are the skin of the Earth, and form a comparatively thin layer covering the rocks of the lithosphere. They therefore occur at the interface between the atmosphere, lithosphere, hydrosphere and biosphere. Soil consists of a mixture of minerals, the soil matrix, organic matter, as well as a porous component that holds gases and liquids. Countless micro-organisms and smaller organisms live in soil and form an integral component of it.

Soils have four important **functions**, namely to support plant growth; store, supply and purify water; modify the Earth's atmosphere; and provide a habitat for organisms. In turn, plants, water, climate and organisms modify the soil. Soil is an important resource which is at the basis of food security, and the responsible and sustainable use thereof is of utmost importance, in particular in countries were fertile soils do not occur in abundance, which is the case in Namibia.

Soil formation is the combined effect of **physical (disintegration)**, **chemical (decomposition)** and **biological** processes that affect the rocks from which the soil forms. Weathering is usually confined to the top few metres of rocks, as the physical, chemical and biological stresses generally decrease with depth.

Five classic factors work together in the **formation of soil**, namely the parent rock, climate, topography of the landscape, organisms and time. As constituents of the weathered rock are moved within the developing soil, distinct soil horizons develop.

Rocks, whether their origin is **magmatic**, **sedimentary** or **metamorphic**, are the source of all soil mineral materials. As the parent material is chemically and physically weathered, transported and deposited, it is transformed into soil. Typical parent mineral materials are the common rock-forming minerals quartz, calcite, feldspar and

Important soil formation definitions

Disintegration/Physical weathering
Disintegration is when rocks are weathered through mechanical processes without chemical change. The main process is abrasion caused by temperature, pressure, frost etc.

Decomposition/Chemical weathering
Decomposition is a chemical weathering process which occurs when the minerals in rocks interact with water to create various chemical reactions. It is a gradual and ongoing process as the mineralogy of the rock adjusts to the near surface environment.

Biological weathering
A number of plants and animals may create chemical weathering through release of acidic compounds, i.e. the effect of moss growing on roofs is classed as weathering. Mineral weathering can also be initiated and/or accelerated by soil microorganisms.

Bioturbation
Bioturbation is the reworking of soils and sediments by animals or plants.

Aeolian sedimentation
This is the deposition of sand due to wind action.

An example of soil formation

An example of the development of a soil begins with the weathering of the bedrock, which would produce the purely mineral-based parent material from which the soil texture forms. Soil development proceeds most rapidly from bare rock in a warm and moist climate, and takes much longer in an arid environment. This is followed by the establishment of lichen and cyanobacteria, followed by plants capable of growing on rocky surfaces, even though there is very little organic material. The plants are supported by the porous disintegrating rock as it is filled with nutrient-bearing water that carries dissolved minerals from the weathering rocks. This allows crevasses and pockets to form that can hold fine materials which in turn start to harbor plant roots. The developing plant roots are associated with fungi which contribute to the break-down of minerals, thus assisting in breaking up the porous rock. By these means, organic matter and fine mineral soil accumulate with time to form proper soil horizons.

mica. Soils that develop from their underlying parent rocks are called residual soils. However, most soils derive from transported material that has been moved by water, wind, ice and/or gravity from its source of origin to the point of deposition.

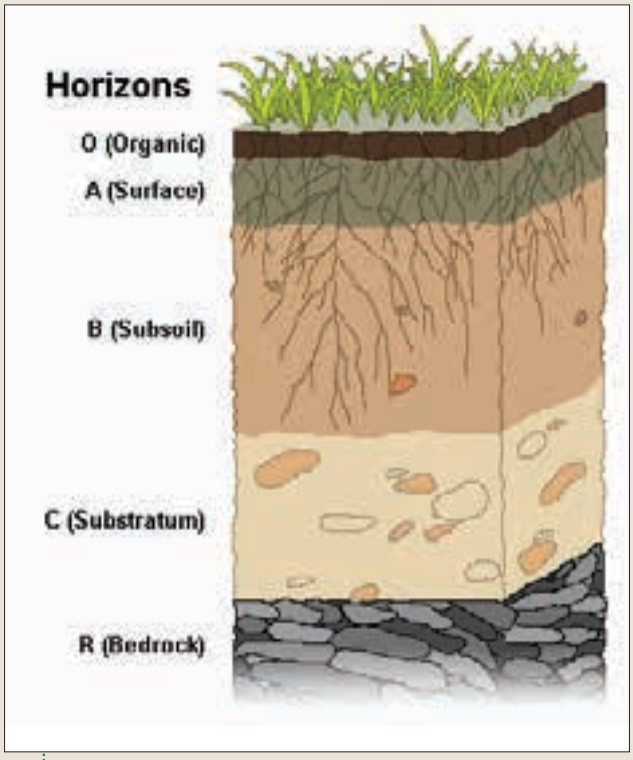
The principal **climatic** factors affecting soil formation are **precipitation** and **temperature**, both of which affect the rates of physical, chemical and biological processes. Temperature and moisture both influence the organic matter content of the soil through their effects on the balance between plant growth and microbial decomposition. Climate is the dominant factor in soil formation, and soils show the distinctive characteristics of the climate zones in which they form. Rocks that will decompose and form soils in a few years in tropical climates, will remain unaltered for millions of years, should that environment become a desert. The reduced vegetation cover of semi-arid and arid areas contributes further to a lack of soil development in dry areas.

The **topography** of a landscape is characterized by slope, elevation and orientation of the terrain. Topography determines the rate of runoff of rainfall, as well as erosion. Steep slopes, for example, encourage rapid soil loss by erosion and allow less rainfall to enter the soil before running off, and hence protecting the rocks from chemical weathering.

Plants, **animals**, **fungi** and **bacteria** all affect soil formation. Animals and micro-organisms, such as earthworms, ants and termites, mix soils as they form burrows and pores, allowing moisture and gases to move about. In the same way, plant roots open channels in the soil. Fungi and bacteria facilitate various chemical exchanges between the roots and the soil, and in doing so create more nutrients within the soil.

Time is the overarching factor affecting all the other factors discussed. Depending on the other factors, it takes decades to several thousand years to develop a proper soil profile. Because of the lack of precipitation, in many parts of Namibia, soil takes a very long time to form.

Soils have **distinctive layers**, usually three or four.



Typical profile of soil horizons
(Source: commons.wikimedia.org/w/index.php?curid=46207693)

The top horizon is called **O-horizon**, and consists of a surface layer of small bits of plant and animal matter in relatively non-decomposed form.

It is underlain by the **A-horizon**, which represents the top or **surface soil**, made up of organic material mixed with mineral matter. This layer is where most of the organic matter accumulates and where most of the soil life is found. It is usually depleted of iron, aluminum, organic compounds, and other soluble constituents. A-horizons may also be the result of a combination of soil **bioturbation** and surface processes that winnow fine particles from biologically mounded topsoil. In this case, the A-horizon is regarded as a "biomantle".

The **B-horizon** or subsoil occurs underneath the A-horizon, and is a subsurface layer that is created from chemical or physical alteration of the parent material. This layer accumulates iron, aluminum and organic compounds from the A-horizon above.

The B-horizon is underlain by the **C-horizon**, which represents the parent rock in various stages of decomposition. It is also called **substratum**. This layer may accumulate the more soluble compounds.

The layer of partially weathered bedrock at the base of the soil profile is called **R-horizon**. Unlike the above layers, R-horizons largely comprise continuous masses of hard rock that cannot be excavated by hand, and usually occur deep down in the profile. Soils formed in situ will exhibit strong similarities to this **bedrock** layer.

The **structure** of a soil is another important characteristic, as it describes the relationship between solid particles and pore space. This, in turn, determines how individual solid parts of the soil bind together, and the arrangement of pore space between them. Soil structure therefore has a major influence on water and air movement in the soil, as well as biological activity, root growth and seedling emergence.

Extensive physical weathering and erosion under arid and semi-arid conditions are the dominant **soil forming processes** in Namibia. Fluvial transportation is a prominent feature in the central highland areas associated with widespread sheet erosion. Over 70% of Namibia's surface area can be classified as highly susceptible to erosion activities, making soil development very difficult in general.

Soil forming processes, which are commonly found in the central highlands of Namibia, are mostly associated with weathering of the bedrock without erosion and transport, i.e. the soil forms in place of the bedrock. Morphologically, such soil profiles are divided into a lower part with a more or less well preserved **petrographic** substructure of the bedrock material, and into an upper part, dominated mainly by disintegrated rock material, which is also called saprolite. The saprolite material can reach up to several tens of metres in thickness and is dependent on the accompanying relief position, dominated by its erosion gradient and the geological substratum.

Aeolian sedimentation processes are active in the Kalahari and Namib Desert, where dunes and Hamada type landscapes prevail. Chemical weathering is hampered, mostly due to the lack of moisture. In the western Namib Desert, however, the breakdown of bedrock material is caused by salt contained in the coastal fog and derived from the marine environment. Dunes and flat sand plains are morphological features dominant in the Kalahari and the Namib Desert.

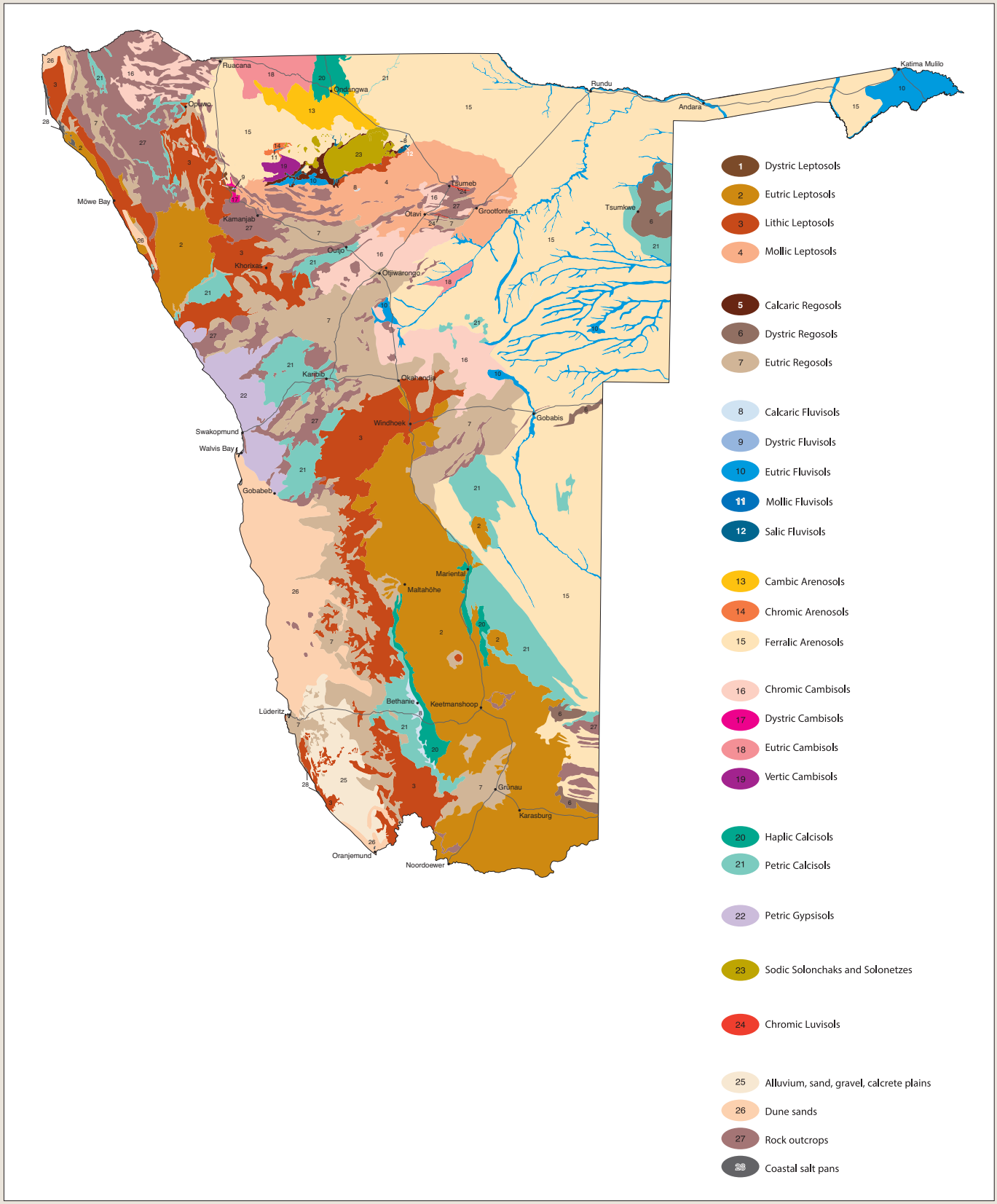
Soils are classified according to their properties, such as the composition, degree of weathering and water retention properties. The United Nations Food and Agriculture Organisation's (FAO) soil classification system, which is widely used internationally, is also used in Namibia. The classification of soils is based on soil properties that depend on the horizons, properties and materials, as well as the processes that formed the soil. There are 32 different soil groups.

According to the Food and Agricultural Organisation's soil classification system, out of the 32 major soil groups the following occur in **Namibia**:

Arenosols, Calcisols, Cambisols, Fluvisols, Gypsisols, Leptosols, Luvisols, Regosols, Solonetz and Solonchaks.

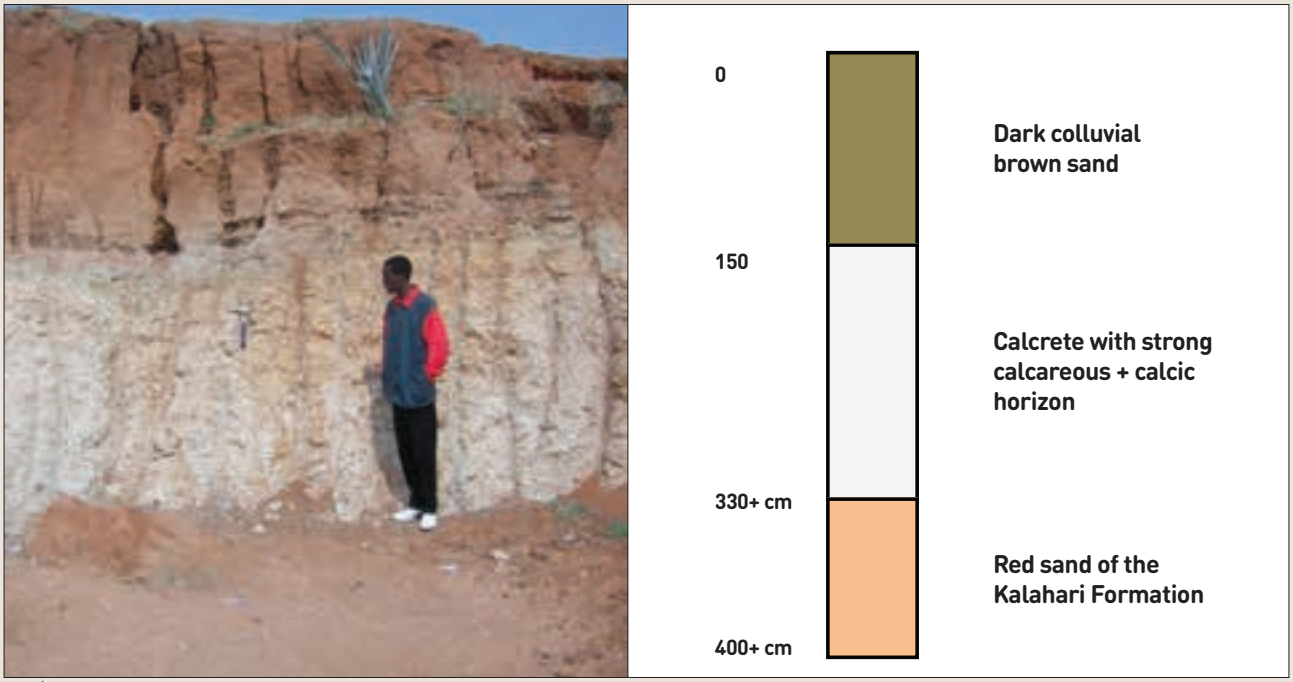
By far the most common soils in Namibia are **Arensols**, **Regosols**, and **Luvisols**. Their main characteristic features include a high sand stratum, low nutrient content, low organic content, alkaline pH-conditions typical for arid climate conditions with high evaporation rates, as well as high salinity.

A large variety of different soil groups such as Cambisols, Gypsisols, Luvisols, Regosols, Solonchaks and Solonetz occurs within the coastal zone, the Namib and the Kalahari areas, whereas the central mountainous plateau, between the Namib and the Kalahari Basin, is mainly dominated by Leptosols and Regosols. Along Namibia's permanent rivers, i.e. the Okavango, Zambezi, Kunene, Kwando-Linyanti-Chobe and the Orange Rivers, Fluvisols are common at various levels adjacent to the rivers on terraces and floodplains. The following map shows the distribution of soils throughout Namibia.



Soils of Namibia

(Source: Ministry of Environment and Tourism, 2002)



Cambisol near Ogongo
(Source: M Schneider, 2009)

Arenosols are formed from wind-blown sand and usually extend to a depth of at least one metre. Sand usually makes up 70% of the soil, with the remainder being clay and silt. The sandy texture allows water to drain through the soil quickly, leaving little moisture for plants and their roots. Few nutrients are retained in the porous sand. Arenosols cover much of eastern and north-eastern Namibia.

Calcisols are found in depressions and typically contain accumulations of calcium carbonate, which can cement the soil underneath the surface to form calcrete. These soils are potentially fertile, but usually lack iron and zinc. Calcisols are often found in areas where the bedrock is marble or limestone.

Cambisols are young soils deposited during sporadic flooding. Since the parent material is only slightly weathered, cambisols are characterized by the absence of larger quantities of clay, organic material, iron and aluminum. However, they have a good water-holding capacity, which gives them the highest potential for crop cultivation. Cambisols occur in the northern and northern-central parts of Namibia. The figure above shows the occurrence of Cambisols near Ogongo.

Gypsisols have characteristic accumulations of gypsum, and are restricted to the very dry areas of the central Namib. The gypsum is dissolved out of the rock and soil, and then carried by percolating waters, before it re-precipitates, sometimes forming the beautiful so-called sand roses. Gypsisols generally have very low levels of fertility.

Fluvisols occur along the larger river courses of eastern Namibia. Some are flooded regularly, especially those along the Zambesi River and its floodplain, while those along the omurambas can be very dry. Some fluvisols can be quite nutrient-rich, and are utilised by farmers in the Kavango and Zambezi Regions.

Leptosols form in actively eroding landscapes, especially in the hilly areas of southern and north-western Namibia. The coarse-grained soils are characterized by the presence of hard rock within 30 cm from the surface. They are therefore the shallowest soils found in Namibia, have a low water-holding capacity, and are easily eroded. They can at best support low densities of livestock and wildlife.

Land degradation next to a watering point
(Source: G Schneider, 2010)

Luvisols occur only west of Grootfontein. These clay-rich soils have a good water-holding capacity and aerated structure, and are hence well suited for agricultural purposes such as crop production.

Regosols are fine-textured soils occurring in actively eroding landscapes. Like Leptosols, they are fairly shallow and never reach depths of more than 50 cm. The central regions of Namibia are dominated by regosols with a sparse vegetation cover, as they cannot provide most plants with sufficient water or nutrients. They can therefore also only support low-density stock farming or wildlife.

Solonchaks and **solonetzes** are the most saline soils. Etosha Pan is the only large area of solonchaks in Namibia, while a sizable area of solonetz soils occurs along the north-eastern border. The soils typically form where evaporation is high, and salt therefore accumulates. Only very specialised plants can grow in such an environment.

A comparison between the geological map and the soil map of Namibia reveals that the soil groups almost follow the major geomorphological and geological boundaries. This is not surprising, as the soils that form in situ reflect the composition of their underlying parent material, whereas transported soils are a function of the geomorphology. This also explains why the soils are not distributed evenly.

Fertile soils only form where the weathering of the parent material allows the formation of a structure with enough pore space to hold water, and to allow the gases to move about. Such **pore structure** will also support the organisms that live in the soil, and which are so important for soil formation.

The **availability of water** is of course also a major factor, as it is required both for the weathering of the parent material, and to sustain the organisms. The **topography** must also be conducive for the deposition of soils. Many of Namibia's mountainous areas do not possess such a favourable topography, whilst the low lying flood plains of the Kavango and Zambesi Regions do.

Namibia's arid environment, with its scarcity of precipitation, is dominated by physical weathering, which alone cannot support soil formation. Even in areas with higher precipitation, only parent rocks that can supply enough nutrients will facilitate the formation of fertile soils. Another limiting factor is the **evaporation rate**, which causes salts to precipitate and soils to become saline. High salinity is not tolerated by most crops.

The cultivation of soil (anthropogenic interventions) also plays an important role in environmental damage to our scarce soil. Scientific and appropriate cultivation methods can improve the fertility of the soils and such examples exist at Hardap, Noordoewer and Stampriet.

As a result, fertile soils are scarce in Namibia, and only occur in selected areas of the country. As it takes thousands of years to form a proper soil profile, soils cannot be considered a renewable resource. They therefore need to be protected at all cost so that they can continue to support Namibia's agricultural sector and all people who live off the soil.

Soil erosion and unsustainable agricultural practices in Namibia

Namibia has seen rapid vegetation change on rangeland due to over-grazing. Overstocking is also often combined with deforestation, which results in species composition change, denudation and soil erosion, especially around water points. Namibia's north-central region has seen a transition from scrub savannah with perennial and annual grasses to open grasslands with predominantly annual grasses and flowering plants. Perennials retain nutrient value for longer into the dry season, and the feed quality has therefore been lost. Life stock has now become adapted to feeding on annual grasses over wider areas, thereby contributing to further denudation, erosion and eventual soil loss.

Rice plantation in the Zambezi floodplain
(Source: G Schneider, 2009)

2.3 ATMOSPHERE

The **atmosphere** is made up of a thin layer of gases that surrounds and insulates Earth. It shields us from radiation given off by the sun and small objects flying through space such as meteoroids. It also protects Earth from the vacuum and cold of space and ensures that overall temperatures remain fairly steady, especially between night and day. It is a moving source of life and essential for our planet's ecology. Without it there would be no air for plants and animals to survive and our Earth would be as barren and dead as the moon.

The atmosphere is made up of five **layers**, each of which operates differently.

The **troposphere** consists of about 80% of the **mass** of the atmosphere and is mainly made up of nitrogen and oxygen. This layer is heated by the Earth's surface and most weather is formed here. Temperature, pressure and density of air reduce as the height (altitude) increases. Hence, high peaks of mountains are snow covered, even in summer and cabins of high flying jets need to be pressurised.

Within the **stratosphere**, an unusual type of oxygen molecule ozone, is abundant and heats this layer as it absorbs energy from incoming ultraviolet radiation from the sun. As a result, it both protects Earth by filtering out harmful ultraviolet radiation and causes the temperature to rise the further away you get from Earth. Because of this, there is very little mixing of gases which makes this layer stable. The air is dry, contains little vapour and is roughly a thousand times thinner at the top of the stratosphere than it is at sea level.

Very little is known about the middle layer, the **mesosphere** given that weather balloons and aircraft cannot fly at this height. It is the coldest place on Earth where temperatures are about -90 degrees Celsius and most meteors entering the atmosphere vaporise upon entry. The mesosphere therefore has a relatively high concentration of iron and other metal atoms arising from meteorites.

Important atmospheric definitions

Troposphere
The troposphere is the layer closest to the surface of Earth and is about 18 km thick.

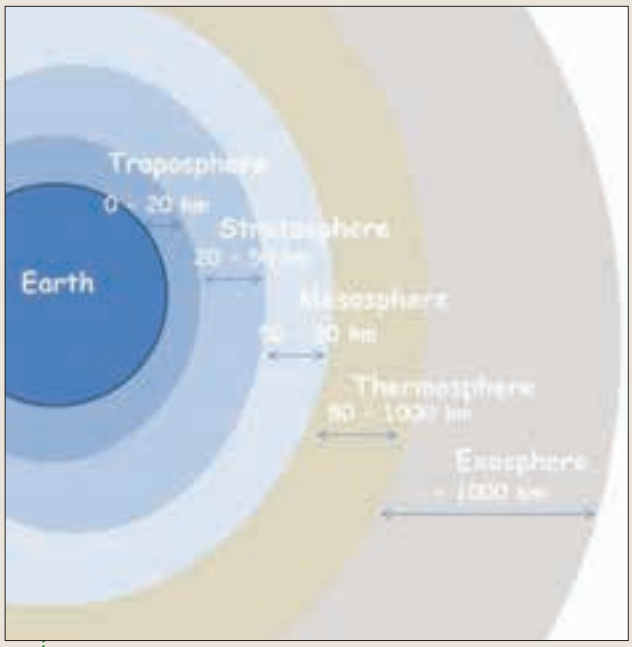
Stratosphere
The stratosphere is the second layer and extends to around 50 km.

Mesosphere
The middle layer consists of the mesosphere and it covers the next 30 km.

Thermosphere
The thermosphere extends from 80 km up to 1000 km.

Exosphere
Although it is estimated to go up to 190 000 km above Earth's surface, there is no clear boundary for the last layer of the atmosphere.

Ozone
Ozone is a gas made up of three oxygen atoms. It occurs naturally in small amounts in the stratosphere, and protects life on Earth from the sun's ultraviolet (UV) radiation.



The layers of the atmosphere
(Source: S Garrard)

Question Box

Q: Where does outer space start?
A: At the edge of the exosphere at about 190 000 km from Earth's surface; although the exact distance is not known as there is no clear boundary. At this point the atmosphere blends into the vacuum of space.

Q: Is the Aurora Borealis (Northern lights) a climate?
A: No. It may be in the sky, but it's not related to climate or weather.

Q: What would happen to the atmosphere if Earth was larger?
A: The atmosphere would be denser. The increased mass and related gravity of a larger planet would pull those gas molecules closer to the surface and pressure would increase.

Q: What would happen to fires if the atmosphere's oxygen levels changed from 21%?
A: Oxygen is essential for fires. If oxygen levels were below 15%, nothing would ever burn. If they were to rise above 25%, fires would become fierce and easily started. Vegetation would never reach maturity under these conditions.

Strange, high altitude clouds called 'noctilucent clouds' or 'polar mesospheric clouds', sometime form near the poles and are much higher up than other types of clouds. Electrical discharges akin to lightning occasionally appear.

Within the **thermosphere** the air is so thin and gas particles collide so infrequently, they become separated based on their chemical composition. Energetic ultraviolet and X-ray photons from the sun also break apart these molecules. Temperatures in this layer can reach highs of 2 000 degrees Celsius and are strongly influenced by solar activity. The Space Shuttle and the International Space Station both orbit Earth within the thermosphere.

The last layer of the atmosphere as it gradually fades into the vacuum of space is the **exosphere**. At this distance, radiation pressure from sunlight exerts more force on hydrogen atoms than the pull of gravity. A faint glow of ultraviolet radiation scattered by hydrogen atoms has been detected by satellites at heights of 100 000 km. This UV glow is called the 'geocorona'. Molecules of gas move in curved 'ballistic trajectories' rarely colliding and eventually being pulled back by gravity. However a small proportion is being lost and the atmosphere is slowly leaking into space every year.

The air we breathe is mainly made up of nitrogen (N_2) (78%) and oxygen (O_2) (21%). The remainder consists of argon, carbon dioxide, neon, helium, and hydrogen. The composition of the present day atmosphere is very different from that of early Earth. Originally it consisted of carbon dioxide (CO_2) and water vapour, probably arising from volcanoes. When Earth cooled the water vapour condensed to create the hydrosphere (oceans and lakes).

The carbon dioxide reacted with calcium and magnesium to produce limestone and vast deposits of this rock precipitated in the sea, greatly reducing the CO_2 content in the atmosphere. This early atmosphere cannot be measured directly so scientists look for indirect evidence, such as the chemical make-up of rocks and the earliest single-celled fossils.

Some fossils suggest early organisms used the process of photosynthesis to use carbon dioxide and release oxygen. This meant carbon dioxide levels went down and oxygen levels went up.

The **layers** of the atmosphere are not separated but interact with each other as the gases circulate around the planet. This movement of molecules helps to form our **weather patterns** and **climate**. It is important to remember that this constant mixing maintains a stable system with respect to temperatures and oxygen levels that helps organisms to survive and limits possible extremes on Earth. There is no single climate on Earth. Instead there are many specialized **climatic regions** and these are linked through the atmosphere. Climatologists study weather patterns over decades and even centuries to understand the way a climate is supposed to behave.

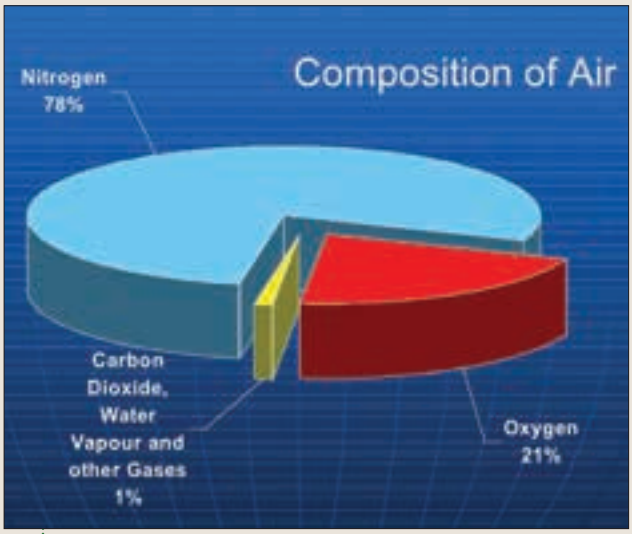
Aurora Borealis visible in Alaska

(Source: travelandleisure.com)

What Are The Northern And Southern Lights?

Like the oceans, Earth's atmosphere has waves that move energy around and create winds. Charged particles (electrons, protons, and ions) collide with atoms of electrically neutral gases exciting them into higher energy states. These ions produce powerful electrical currents at high latitudes and particularly around the magnetic poles. Excess energy is emitted as light, which we see as the colourful auroral display called the Southern and Northern Lights.

Since the beginning of time, people have told stories to explain these natural, but mysterious, occurrences. The Vikings thought they were caused by the shining weaponry of immortal warriors. The Alaskan Inuit people believed the lights were the souls of salmon, deer and other animals. The Menominee Indians thought the lights were the torches of giants living in the North.



Composition of air

(Source: slideshare.net)

The typical climate of Namibia is characterised by a rainy season in summer and a winter season without rain, except for a small amount of rainfall in the south. As the country lies roughly between 17° and 29° south of the equator and along the south western coast of the African continent, the climate is influenced by three major climatic systems. These are the **Intertropical Convergence Zone (ITCZ)** that lies to the north of Namibia, **High Pressure Subtropical Zone (HPSZ)** that lies to the west of Namibia over the Atlantic Ocean and the **Low Pressure Temperate Zone (LPTZ)** that lies to the south of Namibia between the southern tip of Africa and Antarctica.

These three systems move during the year in response to the position of the sun and therefore affect different parts of Earth. They shift south when the southern hemisphere heats up in summer and return north when it cools again in winter.

Namibia's climate is directly affected by the 'struggle' between the ITCZ and HPSZ. The ITCZ feeds warm moist air from the north, while the HPSZ pushes this air back with dry, cold air. Generally it is the high pressure zone that 'wins' and gives Namibia's climate its distinctive dry weather.

Within this high pressure zone there are two particular high pressure cells. These are the **South Atlantic Anticyclone (SAA)** situated out at sea and the Botswana **Anticyclone (BA)** located over the interior of Southern Africa. The SAA causes winds to blow up the Namibian coast from the south and south-west. These strong winds drive the cold waters of the Benguela Current northwards, as well as blowing sand off the beaches and inland to form the barrier of the Namib sand dunes. While the SAA dominates air movement over the coast, the BA controls air movement in the interior.

In **summer** as the ITCZ moves south-wards, it means that the winds of the SAA are less effective at blocking the moist tropical air. Because of this, most rain in Namibia falls during summer. In particular areas in the north of Namibia (Okavango) receive large amounts of rainfall (annual average of 550 – 600 mm).

Important climatic definitions

Climate and Weather
Weather refers to the day-to-day temperature and precipitation activity, whereas climate is the term for the averaging of atmospheric conditions over longer periods of time.

Intertropical Convergence Zone (ITCZ)
The ITCZ is a broad band of air that encircles the Earth at the equator. It is where moisture bearing trade winds from the northern and southern hemispheres meet and giant clouds heavy in rain are typical in this zone.

Subtropical High Pressure Zone (SHPZ)
The SHPZ lies south of the ITCZ and is a band of dry air dominated by cells of high pressure.

South Atlantic Anticyclone (SAA)
This is a stable and powerful high pressure cell which causes descending air to spiral outwards in an anti-clockwise direction.

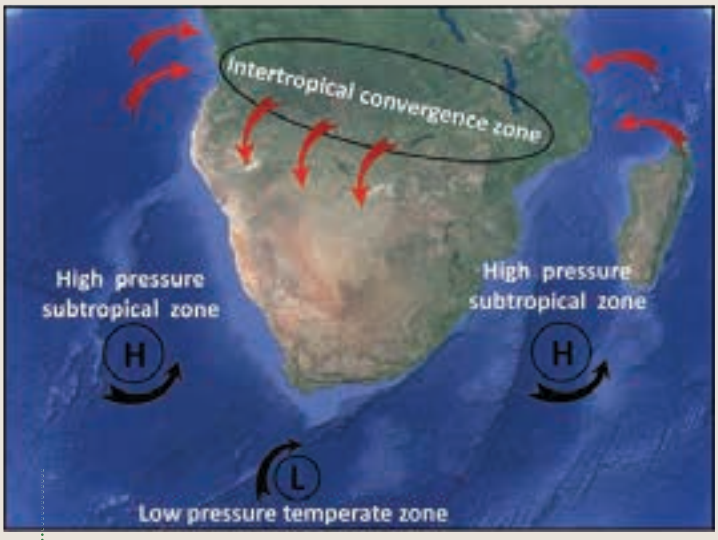
Botswana Anticyclone (BA)
The BA high pressure cell that occurs inland predominantly over Botswana.

Temperate Zone
This zone wraps the bottom of Earth in another broad band of moist air. The main winds are in a westerly direction and carry a number of low pressure systems and cold fronts from west to east, which affect southern Africa in winter.

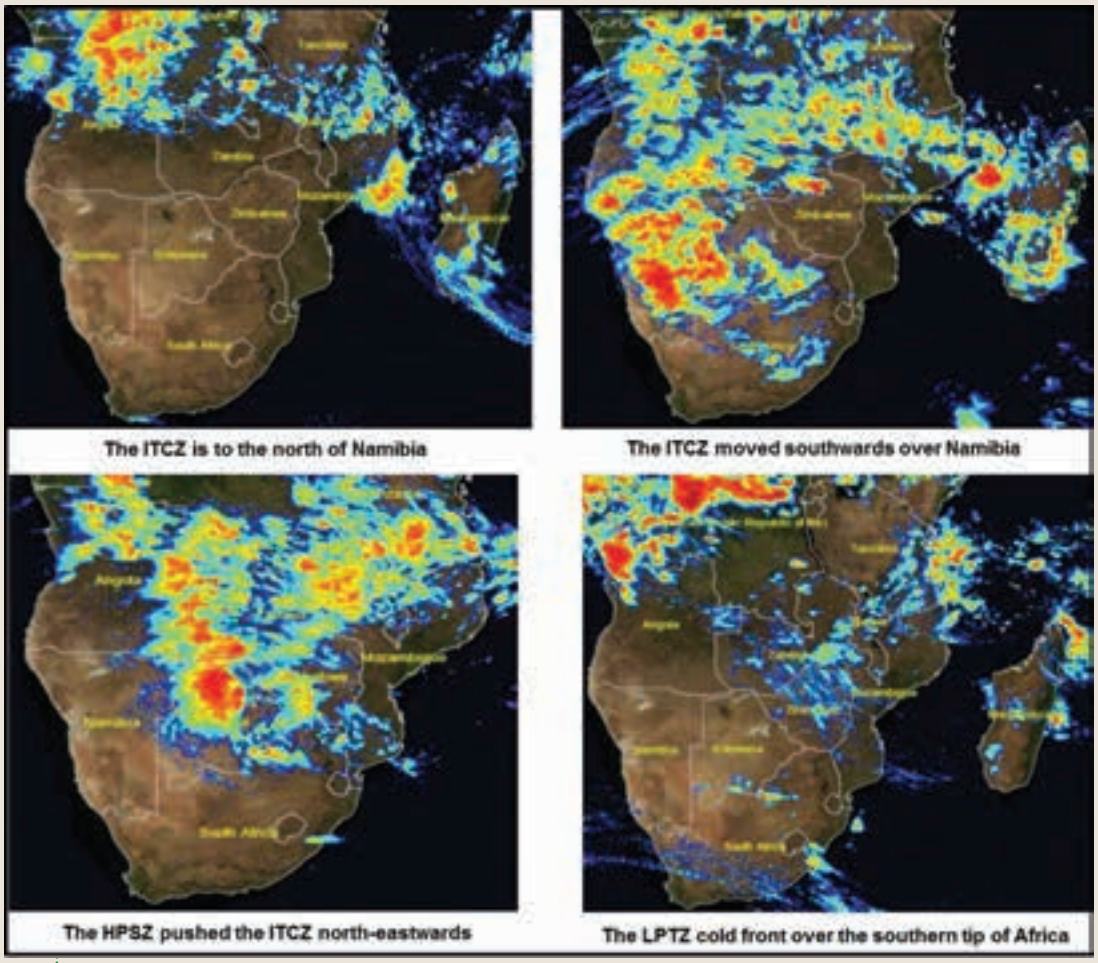
Coriolis force
It is an inertial force (also called a fictitious force) that acts on objects that are in motion relative to a rotating reference point.

In **winter**, however, the ITCZ and SHPZ are further north and the air is dry. Cold fronts sweep across the South Atlantic and Indian Oceans bringing rain to the southernmost tip of Africa. This does extend to southern Namibia where winter rains are typical in the Tsau// Khaeb (Sperrgebiet) National Park.

As a person travels from the north-east to the south-west of Namibia it is clear that there is a **rainfall gradient**. This clearly shows that most rain bearing clouds are fed into the country from the north easterly winds and less moisture remains in the atmosphere the further west and south you travel.



Three major climatic systems affecting Namibia's climate
(Source: P Heyns)



The movement of the ITCZ and its influence on the climate
(Source: P Heyns)

Namibia, like the Sahara Desert has the most variable rainfall in Africa. Frequent shortages as well as flooding are normal. Slight changes to the position of the three major climatic systems (the Intertropical Convergence Zone, the Subtropical High Pressure Zone and the Temperate Zone) can influence the amount and frequency of the rainfall.

Attempts are made to predict the rainfall conditions in Namibia by observing global scale phenomena such as the sea surface temperatures in the equatorial Pacific Ocean close to the South American continent. When these temperatures decline, it is referred to as a *'La Niña'* event and better possibilities for rainfall are predicted for Namibia. When the temperature increases, an '*El Niño'* event may occur and drought conditions can be expected in Namibia.

Wind is a dominating feature of the Namibian coastal climate. It is strongly influenced by the SAA which acts as giant fan, blowing air out of its high pressure in a north-easterly direction towards the south-west coast of Africa. **The Coriolis** force then deflects the air northwards. The winds bring cool air which characterises the relatively temperate and **foggy** climate along the coast. These winds also cause upwelling cells along the coast which are nutrient rich and provide Namibia with its rich fishing resources.

The winds inland are less prominent. However, during winter the BA prevents moist air from flowing in from the north and results in substantial differences in air pressure between the interior and the coast. Hence strong, warm **east winds** develop, reaching speeds of 50 to 60 km/h. These travel westwards towards the coast and carry large quantities of dust and sand.

Fog at Chamais Bay
(Source: G Schneider, 2010)

East wind storm at Gobabeb in the Namib Naukluft Park, about 100 km east of Walvis Bay
(Source: J Henschel)

Important climatic definitions

Desertification
This process is the impoverishment of arid, semi-arid and some sub-humid ecosystems by the combined impacts of man's activities and drought.

Arid and semi-arid areas
An area that receives less than 250 mm of rain is described as arid whereas an area that receives between 250 mm and 500 mm of rain a year is semi-arid.

Climate change is as old as the atmosphere itself. It is indisputable that climates have changed radically in the past in southern Africa; and it is certain that they will change again in the future. Periods of warmth and cold, drought and flood, famine and plenty have occurred repeatedly in the past. At least three major ice ages are known to have affected southern Africa; each lasted several million years. Between the ice ages, considerably warmer conditions prevailed.

Since the turn of the century, approximately 9-year spells of either predominantly wet years, with above normal rainfall; or predominantly dry years with below normal rainfall, have occurred. These spells have affected most of southern Africa, although not always in the same time or region. In general the dry spells have been more persistently dry then the wet spells wet. The living habits of millions of people have had to adjust to these varying conditions, particularly rural populations, who rely primarily on natural resources for subsistence livelihoods.

This is particular to areas where great demand is placed on natural resources such as food, water and energy. The balance between supply and demand can be seriously affected by small changes to climate. Such areas often occur on the margins of deserts or in subtropical **semi-arid areas** which are prone to droughts. Southern Africa falls within this area and much of the subcontinent is prone to **desertification** that may be triggered by drought. Namibia, given its arid environment, is considered the seventh most vulnerable country in the world to the effects of climate change.

Although climate change is a natural phenomenon, there is clear evidence to indicate that recent climate change increases are due to human-induced causes; namely the release of carbon dioxide and other greenhouse gases. Climate change, greenhouse gases and the impact of global warming are discussed in further detail in Section 2.6.

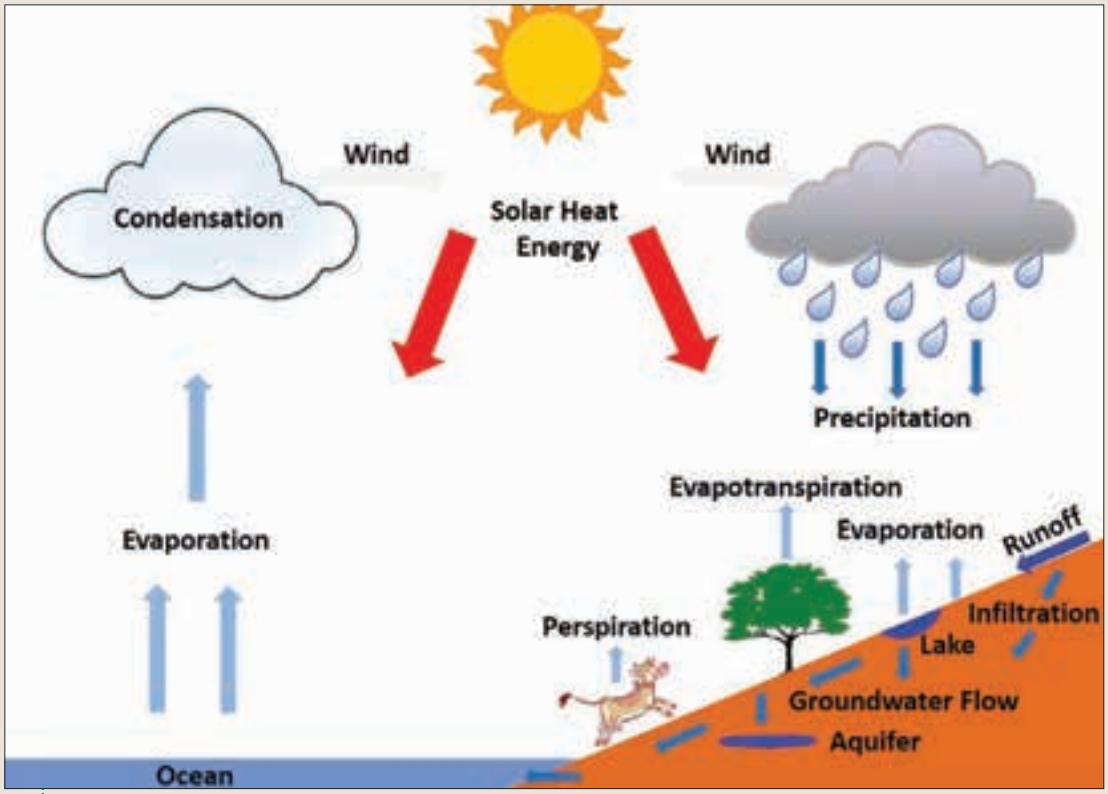
2.4 HYDROSPHERE

2.4.1 HYDROSPHERE - FRESHWATER

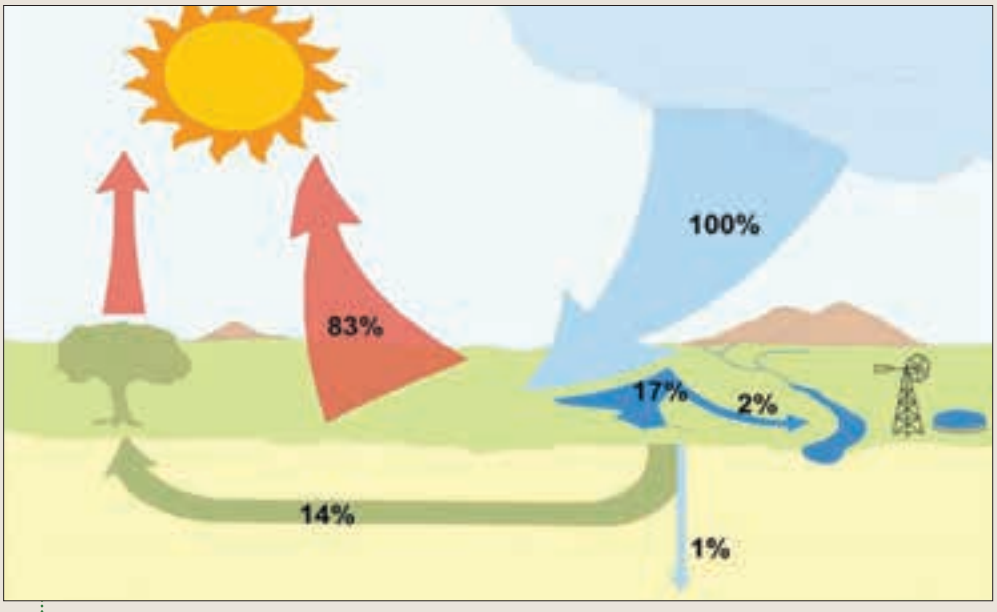
The **water cycle** is driven by the energy from solar heat and the weather systems as described in Chapter 2.3. The heat of the sun **evaporates** water from the surface of the ocean and the invisible water vapour cools as it rises. The rising water vapour may remain invisible or **condense** into clouds at altitude. At the same time the sun also heats the land 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 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 water, or hail or snow.

Once the **precipitation** reaches the ground, the force of gravity takes over and the water may run off on the surface or infiltrate into the ground. Some water may also evaporate back into the atmosphere. Surface runoff flows downhill and accumulates in rivers flowing into the ocean or in surface water bodies such as lakes, wetlands or dams. Water that infiltrates into the ground percolates back to the sea under gravity or it accumulates in aquifers and becomes available as groundwater, or it remains as soil moisture which is used by the vegetation. When the vegetation uses the soil moisture, the water is released back into the atmosphere through **evapotranspiration**.

Most rainfall in Namibia falls from the beginning of December to the end of March and precipitation occurs by means of scattered thunderstorms which can be very intense, but of a short duration.



Water cycle
(Source: P Heyns)

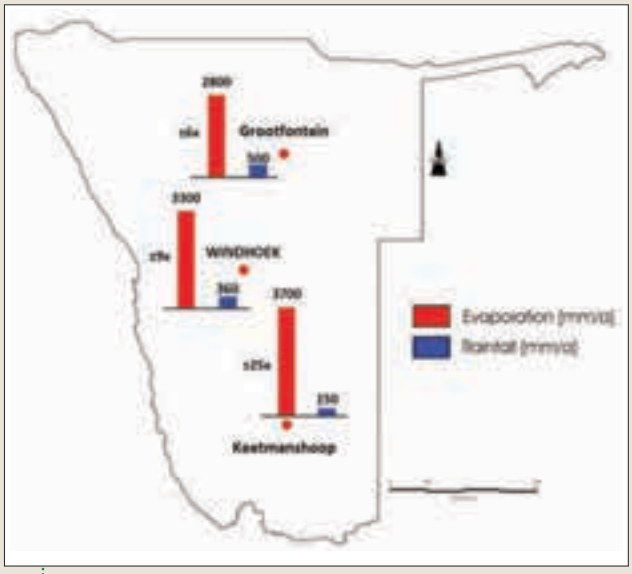


Water balance in Namibia
(Source: P Heyns)

The rainfall is low, variable, erratic, unreliable, spatially unevenly distributed across the country and extremely difficult to predict accurately. Rainfall in arid regions is not only low, but variable, because there can be a huge deviation from the average. In some cases the actual rainfall in a good rainy season can be two times the average or half of the average in a poor rainy season. When rainfall occurs, it is usually unevenly distributed across the land and it may happen that there is a high intensity rainstorm at one place and no rainfall at another, possibly only five kilometres away.

The **mean annual rainfall** varies between zero along the coastline on the Atlantic Ocean to about 700 mm in the north-eastern Zambezi Region. The average mean annual rainfall over the whole country is 250 mm/a and in theory, the total precipitation is estimated at about 200 km^3/a.

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 aridity and the reason why Namibia is the most arid country south of the Sahara. From a hydrological point of view, Namibia is a truly dry, water deficit country.



Deficit between annual rainfall and evaporation
(Source: P Heyns)

These conditions make the occurrence of rainfall unreliable and it is therefore difficult to predict the rainfall conditions that will prevail during a rainy season. This causes an uncertainty about the expected availability of water for agricultural purposes such as dry land crop production and stock farming, as well as for domestic, industrial and mining use.

In order to provide an indication of what the effect of low rainfall, aridity and water scarcity in Namibia means, the mean annual rainfall information has been translated into a **water balance** model to illustrate the situation.

It is estimated that after a rainfall event, on average, 83% of the precipitation on the ground is immediately lost to evaporation. Only 2% of the rainfall ends up as surface run-off into the rivers and 1% infiltrates into groundwater aquifers. The 14 % balance of the rainfall infiltrates the soil and is available to be used by the vegetation to produce biomass while the water is productively lost back to atmosphere through evapotranspiration.

This theoretically means that of 100 drops of rain, only 17 drops are available as surface water which could be impounded in dams, or groundwater that can accumulate in aquifers and as soil moisture that becomes available for the plants. This water is not much, but critical to support socio-economic uses such as domestic, animal, industrial and mining water supply, irrigation, power generation, recreational uses and biodiversity. The following table provides a summary of the water balance of Namibia.

USE	BALANCE (%)	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**

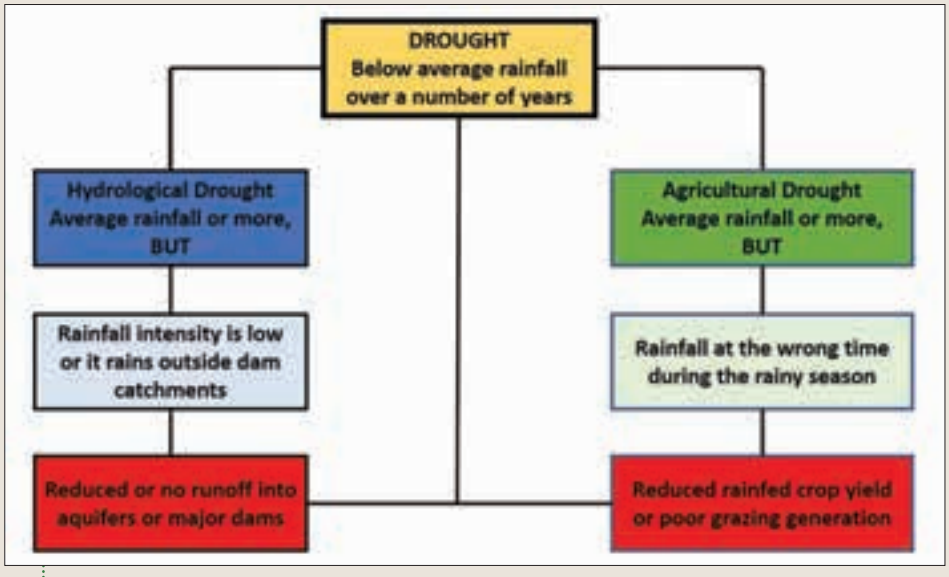
Water balance in Namibia

The 14% portion of the rainfall that infiltrates the parched soil after the dry season is utilised by the natural vegetation and is therefore of critical importance to sustain stock farming, dryland crop cultivation and the preservation of biodiversity. In this regard it is important to know that when overgrazing has denuded the landscape of grass, there is no vegetation that can use the rainfall to generate biomass and the water just runs off unused or evaporates. It is therefore wise to practice good grazing management in order to preserve the grass cover so that biomass can be generated for sustainable and economic stock farming. The farmer should consider to: *"First farm with grass rather than to farm with cattle".*

In an arid country like Namibia, low rainfall is not only expected, but the norm. Rainfall is also very difficult to predict in arid climates because there is in any case a huge natural variation in local precipitation. 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 it is for example predicted that there is a 40% probability of rainfall over Okahandja, one can also argue that there is a 60% probability of no rainfall. If a 40% probability for rainstorm occurs, it is also not really possible to predict exactly where the rainstorm will occur or how much rain will precipitate.

It is well known that the country is technically in a continuous low, average summer rainfall situation. High and low rainfall seasons occur on a periodic basis and there may be some rainy seasons with above average rainfall and very few with exceptionally high rainfall. Many people may think that there was a **drought** when the average rainfall has actually precipitated, but a drought is a relative phenomenon which refers to exceptionally low rainfall conditions during a number of successive rainy seasons.

Drought is therefore something to be expected and must be managed, but in rare occasions, when below average rainfall conditions are so severe or protracted that they are beyond what can reasonably be dealt with in terms of **normal drought** risk management practices, a **disaster drought** can be declared. In such cases, State intervention is considered justified to introduce drought relief measures.



Drought occurrence
(Source: P Heyns)

The type of droughts in Namibia can be classified into two main groups. These are referred to as a **hydrological drought** and an **agricultural drought**.

A **hydrological drought** occurs when the total precipitation during the rainy season is according to the expected average or more, but there was very little or no runoff in the rivers and therefore no water that could be impounded in a dam. A hydrological drought can also be subdivided into a rainfall drought and a runoff drought.

A **rainfall drought** occurs when there is either too little (or no) rainfall in the catchments of dams or when the average rainfall (or better) falls, but the intensity of the rains is so low that no or reduced runoff events occur.

A **runoff drought** can occur when there is not enough rainfall in the catchments of the major dams to cause sufficient runoff from the rivers into the dams. A runoff drought can also be caused by the recovery of vegetation after the previous rainy season, or when initial light rains at the beginning of a rainy season do not cause runoff events, and by the time heavier showers occur later during the rainy season, less water runs off because the increased vegetation cover holds the water back. A runoff drought in the catchments that yield water for the major dams in Namibia can lead to a water crisis.

An **agricultural drought** refers to the failure of rain fed crop cultivation or the poor condition of the natural vegetation available for grazing as a result of generally low rainfall during a rainy season, or where average rainfall or better occurred, but the rain fell too early or too late to be of value during the optimal growing season. Hence the length of the rainy season and the spread of rainfall events during the rainy season in relation to the growing season are therefore critical for successful crop production and grazing. The rainfall frequency is also important for crop production because most arid countries have only between 20 to 60 days per year when rainfall occurs.

An unfortunate aspect about an arid climate is that it is virtually impossible to predict the outcome of a rainy season. The prediction of crop yield is seriously affected by these erratic climatic conditions and has a major influence on staple food production.

The best approach for farmers is perhaps to use their experience and intuition. It is better to prepare the land and to plant after the first rains, instead of waiting to see what will happen. This implies that there are certain risks for the farmer and if the rains fail to come, the government should assist those farmers to recover their production losses. However, a government can

Perennial and ephemeral rivers of Namibia
(Source: P Heyns)

similarly also not take such a risk as far as the national food supply is concerned and has a responsibility to make contingency plans to ensure that a secure supply of staple food will be available in case of a crop failure, even long before the onset of a rainy season.

All water resources come from rainfall and in Namibia a distinction is made between four types of **water resources**. These are **perennial surface water**, **ephemeral surface water**, **groundwater**, and **unconventional water sources**.

Perennial surface water is runoff in rivers or fountains flowing out on the surface throughout the year. Although the flow is perennial, it is also seasonal in nature because the flow is higher during the summer rainy season than in the winter. There are no perennial rivers in the interior of Namibia and the only perennial river runoff that the country has access to occurs in the perennial rivers on the northern and southern borders of Namibia. They are:

- The **Kunene** in the northwest, forming the border between Angola and Namibia, and flowing into the Atlantic Ocean;
- The **Okavango** in the northeast, forming the border between Angola and Namibia, and flowing into the Okavango Delta in Botswana;
- The **Zambezi** in the far northeast, forming the border between Namibia and Zambia, and flowing into the Indian Ocean; and
- The **Orange River**, forming the southern border between South Africa and Namibia, and flowing into the Atlantic Ocean.

The flow in these rivers originates in the neighbouring countries, some as far away as Lesotho, but under international law, Namibia has an inalienable right to a sustainable, equitable, and reasonable share in the water of those rivers. However, the other basin states have the same right, and the share of each sovereign state must be negotiated between the river basin states to ensure

that allocation of water to each state is fair and that the environmental integrity of the rivers are not adversely affected by overuse or other forms of exploitation.

The only perennial rivers that flow through terrain where it is possible to build dams to store water for long term use in the arid interior of Namibia, or to generate hydropower, are the Kunene and the lower Orange.

While perennial river water is located on the borders and easily accessible in the border areas, the water is remotely located from the water users in the interior of Namibia. This means that it must be transported over long distances by pipelines or canals to reach consumers.

The **perennial fountains** in Namibia normally originate from groundwater flowing out on the surface and have been an indispensable source of water during the dry season for the indigenous peoples of the country for centuries. Many towns in Namibia are located at places where open water from fountains made it possible for people to settle, for example Windhoek, Rehoboth, Keetmanshoop, Otjiwarongo, Gobabis, Grootfontein, Otavi and Outjo. However, the flow of water from fountains and springs is insignificant in comparison to the availability of water from the other sources of water. Due to the erratic rainfall conditions in Namibia, the flow of the rivers in the interior of the country is **ephemeral**, irregular and unreliable. Therefore, dams have to be constructed to capture this water during the rainy season and store it for use during the whole year.

Eleven major dams have so far been constructed in the country to utilize some of this potential. The total storage capacity of those impoundments is about 1522 Mm^3 but the 95% assured safe yield is **only 207 Mm^3/a or 13%**, which is an indication of the low efficiency of surface water storage facilities in an arid environment.

It is estimated that the sustainable safe yield from the dams that could be constructed on the ephemeral rivers in Namibia to utilize the seasonal surface runoff, is at least 200 million cubic metres of raw water per annum (Mm^3/a).

Due to the high rate of evaporation from open water surfaces in dams, it is important to conserve as much of the water available in the dams as possible. This can be done by the following means:

- To transfer the water from dams with less favourable evaporation characteristics to dams with more favourable evaporation characteristics;
- to store the water from a dam underground in an aquifer;
- to use the water in a dam at a higher yield, or before it evaporates, but at a lower reliability.

In many cases the rainfall causes the rivers to flow, but the runoff is not enough to reach a dam or to flow into the sea and the river may even dry up on the way because all the water infiltrated into the river bed. This has the advantage that the water can become available as groundwater and groundwater cannot evaporate. This makes it possible to use surface water and groundwater on a conjunctive basis.

The occurrence of groundwater in Namibia is broadly associated with six types of hydrogeological environments.

These are **alluvial aquifers, porous sediments, carbonate rocks, secondary structures in sedimentary or crystalline rocks and volcanic intrusions**. The magnitude, recharge potential and supply capacity of the groundwater sources depend on rainfall and the hydrogeological conditions while the quality of the water is affected by the geology and the age of the water.

The adverse climatic conditions also make groundwater a very scarce resource. More than 150 000 boreholes have been drilled in Namibia to find water and to understand the hydrogeological environment. About 60% of the boreholes drilled are suitable for the purpose for which they have been drilled and can be considered successful. The number of boreholes in use in Namibia today is about 40 000 and about 45% of the water used in the country comes from groundwater. It is estimated that the sustainable safe yield of the useable groundwater sources in the country is at least **300 Mm^3/a**.

The **total assured yield of both surface and underground water resources**, excluding the perennial rivers, is estimated at only 500 Mm^3/a.

There are a number of **unconventional methods** to conserve water which is seen as an additional source of water that does not have to be supplied from new water and is therefore regarded as **unconventional water resources**. These are:

- The recycling of water in industrial and mining processes;
- the reuse of water for industrial or irrigation purposes;
- the reclamation of domestic sewage effluent to potable water quality standards;
- the conjunctive use of surface water and groundwater;
- the artificial recharge of groundwater resources with surface water;
- the banking of treated surface water in depleted aquifers, also referred to as managed aquifer recharge;
- the use of pumped storage dams;
- The use of storage dams off the rivers;
- the desalination of brackish groundwater or sea water; and
- Water demand management.

When water is **recycled**, water that has been used in an industrial or mining process or in a thermal power plant is reused without improving the quality of the water before it is used again.

When water is **reused**, waste water or domestic sewage effluent is treated and disinfected to achieve a quality that allows the water to be reused for watering sport fields or public gardens and it is also possible to release the water back into a natural stream.

When water is **reclaimed**, waste water or domestic sewage effluent is treated and disinfected to achieve potable water quality, which means it is fit for human consumption.

It is estimated that the existing facilities producing unconventional water resources can yield at least 15 Mm^3/a, but there is much more potential still to be developed. Other options which have been investigated in Namibia are rainwater harvesting, fog harvesting and weather modification, but these have only limited applications and are generally considered to be of no major economic value. Public water awareness to save water, to practice water conservation and make more efficient use of water are all seen as additional measures to stretch the availability of existing water sources.

Public gardens in Swakopmund are irrigated with semi-purified water
(Source: G Schneider, 2017)

The Windhoek Water Reclamation Plant reclaims potable water from domestic waste water
(Source: Wingoc)

2.4.2 HYDROSPHERE - OCEANS

Oceans compose much of the planet's hydrosphere and cover almost 71% of Earth's surface. Despite this, oceanographers have shown that less than 5% of the oceans have been explored.

As the world ocean is the principal component of Earth's hydrosphere, it is integral to all known life, forms part of the carbon cycle, and affects climate and weather patterns. The world ocean is the habitat of 230 000 known species, but because much of it is unexplored, the number of species that exist is likely to be much larger, possibly over 2 million. The origin of oceans remains unknown. They are thought to have formed in the Hadean period and may have been the impetus for the emergence of life.

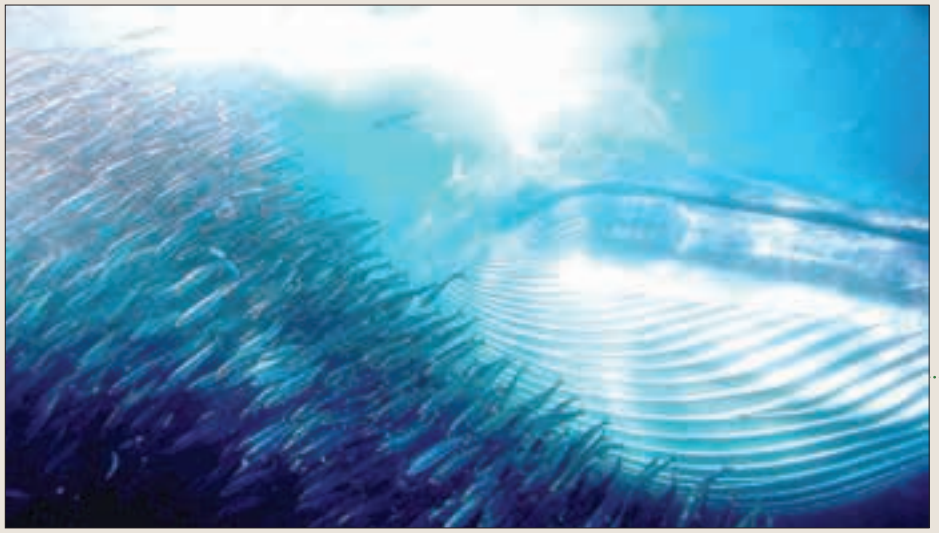
There are five oceans covering the planet, namely the Pacific, Atlantic, Indian, Southern (Antarctic), and Arctic Oceans. Southern Africa is bordered by the Atlantic Ocean to the west and the Indian Ocean to the south and east.

The **Benguela Current** is one of several large, cold currents that flow along the western margins of the world's continents. It flows northwards along the western boundary of Namibia at a speed of between 400 and 1 000 m per hour, and together with the South Atlantic Anticyclone strongly influences weather patterns along the coast. It is fed by the South Atlantic Ocean and via the Agulhas Current of the south coast of South Africa. The Angola – Benguela Front forms the northern limit of the current, generally near the mouth of the Kunene River. To the west lies the **continental shelf** about 150 km off the coast (at a depth of 200 m).

Winds are one of the main physical drivers of the Benguela Current, both on an oceanic scale, generating the heavy south-westerly swells that are typical of our coastline, and locally, through the northward-flowing long shore currents which deposit large amounts of sediments along the coast. The water is swept away from the shore due to winds driven by the South Atlantic Anticyclone and the effects of the **Coriolis force**. Upwelling cells form behind these offshore flows due to deep water rising to replace the surface water. These cells are rich in inorganic nutrients; the major contributors being nitrates, phosphates and silicates.

Groups of drifting microscopic plants, called **phytoplankton**, consume the nutrients once they reach the sunlit surface.

These plants serve as the basis for a rich food chain which ranges from minute animals called **zooplankton** right up to pelagic baitfish (e.g. anchovy, pilchard, round-herring), **demersal** fish (hake, orange roughy, monkfish), **predatory** fish (snoek), mammals (e.g. seals and dolphins) and seabirds (e.g. African penguins, cormorants, pelicans, terns and others).



Shoal of sardines being chased by a whale
(Source: Michael AW, medium.com/vantage)

African Penguin
(Source: BCLME)

These nutrients and associated blooms of phytoplankton support some of the highest concentrations of zooplankton and other marine life found in the world, hence providing the Namibian coast with exceptionally rich fish and marine resources. The Lüderitz Cell is the most important and largest of the upwelling areas. From these, the northward flowing Benguela distributes the nutrients up the coast. Smaller upwellings also occur along the coast at Cape Fria, Palgrave Point and Conception Bay.

The value of the fish resource has varied over the years. The reason for this is complex but there is consensus that this is due to overfishing, often by illegal fishing vessels from other countries, as well as changes to the plankton populations. Namibia now has an exclusive economic zone extending 200 nautical miles (equivalent to about 370 km) off the coast to protect its marine resources.

Although the Benguela is generally a cold current, water temperatures along the coastline do vary a good deal during the year. The coldest water is in the south and close to the coast, especially in the area of the Lüderitz Cell upwelling. Cold water spreads north during the winter as a result of the stronger south westerly winds, while relatively warm, salty and nutrient poor water from the Angola Current pushes south in the summer.

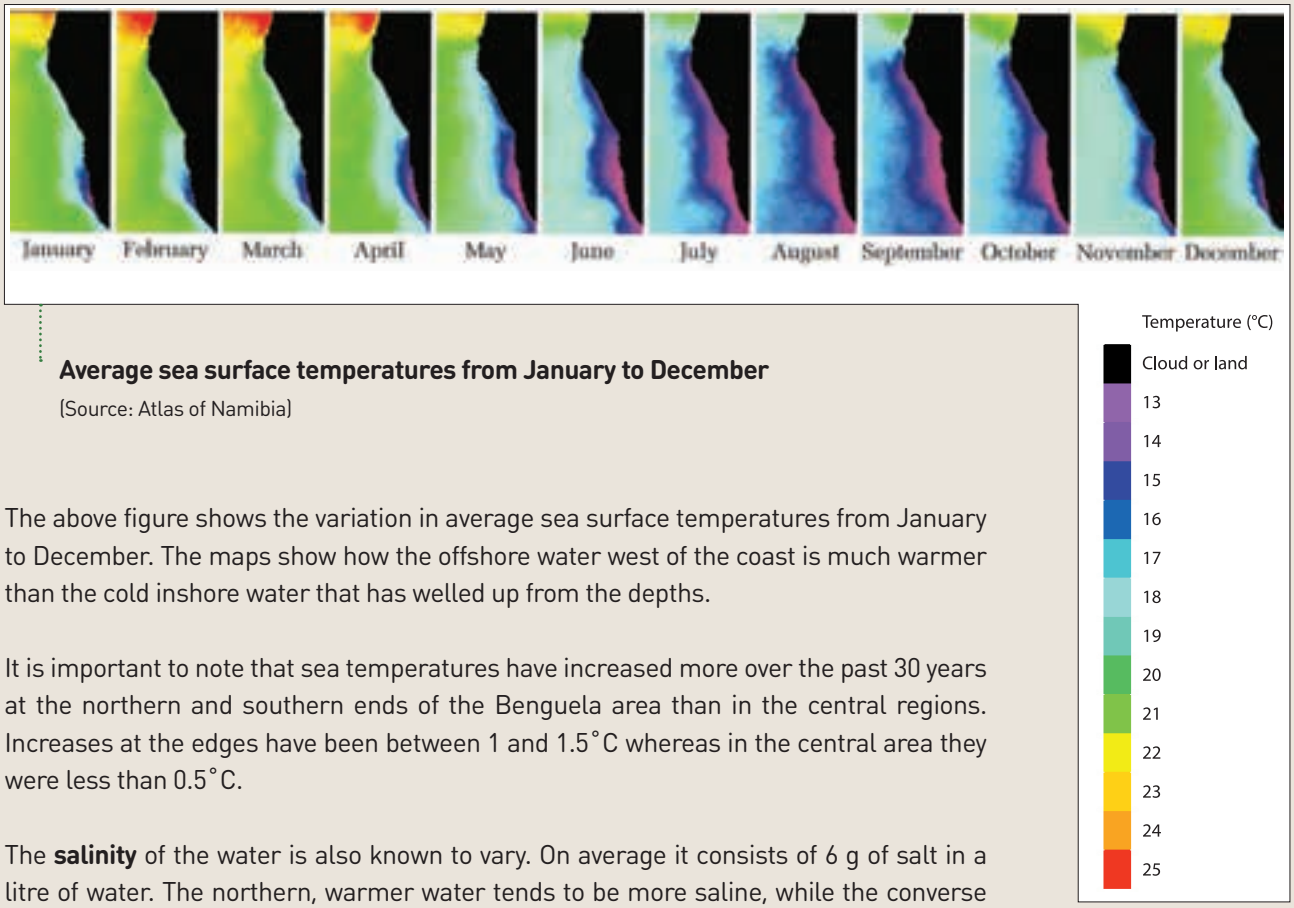
Important oceanic definitions

Demersal
Deep water species that occur at the sea bottom far off the coast.

Pelagic
A group of fish that inhabits the water column (not near the bottom or the shore) of coasts and open oceans. They occur closer to the shore and water surface than demersal species.

Phytoplankton
Phytoplankton are microscopic organisms that inhabit the upper sunlit layer of almost all oceans and bodies of fresh water on earth. They create organic compounds from carbon dioxide dissolved in the water, a process that sustains the aquatic food web.

Dinoflagellate
Dinoflagellate is a large group of flagellate eukaryotes (single celled organisms). Most are marine plankton, but they are also common in freshwater habitats.



Average sea surface temperatures from January to December
(Source: Atlas of Namibia)

The above figure shows the variation in average sea surface temperatures from January to December. The maps show how the offshore water west of the coast is much warmer than the cold inshore water that has welled up from the depths.

It is important to note that sea temperatures have increased more over the past 30 years at the northern and southern ends of the Benguela area than in the central regions. Increases at the edges have been between 1 and 1.5˚C whereas in the central area they were less than 0.5˚C.

The **salinity** of the water is also known to vary. On average it consists of 6 g of salt in a litre of water. The northern, warmer water tends to be more saline, while the converse is true for the southern cold water. Both, temperature and salinity, affect the density of water and hence impact flows, as water will move from zones of higher to lower density.

Other than man made threats, there are various natural events that interrupt or limit biological production along the Namibian coast. The most severe of these are the **Benguela Niño events** which result when the warm water from Angola sometimes persists much longer than normal. This warm water reduces the upwelling and limits the availability of oxygen in the water. In addition, in areas of high productivity, excessive amounts of phytoplankton and zooplankton can strip all the available dissolved oxygen, and leads to mass mortality of these organsims.

This phenomenon associated with the Benguela system phenomenon is called the **black tide**. Subsequent anoxic (without oxygen) decomposition of the organic material by sulphur reducing bacteria can result in the formation and release of methane and hydrogen sulphide from the sea bed. These eruptions can have a devastating effect on marine animals given that hydrogen sulphide is a respiratory poison.

Methane release is also of concern as it is a major greenhouse gas. During black tides the sea water is brown, yellow froth can be seen on the beaches and a strong smell of 'rotting eggs' is noticeable along the Namibian coast.

Crayfish trying to escape the water during a red tide event
(Source: BCLME)

Red tides, also known as harmful algal blooms, can extend over several square kilometres of ocean and are caused by blooms in a marine plankton group called **dinoflagellate**. Some of these species are toxic and result in extensive mortalities of shellfish and fish through direct poisoning. During these events, thousands of lobsters are seen walking out of the sea due to the lack of oxygen.

Since the breakup of Gondwana some 132 million years ago, the coastline of Namibia has undergone many changes. Sea levels have varied from around 400 m below to more than 400 m above current levels. When the coast was 400 m below current levels, it extended Namibia's land surface westwards for kilometres. The cobble and boulder deposits found on the edges of beaches can be attributed to sea levels around 5 000 years ago being about 1.5 m above today's level.

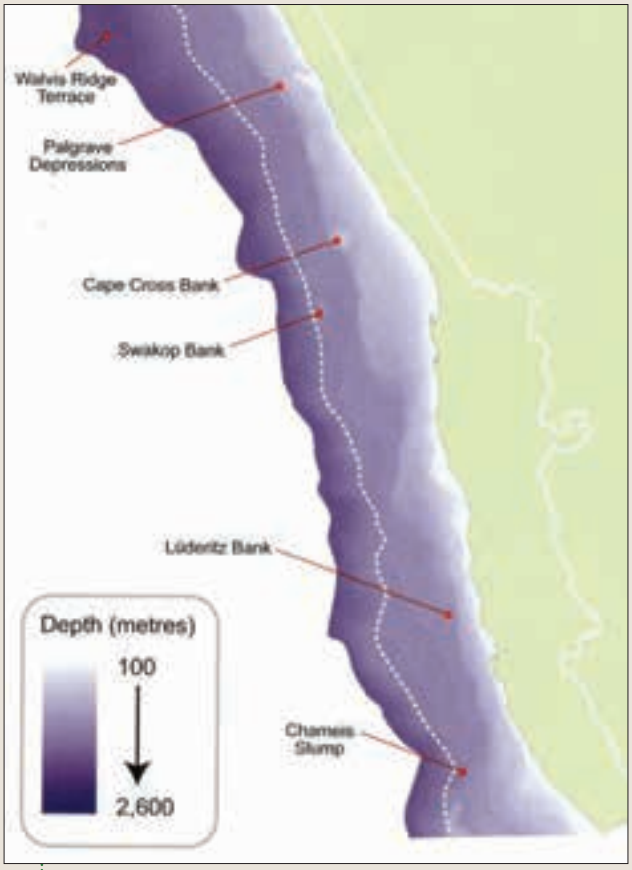
The Walvis Ridge occurring off the coast of Namibia
(Source: Robertson et al., 2012)

The floor of the south East Atlantic Ocean bears scars from the breakup of Gondwana and separation of the Namibian and Brazilian coasts. The **Walvis Ridge** is an underwater mountain range made up of magmatic rock, that extends southwest of Cape Frio for 2 500 km towards the mid-Atlantic Ridge. The ridge rises over 3 000 m above the sea bed. Two islands namely Tristan da Cunha and Gough Islands form part of the Walvis Ridge and rise above the water surface. The mid Atlantic ridge marks the line along which the drifting continental plates continue to part. The Walvis Ridge divides the Walvis Basin to the south from the Namibe Basin in the north, forming a major barrier to the circulation of deep oceanic waters.

Beneath the waves of the South Atlantic, the **topography** is complex. Immediately offshore we find the continental shelf. This is about 140 km wide for the majority of the coastline narrowing to 30 km near the Angolan border, and extending further out at the Orange River mouth. West of the shelf edge, the sea floor drops to the abyssal plain which can reach depths of more than 5 000 m. The ocean floor is covered in sediments of various kinds and origins. The continental shelf is dominated by sand and muddy sand. Mud predominates in deeper waters west of the shelf edge, as well as closer inshore near some of the river mouths.

Namibia's coastline is 1 570 km long and consists of 54% sandy beaches, 28% mixed sandy and rocky shores, 16% rocky shores and the remaining 2% are lagoons. Coastal zones are generally areas of high energ and dynamic environments, where tides and storms constantly alter the shape and form of the shore. Although the Namibian coast does not experience substantial tidal differences, the high winds and storms that frequently batter it ensure that it is constantly changing and therefore a very dynamic coastline.

The effects of the southerly winds and the Benguela Current and associated long shore drift are clearly seen through the formation of the north facing spits of Sandwich Harbour, Walvis Bay and Baia dos Tigres north of the Kunene River mouth in Angola. Many of these coastal spits are associated with the mouths of ancient rivers. The shape, direction and width of these spits have changed substantially over time. The following figure shows the change to the Walvis Bay spit between 1973 and 2010.



Water depths along the Namibian coast (the edge of the continental shelf is shown as a dotted line)
(Source: Robertson et al., 2012)

Changes to Walvis Bay spit between 1973 and 2010
(Source: Robertson et al., 2012)

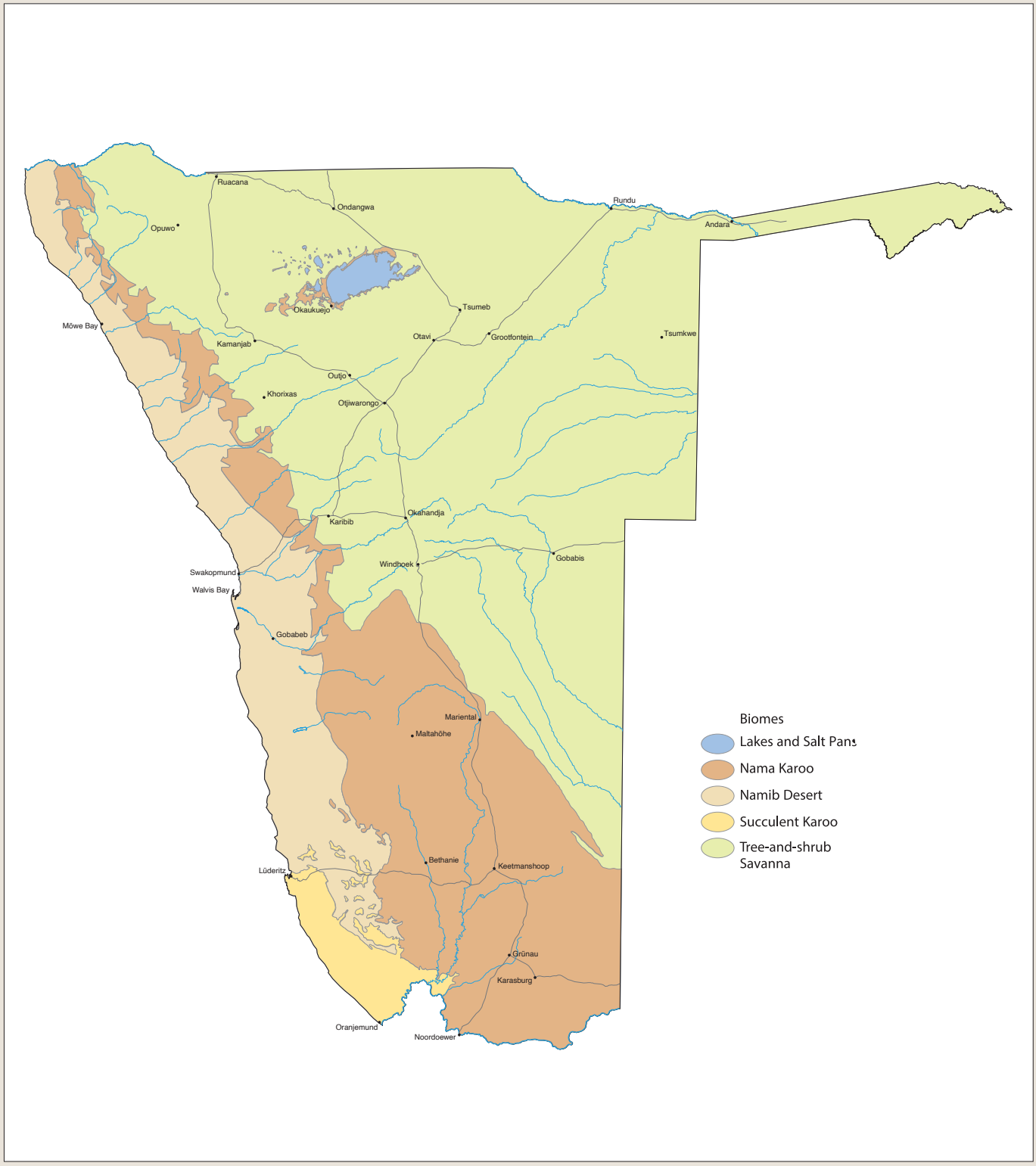
Sandwich Harbour
(Source: M Pfaffenthaler, 2009)

2.5 BIOSPHERE

The **biosphere** is Earth's self-regulating zone of life. It is where all living beings interact with each other and the world around them, including the other spheres (i.e. lithosphere, hydrosphere, and atmosphere). It represents all the ecosystems of the world linked together. Other planets in our solar system have an atmosphere, hydrosphere and lithosphere, but as far as is known, only Earth boasts a biosphere. Whilst the entire biosphere is connected, it is often easier to understand how the environment operates if it is broken down into smaller parts. One way to do this is to divide Earth into geographic zones called **biomes**.

A biome is an area on Earth that shares similar plants and animals, as well as **climatic** (such as temperature and amount of light) and **abiotic** features (such as soil and water availability). Not all scientists classify biomes in the same way. Some use broad classifications based on the effects of **temperature and rainfall on vegetation** and suggest that there are only six biomes on Earth, namely forest, grassland, freshwater, marine, desert, and tundra. Other scientists use more precise classifications and list dozens of different biomes. For example, they consider different kinds of forests, such as rain forests and temperate forests to be different biomes.

Boundaries between biomes cannot be defined precisely and there are usually transition zones between biomes, e.g. Walvis Bay and Sandwich Harbour lagoons are transition zones between terrestrial and aquatic biomes. Biomes also move as a result of climate changes over time. Ten to twenty million years ago, Namibia had a much higher humidity, with many more rivers than today, so the vegetation would have been quite different.



Biomes in Namibia

(Source: Ministry of Environment and Tourism, 2003)

A biome is different from an ecosystem. A biome is usually made up of many ecosystems. For example, an aquatic biome can contain ecosystems such as coral reefs and kelp forests. Namibia has 4 terrestrial (land) biomes, namely Tree and Shrub Savanna, Nama Karoo, Namib Desert and Succulent Karoo, and 2 aquatic biomes, fresh water, salt pans and lakes, (where Etosha pan is the only aquatic biome) and the marine biome.

Hoodia species are endemic to the arid regions of south-western Africa
(Source: G Schneider, 2009)

Important ecological definitions

Biome
A biome is an area on Earth that shares similar plants and animals, as well as climatic (such as temperature and amount of light) and abiotic features (such as soil and water availability).

Vegetation type
A plant community with immediately distinguishable characteristics based on and named after the apparent dominant plant species.

Endemism: When a species is unique to a defined geographic area and is usually restricted to that area.

Ecosystems
An ecosystem is the interaction of living organisms with each other and the non-living aspects of the environment (air, water and mineral soil), to form a system.

Habitat
A habitat is an ecological or environmental area that is inhabited by a particular species of animal, plant, or other type of organism.

Niche
An ecological niche is the part of the environment into which a species fits, and to which it is adapted.

Biodiversity is a term that refers to the variety and variability of animals, plants and other organisms (such as bacteria and fungi) that are found on Earth. It also looks at the differences within species (i.e. variability in different populations and individuals), between species, and between ecosystems.

TERRESTRIAL BIOMES IN NAMIBIA	
Tree and shrub savanna: Acacia Savanna • Annual rainfall of 250-400mm; • dominated and characterized by a wide variety of grass species and acacia species such as camel thorn and blackthorn; • supports a high concentration of various species which are endemic to the region, and supports large plains game including herd animals and predators; • contains the headwaters and catchments of most ephemeral rivers in Namibia; • vulnerable to inappropriate management and over-use resulting in desertification and bush encroachment; • nine vegetation types in this biome.	
Tree and shrub savanna: Broad-leafed Savanna • Annual rainfall of 450-700mm; • high species diversity, especially at the interface with the wetland; • deciduous tree species are characteristic including Zambezi teak, mopane and wild seringa; • high numbers of large mammals are present including 70% of Namibia's elephant population and the majority of the buffalo and hippopotamus populations; • important to trans-boundary cooperation as ecosystems are shared and species move across national boundaries; • forest fires are a common occurrence in this biome; • eight vegetation types found in this biome.	
Nama Karoo • Annual rainfall is 100-200mm; • dominated by dwarf shrubs, yet characterized by high variety of plant species due to varied lithology; • harsh climate with large seasonal and daily temperature variations; • sensitive to over-grazing and degradation which can lead to desertification; • seven vegetation types in this biome.	
Succulent Karoo • Characterised by winter rainfall and fog; • dominated by a single vegetation type, made up of succulent shrubs and dwarf shrubs; • greatest plant diversity in Namibia is found in this biome due to a variety of habitats; • many endemic plants found in this biome.	

TERRESTRIAL BIOMES IN NAMIBIA

Desert Biome

- Low rainfall (less than 50mm annually), and lack of surface water;
- sparse vegetation dominated by annual grasses and dwarf shrubs;
- large habitat diversity including mountains, gravel plains, sandy seas;
- coastal fog plays a vital role in supporting many plants and animals and in moderating temperatures;
- strong winds;
- ephemeral rivers cross the biome providing linear oases where large trees and water sources support many of the larger mammals and animals;
- systems within this biome are extremely sensitive and fragile and prone to long-term degradation with long recovery periods;
- three vegetation types are found in this biome.

AQUATIC BIOMES IN NAMIBIA

Coastal/Marine

- Characterized by the cold Benguela current which produces a nutrient-rich upwelling system;
- highly productive system which supports some of the highest concentrations of marine life in the world;
- multiple habitats including the littoral, shelf and abyssal zones, islands, lagoons and estuaries.

Lakes and salt pans

- Pans are underlain by limestone and the shallow, saline soils limit growth of trees.;
- the plains surrounding the pans are dominated by grass and dwarf shrubs.

(All Photos: M Pfaffenthaler)

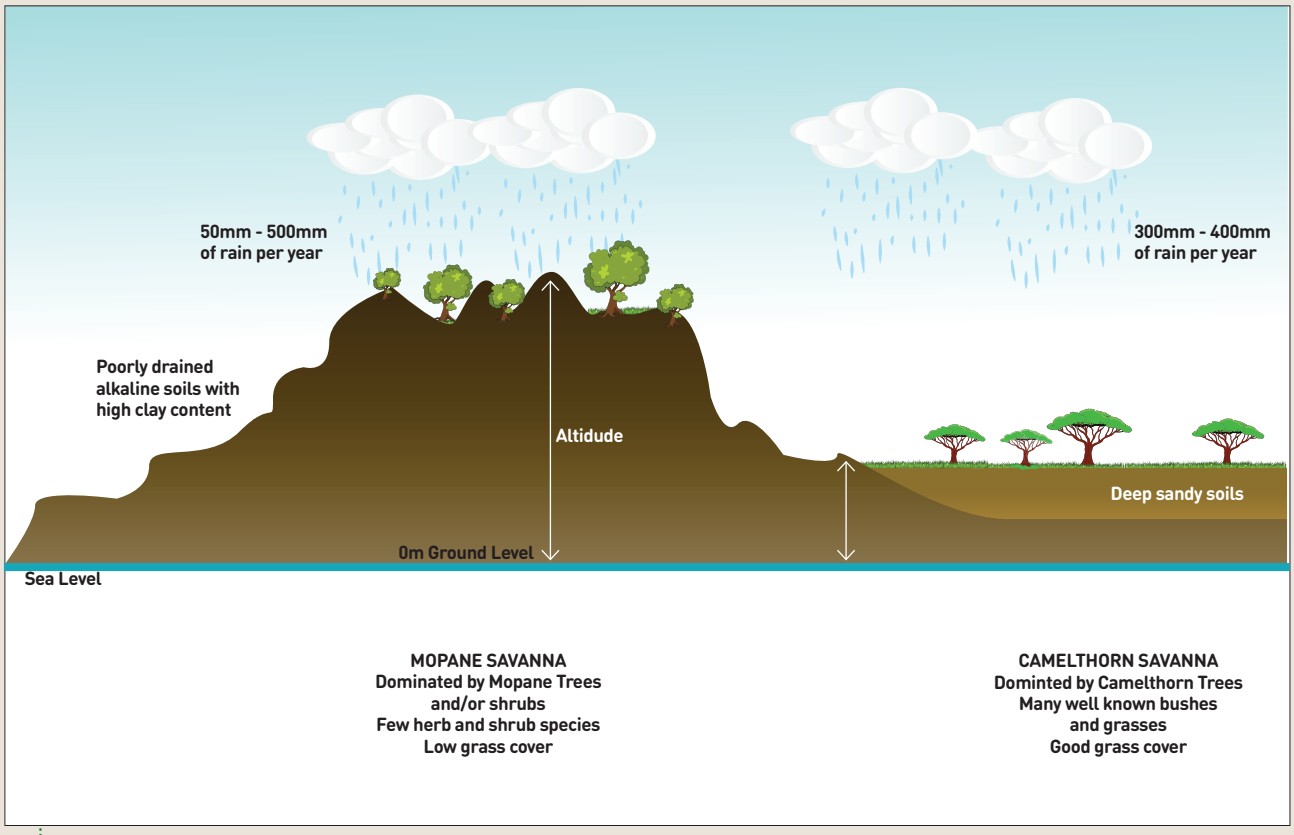
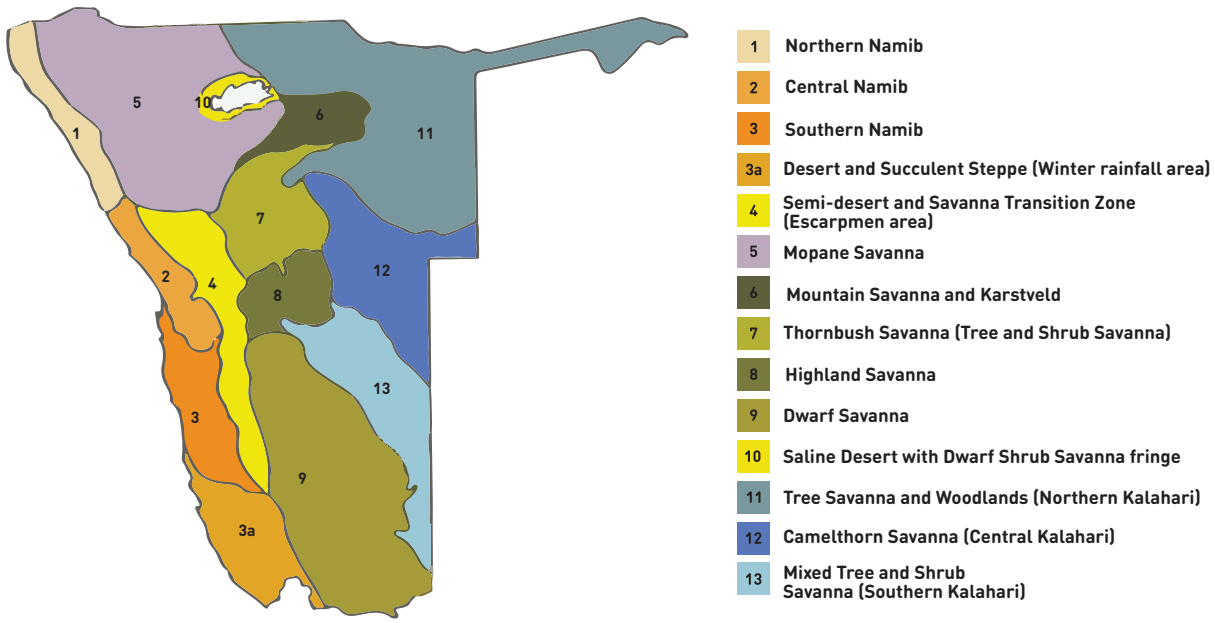


Diagram showing the differences between Mopane Savannah and Camelthorn Savanna

(Source: M Pfaffenthaler)



Vegetation types of Namibia

(Source: Giess, 1971 in Tarr (ed), 1996)

If one drives across Namibia it becomes obvious that the landscape within terrestrial biomes changes constantly. The topography varies (from rivers and mountains to broad plains and narrow valleys) and so too does the geology and soil. This diversity in landscape gives rise to a large variety of different vegetation types within any given biome. It is generally accepted that there are fourteen major vegetation categories in Namibia.

Vegetation types are determined by the dominant and most conspicuous plants in an area. The floral diversity in turn underpins the kinds of animals that are found in this area. So in this way vegetation types are usually an index of habitat diversity. The diagram above schematically compares two different vegetation types, namely mopane savanna and camel thorn savanna, and indicates the different factors that result in different plant communities growing there.

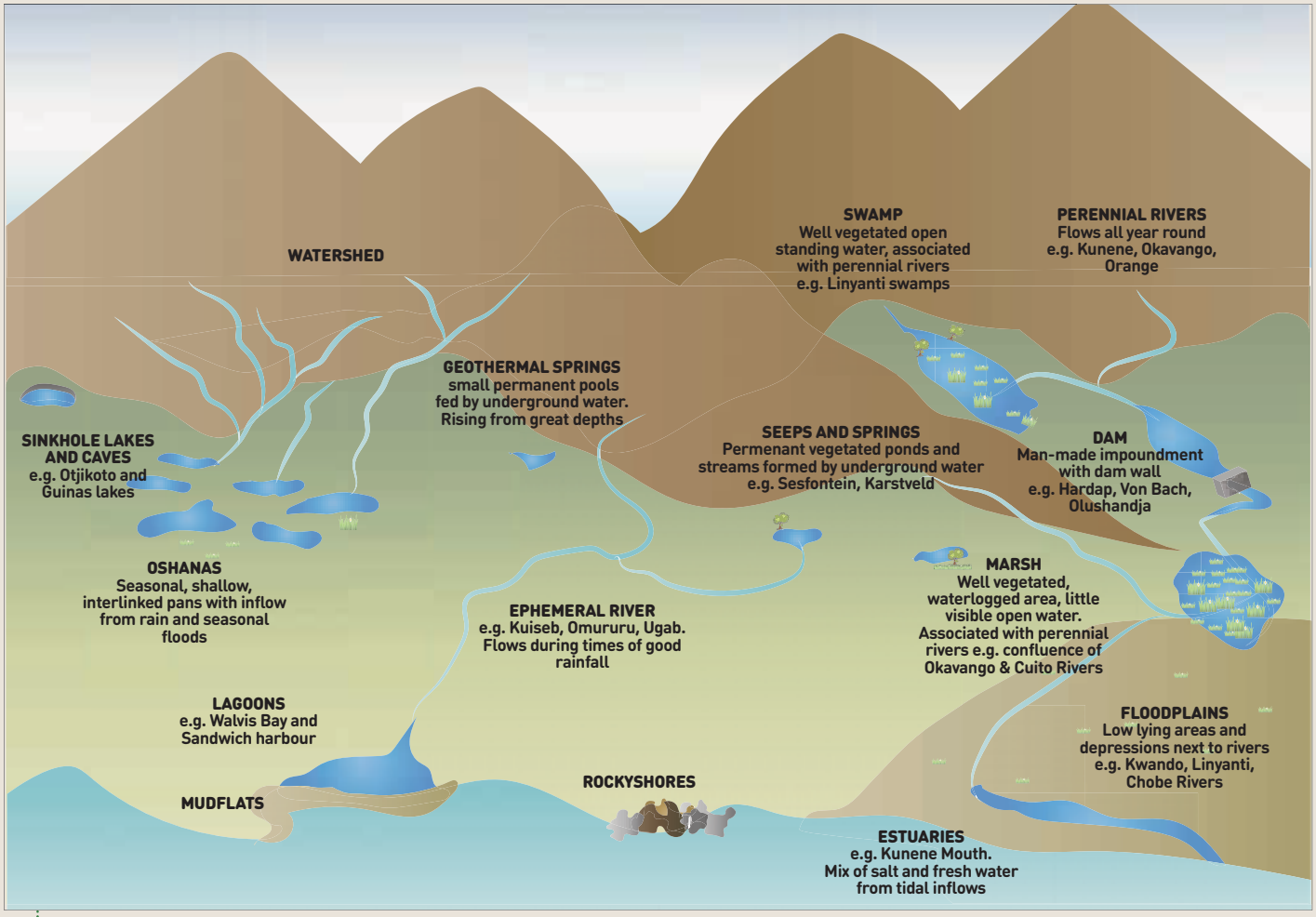
Although Namibia is an arid country, there are a **number of freshwater systems**, scattered throughout the terrestrial biomes. Collectively these are referred to as **wetlands** and include springs and ephemeral wetlands such as those found in the Namib Desert, ephemeral rivers, the oshanas (i.e. a large, shallow pool of water that forms during the rainy season) of northern central Namibia, and the flood-plains of the perennial border rivers. Altogether wetlands make up 4% of Namibia, which is a large proportion of the landscape for such an arid land.

Vegetation type 4 – Semi desert and savanna transition zone
(Source: M Pfaffenthaler)

Vegetation type 1- Northern Namib
(Source: M Pfaffenthaler)

Perennial Zambezi River
(Source: M Pfaffenthaler)

Ephemeral Ugab River flowing in February 2017
(Source: M Pfaffenthaler)



Different types of water systems distributed across Namibia

(Source: M Pfaffenthaler, taken from Barnard, P. (ed) 1998)

Namibia's wetlands are the country's most productive and biologically diverse ecosystem. The diagram shows the types of water systems distributed across Namibia. The **Etosha pan** is such a large pan that it has been designated as a biome rather than an aquatic feature within a terrestrial biome.

The marine biome is divided into five zones, namely the **intertidal**, the **pelagic**, the **benthic**, the **abyssal** and the **hadal**.

The intertidal or eulittoral zone is where the sea meets the land. This is the area where the water level is forever changing between high and low tide marks. The animals and plants that have adapted to live in this zone are different from other marine organisms as they have to cope without water for at least half of the day. Marine snails (molluscs), star-fishes, algae and crabs are some of the life-forms that are found in this marine biome zone.

The **pelagic zone** is the zone which is found in the open seas, neither to close to the shore or to the bottom. It is an enormous zone, covering a substantial part of Earth's surface and varying in depth from 20 m to 11 km. The pelagic zone is exposed to a great variability in climatic conditions. This allows for a wide variety of marine creatures to thrive in this zone, although most of the life is found in the surface zone, where light, pressure, temperature, salinity and dissolved oxygen are optimal.

The intertidal and littoral zones teem with life
(Source: M Pfaffenthaler)

Benthic communicty offshore Oranjemund
(Source: G Schneider, 2014)

A dominant feature of the pelagic zone is the mixing of cold water with warm. When nutrient rich cold water wells up along the cost of Namibia it provides food for hundreds of species of fish, sea birds and mammals. The section of the pelagic zone that extends from the **intertidal zone**, roughly to the edge of the continental shelf is called the littoral zone. The area is characterized by high biodiversity.

The **benthic zone** of the ocean is the zone that is found at the bottom of the water. It includes the sediment surface as well as some subsurface layers. The depth of the benthic zone varies substantially. It begins at the shore line (intertidal or eulittoral zone) and extends downward along the surface of the gently sloping continental shelf until about 200 m depth, after which the gradient greatly increases and the area is known as the continental slope. The continental slope drops down to the deep sea floor. The deep-sea floor is called the abyssal plain.

Did you know?

Namibia has 1 754 km of coastline, which runs the entire length of its western boundary. In addition, it has rights over a section of the ocean. There has been a long standing dispute over Namibia's maritime border with South Africa. The maritime border between Angola and Namibia has been agreed – it projects westwards from the middle of the mouth of the Kunene River. Namibia and South Africa only have a Memorandum of Understanding, and the finalisation of the maritime border from the Orange River mouth is pending.

Namibia has submitted an application for the extension of its territorial continental shelf to the United Nation's Commission on the Limits of the Continental Shelf. Should it be awarded in Namibia's favor, the country's territorial boundary will be extend by over 1 million km^2, a significant area in which Namibia could look for unexplored hydrocarbon reserves and other minerals at the bottom of the Atlantic Ocean.

The **abyssal zone** is the zone which is in the deepest part of the ocean and incorporates the column of water that is 4 000 to 6 000 m deep. This part of the ocean never receives any sunlight, is very cold, lacks nutrients and is under extreme pressure. Most life on the abyssal plain and in the abyssal zone is found in proximity to hydrothermal vents. These vents provide the heat energy for life that the sun provides for life in shallower water and on land.

The **hadal zone** incorporates the water column and benthos of the ocean trenches and covers those areas that are 6 to 11 km deep. Very little life has so far been found in these trenches although exploration has revealed that there is more than we originally thought, and most life isagain found in proximity to hydrothermal vents.

Did you know that the mosquito is a habitat for four different parasites?

There are four different malaria parasites in the world, all of which belong to the genus Plasmodium. Collectively these micro-organisms are responsible for millions of deaths worldwide. It is these creatures and not the mosquitos that make you ill. The mosquitos simply provide the habitat that these creatures need to ensure their survival, while at the same time making sure that they do not suffer from hosting the parasites.

Malaria parasites have very specific habitat needs. For example during its life cycle *P. vivax* lives in two hosts (habitats), namely:

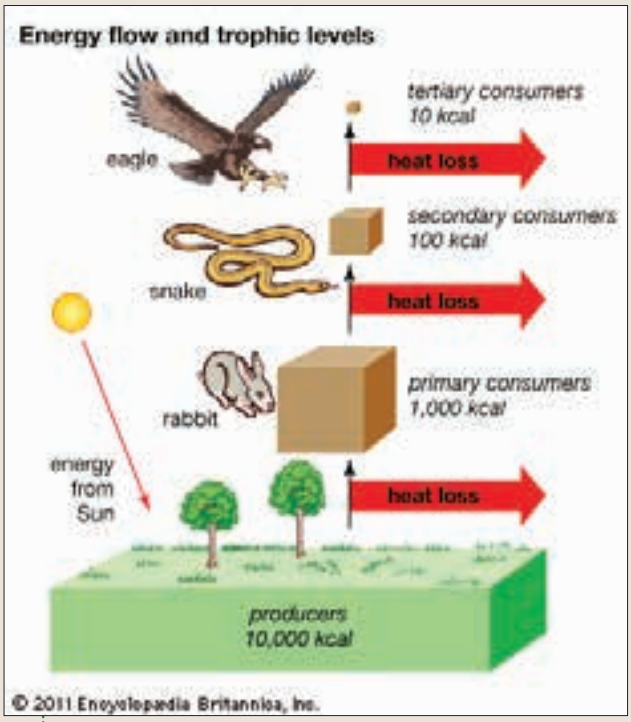
- **Liver and blood cells of humans -** They can infect and stay dormant as hypnozoites in the liver for a number of years until the liver cells erupt and the merozoites are released into the blood stream. Here they multiply rapidly destroying each blood cell they invade and causing malaria.
- **Salivary glands of Anopheles mosquitoes -** Some of the parasites form gametocyctes which are picked up by the Anopheles mosquitos when they take a blood meal from a human. These then travel to the salivary glands of these mosquitoes, where they become sporozoites. When the mosquito takes a blood meal from another human, these sporozoites are injected with the mosquitos saliva into the human, who will then become infected with malaria parasites, which in turn will invade the liver and blood.

Whilst Earth can be divided up into geographic areas called biomes, which can be observed in the landscape, the way that these biomes function or work is through the interaction of living organisms with each other and the non-living aspects of the environment (like air, water and mineral soil). These interactions form systems called **ecosystems**. The coastal environment is a good example. Here, we cannot divide the marine from the terrestrial components. Instead we need to view it as a system where terrestrial and marine processes interact and influence the make-up of the ecosystems that exist there such as estuaries, rocky shores, and islands.

Careful observation reveals that not all of Namibia's animals and plants are found in all biomes, nor are they uniformly distributed within a specific biome. Instead we find that particular species inhabit specific areas, where they are able to find **food**, **shelter**, **protection** from predation and **mates** for reproduction. We call these particular areas **habitats**. Every organism has a certain habitat in which it thrives, although some can thrive in a range of habitats. Vegetation types are habitats for a range of animal and plant species adapted to live within the climatic, geological and soil conditions of that area. However, habitats do not need to be a geographic area. It can be the inside of a rotting log or cave or even the body of another organism.

Within an ecosystem, organisms not only occupy habitats, but they play specific roles within the ecosystem. This specific role is called an organism's **niche**. A nice way to think of a niche is how an organism "makes a living" (e.g. is it a producer, consumer, or decomposer?), and how it interacts with other organisms.

If ecosystems are to function properly, niches cannot be left vacant, and should an organism no longer fill that niche, a new one will come in to fill it. However, certain species occupy specific niches. In this way nature has evolved to allow many organisms to live together without one species out-competing the other. Ecosystems that have a great variety of organisms, may have more than one species occupying very similar niches, but there will never be a total overlap.



Energy flow through the food chain

(Source: media1.britannica.com

Did you know that some species are able to 'steal' niches from others?

Prosopis species are a group of woody trees that were introduced to Namibia in 1897 as shade and fodder trees. They are considered an **invasive species** because it is a non-indigenous plant that has a negative impact on the habitats it affects, as well as the broader environment. Why has it been possible for Prosopis to encroach to such a huge extent? One theory is that there may have been **"empty niches" which Prospis successfully occupied, or that Prospis out-competed an existing indigenous species**, having originated in the semi-arid ecosystems of Mexico and the Southern United States.

In Namibia Prosopis has invaded the ephemeral river systems and has a detrimental effect on them. Prosopis invasion along the Fish River between the Hardap and Neckartal Dams has not only destroyed indigenous vegetation, it has had a dramatic impact on groundwater levels. The trees could use as much 18% of the total capacity of the Neckartal Dam, and this has implications on the health of ecosystems.

Earth can house a great variety of organisms because there are thousands of different habitats and niches that they can occupy. But how exactly do these become **integrated ecosystems** that unite other ecosystems as well as the atmosphere, lithosphere and hydrosphere?

Concepts such as biomes are easier to understand than ecosystems because they are areas that can be seen, whereas **ecosystems** are the mechanics that make those biomes function. And these are not always directly visible. In ecosystems the biotic (living) and abiotic (non-living) components are linked together through **energy flows, nutrient cycles, and symbiotic relationships**.

All organisms need **energy** to power their bodies, just like cars need energy to power their engines. The sun is the source of energy for most life on Earth, however, some organisms living deep down in the ocean, where the sun cannot penetrate, obtain their energy from thermal vents in the Earth's crust. Most organisms are unable to harness the energy from the sun, and have to rely on a very special group of organisms to do so. These are plants and they are able to convert the sun's energy into chemical energy (food). This energy then flows to other organisms through **food webs**.

Organisms that are able to convert solar or thermal energy into food are called **producers**. The animals that eat producers or other animals are referred to as **consumers** and **decomposers** break down dead plant and animal material and wastes and release it again as energy and nutrients into the ecosystem for recycling.

Producers form the **first trophic** level of the food chain. The total amount of energy that they can produce from the sun is called the **gross primary production. Net primary production** is the surplus energy that is available for subsequent trophic levels, once the plants have used some of the energy for themselves. At each trophic level of the food chain, energy is used for respiration, growth and reproduction and some is lost as heat, so less energy is available for the next trophic level. For this reason the numbers of steps that can be found within a food chain are limited and the number of organisms that each trophic level can support decreases as one moves 'up' the food chain, e.g. a lion (**tertiary consumers**) must eat several zebras (**secondary consumers**) to get enough energy to survive. An example of a simple energy flow is provided in the figure below. It shows a food web in the Nama Karoo biome and demonstrates the various pathways that energy can follow. It should be noted that energy flows are rarely as simplistic as shown.

Energy Flows
In ecology energy flow refers to the flow of energy through a biological food chain.

Nutrient cycle
A nutrient cycle (or ecological recycling) is the movement and exchange of organic and inorganic matter back into the production of living matter.

Trophic level
The trophic level of an organism is the position it occupies in a food chain. A food chain represents a succession of organisms that eat another organism and are, in turn, eaten themselves. Food chains start at trophic level 1 with primary producers such as plants, move to herbivores at level 2, predators at level 3 and typically finish with carnivores or apex predators at level 4 or 5.

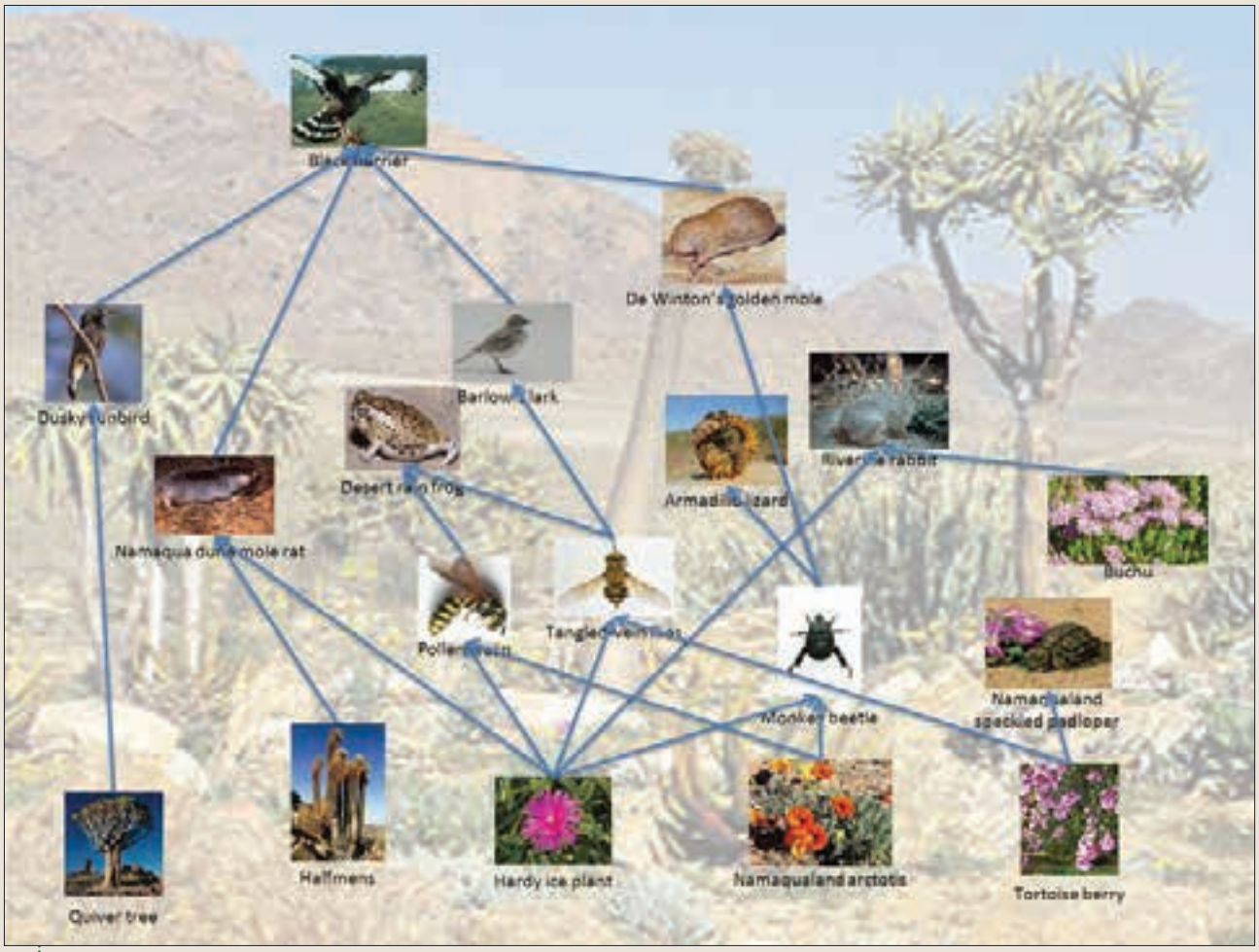


Diagram of a food web in the succulent Karoo
(Source: safoodwebs.weebly.com/succulent-karoo.html)

Symbiosis
Symbiosis is any type of a close and long-term biological interaction between two different species, be it mutualistic, commensalistic, or parasitic.

Mutualism or interspecies reciprocal altruism is a relationship between individuals of different species where both individuals benefit, e.g cellulose digesting bacteria living in the stomachs of zebra.

Commensalism describes a relationship between two living organisms where one benefits and the other is not significantly harmed or helped.

Parasitism
A parasitic relationship is one in which one member of the association benefits while the other is harmed.

Why are nutrients important and why are we losing them?

If we do not manage nutrient cycles properly, then the elements necessary to sustain healthy plant growth are lost. If we compromise the foundation of the food pyramid then all subsequent levels suffer. The introduction of water born sewerage means that many nutrients are taken away from soils and discharged in water courses and oceans. Large scale agriculture has also resulted in accelerated land erosion with the result that soil is carried off by rivers and dumped in the sea. Human alterations to nutrient cycles have resulted in too many nutrients in aquatic ecosystems and a serious depletion of nutrients in our soils. This has had negative implications for both aquatic and terrestrial ecosystems, and affects food security and quality of living for people.

How do Acacias and Mopane trees enhance soil fertility?

Two of the most limiting factors in arid ecosystems are lack of moisture and nitrogen. Yet numerous studies have shown that many species of Acacia and Mopane are able to convert large amounts of atmospheric nitrogen into organic compounds under arid conditions. This is known as nitrogen fixation.

They do this with the help of tiny organisms called Rhizobium, which live together in nodules on the roots of the acacias. Research has shown that this relationship represents the best source of the 'ideal' fertilizer in arid regions. This is not only important for productivity in natural systems but may be an important way of improving fertility in agricultural lands located in semi-arid and arid ecosystems.

The **nutrient cycle** can be considered nature's recycling system. Unlike the energy from the sun, which flows through the ecosystem along unidirectional pathways, the recycling of chemical elements such as nitrogen, carbon, water, phosphorous, sulfur and oxygen is cyclic, from the physical environment, into living organisms and then back to the physical environment. This is achieved as a result of:

- Plants producing food;
- organisms feeding, digesting, moving around and excreting matter;
- other organisms in the soil decomposing the matter back into these elements.

The nutrients which make up 95-98% of the mass of living organisms are carbon, hydrogen and oxygen. However, in order to survive and reproduce, organisms also need chemical elements such as nitrogen, phosphorous, sulfur, potassium and calcium (known as macro nutrients), as well as small amounts of micro nutrients such as iron, copper and chloride.

Ecosystems are not established purely as a result of organisms eating each other. Plants and animals are constantly interacting with each other to enhance their chances of survival. Organisms need to grow, move and ultimately reproduce so that their genes can be passed onto the next generation. A variety of strategies have been adopted to allow organisms to successfully occupy given niches and to live long enough to breed. One of the most fascinating is symbiosis, where two different species share a special kind of relationship that helps one or both of them to survive.

Symbiosis abounds in fig trees

The Strangler fig *(Ficus burkei)* is found in the Karstveld, along the Okavango River and in the eastern Zambezi Region. It is a fascinating tree because it demonstrates all three types of symbiotic relationships.

It has a **mutualistic relationship** with its only pollinator, the fig wasp. In fact, it could not survive without the fig wasp and the fig wasp could not survive without the fig tree. The fig 'fruit' (or synconium) is filled with tiny male and female flowers which cannot pollinate each other as they mature at different times. Some of the female flowers have short-styles and some have long-styles. The female fig wasp is able to enter into the syncomium through a tiny opening (ostiole). Once inside she lays her eggs in the short-style flowers, where they can develop safe from predators. When the eggs hatch the male wasps inseminate the females. The pregnant females must leave the synconium to find new ones, where they can lay their eggs. On the way out of the synconium, the females collect pollen from the mature male flowers. When they find new synconia, on another tree the females enter and whilst looking for short-style flowers in which to lay their eggs, they pollinate the female flowers with the pollen.

Fig fruits are eaten by many creatures including birds and monkeys. The fig seeds are often excreted onto the branches of other types of trees, where some of them germinate and grow into an epiphyte (a plant that lives on other plants). At this stage the young fig and the host tree have a **commensalistic relationship** as the fig benefits from the water and nutrients captured in the nooks between the branches, whilst the host tree remains unaffected.

Unfortunately for the host this often changes. The fig's aerial roots wind their way down the trunk of the tree and when they reach the ground the fig has access to increased nutrients and water in the soils. As the fig grows its roots, which are wrapped around the trunk of the host tree, thicken and tighten, preventing the host tree from growing, thus strangling it to death. This is an example of a **parasitic relationship** where the fig benefits from the relationship whilst the host tree is harmed and ultimately killed.

***F. Burkei* growing around its host tree**
(Source: M Pfaffenthaler)

Biodiversity refers to all the different animals, plants, fungi, bacteria and viruses in an ecosystem. Our Earth boasts a phenomenal diversity of life. We have described about 1.6 million species, but exactly how many species exist is unknown. Estimates vary from 7.4 million to 10 million eukaryotic species (any organism whose cells contain a nucleus and other organelles enclosed within membranes).

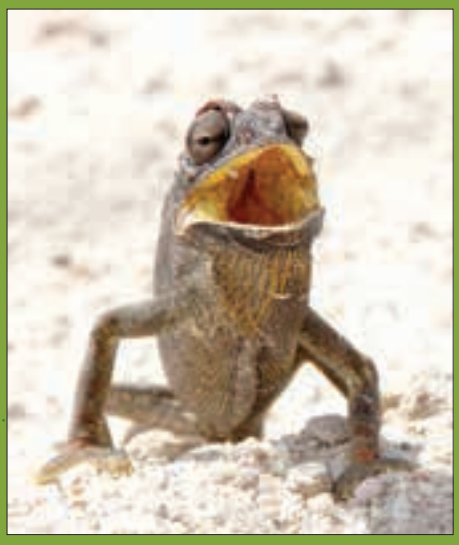
The estimated number increases to 1 trillion species if microbial species (bacteria, viruses etc.) are included. Humans are just one species out of these millions. We need to remember that Earth is not ours alone. We need to share it with the millions of other species that have a right to live here too. In fact, these species are the building blocks of life, without which, life as we know it, would not exist.

Some interesting facts about Namibian Biodiversity

- Compared to wetter climates, Namibia's diversity is low, however, when compared to other arid environments, diversity is high.
- The north-eastern areas of Namibia generally have the highest overall terrestrial biodiversity due to higher rainfall, the presence of perennial wetlands and forest habitats.
- Other areas of high biodiversity are the highlands of Central Namibia and smaller highlands in the south and west of the country, the Karstveld around Tsumeb, and isolated mountains such as the Brandberg. All of these areas have a high number of different habitats, which supports a variety of different life.
- Unlike most other species, scorpion diversity is highest in the southern and western parts of Namibia, as they are better adapted to arid habitats.
- Namibia boasts a high level of endemism – 20% of described species are endemic.
- Endemism is especially high in plants, invertebrates, reptiles and frogs. Namibia is one of the few dryland countries in the world with internationally recognized biodiversity hotspots, namely the Tsau //Khaeb (Sperrgebiet) National Park, situated in the Succulent Karoo floral kingdom and the rugged Namib Escarpment, which is part of Africa's great western escarpment and an area of particularly high endemism.

The number of described species in Namibia and levels of endemism are presented in the following table:

TAXONOMIC GROUP	NUMBER OF DESCRIBED SPECIES	% OF SPECIES THAT ARE ENDEMIC
Reptiles	254	28%
Insects	6421	24%
Plants	4334	17%
Amphibians	50	12%
Arachnids	618	11%
Fish	114	8%
Mammals	229	7%
Birds	676	2%



Namaqua chameleon *(Chamaeleo namaquensis)* is one of the largest chameleon species in southern Africa. It is common in the Namib Desert.

(Source: M Pfaffenthaler)

2.6 CLIMATE CHANGE

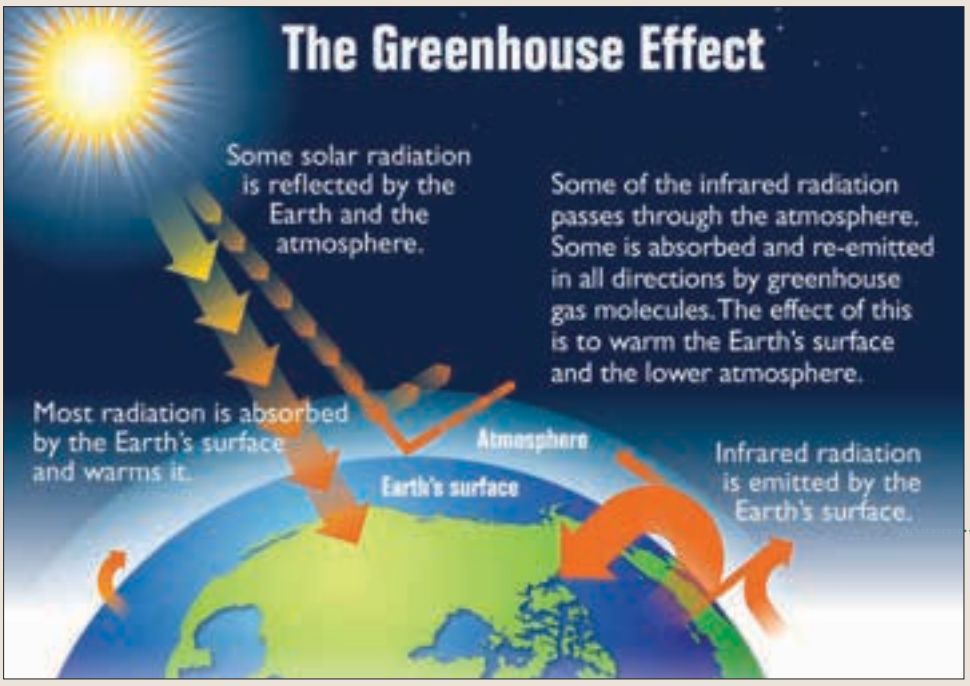
The climate of the world has changed over millions of years. There have been warmer and cooler periods, each lasting thousands to millions of years. Natural causes of this climate change include changes in the orbit of the Earth around the sun, the amount of energy emitted from the sun, oceanic upheavals and volcanic eruptions.

Over the last 4.5 billion years we know that Earth's climate has varied from tropical to ice ages. Since the last ice age, which ended about 11 000 years ago, the climate has been relatively stable. However, over the last century, the average global temperature has increased by more than 0.7°C. This amount may not seem like much, but small changes to the temperature can lead to big impacts. Some impacts are already occurring, for example, snow and ice covers are decreasing, and sea levels are rising while rainfall patterns and growing seasons are changing. The causes are not fully understood; however, most climate scientists agree that the recent warming since the middle of the last century cannot be explained by nature alone and is also due to the burning of fossil fuels.

The combustion of fossil fuels to drive engines signalled the beginning of the industrial revolution, and was perhaps one of the most brilliant inventions by mankind. It totally changed our way of life and brought an improved standard of living to so many. However, the burning of fossil fuels releases carbon dioxide and other gases like nitrogen dioxide and sulphur dioxide into the atmosphere. These gases trap heat and contribute to atmospheric warming. All of these gases collect and act like a glass in a window, creating a 'greenhouse effect' over the planet which traps the heat.

As mankind keeps burning more and more fuels and adding increasing amounts of greenhouse gases to the atmosphere, the planet becomes progressively warmer resulting in unpredictable weather and more frequent droughts, heat waves, floods and cyclones and fires.

Whilst **global warming** affects all nations, it is the people in the poorest countries who have been burning fossil fuels for a much shorter period of time and in much smaller quantities, who are likely to suffer the most, because they are more vulnerable to climatic extremes. Global warming will not only affect people's standard of living, but biodiversity will also be affected. For example,



Greenhouse effect
(Source: energyeducation.ca/encyclopedia/Greenhouse effect)

Important climate change definitions

Climate change
Climate change is a change in the global and local weather conditions and takes place on the scale of tens, hundreds and thousands of years. Global warming refers to the long-term increase in the average global temperatures.

Combustion
It is a high-temperature exothermic redox chemical reaction between a fuel and an oxidant, usually atmospheric oxygen. Incomplete combustion of fuels also releases small particles of solids, such as carbon.

Fossil fuels
Fossil fuels are carbon based materials that originate from plant matter. They include coal, gas, oil, diesel, and petrol. They are combusted to produce energy.

Greenhouse effect
Short wave radiation from the sun enters the glass of a greenhouse and is absorbed by the objects within. As their temperature rises they give off long wave radiation which cannot pass through the glass and is trapped within. Hence the temperature within the structure rises. The gases within the atmosphere act as a glass.

Ozone
The gas ozone occurs naturally in air and is made up of three oxygen molecules (O_3), unlike oxygen which is made up of two oxygen atoms (O_2).

Clean energy
A term used for energy from renewable sources like solar, hydro, wind and geothermal energy.

plants and animals that are unable to adapt to the effects of the changing temperature, will die or move away to cooler places, if they can. The same applies to people. Climate refugees are already a reality and the problem is expected to increase in the near future as more people are forced to migrate from their homes in order to avoid the negative impacts of global warming.

One of the greenhouse gas emissions of concern is ozone. Scientists have divided ozone into good ozone and bad ozone. 'Good ozone' is found in the upper stratosphere and is formed when UV light strikes oxygen molecules splitting them into two oxygen atoms. These unstable atoms then combine with O_2 to form O_3.

Ozone in the stratosphere is essential for our survival because it shields Earth from harmful UV rays. Some 'good ozone' occurs in the troposphere, usually at ground level and is released by plants and soil. However, most of the O_3 found at this level is **'bad ozone'** and is formed from combustion, when nitrogen oxides and volatile compounds react with UV light, creating haze or smog.

High ozone levels occur in cities during the warm summer months and peak in mid to late afternoon, after exhaust fumes have had time to react with sunlight. At threshold levels, pollution alerts are issued as ozone can damage lung tissues and is harmful to all types of cells.

In the stratosphere, ozone levels vary seasonally. It was discovered that chlorofluorocarbons **(CFCs)**, used in insulating foams, solvents, soaps, cooling equipment like air conditioners, refrigerators and 'take-away' containers, were responsible for depleting the ozone to such an extent that it was causing a substantial thinning of the 'good ozone' layer over the poles and other places where human populations are dense. These areas are known as 'ozone holes'. Cumulonimbus clouds carry CFCs high into the stratosphere, where UV light breaks them down to react with ozone. It has been found that one chlorine atom can break apart more than 1 million ozone molecules.

In 1987, almost every country in the world, including Namibia, signed the Montreal Protocol, agreeing on a plan to phase out damaging CFCs. This protocol has been the most successful climate agreement ever, because nearly 100 polluting chemicals have been almost totally phased out and the ozone layer is slowly healing. The Montreal Protocol is now focusing on phasing out hydrofluorocarbons (HFCs), another potent group of greenhouse gases. HFCs are used in refrigerators and air conditioners and have 1 000 times the heat trapping powers of carbon dioxide. Air conditioner manufacturers have already started researching friendly alternatives for HCFs.

Other greenhouse gas emissions include **nitrogen dioxide, sulphur dioxide and carbon monoxide**. Nitrogen dioxide is reddish-brown in colour and when it collects in a haze, it is called smog. Nitrogen dioxide also reacts with water vapour to form nitric acid, which is contained in acid rain. Sulphur dioxide also causes acid rain and damages and/ or kills trees and crops. Carbon monoxide is toxic and, if inhaled, can cause death. Another gas of concern is methane, which is produced when organic material is decomposed by bacteria. The beef industry across the globe is responsible for annually releasing large volumes of methane into the atmosphere.

Greenhouse gas emissions from the urban centres of Namibia are relatively small compared to big cities like Tokyo and New York. However, a large portion of Namibia's contribution to global warming is through **veld fires**.

Fifty percent of Namibia is covered by **savanna vegetation**. Savannahs are the most fire-prone vegetation on Earth and have evolved with and are dependent on fire. However due to intense utilisation by people for agricultural, pastoral and management activities, savannahs are burnt more than they should be and often at the wrong time of the year. Between 1997 and 2009, savannah fires accounted for 60% of total global fire emissions. These fires release large amounts of gases (e.g. carbon dioxide) and particulates into the atmosphere, exacerbating the greenhouse effect and contributing as much as a third of the ozone in the lower atmosphere.

In addition, uncontrolled high intensity fires ('wild fires') occur regularly in the north eastern part of Namibia. They rage hotter and more aggressively than natural veld fires. Not only do they pump large amounts of greenhouse gases into the atmosphere, they also negatively impact Okavango community livelihoods through loss of life and property (houses, food stores and fences). They reduce the availability, productivity and long-term sustainability of the natural resources leading to increased poverty.

Wild fires are caused by lightning, but huge areas in communal areas are also deliberately burnt by local subsistence farmers. Incorrect range and fire management practices on commercial farms and extensive bush encroachment also contribute to the occurrence of these fires.

Did you know?

Carbon production per person - Human activities are a major cause of the increase in carbon in the atmosphere. Approximately 40 billion tonnes of carbon are added each year. This is just less than 6 tonnes of carbon per person per year.

NASA study - Off the coast of Namibia, for several months every year, a layer of smoke drifts over a persistent layer of low clouds. Hence it is seen as the perfect place to investigate how haze and clouds interact to influence global warming. On 29 August 2016, a NASA research plane began a month of flights into the heart of the smoke and clouds, taking off from Walvis Bay. There are plans for the study to continue in 2018.

Environmental awareness – In 2015, the Hanns Seidel Foundation (HSF) Namibia, in partnership with the Desert Research Foundation of Namibia (DRFN) implemented a three-year project to support national efforts for public awareness on environmental protection and climate change. Its aim is to use a dynamic approach to engage with a variety of stakeholders across the country including schools, the media, social entrepreneurs and political decision makers.

Veld fire near Ganab
(Source: T Wassenaar, 2012)

Did you know?

Construction of the first wind farm near Lüderitz was recently completed. An environmental impact assessment was done and a power purchase agreement with NamPower is in place. According to a statement by the developer Innosun:

"Wind technology is mature. There have been improvements in wind turbine technology and it has grown to be extremely competitive. We also believe Lüderitz is one of the top regions in the world to harness wind technology.... if you compare a 200 megawatt coal power plant against a wind farm with the same installed capacity, the cost per kilowatt hour at the end will be cheaper and more competitive from wind," based on results from projects in South Africa.

The NASA Research Plane in operation in Namibia
(Source: S van Eeden, 2016)

Namibia is one of the countries identified as being vulnerable to **climate change** due to its arid environment, recurrent droughts and desertification. Many Namibians are dependent on traditional land usage centred on livestock and crop production and are likely to be impacted, particularly those in the lower income groups. It is predicted that the country will become hotter (with an increase in temperatures of between 1°C and 3.5°C in summer and 1°C to 4°C in winter in the period 2046 - 2065. In most of central Namibia, it is predicted that the rainy season will become shorter by 20 days. The area between Maltahöhe, Helmeringhausen and Gibeon in the south, and around Khaudum National Park and Tsumkwe in the north-east is expected to have a reduction of 60 days. Only scattered areas across Namibia are expected to have an increase of up to 20 rainy days per season.

Rainfall is likely to become more intense and variable. During flooding events, the country will become more at risk to disease outbreaks such as cholera and vector-borne diseases such as malaria. Namibia's dominant savannah vegetation will give way to more desert and arid shrub land vegetation types. This shift would mean that most of Namibia's western and southern parts will become drier and more unproductive for agricultural purposes. It is also believed that the increase in bush encroachment (which reduces the grazing capacity of farming lands) is a result of the warmer climate which has occurred over the last hundred years approximately. A warmer climate favours trees more than grasses.

Overall, climate change will pose a major challenge to food security in rural households. Gross domestic product is predicted to decline between 1.1% and 3.1% due to climate change losses. In recent years, the country has encountered its worst drought in over thirty years resulting in on-going concerns over water shortage. Namibians need to be prepared and able to adapt in order to increase the country's resilience to these events.

In 1995 Namibia ratified the United Nations Framework Convention on Climate Change (UNFCCC). This was followed by the establishment of the National Climate Change Committee (NCCC) by the Ministry of Environment and Tourism. The NCCC is tasked to both communicate with UNFCCC, as well as develop climate change projects and programmes, develop national positions on climate change, define capacity building needs and advise on a national strategy for adaptation to climate change.

In order to reduce Namibia's carbon footprint, the country needs to implement mitigation efforts to reduce greenhouse gas (GHG) emissions. As a Non-annex 1 party to the UNFCCC, Namibia is not obliged to reduce its GHG emissions. However, the country is dependent on energy from South Africa and its favourable conditions for renewable energy makes the transition to a low carbon economy an important long term goal. According to experts, Namibia has great potential to increase its clean energy supply by using renewable resources. The country can also promote the use of more efficient energy and clean energy technology as an alternative to traditional energy sources i.e. coal. Examples of renewable energy technologies include solar power, wind turbines, biomass and hydroelectricity. These technologies are discussed in further detail in Section 3.2.

Other than developing new technologies to reduce GHG emissions, Namibians should be developing strategies to cope with the current impacts of climate change. To do this effectively, it is important for people to become educated on the subject and put aside all cultural, religious and, preferential differences for the sake of humanity and the survival of it. This process of adapting to the effects of climate change is called **climate change adaptation**. This is necessary in order to reduce the impact of climate change by developing new innovative ways and measures to adapt.

In order to raise awareness of climate change, particularly amongst rural communities, the Ministry of Environment and Tourism distributed community climate change adaptation toolkits in 2011 to all 14 regions of Namibia translated into local languages. A number of events were coordinated, especially to engage with the youth, and included national symposiums, festivals and awareness campaigns. One of the many initiatives included the Namibian Youth Conference on Climate Change which took place in October 2015. The conference brought together young people from all across Namibia to discuss the most pressing concerns of the youth relating to climate change. The findings of the conference were then collated to form a position paper for the Government to take to the 21st UNFCCC Conference of the Parties (COP 21) negotiations in Paris in December 2015.

Other key milestones in Namibia's response to climate change have been the approval of the National Climate Change Policy in June 2011 by the Namibian parliament, the gazetting of the Disaster Risk Management Act in 2012 and the launching, in 2014, of the Climate Change Strategy and Action Plan for the period 2013 – 2020.

With international attention on climate change, various funding windows opened up. Some examples include the Global Environmental Facility (GEF) through which Namibia attracted a number of projects including the Climate Change Adaptation Project under the Country Pilot Partnership Programme which ran from 2008 to 2012. Hands-on initiatives have been rolled out across the country, in particular within the Omusati Region, aimed at drip irrigation, conservation agriculture and rearing of indigenous livestock. One such project was the establishment of the Olushandja Horticulture Producers Association (OHPA) located along the banks of the Etaka Dam in the Onesi constituency. OHPA applied for a grant through the Environmental Investment Fund (EIF) to enable them to implement a conservation agriculture project. The project involves the use of drip irrigation and organic fertilisers. There have been substantial improvements in the fertility and water-holding capacity of the soil leading to better crop yields. The funding has also allowed the association to build capacity amongst its members.

Since 2002, the European Union has become a strong supporter of climate change actions in developing countries, including Namibia. The assistance has been focused on a range of initiatives being undertaken by the private sector, parastatals, farms, unions and NGOs. The aim was to enhance Namibia's ability to adapt to climate change in particular in rural areas and to develop effective mitigation techniques through developing, testing and disseminating solutions and practices.

Less fog at the Coast

Fog formation in Namibia is associated with the upwelling of the cold Benguela Current and high pressure cells, which cause subsiding warm air masses. Eventually these air masses cool down until the dew point temperature is reached and fog occurs. This fog is driven by the sea breeze into the desert. Here it provides just enough moisture for many desert adapted species to survive. However, this may change in the future.

If the Benguela Current warms because of climate change, it may lead to reduced fog production and affect the biodiversity along the entire coastline. In 2013, the Gobabeb Research and Training Centre in cooperation with the Southern African Science and Service Centre for Adaptive Land Use (SASSCAL) developed the FOGNET programme. Its aim was to observe the special fog distribution in the Central Namib and link it to climate change. Nine meteorological tower stations were set up through the Central Namib. The stations measure fog precipitation, temperature, relative humidity and radiation. Comparing data between the stations continues to provide detailed information about the impact of climate change on fog distribution within the research area.

Fog measurements at Gobabeb
(Source: T Wassenaar, 2014)

Namib Desert fog
(Source: G Schneider, 2007)

3

HOW WE BENEFIT FROM ECOSYSTEMS SERVICES

3.1 USE OF NATURAL RESOURCES

Namibia is a land with a variety of natural resources spread across the entire country. Some of these resources, such as diamonds, gemstones and granite are **non-renewable**, whilst others, such as forests, wildlife, fish, water and soils are **renewable if they are not overused, polluted or lost**. Whilst one of Namibia's development goals is to become increasingly industrialised, we are still a nation defined by a rural population, dependent on subsistence farming and livestock. In addition, our industries are primarily based on the extraction of natural resources, e.g. mining, fishing and agriculture with very little beneficiation of the natural resources.

In Chapter 2, the different spheres of the planet and how they work and interact were presented. These concepts are important to understand because if one does not appreciate how the planet 'works' to keep humanity alive, then one will not appreciate why it is so important to utilise it responsibly. Moving into the future, mankind faces many challenges in the sustainable use of the planet. These include, but are not limited to:

- An exponentially growing human population that is expected to reach 8.5 billion by 2030.
- Increasing desertification, which is a type of land degradation in which relatively dry areas of land become increasingly arid as a result of climate change and over-exploitation of the soil. This results in the land typically losing its bodies of water as well as vegetation and wildlife.
- Increasing migration of people from rural to urban environments.
- Climate refugees that are being displaced from their own lands and moving to places that are cooler, located at higher altitudes, have better infrastructure etc..
- Increasing loss of biodiversity due to habitat loss and over-exploitation.
- Ongoing loss of valuable topsoil into our oceans and lakes.
- Polluting of fresh and salt water environments; and
- Increasing human conflict due to competition for space and natural resources.

The challenges listed above are daunting in themselves, but by far the most difficult challenge to overcome is Man's perception of the environment and the need to protect it. As people move to the cities and become immersed in technological lifestyles, they become separated from the natural environment and forget how fundamental it is to their lives. For example, many people believe that food comes from the supermarket and have no idea from whence it originates - that wheat must be grown in the soil, or that animals must be slaughtered for meat. Added to this is the very powerful notion that people can engineer all of our problems out.

Crayfish, a valuable Namibian marine resource that must be protected from over-exploitation
(Source: BCLME)

What are Namibia's natural resources?

Sunlight
Sunny conditions in Namibia contribute to its aridity; nevertheless it is a limitless energy resource and has huge spiritual, aesthetic and health benefits which are important for the tourism industry.

Soil
People tend to take soil for granted but without soils we would not have life as we know it, because plants need soils in which to grow. In addition, soil and sediments provide habitat for millions of species that play essential roles in the recycling of nutrients, soil stabilization, water purification and carbon sequestration. Soil is one of our most valuable resources that should be conserved at all costs.

Water
Namibia has limited water resources due to low rainfall conditions and a high evaporation rate. Water resources are distributed very unequally across Namibia, which impacts hugely on water supply. The growth of Namibia's economy and the health of its citizens are inextricably linked to the availability of fresh water.

Minerals
Namibia is fortunate to have a variety of minerals such as diamonds, uranium, gold, zinc, copper, lead, gemstones, granite and marble and salt. Mining is a pillar of the Namibian economy with both large scale mining and small scale mining taking place.

Wildlife resources
Namibia is blessed with a range of spectacular wildlife that is well adapted to life in arid and semi-arid conditions. Many people have realized the potential that wildlife has for income generation. We have a variety of national parks, commercial farms, private reserves and communal conservation areas, all of which benefit from ecotourism, hunting and craft trade.

Indigenous plants
Namibia boasts a great variety of indigenous plants that have medicinal or cosmetic value and are harvested for both cultural and economic reasons. Other plants are used extensively to support subsistence lifestyles e.g. thatching grass for building, and reeds for making baskets, mats etc.

Forests
The savanna woodlands of Namibia are home to some hardwood trees that are used in the building and craft industries. Many of Namibia's trees are used for firewood, as a large majority of Namibians do not have access to electricity or gas.

Fisheries
Namibia has one of the richest fishing grounds in the world, due primarily to the presence of the Benguela Current. Upwelling caused by the current brings nutrient rich waters from great depths that stimulate the growth of microscopic marine organisms. These in turn support rich populations of fish, which form the basis of the marine fisheries sector.

People
People are one of Namibia's most valuable resources. They can have both a positive and negative impact on the environment, depending on the way in which they use the other natural resources.

Namibia has a variety of natural resources, including wide open spaces
(Source: G Schneider, 2012)

But consider this for one minute. Mankind could not survive without air for more than three minutes, without water for more than three days and without food for more than three weeks. Despite all the things Man has learnt to manufacture, these cannot be made in the quantities that are required to support over 7 billion people, as well as the other millions of species on Earth. And all of the ingredients that we need to manufacture for our technological solutions come from the minerals provided by Earth. Whilst mankind will rely on ingenuity to engineer solutions that allow Earth to support our enormous human population, it cannot be done in the absence of a healthy functioning planet. And all people, not only the rural populations who make a direct living from the land, need to play a role.

The four broad categories of ecosystem services:

- **Regulating services**, such as the control of climate and natural hazards, water purification, waste management, pollination and disease control
- **Supporting services**, such as nutrient cycling, soil formation and primary production
- **Provisioning services**, such as the production of food and water
- **Cultural services**, such as spiritual and recreational benefits

Mankind cannot get away from the fact that human welfare is reliant on Earth's **capital stock**, which generates a **flow of goods and services** that support human well-being. Capital stock is made up of natural capital, manufactured capital, human capital and social capital (institutional rules, norms). **Natural capital** includes the lithosphere, hydrosphere, atmosphere and biosphere. **Ecosystem services** are the range of goods, services and attributes that natural capital provides, that generate value and contribute to economic production. Every minute of every day, ecosystems provide us with a variety of different services that make life meaningful. Because many ecosystem services have no viable or feasible substitutes (e.g. the influence of the atmosphere on climate regulation and the hydrologic cycle), the price or value of these **non-substitutable services** rises dramatically towards infinity as the demand for these services approaches the available supply (which is fixed), or the supply approaches a minimum level that is required for human survival.

The elements of a human's well-being, which are generated from ecosystems services, are outlined in the boxes below.

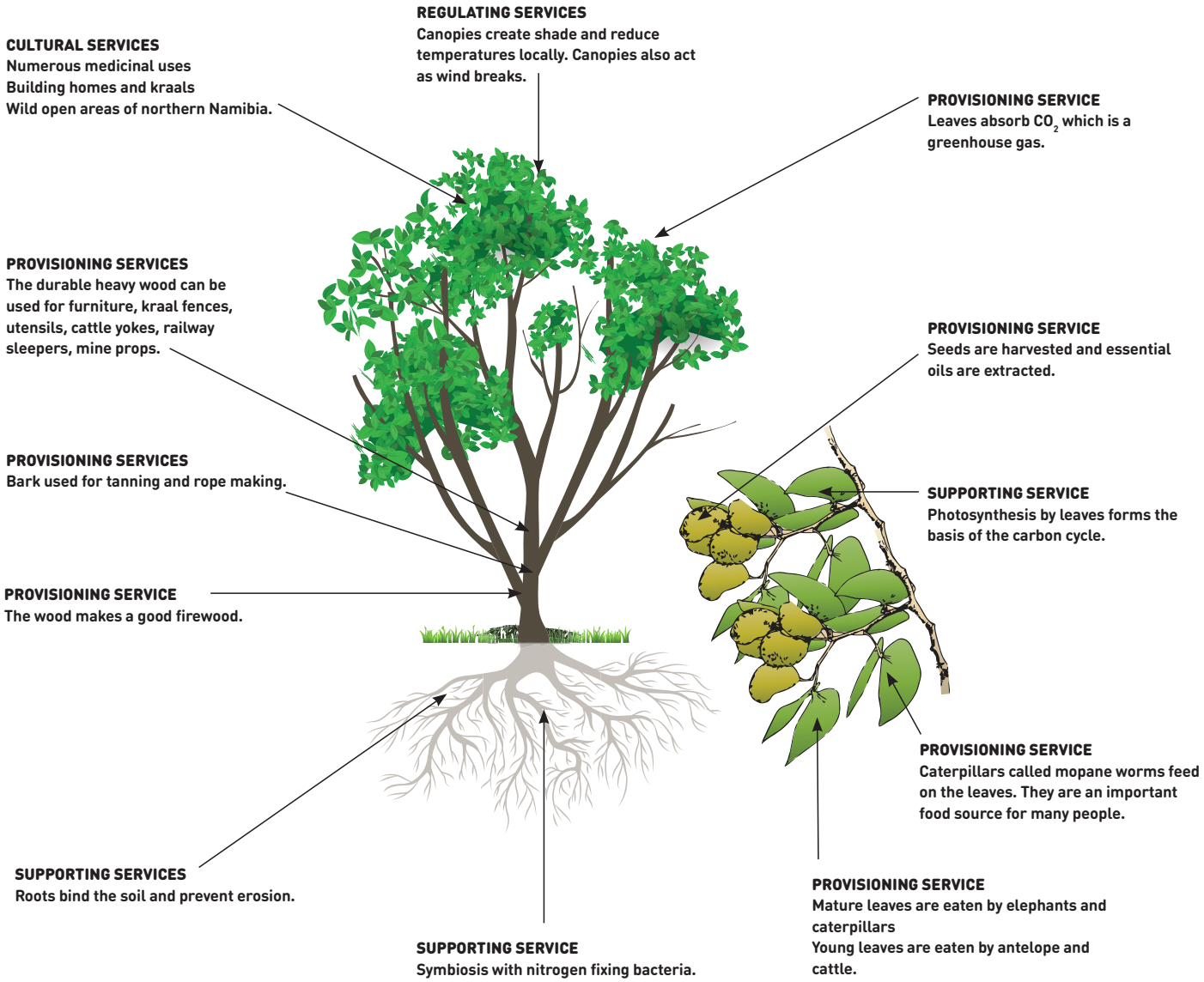
Elements of human well being generated from ecosystem services
(Source: Millennium Ecosystem Assessment)

Most people understand that the oceans are important because they provide us with food such as fish, oysters, seals and kelp. However, fewer people appreciate that the oceans are by far the largest carbon sink in the world. About 93% of carbon dioxide is stored in algae, vegetation and coral under the sea. If marine habitats, such as kelp forests, are destroyed, mankind not only destroys the **provisioning** services that those ecosystems afford, but the planet loses an important **regulating** service, namely carbon sequestration. This means that more carbon dioxide is released into the atmosphere and global warming is exacerbated. By storing CO_2, ocean ecosystems provide a valuable regulating service. The following diagram indicates how many ecosystem services one tree can offer and just how valuable a tree is to mankind.

In the early 2000s, a group of ecologists attempted to quantify the **price of replacing our planet's ecosystem services**. They calculated that it would cost over U$ 3 trillion – more than the entire global gross national product (GNP) at the time! They demonstrated that the world cannot afford to replace these services and that therefore mankind must work to protect the planet's ecosystems.

Across the globe and in Namibia too, thousands of people are abandoning the rural areas and moving to cities, hoping that it will provide opportunities to build a better life. Many governments support this policy of urbanization because it is easier and often cheaper to provide people with water, electricity, schooling etc. if they are all living close together.

Namibia is a vast land with communities scattered over great distances, so the provision of services is an expensive challenge for the Namibian government. Many of Namibia's major urban centers, (e.g. Windhoek, Swakopmund, Walvis Bay and Lüderitz) are located far from water and electricity sources, so the expansion of cities is an extremely expensive undertaking. In many cases looking after the natural resources in a rural area and finding ways for people to make a living off the land is far less expensive and more sustainable than growing cities. It also offers a better quality of life for people, than living in informal settlements. This is why one of the long



Magical mopane trees - providing valuable ecosystem services for all

(Source: M Pfaffenthaler)

term aims of Namibia's Vision 2030 is the sustainable management and conservation of Namibia's natural habitats and wildlife species.

This chapter aims to showcase how the environment is providing ecosystem services to Namibians. A range of examples are provided, from communities who have made a decision to stay on the land and enhance their standard of living through improved management of their natural resources, to practices that are being implemented by governments and businesses to make use of the country's natural resources whilst conserving ecosystems. Some of the many challenges, that natural resource managers have to deal with, are highlighted.

Wetlands – Namibia's richest ecosystems

Although Namibia's wetlands make up just less than 5% of the country's surface area, they directly support about 30% of the human populations that live in close proximity to these water sources. The ecosystem services, which fresh and salt water ecosystems provide, are numerous. They include:

- Water provision;
- Contribution to climatic stability;
- Sediment and erosion control;
- Flood control;
- Maintenance of water quality and abatement of pollution;
- Contributions to grazing and agriculture;
- Maintenance of surface and underground water supply;
- Provision of habitat for wildlife;
- Contributions to fisheries; and
- Contributions to the multimillion dollar ecotourism industry.

If the natural functions of wetlands are maintained, these benefits are available for humans to use free of charge. However, if wetlands are degraded or destroyed, these functions have to be provided artificially. The cost of doing so is exorbitant and should a wetland have to be restored, the costs are even more. To avoid these unnecessary and large financial costs it is imperative that Namibia manages the utilization of its wetlands very carefully, in particular abstraction of water for other, drier parts of the country.

The economic value of wetlands and wetland resources

The following values, extracted from the wetland area of the Zambezi River Basin (an estimated 220 000 ha) can be used as a typical Namibian example to illustrate the economic value of wetlands and some wetland resources.

- The **net total direct-use economic value/year** generated from livestock production, crops, fish, wild animals, water fowl, reeds, grass, and palm leaves is **estimated to be US$ 4.8 million**.
- The **net total indirect-use economic value/year** due to flood control, sediment retention, nutrient recycling, erosion control, provision of wildlife habitats, breeding and nursery grounds for fish & waterfowl is **estimated to be US$ 22 million**.
- Although they were not estimated in this study, economists recognise the **non-use value of wetlands**. These are the values associated with their preservation for later use (the option value) or to hand down to future generations (the bequest value) or just to know they exist (the existence value).

Fishing in the Zambezi River

(Source: M Pfaffenthaler)

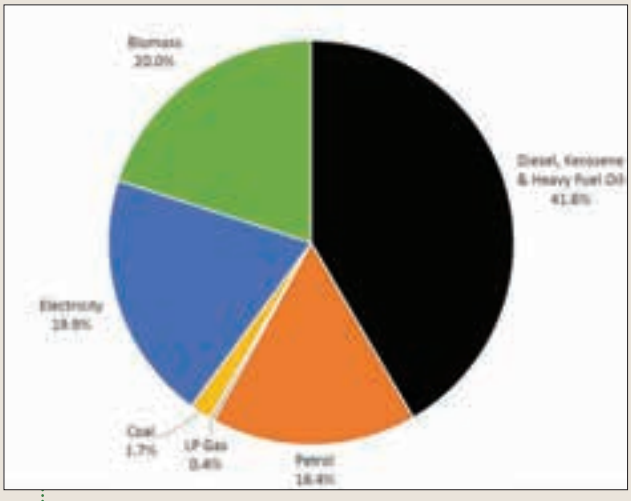
3.2 USE OF ENERGY AND FOSSIL FUELS

Access to energy and security of energy supply are key ingredients for the development and success of any nation. Urban life, industrial activities and transport cannot be imagined without energy, i.e. electricity and a variety of liquid fuels. At the same time, lack of access to energy deprives people of opportunities to develop and improve their living conditions. It can therefore be said that **electricity** and **fossil fuels** are pivotal to our society and the way we live. But the use of any energy, including renewable energy, does not come without a cost for the environment.

Fossil fuels and geothermal energy are found in the **lithosphere** (although fossil fuels are derived from the biosphere), whilst wind is an ecosystem service provided by the **atmosphere**, water by the **hydrosphere**, and the **biosphere** provides wood. Fossil fuels are **non-renewable resources**, whilst solar energy and wind are renewable resources. In a healthy sustainably managed environment, wood and water are considered renewable resources; however, they are often utilised unsustainably, which can render them in the worst case non-renewable.

Namibia's energy sector comprises the formalized electricity, upstream oil and gas, downstream liquid fuels subsectors, and the less formalized downstream gas and thermal energy subsectors. In addition to that, Namibia has great potential for renewable energy. In terms of consumption, Namibia's energy sector is dominated by liquid fuels, which accounted for some 58% of all energy consumed in Namibia in 2014. Electricity accounted for some 20%, and biomass for another 20%.

Namibia therefore remains fully dependent on liquid fuel imports, and also imports a sizeable proportion of its electricity requirements. The country has little influence over the price of these energy imports. In contrast to the electricity and oil and gas sectors, the local biomass sector has a much lower profile, despite its immediate relevance as the main household fuel source for most Namibians.



Energy consumption by type (2014)
(Source: National Energy Policy)

The main **domestic uses of energy** are cooking, lighting and heating. Wood and wood products remain the most utilised energy sources for cooking in Namibia, followed by electricity and to a lesser extent liquid petroleum gas (LPG). Even in urban areas, 20% of all households still cook on fire. While electricity is the most common source of energy for lighting, used by 70% of urban households, only some 15% of rural households have access to electrical lights, and need to resort to candles and paraffin. Wood is also the major source of energy for heating, and only 28% of all Namibian households use electricity for that purpose, mainly in urban areas.

Commercial and **industrial applications** of energy are found in all aspects of the Namibian economy, including agriculture, communication, fisheries, manufacturing, mining, tourism, trade, transport, and water. Transport and the agricultural sector account for 63% of the total energy consumed in Namibia. As an energy source, these sectors mainly use petrol and diesel, which in its refined state is 100% imported, as Namibia currently does not have any oil production or refining capacity. However, exploration is ongoing, and some oil has been found, albeit not in commercial quantities. The mining industry uses diesel and electricity, while the manufacturing and service industries rely heavily on electricity.

Namibia's Vision 2030 envisages an industrialised nation with job opportunities for all its citizens. The most fundamental condition for the development of such an industrialised nation is the availability of **affordable and reliable energy**, and an increase in the electricity demand can therefore be predicted. As Namibia endeavors to uplift the living conditions of its citizens, and alleviate poverty, the domestic electricity demand can also be expected to rise.

The main players in the **Namibian energy sector** are the **Ministry of Mines and Energy (MME)** as custodian of Namibia's energy sector; the **Electricity Control Board (ECB)** as the country's electricity regulator; Namibia's electricity utility **NamPower** as the entity that generates, imports, exports and transmits electricity; the Regional **Electricity Distributors (REDs)** as the distribution licensees in certain areas of the country, and **Namcor**, i.e. the **National Petroleum Corporation of Namibia** as the entity that ensures security of supply of petroleum products.

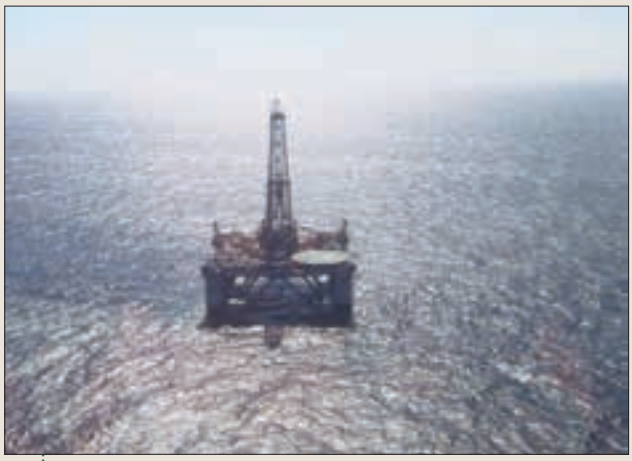
MME ensures the adequate and affordable supply of electricity and petroleum products for the country by administering and applying the relevant legislation. MME is also responsible for minimising the negative impacts of petroleum resource exploitation on the environment through the strict monitoring of compliance with the conditions of hydrocarbon exploration licenses. It further contributes to the creation of value for society from petroleum exploration, possible future production and supply. The ECB exercises control over the electricity supply, transmission and distribution industry. Its main responsibility includes regulating electricity generation, transmission, distribution, supply, import and export in Namibia through setting tariffs and issuance of licenses.

Namibia's energy sector can be subdivided into **primary** and **secondary energy sources**. The **primary energy** sources include liquid fossil fuels such as petrol, diesel, paraffin and LPG; **biomass** in the form of wood and charcoal; and to a lesser degree coal. The main **secondary source** of energy in Namibia is **electricity**, which is generated locally as well as imported from other countries.

Primary energy sources

As Namibia does not have its own oil resources, and also no refining capacity, so that all refined petroleum products need to be imported. Namcor is also active in the sourcing and selling, as well as the distribution of petroleum products. A total of more than 8 million barrels, or 1.3 billion liters of refined petroleum products were imported in 2016, exclusively from South Africa, at a cost of US$ 842 million.

Exploration for oil and gas is ongoing in Namibia, mainly in the offshore and the **Owambo Basin** of northern Namibia. Private international companies and Namcor participate in this search for hydrocarbons, however, so far, oil has not been found in commercial quantities.



Drill Rig in Namibian waters
(Source: G Schneider, 2012)

Natural gas was discovered approximately 170 km off the southern Namibian coast in 1974. Eight wells have since been drilled to appraise the quantity and quality of the gas of what has become known as the **Kudu Gas Field**. Some 1.3 trillion cubic feet of gas have been located, and the Namibian government has identified the development of this gas field as a strategic priority for local electricity generation. Gas from the Kudu Field could be transported through a pipeline to an 885 MW gas power station, that is planned to be built some 25 km north of Oranjemund. This would also require the drilling of production wells, installation of subsea equipment, and the installation of a floating production

system. However, the costs of such an investment and the remote location in relation to the main off-takers of the electricity generated on site have so far hampered the development.

In 2016, more than 50% of the country's population continued to rely on the daily use of woody **biomass** as a source of thermal energy, mainly for cooking food and preparing hot water. The majority of rural Namibians and an estimated 20% of the population residing in urban and peri-urban centers depend directly on the regular use of woody biomass, or its derivative products. In addition, select commercial and industrial users have begun to switch some of their thermal energy supplies from electricity, heavy fuel oil or coal to locally harvested woody biomass.

Cooking on fire
(Source: images.robertharding.com)

Namibia is endowed with a variety of bioenergy resources, including solid woody biomass and different sources of organic matter. As a primary feedstock, bioenergy resources can be turned into other energy carriers, such as wood chips, pellets, charcoal, biogas and biofuels. Amongst the most significant sources of Namibian bioenergy is the country's woody biomass resource, which mainly exists in the form of encroacher bush. Its sustainable use can become a valuable contributor to the country's socio-economic development, and a major value driver in rural Namibia. The Namibian charcoal industry produces tens of thousands of tonnes of charcoal every year, most of which is exported.

In the future, locally harvested woody biomass from encroacher bush is likely to play a more pronounced role in Namibia's supply of thermal and electrical energy. The rapid advancement of technology is expected to invigorate the development of the local biomass industry. Such development, however, requires local biomass harvesting and utilization to be guided by sustainable land-use practices to minimize the industry's overall carbon footprint.

Secondary energy sources

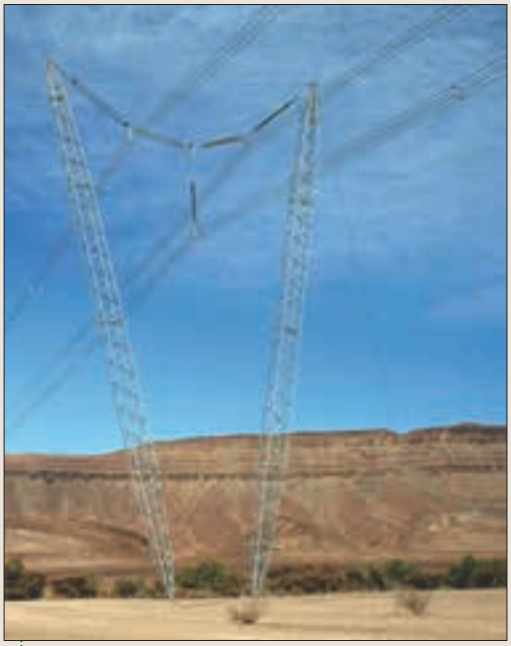
The **locally produced electricity** is mostly sourced from the Ruacana Hydropower Station on the Kunene River and to a much lesser degree from the Van Eck coal-fired power station in Windhoek. A small, but growing percentage is sourced from solar power generation. The first plant to generate electricity from wind is presently being commissioned.

The **current annual electricity demand** in Namibia is 4 400 GWh, and the annual growth rate about 3%. Approximately 60% of Namibia's electricity demand is currently **imported** from neighboring countries at a cost of some N$ 4 billion. It is derived mainly from South Africa, but also from Zambia and Zimbabwe, with whom Namibia is linked via electricity interconnectors. Power generation in the countries of origin, i.e. South Africa, Zambia and Zimbabwe, is by means of coal-fired power plants, hydropower, and a nuclear power plant in South Africa.

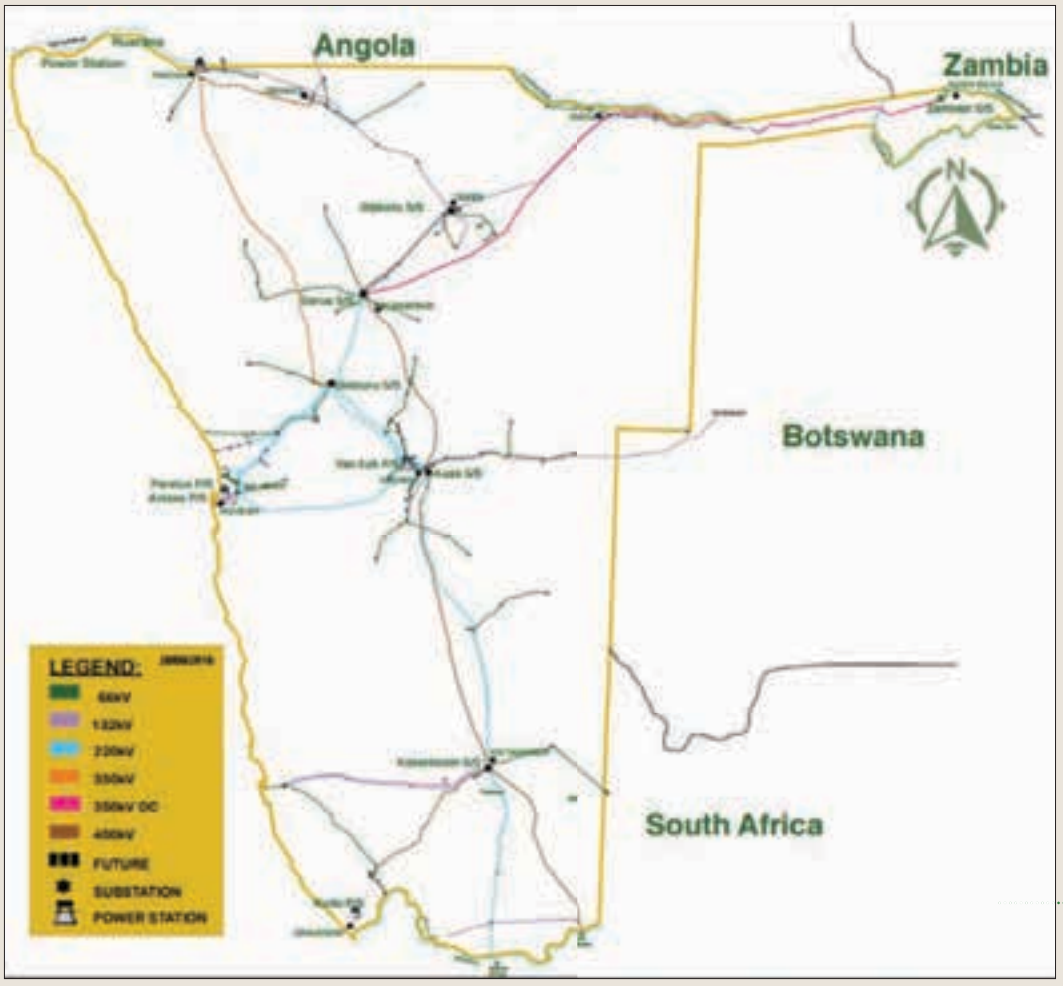
Trading of electricity in the southern African region is facilitated by the **Southern African Power Pool**. However, buying electricity from other countries makes Namibia vulnerable to prevailing conditions in these countries, such as domestic demand and infrastructure maintenance. Namibia's contracts with neighbouring countries will end within the next three to eight years; namely South Africa in 2022, Zambia in 2020, and the one with Zimbabwe in 2025. Thereafter the contracts will need to be renegotiated, which may negatively affect pricing in Namibia.

The Southern African Power Pool

The Southern African Power Pool (SAPP) was created with the primary aim to provide reliable and economical electricity supply to the consumers of each of the SAPP members, consistent with the reasonable utilization of natural resources and the effect on the environment. The members of the SAPP have created a common power grid between their countries and a market for electricity in the SADC region which allows their customers to benefit from the advantages associated with this market. Member countries are Angola, Botswana, DRC, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.



Electricity transmission
(Source: NamPower, 2017)



The Namibian Grid
(Source: NamPower, 2017)

The Namibian Grid

NamPower owns, operates and maintains power plants and a world class transmission system and network of 66 kV to 400 kV overhead lines. The utility has over the years continued to maintain and develop the country's transmission system to accommodate future demand for electricity as well as expected future generation and imports of electricity.

As the voltage on the transmission lines is too high to connect customers directly, the electricity is stepped down to lower voltages as it enters the medium voltage distribution system and becomes the responsibility of the REDs.

Locally produced electricity

Namibian electricity generation currently makes use of hydropower, heavy fuel oil, coal, diesel, and solar. Despite the fact that electricity generation happens on Namibian soil, the country is still dependent on neighboring countries, as the water for hydropower generation comes from a resource that is shared with a neighboring country and is dammed upstream before it enters Namibia; and heavy fuel oil, coal and diesel which are used in power plants are 100% imported.

Worldwide, **Hydropower** is the most widely used renewable source of energy and the global hydropower generating capacity is about 740 000 Megawatt (MW), accounting for roughly 16% of total world electricity generation. The water flowing in a river is impounded by a dam. This raises the level of the water in the reservoir behind the dam wall and the water is at a much higher level than the original river bed. This difference in water level is called the hydraulic head. When the sluice gates are opened, the water is released from the dam and flows under gravity via a penstock to a turbine. The kinetic energy of the descending water turns the turbine, which is directly connected to a generator that generates the electricity that is supplied to the consumers.

The **Ruacana Hydropower Station** located on the Kunene River is by far the largest electricity generator in Namibia. It was commissioned in 1978 when it consisted of three 80 MW hydro-generators. A fourth unit of 92 MW was commissioned in 2012. The original generators were upgraded and by 2016 added 5MW to each unit. This gives the Ruacana power station a total nameplate generating capacity of 347 MW. It is connected via a 570 km long 330 kV power line to the Namibian grid.

The output of the station depends on the amount of water available in the Kunene River, which can unfortunately not be regulated, as the upstream storage dams were damaged during the war of the 1980s. As a result, the station is run at full output level as a base load power plant during the rainy season only, while for the remainder of the year it is operated predominantly as a peaking power plant.

Ruacana Hydropower Station

(Die Republikein, undated, annotated by P Heyns)

Underground machine hall at Ruacana

(Source: namibian.com.na/156682/archive-read/Ruacana-adds-15MW-to-power-grid)

The Andara Power Station
(Source: P Heyns)

It is noteworthy that the first hydropower installation in Namibia was erected at the **Andara Mission Station** on the Okavango River in the late 1890! Later, in 1963, two turbines were installed at the Hardap Dam, but they are not in use any more.

Since 1990 investigations were made into the possible construction of an additional hydropower plant on the Kunene River, at either the Epupa or Baynes sites. The studies revealed that while the Epupa site was technically preferable due to its greater storage capacity, the Baynes site would be less disruptive to the life of the indigenous Himba people, and would have lower environmental impacts.

The Baynes site, about 200 km downstream of Ruacana, has therefore been selected as the preferred site. The height of the Baynes dam wall will be 200 m, while the water head on the turbines will be 187 m. The reservoir will hold 2 650 million m^3, will be 43 km long and have a maximum width of 4 km. The area inundated by the reservoir would be 57 km^2. It is envisaged that the generating capacity of the power station would be 600 MW which will be shared equally between Angola and Namibia. Studies have also been undertaken on the hydropower potentials of the Okavango and Orange Rivers. The Baynes hydropower scheme has not yet been developed but is viewed of strategic importance to Namibia and the likelihood of it being developed in the future is high, assuming that Namibia can find financing for such a development and it is awarded an environmental clearance certificate in terms of the Environmental Management Act of 2007.

That 'dam' question – the Epupa Debate

The option of a hydropower dam at Epupa Falls caused much discussion and debate in the early 1990s. The Namibian government hoped that the study, which was funded by Norwegian and Swedish aid agencies (NORAD and SIDA), would justify the plan to construct a dam on the Kunene River. But several international reviewers, coordinated by local and international non-governmental organisations (NGOs), criticised the study and stated that it contained "inadequacies in its sections on economics, social and environmental impacts, hydrological assumptions and alternative energy analysis." One reviewer, Professor Sidney Harring at the City University of New York and a former Fulbright fellow in Namibia stated that "Large scale dams are no longer simply engineering matters: the human and environmental impacts are fundamental and must be given full weight."

The Namibian government argued that the 500 million dollar project would result in schools and jobs to the region and provide between 200 to 360 megawatts of much needed energy for Namibia. However, the resulting lake would have flooded 380 km^2 of land inhabited by thousands of Ovahimba people and their argument was that they did not need the work as they already had their livestock off which they lived. At a tribal council meeting, a Ovahimba elder argued that "If the dam is built our grazing area will be destroyed, our ancestors' graves will be destroyed, and more people will come and settle here.....They will have to build the dam on top of us." Besides the social costs and the flooding of miles of green riverbank which is the main source of dry-season grazing for Ovahimba herders, the dam was criticised as it would have created a reservoir so large that the rate of evaporation would have amounted to many times Namibia's total urban consumption. It was also felt that the study underestimated the viability of wind and solar energy alternatives for the region.

Worldwide, **coal-fired, thermal power** stations provide some 41% of all electricity used. Thermal or steam coal is blown into the combustion chamber of a boiler, where it is burnt at high temperature. The energy thus produced is used to generate steam. The steam is used to turn a turbine, which is driving a generator producing electricity. Any thermal power plant has a number of by-products, which need to be considered in its design and operation.

Typically, a thermal power plant produces excess heat which is released into the atmosphere, often via the characteristic cooling towers. In addition, **carbon dioxide, nitrogen oxides, sulfur oxides, ash and water vapor** emanating from the burning of the coal need to be discharged, hence coal-fired power plants have large stacks. Coal fired plants are known be one of the main sources of carbon dioxide emissions worldwide and therefore a contributor to **greenhouse gas emissions**. Despite readily available technology, many facilities worldwide have not installed the necessary equipment to control pollution.

The **Van Eck coal-fired power plant** on the outskirts of Windhoek was commissioned in 1973, and has a total nameplate generating capacity of 120 MW, using four 30 MW generators. Due to the frequent water constraints in Windhoek, the plant was designed as a dry cooled station. The coal is imported from South Africa, which is costly, and the plant is therefore operated only as a standby and peaking power station.

The stacks are not equipped with air filters, but the facility does make use of cyclones to reduce fall-out dust. The Van Eck power station is an aging plant, which is prone to age-related breakdowns, and runs below capacity. Nampower is currently upgrading the facility because in the short term Namibia does not have an option but to continue using the power station.

In a **diesel power station**, a combustion engine burning diesel fuel drives a generator which produces electricity. Due to the price of diesel fuel, this method of electricity generation is more expensive than hydropower or electricity generated from coal. Diesel is therefore usually only used to generate small amounts of electricity and on the basis of stand by for peak electricity demand.

The Van Eck Power Plant
(Source: NamPower, 2017)

The **Paratus power station** in Walvis Bay operated six diesel engines with a capacity of 4 MW each. Like Van Eck, Paratus was commissioned in 1976, and in 2016, after 40 years of service, was disconnected from the grid. The **Anixas power statio**n near the old Paratus power station was commissioned in 2011, and its new and proven technology guarantees power supply to the Walvis Bay industry and residents. The station has three diesel engines with a capacity of 7.5 MW each. Anixas is a stand-by station for periods of peak power demand.

Apart from these conventional methods to generate power, **energy sources** such as solar and wind are receiving more and more attention. NamPower has recently awarded a tender for a 37 MW solar photovoltaic plant near Mariental. The company has also undertaken a detailed study, which has identified some 31 000 km^2 of land as suitable for solar photovoltaic plants, and the first 4.5 MW **solar power plant** was commissioned in Omaruru in 2015. A 5 MW solar power plant is in operation near Otjiwarongo, and three others at Grootfontein, Osona and Karibib have been comissioned. Another plant with a capacity of 3.4 MW has recently been completed near Arandis, and more are in the development stage near Tsumeb, Otavi, Outjo, Khorixas, Okakarara, Mariental, and Keetmanshoop.

Omburu Photovoltaic Plant
(Source: Solarage)

Under the **Renewable Energy Feed-in Tariff Programme (REFIT)**, 14 **independent power producers** will each generate 5 MW from renewable energy sources, resulting in an additional 70 MW which is to be fed into NamPower's grid. The first projects in Grootfontein and Okahandja were commissioned in 2016, and a further project in Karibib was commissioned in May 2017. Construction of two solar power plants with a combined capacity of 10 MW is ongoing near Gobabis. Others are already in the development phase and expected to be completed by the end of 2017, or early 2018. This currently amounts to a very small percentage of the electricity required, but in the long run Namibia is aiming to harness its solar potential to its full extend.

The construction of a 45 MW **wind power plant** under REFIT near Lüderitz is almost complete, and another wind plant with a capacity of 44 MW is currently under construction in the same area. Lastly, a feasibility study and an Environmental Impact Assessment are currently being completed for a 20 MW **biomass power plant**, using encroacher bush as a fuel.

Another important development is taking place in form of **numerous off-grid projects**, where renewable energy sources are used to generate electricity for local consumption, but the power generated is not fed into the grid. For example, in 2012, a 200 kW **combined solar and diesel hybrid power plant** and a mini-grid for distribution were installed at Tsumkwe, some 300 km away from the nearest grid transmission line. Namibia's biggest off-grid solar power plant was installed at Gam village near Tsumkwe in 2014. Its solar panels provide the whole settlement of approximately 1 600 people with solar energy.

In addition, some remote villages have received solar installations from the Ministry of Mines and Energy under the auspices of the **Rural Electrification Program**. But even if within reach of electricity, it makes sense for larger companies to generate their own electricity, in order to take pressure off the national grid during daytime, when solar energy can be harvested. Some leading examples are NamPower themselves (103 kW), Namibia Breweries (1.1 MW), and a supermarket chain which has equipped 13 of their stores with a total of 1.5 MW, to name but a few.

Rooftop solar installation at NamPower
(Source: J-M Smith)

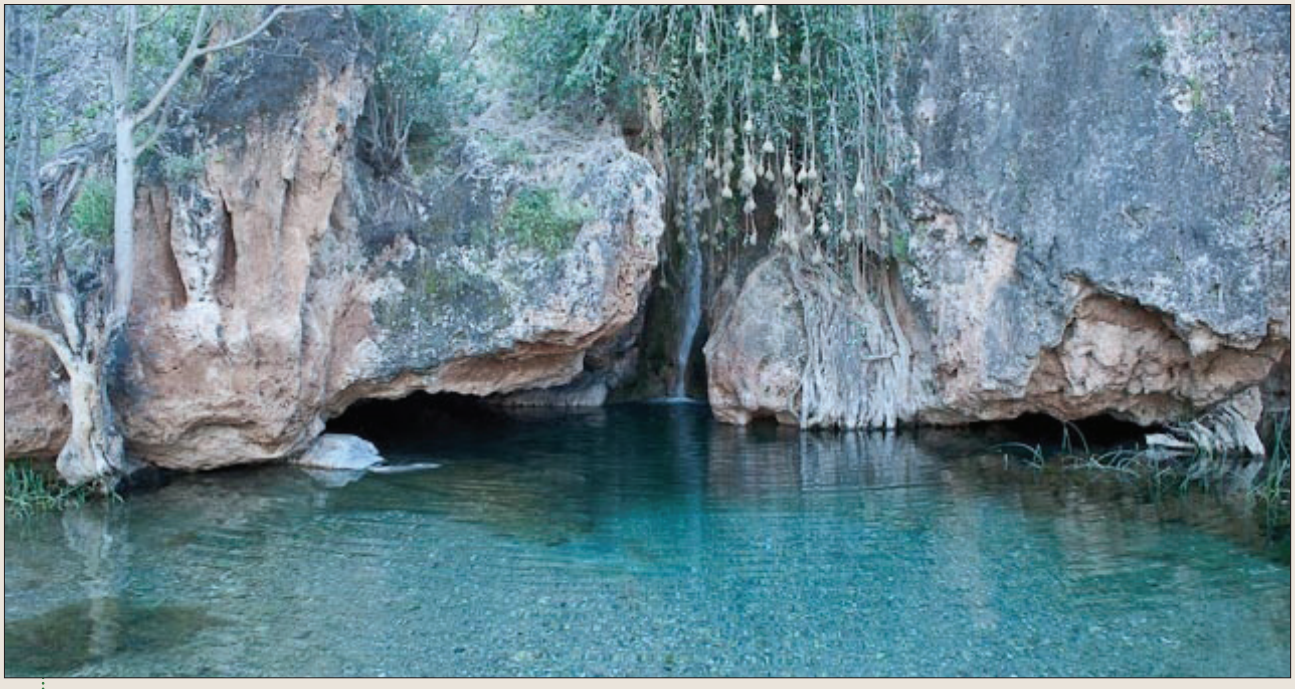
Other energy sources

Apart from the electricity sources currently utilized in Namibia, electricity is also generated using **nuclear power and geothermal energy** in other parts of the world.

Like all other **thermal power plants, nuclear reactors** work by generating heat, which boils water to produce steam to drive turbines, which in turn drive generators. In a nuclear reactor, the heat is the product of nuclear fission, which is the process in which the nucleus of an atom splits into smaller parts. The only naturally occurring fissionable element, the uranium isotope U-235, is frequently used for this process. Electricity was first generated by a nuclear reactor in 1951, when a reactor in the USA lit up four light bulbs. A small reactor in Russia was the first to supply the grid, and operated from 1954 to 2002. Since 1956, industrial-scale nuclear power stations have been in operation, and today some 12% of total electricity generated worldwide is from nuclear power plants.

While Namibia is a major producer of uranium in the world, it has so far not participated in the other activities of the so-called nuclear fuel cycle except uranium mining. The nuclear fuel cycle comprises mining and milling of uranium ore; subsequent conversion, enrichment, and fuel fabrication; the use in a reactor for electricity generation; and final storage, and reprocessing or disposal of used fuel. However, Cabinet has tasked the Ministry of Mines and Energy to establish the **feasibility of nuclear power generation** for Namibia, and in response the Ministry is developing a **Nuclear Fuel Cycle Policy**. However, the potential development of a nuclear power plant is a long-term exercise, with many development and licensing stages, including environmental impact assessment and clearance.

Geothermal energy is another form of energy that can be used for electricity generation. Geothermal energy is the heat from within the Earth. It is energy from hot water found within shallow ground as well as rock formations deeper beneath the Earth's surface, and extending even deeper to the extremely hot temperatures of molten magma. With increasing depth the temperature of the Earth's interior rises. Wells can be drilled into underground reservoirs for the generation of electricity.



The hot spring at Ogongo
(Source: F Weldhagen)

Some geothermal plants use the steam from a reservoir to power a turbine and generator, whilst others use the hot water to boil another fluid, usually an organic compound with a low boiling point, that vapourises and turns a turbine. Countries with hot rocks close to the surface have a good potential to generate a substantial amount of electricity from geothermal energy at reasonable prices. Iceland for example, generates 33% of its electricity from geothermal sources.

Namibia has a **potential for geothermal energy, albeit limited**. A number of hot springs occur throughout the country following a north-south line. This line extends from Warmbad in the south via, Ai-Ais, Rehoboth, Windhoek, and Gross Barmen to Ogongo near Sesfontein in the north. The original name of Windhoek, /Ai-//Gams, meaning hot water, bears testimony to this. However, reservoirs are not very large, and can only be utilized locally for heating or spas, and not for electricity generation on a large scale.

Challenges, opportunities and risks

All these various forms of energy that generate electricity have their challenges, opportunities and disadvantages. Cost is always a major issue too. It is therefore important for any country to develop what is generally referred to as a balanced **energy mix**. Over-reliance on one type of energy bears the risk of dependence and problems in case of failure, while developing a mix gives higher security of supply, i.e. when one source fails another one can compensate; a balanced energy mix also provides an opportunity to minimize the negative impacts.

With **climate change** being an overarching factor in many development discussions and decisions, electricity generation and its associated greenhouse gas emissions, in particular carbon dioxide, is also subject to scrutiny. However, electricity generation is not the only source of greenhouse gas emissions in Namibia. Burning of wood, for cooking in rural Namibia but also in urban areas, contributes towards the country's carbon footprint. Similarly, cutting down trees increases our footprint given that when alive, trees are an excellent carbon sink as they convert carbon dioxide into oxygen.

Generation of electricity using **hydro-carbons** (fossil fuels such as coal, oil, and natural gas) are commonly regarded as not clean, although the various fossil fuels give rise to very different emissions when used to generate electricity. In the first place they emit greenhouse gas such as carbon dioxide, which is associated with global warming. Then, if the burning process takes place in the absence of sufficient oxygen, toxic carbon monoxide and soot are emitted. Coal and oil also contain sulfur compounds, which release sulfur dioxide when burnt, which in turn can lead to acid rain. Acid rain changes the pH of soils, negatively impacting on a range of issues from soil biota to plant communities. In some parts of the world, the emissions of power plants, coupled with heavy traffic using petrol and diesel, are so massive that entire ecosystems are affected and the fresh air supply for human populations becomes an issue, with Beijing currently being the most prominent example. The technology available to treat the greenhouse gases arising from the combustion of fossil fuels is insufficient to solve the problem. There is a strong global movement to significantly reduce the emissions that contribute to global warming.

Hydropower is generally considered a clean energy, as its generation does not produce any greenhouse gases. But building a dam may bring about a variety of negative impacts on the natural environment, as it disrupts aquatic ecosystems and inundates large tracts of land that previously hosted terrestrial ecosystems. The associated infrastructure also requires land, which requires clearing of natural vegetation. So whilst impacts on the atmosphere are less, impacts on the biosphere and hydrosphere are pronounced. Building a dam can also require the relocation of communities, and has the potential to destroy important historical and archeological sites. Thus when considering to build a dam for hydroelectric power, difficult decisions need to be made. The location of important graves of the Himba people in an iconic landscape with high tourist potential led to the no-go decision of the proposed Epupa Dam in northern Namibia. And whilst the alternative site further west in the Baynes Mountains was seen as the better alternative, it too will also create problems. For example the aquatic ecosystem at the mouth of the Kunene River, an important wetland on the coast of western Africa, will be severely affected as the amount of available water downstream from the dam will be reduced. Another environmental impact associated with hydroelectric dams relates to the considerable amounts of reinforced concrete that are required to build a dam wall and its associated infrastructure. The production of cement requires a large amount of energy, derived either from coal or wood, and results in substantial volumes of greenhouse gases being emitted.

The Paris Agreement

The so-called Paris Agreement of 2016 builds on the Convention on Climate Change and brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below two degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives.

147 countries have ratified the Paris Agreement, Namibia is amongst them and has submitted a new Climate Action Plan to the UN Framework Convention on Climate Change. In this plan, Namibia commits to reduce greenhouse gas emissions dramatically by 2030, reduce deforestation by 75%, and increase the share of renewable energy in the total energy generation to 70%. This will cost about US$ 33 billion. Accession to the Paris Agreement gives Namibia access to the Clean Climate Fund, and projects dealing with climate change adaptation with reference to water, food and energy security are under way.

In many parts of the world **nuclear power** is seen as a clean energy source, again because it does not contribute significant amounts of carbon dioxide to the atmosphere. For this reason some people advocate that compensating nuclear fuel for fossil fuels to generate electricity is good because it will play an important role in reducing the emission of greenhouse gases. But while nuclear power generates lots of carbon-free energy, it is an energy source that is rejected by many people because of the associated radiation risks and the difficulties with the disposal of nuclear waste.

Prominent accidents such as the one at Chernobyl in 1986 have released large amounts of radioactive material into the environment with disastrous consequences for humans, fauna, and flora. The more recent accident at Fukushima has once again demonstrated the vulnerability of human constructions when it comes to the forces of nature. Considerable destruction occurred as a result of a submarine earthquake, which generated the tsunami, that hit the coast of Japan in 2011. The damage to the Fukushima nuclear plants rendered an area of 150km2 uninhabitable, resulting in the displacement of local communities. No deaths occurred as a result of the release of radiation.

Many people also reject nuclear energy because the end product, **nuclear waste**, remains radioactive for a long time. Storage of nuclear waste needs to be carefully addressed and managed well beyond the lifespan of the current generations. Such a liability is not readily taken on by society. Like fossil fuels, uranium is a non-renewable resource, however it is more abundant than fossil fuel. Despite these disadvantages, more nuclear power plants are currently under construction than at any time in the last 25 years, in a drive to reduce carbon dioxide emissions.

Because they are renewable resources, **solar and wind energy** are considered the **ultimate solution** in clean energy production. More recently, they have also become more cost competitive. While emitting no greenhouse gases or other waste during the generation stage, there are negative environmental impacts associated with the development of these technologies, which renders them less clean than one would think. The manufacture of both, solar panels and windmills, require large amounts of raw materials. Both solar and wind have a major disadvantage in that they cannot generate electricity if the sun is not shining or the wind is not blowing or is fluctuating too much. Therefore, these technologies require power systems back up technology, which are often not environmentally friendly. Solar and wind farms usually cover large areas where they interfere with other forms of land uses and impact on biodiversity and aesthetics. The comparatively small Gam solar power plant, for example, covers an area of two soccer fields. Windmills can pose a significant threat to bird populations, and the noise pollution they cause influences terrestrial ecosystems. Technology development is therefore unfortunately often associated with some form of environmental degradation, as is the case with the other forms of electricity generation.

Lastly, whilst solar and wind technology is very important in Namibia's energy mix, it brings an additional challenge for NamPower. The intermittent nature of solar and wind power can pose a problem for the transmission and distribution of electricity, due to the inherent variations.

Geothermal energy has the risk that certain greenhouse gases can be released from underground during the extraction process, and that surface instability can be caused. But other than that the potential impacts are small. However, because geothermal energy is linked to very specific geological conditions, it is not an option that is readily available everywhere.

Concluding remarks

It is important to remember that there is no such thing as clean energy and as long as people's energy needs continue to grow, electricity generation will continue to have an impact on the environment. However, the considerable progress made since the climate change debate started about 30 years ago, suggests that sustainable solutions could be achievable in the long run, if all nations committed to developing an energy mix that is tailor-made for their country's conditions, whilst ensuring reduced greenhouse gas emissions and minimizing other negative environmental impacts. It also requires a large commitment to the more efficient use of energy.

In order to support this, the Namibian government has worked on a number of policies, such as the National Energy Policy, the Renewable Energy Policy, and the Independent Power Producer Policy. In addition, government has finalised the National Integrated Resource Plan (NIRP). The NIRP assesses the full range of power supply development options that can meet future national needs. It provides information on the size, type and timing of supply projects needed in the electricity supply industry. The Energy Policy was developed in 2016-2017 and addresses the following aspects:

- The supply, transmission and distribution of both, electricity and fuel (petrol and diesel), as well as the development of an oil and gas sector.
- The development of the country's bio-energy resources, focusing on solar and thermal and cross cutting issues, including the need to 'limit' the adverse impacts of Namibia's energy sector on the natural environment.
- The integration of energy planning into all national development planning activities throughout all tiers of government.
- The development and maintenance of a comprehensive, quality-assured, and credible data base of energy resource and consumption data for Namibia.

Electrical transmission lines
(Source: A Engelhardt, 2016)

3.3 USE OF FRESH WATER

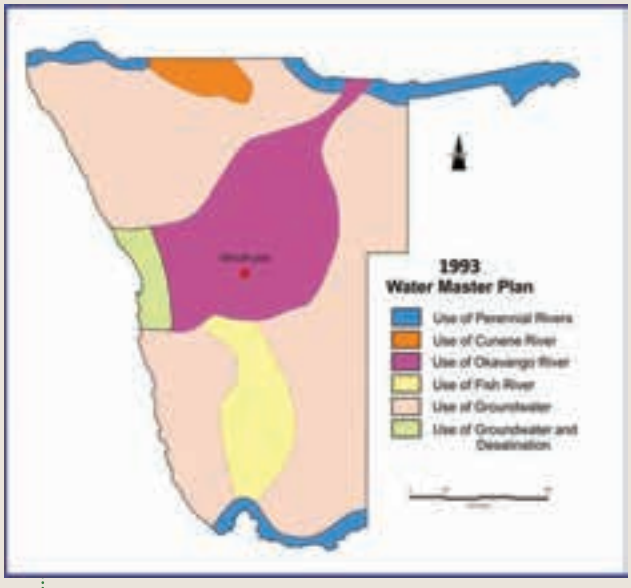
Namibia is the most arid country in the Southern African Development Community and water resources are scarce. To truly understand and manage this essential, non-renewable resource, one has to consider water within the context of its ecosystems, be it riverine, lake or sea. In Section 3.1 the use of wetland ecosystems was discussed and the numerous ecosystem services they provide were listed; water provision being just one of them. In this section the book focuses on the issue of **water provision and use** because it is so critical to Namibia's welfare, and Namibia's water policies and plans should be better understood.

Water supply for a nation

Namibia needs to plan and develop its water supply infrastructure to ensure the long term availability of water to the country. The primary objective of this planning is to have adequate **water schemes** in place where and when required. Poor planning, bad management and a lack of implementation are not an option. Since 1973 water development in Namibia has been guided by the **Master Water Plan** which has a thirty-year planning horizon, and is updated every 20 years.

The main directives of the 1993 Master Water Plan are:

- Water from the **perennial rivers (Kunene, Orange, Okavango, and Zambezi)** on the northern and southern borders of Namibia should in principle be used for domestic use and irrigation by nearby communities to reduce pumping costs and energy demand.
- Water from the **Kunene** should be diverted into the northern, ephemeral Cuvelai basin. This water scheme is the **Cuvelai Water Supply Scheme**.
- Water from the **Okavango** should be imported to the central area of the country to augment the water and groundwater resources, which would not be able to meet the demand in the future. This project is called the **Eastern National Water Carrier (ENWC)**.
- Water from the **ephemeral Fish River** should be reserved for domestic use and irrigation. A number of dams should be built as the demand increases to store the runoff in the river during the rainy



The 1993 Master Water Plan
(Source: P Heyns)

Important water schemes for Namibia

Cuvelai Water Supply Scheme
The Cuvelai Water Supply Scheme collects water from the Kunene for the northern Cuvelai area.

Eastern National Water Carrier
The Eastern National Water Carrier collects water from the Karstveld, and in future perhaps the Okavango River to supply and augment current water resources in central Namibia.

Central Namib Water Supply
The Central Namib Water Supply collects water from groundwater aquifers (Omdel and Kuiseb aquifers) and the Areva desalination plant to supply the Central Namib.

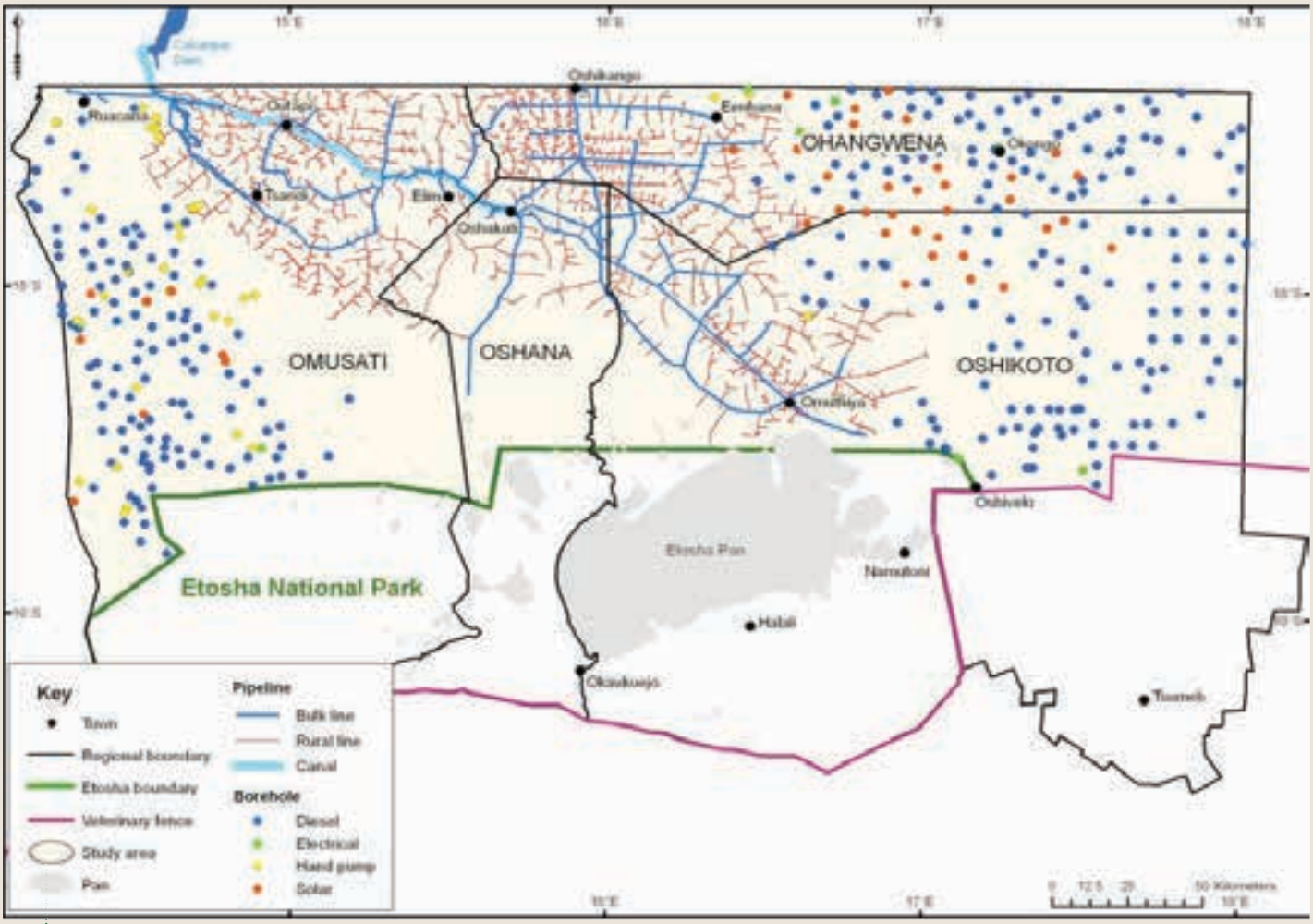
Fish River and perennial rivers (Kunene, Orange, Okavango and Zambezi)
The water from these resources is used for local irrigation and domestic use.

season. Water from these dams could also be used to augment the local groundwater resources when they become insufficient to meet the demand of small towns or the agricultural sector.

- The groundwater resources in the alluvium of the **Kuiseb** and **Omdel aquifers** supplying the central Namib area should be augmented by **desalination** of sea water and the available water resources should be used on an integrated basis. This scheme is known as the **Central Namib Water Supply Scheme**.
- The rest of the country should rely on groundwater resources in cases where the quality and quantity of the sources are available to meet the demand.

More than half of the population in Namibia lives in the north within the **Cuvelai Basin**. The Cuvelai drainage system originates in southern Angola and drains into the Etosha Pan. The surface runoff during the rainy season is ephemeral and unreliable while deeper lying groundwater is generally too saline for human and animal consumption. Although shallow wells can provide potable water, it is often polluted, unsafe and dries up. The only way to provide reliable water is to import water from the **perennial Kunene River**.

Namibia draws water from the Kunene River at the **Calueque Dam** in Angola, about 18 km north of the border. Namibia may, according to a water treaty between Angola and Namibia, abstract 180 million m^3 of water per annum. The water is pumped into a canal that runs across the border into Namibia and continues southwards to the **Olushandja Dam** where it turns south-easterly via Ombalantu and Ogongo to Oshakati. At each of the larger towns there are water treatment plants and potable water is supplied to the local population through an integrated network of pipelines.

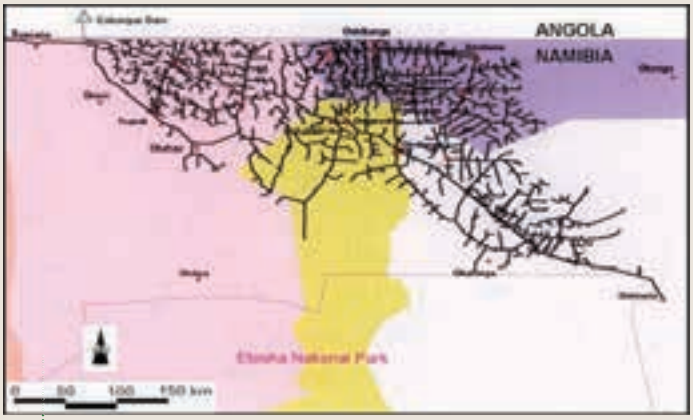


Layout of the water supply infrastructure in the Cuvelai Area

(Source: P Heyns)

Cuvelai water scheme coverage by 1990

(Source: P Heyns)



Cuvelai water sheme coverage by 2010

(Source: P Heyns)

Eastern National Water Carrier

(Source: P Heyns)

Canal between Grootfontein & Omatako

(Source: P Heyns)

The development of this system started in the early 1960s, and after Independence in 1990, the rural network was extended. The canals and dense network of primary, secondary and tertiary water reticulation pipelines total several thousand kilometers in length and supply safe, potable water to more than 90% of the people in the northern Cuvelai Basin. The images above compare the status of the water development in 1990 with that in 2010.

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

This project is being developed in phases according to water demand, the potential of the internal water sources to meet demand, and the availability of capital funds. The water carrier has three main components:

- **Three dams**, namely **Von Bach**, **Swakoppoort** and **Omatako** in the central area of Namibia. These

dams are linked to each other and can be operated on an integrated basis to optimise the yield.
- The 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**. The canal has a parabolic shape to reduce evaporation losses from the canal. The full supply capacity of the canal is 60 Mm³/a.
- **Pumping main** between Rundu on the Okavango River and Grootfontein. This development should have been completed by 2010, but has been delayed until at least 2020 due to the conjunctive use of surface and groundwater sources, the reclamation of domestic sewage to potable water, innovative water resource management practices and the water demand management programme in central Namibia.

The central coastal towns of Namibia, Walvis Bay, Swakopmund and Henties Bay, as well as Arandis, and the three uranium mines Rössing, Husab and Langer Heinrich, respectively some 60 km north-east and south-east of Swakopmund, are the main centres of economic activity in the central Namib Desert. All these developments are supplied with water from alluvial aquifers in ephemeral rivers and a desalination plant at Wlotzkasbaken. **The Omdel Aquifer** lies north-east of Henties Bay in the Omaruru River and the **Kuiseb Aquifer** is south-east of Walvis Bay in the Kuiseb River. The Kuiseb Aquifer comprises three water compartments located at Swartbank, Rooibank and Dorop near the sea. The well-fields in these aquifers are linked to the supply centres by means a network of more than 200 km of pipelines, pump-stations and reservoirs. The Omdel Dam was built to enable the artificial recharge of the Omdel aquifer and to secure a supply of water for Swakopmund, the Rössing Uranium Mine and Henties Bay. For many years, the sustainable extraction of water from the Omdel was possible, however with the growth of all the coastal towns, the required demand has exceeded the sustainable yield of the Omdel. There is also a **desalination plant at Wlotzkasbaken**, which has a current supply capacity of 13 Mm³/a.

The plant has a modular design and the desalination units can be increased over time as the demand increases to supply 20 Mm³/a.

The water demand and the safe yield of the water resources in the central Namib in 2016 are shown in the following table. The pipes between Walvis Bay and Swakopmund are unidirectional, only allowing water to flow from Walvis Bay to Swakopmund. Thus at present, the Kuiseb aquifers only supply water to Walvis Bay, Rooibank etc., whilst the desalination plant and Omdel aquifers supply water to all of the towns, mines and farms north of the Swakop River.

Areva Desalination Plant

(Source: G Schneider, 2011)

Central Namib Water Supply Scheme

(Source: P Heyns)

CONSUMER GROUP	WATER DEMAND (Mm^3/a)
Arandis	0,34
Henties Bay	0,57
Swakopmund	4,99
Walvis Bay	6,92
Small consumers	0,88
Subtotal Domestic and Industry	**13,70**
Mines	13,60
TOTAL	**27,30**

WATER SOURCE	SUSTAINABLE YIELD (Mm^3/a)
Kuiseb Aquifers	7-11
Omdel Aquifer	3-9
Areva Desalination Plant	13-20
TOTAL	**23-40**

Estimated water demand and water resources in 2017
(Source: P Heyns)

The water demand at the coast has jumped since the end of 2016 as the Husab mine went into production. In the table on the left, it can be seen that the 2017 estimated total water demand for the central Namib is 27,3 Mm^3/a. In the table on the right the total availability of the groundwater sources, based on the lower sustainable abstraction, plus the present capacity of the desalination plant, is 23 Mm^3/a. This means there is a shortfall of 4,3 Mm^3/a between the demand and supply, which will also increase over time. For future increased demand the focus must be on increased desalination. As desalination plants require large amounts of electricity to function, the emphasis should be on solar and wind driven plants. As advocated in the Harambee Plan, consideration will be given to develop an additional desalination plant to come on stream by 2020 and supply 25 Mm^3/a. This target is designed to address the water security situation at the coastal towns and meet the growing water demand for domestic, industrial and mining use. It is anticipated that this development will need to be done on a private – public participation (PPP) basis as this will free up financial resources for the construction of critical water infrastructure in other parts of the country, such as dealing with the looming water crisis in the central area of Namibia.

Storage of water resources

Large **dams** are capital intensive structures that are normally used to supply water for domestic use, industry, mines, irrigation and hydropower generation or for a combination of those uses. Such dams will normally not be built unless they are economically viable or of strategic importance to ensure a reliable supply of water, the reason being that dams are very inefficient and have a large impact on the environment. The eventual selection of a dam site is determined by a number of natural factors, such as the hydrology, topography and geology, as well as the location of the future consumers of the water.

Ten major dams have been built in Namibia and one is under construction on the Fish River at Neckartal near Keetmanshoop, while a feasibility study is being done for another dam on the lower Orange River, about 6 km upsteam from Noordoewer. A list of the major dams in Namibia is provided in the following table. The construction of the Neckartal Dam in the south of the country will be completed by 2020 and will increase the yield of the Fish River system with 80 Mm^3/a. The preliminary Namibian share in the yield of the proposed dam on the Orange may be about 300 Mm^3/a.

Neckartal Dam

(Source: HP.Baumeler)

Von Bach Dam

(Source: idreamafrica.com.na)

DAM	MAIN PURPOSE	TYPE OF STRUCTURE	HEIGHT (m)	CAPACITY (Mm^3)	95% SAFE YIELD (Mm^3/a)
Hardap	Domestic use and irrigation	Rockfill	30	300,2	50,0
Naute	Domestic use and irrigation	Concrete gravity arch	37	83,6	12,0
Swakoppoort	Domestic use	Concrete arch	33	63,5	4,7
Von Bach	Domestic use	Rockfill	35	47,5	6,9
Omatako	Domestic use	Earth embankment	12	43,5	2,1
Omdel	Aquifer recharge	Earth embankment	36	42,0	5,2
Oanob	Domestic use	Concrete arch	55	34,5	4,5
Otjivero	Domestic use	Concrete gravity	21	17,6	1,4
Dreihuk	Domestic use	Rockfill	21	15,5	0
Friedenau	Domestic use and mining	Concrete gravity	23	6,7	0,5
Neckartal	Domestic and Irrigation	Curved concrete gravity	78,5	857	120
TOTAL				**1521,7**	**207,3**

Major dams in Namibia

(Source: P Heyns)

The two major demands on water resources in Namibia are either urban centres, or agriculture for both the commercial and communal farming areas. From the information shown in the following two tables it can be concluded that, in theory, the present water resources, which have been mobilised for supply [namely 644Mm³/a], can meet can meet the estimated demand [about 646Mm³/a] until 2025/2026, but additional water resources will have to be mobilized to meet future demand. It is clear that water is a limiting factor in all facets of development in Namibia. The low and unreliable rainfall severely restricts the possibilities for reliable food production through dryland crop farming and although irrigation can improve the situation, it is mostly restricted to the areas adjacent to the perennial rivers.

SOURCE	REMARK	VOLUME (Mm³/a)	
		POTENTIAL	MOBILISED FOR USE
Kunene	(at Ruacana)	5 500	70
Okavango	(at Rundu)	5 000	-
Okavango	(at Mukwe)	10 000	36
Cuando	(at Kongola)	1 300	-
Zambezi	(at Katima Mulilo)	40 000	15
Orange	(at Noordoewer)	11 000	148
TOTAl			**269**
Perennial surface water	Installed abstraction capacity		269
Ephemeral surface water	Full development at 95 % assurance of supply	200	210
Groundwater	Estimated long term sustainable safe yield	300	150
Unconventional water	Reclamation, re-use, recycling, desalination	15	15
TOTAL			**644**

Water resource potential and availability

(Source: P Heyns)

CONSUMER GROUP	DEMAND (Mm³/a)			
	2015	2020	2025	2030
Urban	80.0	91.1	103.5	117.2
Rural Domestic	10.6	10.9	11.1	11.4
Livestock	86.8	86.8	86.8	86.8
Irrigation	204.6	344.6	379.8	497.2
Mining	17.2	18.1	19.1	20.3
Tourism	27.5	31.9	35.2	38.9
TOTAL	**426.7**	**583.4**	**635,5**	**771.8**

Estimated water demand in Namibia

(Source: P Heyns)

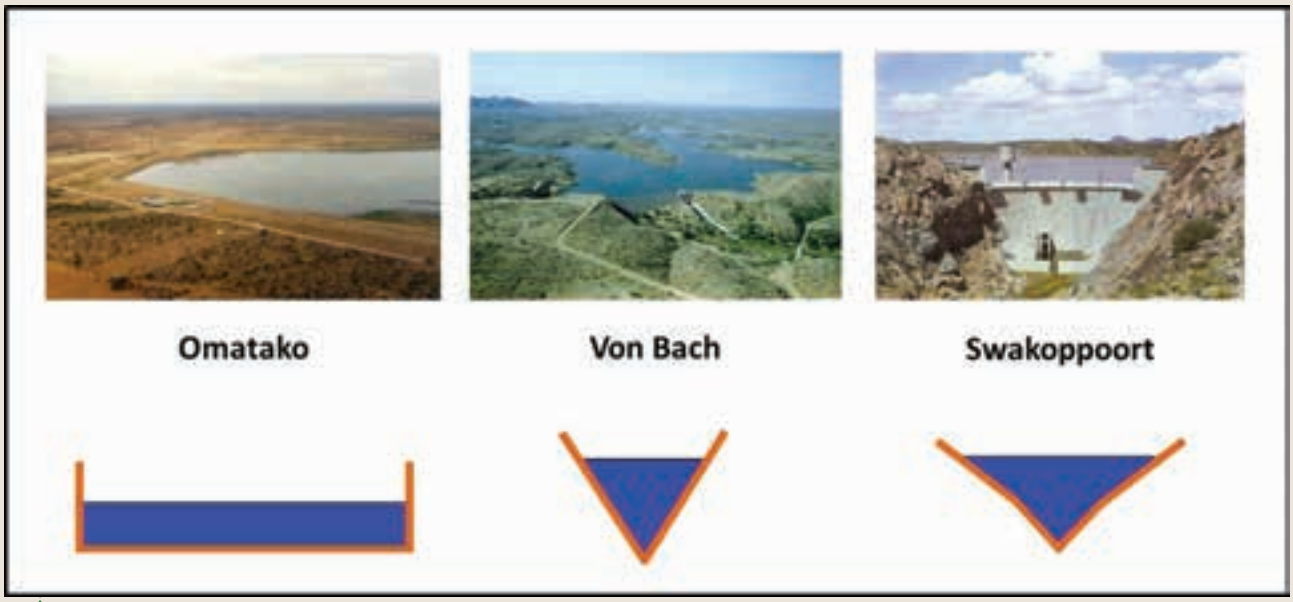
Because of high evaporation and marginal soils, agricultural practices consume huge quantities of water. Stock farming is practiced almost everywhere in the country; however, it is limited by the availability of grazing, which in turn is subject to low rainfall and poor rangeland management and compounded by long periods of drought conditions. This situation illustrates the need to be innovative to meet the water supply challenges and to conserve or save the country's precious water resources as much as possible. Namibia has developed some innovative methods to achieve water saving. These are explained in the following sections.

Saving water through inter-basin water transfers

The mean annual precipitation in the central area of Namibia varies between 300 and 400 mm while the mean annual potential evaporation varies between 2 800 and 3 200 mm. This deficit between rainfall and evaporation means that the loss of water through evaporation from open water surfaces in the dams is extremely high and various methods to reduce evaporation have been considered.

Water engineers have increased the efficiency of using surface water resources by making use of inter-basin water transfers in an innovative way. The aim of these transfers is to limit the amount of evaporation i.e. is to transfer water from a dam with less favourable evaporation characteristics (a dam with a larger surface area has more evaporation losses) to a dam with more favourable evaporation characteristics (a dam with a smaller surface area and less evaporation losses).

Four large dams have been built in central Namibia, namely the Von Bach, Swakoppoort, Omatako and Otjivero. The Otjivero Dam supplies water to Gobabis while the Von Bach, Swakoppoort and Omatako supply water to the capital, Windhoek, a number of small towns and two mines. The Swakoppoort and Omatako dams are linked by pipelines to the Von Bach Dam. The Von Bach Dam is the nearest to Windhoek and has the most efficient basin characteristics because the surface area of the water is smaller in relation to the Omatako Dam and the Swakoppoort Dam. The water that is impounded in the Omatako and Swakoppoort Dams after the rainy season is transferred as soon as possible to the Von Bach Dam, provided there is space available in the Von Bach Dam to store the water. In this way the quantity of water that would have evaporated from the larger surface areas of these dams is reduced.



Basin shapes of the linked central area dams

(Source: P Heyns)

Evaporation reduction systems

Another innovation aimed at reducing evaporation and increasing yield, was applied at the Otjivero Dam, the 4th largest dam built in central Namibia. The Otjivero Dam comprises a main dam and an upstream silt trap dam as shown in the following figure.

The Otjivero silt trap dam and the main dam

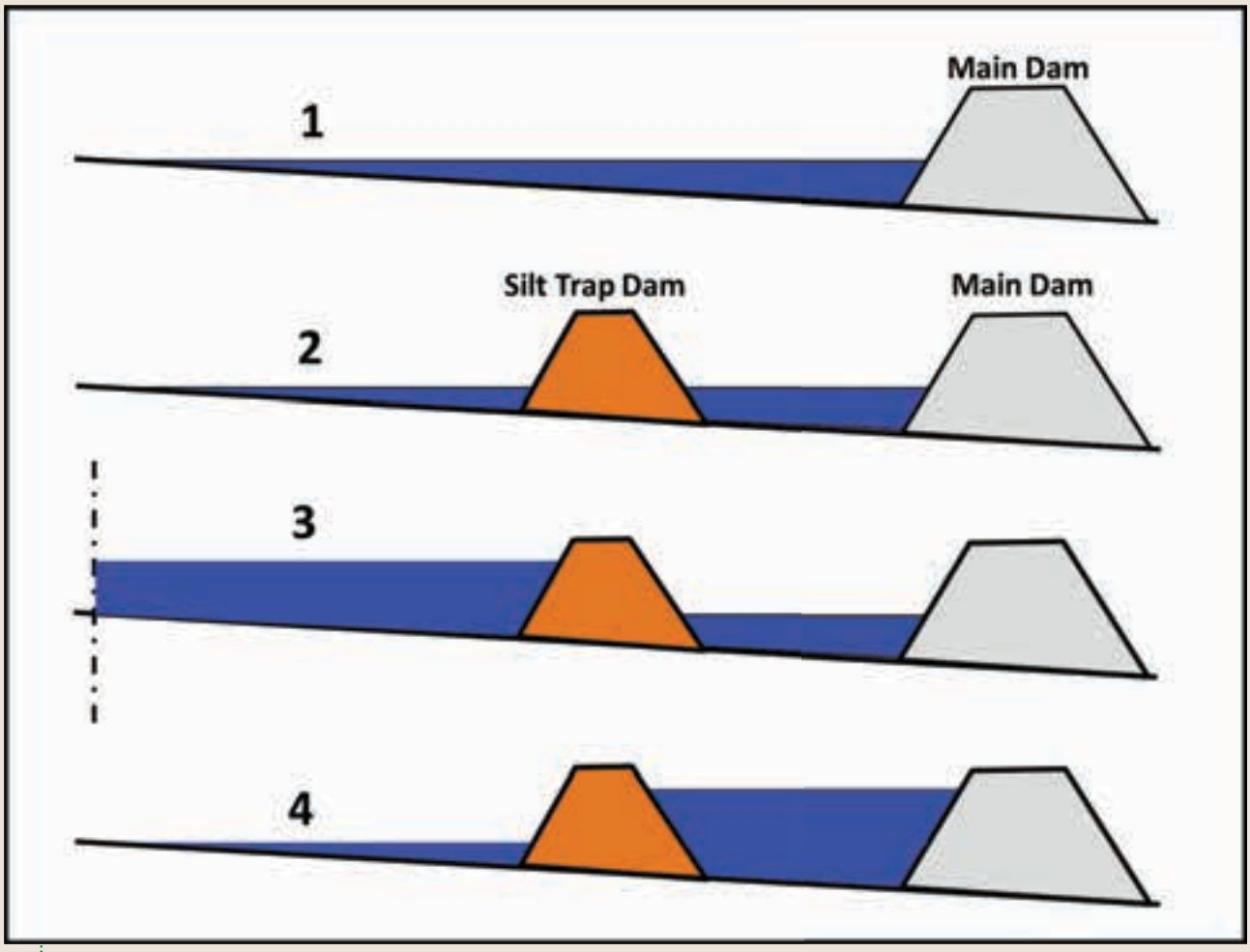
(Source: P Heyns)

Otjivero silt trap dam

(Source: P Heyns)

Otjivero damwall

(Source: G Schneider, 2011)



Evaporation reduction system

(Source: P Heyns)

If only the Otjivero Main Dam had been built, it would have been relatively shallow and had a large surface area from which a lot of water would have evaporated (See 1 in the figure above).

The silt load in the runoff to the dam was predicted to be high and the dam basin would have been prone to heavy siltation. It was therefore necessary to construct a silt trap dam upstream of the main dam. This improved the evaporation characteristics of the main dam as the water depth was increased and the surface area reduced (2).

When the water level in the silt trap dam is higher than in the main dam, it is possible to transfer the water under gravity from the silt trap dam into the main dam (3).

When the water in the two dams is at the same level, water is pumped from the silt trap dam into the main dam. In this way the water in the silt trap dam ends up in the main dam basin which is much deeper and has a much smaller surface area (4).

Conjunctive use of surface water and groundwater

Conjunctive use is conserving the available underground water while the surface water is utilised first. A surface water or groundwater source normally has a sustainable safe yield, but when a dam and an aquifer are interlinked, water can be abstracted beyond the sustainable safe yield of each of the individual sources. The water in the dam can be used more quickly to obtain a higher yield, but the ability of the dam to supply water in the longer term will be lower. However, less water evaporates over this time and the efficiency of the surface water sources is increased. This faster use of water means that water that would have evaporated is available for use and when there is any shortfall in the supply from the dam, the groundwater source serves as a back-up. Water can be sourced from the stored groundwater which would not have evaporated while the surface water was used.

The conjunctive use of surface water from perennial and ephemeral rivers, groundwater and unconventional water sources, such as reclaimed effluent, is an important management tool to conserve water, to increase resource efficiency and to reduce water supply costs. Similarly, if an aquifer has to be over-abstracted for some time, the depleted groundwater in the aquifer can be recharged with water from the dam.

In this way water that would have evaporated from the dam is saved and stored in the aquifer for later use when the water level in the dam is low. The available space in the aquifer is also replenished with water from an additional resource that comes from beyond the recharge area of the aquifer. This further increases the yield of the aquifer. The conjunctive use of surface water and groundwater has a number of different meanings and applications in Namibian terminology. A difference is made between:

- The conjunctive use of surface water and groundwater;
- the artificial recharge of an aquifer with surface runoff; and
- the banking of purified surface water in an aquifer.

Important water definitions

Conjunctive use
Conjunctive use is when a groundwater resource that is linked to the same water supply scheme as a surface water source, is held in reserve as a back-up while the surface water resource is used.

Artificial aquifer recharge
Artificial aquifer recharge is when surface runoff in a river is collected in a dam to allow the sediments and silt material in the water to settle out in the dam and then to use the clear water to recharge the aquifer more efficiently than a normal runoff event, thus improving the yield of the aquifer

Water banking
Water banking is when the raw water in a reservoir is purified in a conventional water treatment plant and used to recharge an aquifer that is over abstracted beyond its natural recharge potential.

Water Demand Management (WDM)
WDM attempts to reduce wastage and to enhance efficient use of water through the reduction of water losses and water wastage, block water tariffs, punitive water tariffs for excessive water use and educating the water users about measures to save and conserve water.

The Karst Aquifers in the vicinity of Grootfontein and Tsumeb in the north of Namibia have been thoroughly investigated to determine their sustainable safe yield. It was determined that 12 Mm^3/a could be abstracted over a period of three years, but then the aquifer should be allowed to recover over the next 15 years to replenish the 36 Mm^3 abstracted. The Kombat Mine has to be dewatered for mining purposes, and this water was supplied to Okakarara for many years instead of using the Tsumeb aquifer.

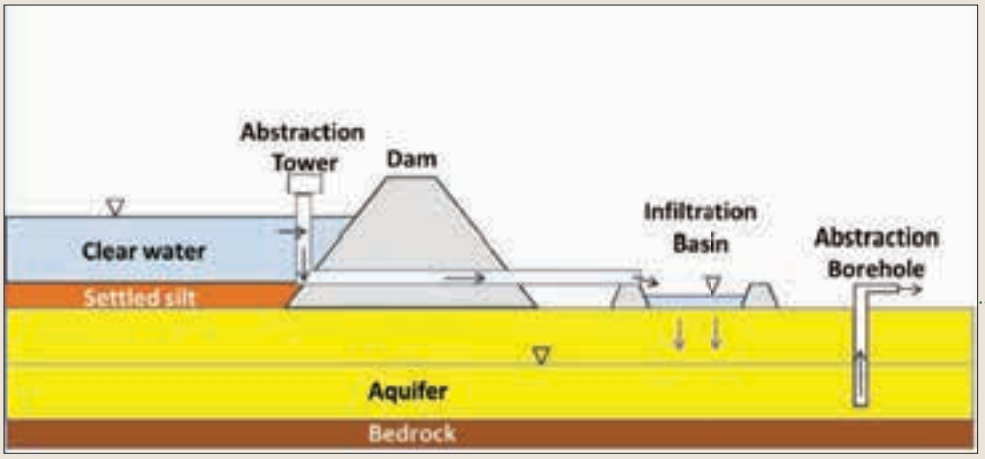
It was also found that the closed Berg Aukas Mine in the Karst Aquifer near Grootfontein has a large stored volume of water in the mine's excavations and about 4 Mm^3/a can be abstracted sustainably, when required, for augmenting the water supply to the central area of Namibia. Another example is the disused Abenab Mine between Tsumeb and Grootfontein. This aquifer is at present under consideration for linking to the Omatako canal to augment the water resources in the central area, as it contains vast amounts of good quality water.

By having the available groundwater in the Karst Aquifers and mines like Kombat, Berg Aukas and Abenab for use on a conjunctive basis, the 95% assured safe yield of the three dams can be increased from 20 to 30 Mm^3/a, without actually having to use the groundwater, unless the dams have dried up. The unused groundwater therefore serves as an insurance against supply failure in the event that the dams have been used at a higher yield, with a lower reliability, and thus using water that would have evaporated from the dams. Due to increased water resource conservation, improved water use efficiency and water demand management strategies, the need to link the internal water resources of Namibia with the Okavango River will most probably not be necessary before 2020.

Artificial aquifer recharge

The Omdel Aquifer is an alluvial aquifer at the mouth of the Omaruru River near Henties Bay. The natural recharge of the aquifer comes from erratic and unreliable ephemeral surface runoff and underground flow. In studies done on the runoff and recharge in the Omaruru River, it was found that although the aquifer sediments were relatively coarse, about 80% of the water during flood events flows directly into the sea without recharging the aquifer. Therefore in 1989, the **Omdel Dam Artificial Recharge Enhancement Project** was proposed to improve recharge to the aquifer.

The project comprises the Omdel Dam (see figure below), constructed about 36 km north-east of Henties Bay at a suitable site located upstream of the aquifer. The purpose of the dam is to impound the runoff. This allows the sediments and fine materials in the water to settle. The clear water is then decanted off from the top, through an abstraction tower and channeled downstream along the river bed and collected in infiltration basins. Here the clear water infiltrates and recharges the aquifer artificially.



Omdel aquifer artificial recharge enhancement project
(Source: P Heyns)

The dam was completed in 1996. The embankment of the reservoir is a unique and innovative design as it has to 'float' on about 45 m of alluvial material that could not be excavated down to bedrock level due to the water in the alluvium. The embankment comprises an impervious clay core and a downstream blanket of clay, supported by upstream and downstream shoulders constructed from permeable sandy soils. The control of seepage under the embankment is achieved by means of a complex, drainage system.

The Omdel Dam Project was the first major water infrastructure development in Namibia that was subjected to an environmental impact assessment during the feasibility study phase. In 1996 the project was the recipient of the prestigious Shell Environmental Award from the then Right Honourable Prime Minister of Namibia and patron of the Award, Dr Hage Geingob.

Abstraction tower of the Omdel dam
(Source: P Heyns, 2005)

Water banking in the Windhoek aquifer

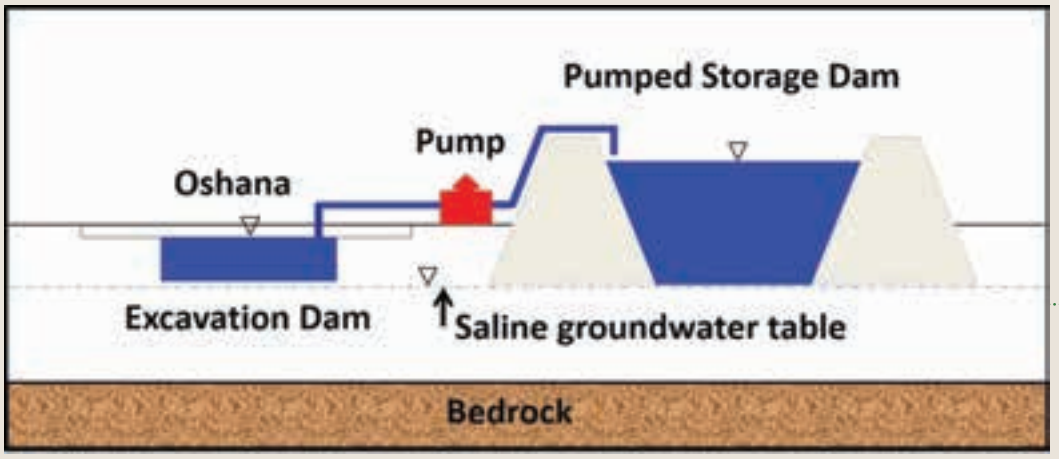
Water banking is also referred to as managed aquifer recharge. The Windhoek Aquifer is located in the foothills of the Auas Mountain to the south of the City of Windhoek and has been an important source of water for more than a hundred years.

The total present water demand in Windhoek is about 35 Mm^3/a and the City has three sources of water supply, namely groundwater from the aquifer, reclaimed domestic sewage effluent from the Windhoek reclamation plant, and surface runoff purified at the Von Bach Dam. The domestic sewage water reclamation plant was built in 1958 and its pioneering design was recognised world-wide. Von Bach Dam was completed in 1970.

The Windhoek Aquifer consists of a number of geological units which can store water in fractures. A pilot project was started to bank water on an experimental basis by injecting water into the aquifer. The groundwater is of a very high quality and complies with Group A water according to the Namibian Guidelines for the Evaluation of Drinking Water for Human Consumption. Care is taken to not contaminate the aquifer. Therefore prior to aquifer recharge, the water is chlorinated and treated with granular activated carbon before it is injected into the aquifer. The groundwater stored in the aquifer cannot evaporate and the water that would otherwise have evaporated from the Von Bach Dam is banked for later use. When the aquifer has been fully recharged, the quantity of water replaced would represent more than one year of supply to meet the demand of the City of Windhoek. Hence, the banking of water in the Windhoek Aquifer significantly improves the security of supply.

Pumped storage dams

Due to the flat topography of the landscape of the Cuvelai basin in the north of Namibia, there are no possibilities for the construction of conventional dams. One way of storing runoff during the rainy season is to build excavation dams in the oshanas. A complication is that the groundwater in the Cuvelai is saline and the depth of an excavation dam is limited to about three to four metres below ground level, down to the saline water interface. If the dams are made deeper, the fresh water will be contaminated by the saline groundwater. One option is to make the surface area greater. However, this is not efficient as the area of water exposed to evaporation will be more for the same water depth. In order to improve the evaporation characteristics of the dam, the depth of water in relation to evaporation area must be increased. This is done by raising the dam above the normal ground level and thus increasing the water depth. A pumped storage dam is illustrated in the following figure.



Excavation and pumped storage dams
(Source: P Heyns)

Recycling water and fresh water substitution

Recycling of water is defined as the reuse of water without any further treatment. The use of saline water instead of fresh water is a method used to conserve scarce water resources. The mining industry is confronted by economies of scale when it comes to water saving strategies due to the sheer amount of water they use and the fact that they must pay the full cost to recover capital and operating costs. It has therefore become viable for some mines to take action to save water through the recycling of water from the slimes dams. Rössing Mine serves as an example.

The quantity of freshwater used by the mine has decreased dramatically from 9.5 Mm^3/a in 1977 to 2.1 Mm^3/a in 2015. The total amount of water used by Rössing has remained more or less at 1997 levels, but the freshwater use has largely been replaced by the use of recycled water and the abstraction of saline water (freshwater substitution) for dust suppression from an aquifer in the Khan River. A brief financial cost benefit analysis by Rössing showed that by 1994 the benefit to recycle the water from the slimes dams outweighed the costs of fresh water by approximately N$ 67 million.

In towns like Windhoek, Walvis Bay and Swakopmund domestic sewage effluent is treated to yield a quality of water that is fit for reuse to water gardens, parks and sport fields. The reclamation of domestic sewage effluent to potable water quality standards (fit for human consumption) in the City of Windhoek has been practiced successfully for nearly 30 years.

Sustainable management of water resources Namibia

Because of the ever increasing water demands of our urban centres, which are remotely located from water sources, Namibians are now, more than ever, focussed on managing their water demand. Water Demand Management (WDM) is a fundamental part of the sustainable management of the water sector in our arid country. It focuses on finding ways to "stretch" the available water supplies instead of building additional infrastructure to supply more water to meet a wasteful demand. WDM can be implemented in many ways. These tools include market mechanisms such as economic pricing and incentives, non-market mechanisms such as the application of standards, quotas and fines on water use and direct intervention such as repairs to leaks, reduction of non-revenue water and promotion of water efficient technologies. All three of these tools are applicable to the industrial, commercial, civil and private sector. The way that individuals can contribute positively to WDM is discussed in Chapter 4. Some ways that Government currently implements water demand management are to:

- Inform the public on how to save water and what to do;
- charge water tariffs to recover delivery costs;
- promote the principle that water is valuable;
- make provision for the recovery of cost from the poor;
- impose a rising block water tariff system to charge large consumers a penalising price for water;
- reduce water losses from pipelines, taps etc. through effective monitoring and maintenance;

- charge tariffs on waste water produced in order to promote reduced consumption and efficient practices;
- avoid locating high water using industries in areas with scarce water sources;
- use technology to use fresh water more efficiently and to recycle, reuse, and reclaim waste water; and
- adopt better agriculture methods and use more efficient technologies so as to reduce the volume of water required for irrigation.

Rainwater harvesting is a practice that needs to be encouraged throughout Namibia, but particularly in the northern parts where rainfall is higher. Some municipal bylaws prohibit people from harvesting water from their roofs and where these laws are still in place, they should be abolished. If rainwater falling on a roof is diverted into a tank, this water can be used in the garden or in the home, although the later will require purification (chemical or boiling).

Concluding remarks

Namibia is making a constructive contribution to meet the global challenge to utilise its water resources sustainably in order to supply water for socio-economic development. By using the available surface and groundwater on a conjunctive basis and reducing evaporation by using innovative ways to improve water resource efficiency, the security of water supply in an arid environment is being improved considerably. In addition, these measures enable Namibia to be better prepared and more resilient to combat the adverse effects of periodic major droughts and climate change.

Some 10 000m³ of water is reclaimed daily from the Rössing Mine tailings dam and re-used in the processing plant. Recycle lakes on the right

(Source: K-A Terblanche)

3.4 THE VALUE OF MINERAL RESOURCES

Mineral resources are found in the lithosphere, in bed rock or sediments. Typically one does not think of geology as providing ecosystem services. Yet Namibia's lithosphere provides a wealth of ore deposits as well as geothermal energy, both of which are provisioning services. Because mining is so prevalent in Namibia and has been expected to meet legal requirements for environmental management for many years, this book explores utilisation of mineral resources in depth. The aim is to showcase some of the advances that have been made towards the sustainable use and management of resources. Following a historical introduction, the second part of the chapter introduces the environmental issues and safeguards in place for each stage of a mine's life cycle. Clearly every mine has its particular issues that need to be addressed which are specific to the ore that is being mined, the processes being used and the nature of the site. The chapter ends with a brief summary of the different mining sectors which aims to provide an insight into the complexity and wealth of mineral resources that are being explored and developed in Namibia.

Mining plays a vital role in the Namibian economy and currently contributes 11.1% to Namibia's GDP, 7.3% of all taxes paid to the Namibian tax coffers come from mining, and 74% of all export earnings are also derived from this sector of the Namibian economy. Equally important is local employment with thousands of people employed directly and many more employed by businesses that support and service the mines. However, minerals are a non-renewable resource, which means that at some stage the orebodies will become mined out. If mining is to maintain its elevated position in the Namibian economy, mineral resources need to be managed very carefully.

Mining in Namibia

(Source: Chamber of Mines of Namibia, 2016)

While there are many opportunities to develop the mineral resources of Namibia, there are also numerous challenges. The country has a well exposed geology that harbors potential for new mineral finds. The Namibian Geological Survey's excellent data base and its internationally acclaimed high resolution airborne geophysical survey, covering the entire country, supports exploration efforts.This is important, as the deposits that were visible on the ground, such as the famous green hill at Tsumeb, have long been found. Now the aim is to find mineral deposits that are concealed and occur at depth. Namibian policy and legislation actively promotes exploration and mining, and aims at attracting investment.

A brief history of mining in Namibia

According to archaeological evidence, the earliest mining activities in Namibia (copper smelting) took place at least 400 years before present in the area west of Windhoek. It is also well established that the indigenous people of the Otavi Mountainland made use of the abundant copper ores in the area for many centuries. The first written accounts of Namibia's mineral resources can be found in reports from the second half of the 18th century. The discovery of **guano** on Ichaboe Island in 1828 greatly stimulated interest in the area, and eventually led to the discovery of the Pomona **silver-lead** occurrence in 1857. Just a year earlier, in 1856, Namibia's first formal mine, the Matchless Copper Mine had opened near Windhoek. Extensive exploration soon led to the opening of the Natas, Pot and Sinclair Copper Mines. Formal mining at the well-known Tsumeb copper deposit started in 1906, and the first smelter was established there in 1907. Other deposits in the Otavi Mountainland were also exploited and a railway line was built for ore transport to Swakopmund. The holding company Otavi Minen und Eisenbahngesellschaft became one of the most profitable ventures in Namibian history.

The Khan copper mine east of Swakopmund came on stream in 1905. Copper was also produced from 1907 onwards at Otjizonjati east of Windhoek, and at Gorob and Hope southeast of Swakopmund. The first tin discoveries were made in 1908 near Omaruru, and by 1912, 14 tin mines had been established. The most important discovery was, without a doubt, made in 1908, when the first Namibian **diamond** was found near Lüderitz. More discoveries were soon made to the south of the original find, and by 1913, 20% of the world's diamond production came from Namibia. Today's diversity of Namibia's mining operations reflects the wide variety of ore, associated with the various geological rock units. In terms of revenue, the diamond mines are by far the most important mining operations in the country.

Formation of mineral deposits: Desert Diamonds

The world's largest gem diamond deposit, consisting almost entirely of gem-quality stones, occurs in the Namib Desert. The long-lived and lengthy sedimentary "conveyor belt" that transported sand, mud and gravel down the Orange River from the hinterland of southern Africa to the Atlantic Ocean and then northward along the Namib shore and back on land again, did not only carry sand, but also diamonds. Released from their original host rocks, millions of carats of diamonds were sent on a journey down the rivers flowing westwards towards the Atlantic coast. These diamonds were eventually deposited in beach terraces and windblown deposits, some of the bigger, and therefore heavier stones were deposited in the terraces of the Orange River before they reached the ocean.

Diamond in sediment matrix
(Source: O Medenbach)

The history of the Tsumeb Mine

The Tsumeb ore body is a polymetallic, pipe-like structure containing lead, copper, zinc, silver, arsenic, antimony, cadmium, cobalt, germanium, gallium, iron mercury, molybdenum, nickel, tin, tungsten and vanadium. It is located in the northern part of the Otavi Mountainland in moderately folded dolomitic sediments.

The copper deposits of the Otavi Mountainland were worked by local people for time immemorial. Evidence for their smelting sites, where they utilised termite hills for furnaces, was found at Tsumeb, Gross Otavi and Otjikoto.

In 1892, a London-based company was granted a concession for exploration in the area. Their prospector Mathew Rogers arrived at Tsumeb on 12 January 1893, and described an entire hill covered in the bright green and blue colours typical for some copper minerals: "...on first seeing such a grand and prominent outcrop I could scarcely conceal my astonishment and delight....few mineral outcrops present such exceptional indications as this one."

Two shafts were sunk in 1894, followed by two more shafts in 1904. Regular shipments of ore commenced with the completion of a railway between Tsumeb and Swakopmund in August 1906. In 1907, the first smelter was built at Tsumeb.

Large-scale exploitation of metal deposits in the Otavi Mountainland has played a vital role in the economic development of Namibia for more than a century. However, Tsumeb has remained the most important deposit, and has, between 1905 and 1990, when the mine closed, produced 24.6 million tonnes of ore, yielding 4.2 million tonnes of metal comprising 1.7 million tonnes of copper, 2.8 million tonnes of lead, 0.9 million tonnes and zinc, and many by-products such as arsenic, antimony, vanadium and germanium.

Underground work at Tsumeb around 1920

(Source: Namibia Scientific Society)

Mineral exploration in Namibia

Exploration for mineral resources is ongoing with Exclusive Prospecting Licenses (EPLs) located all over Namibia, on land and in the ocean, and covering a wide variety of minerals. Exploration is a high risk business, as only 5% of all exploration projects lead to the development of a mine, while 95% result in the write-off of the investment. Only companies with a sound financial position can undertake exploration activities and such companies are mostly from outside Namibia. Exploration activities always impact on other land uses, such as farming and conservation, because when accessing the mineral resources, surface disturbance is unavoidable. The negative impacts associated with exploration on land are:

- Noise pollution from drill rigs and generators;
- light pollution from drill rigs and vehicles operating after dark;
- dust generation from drilling activities and vehicles, which have the potential to impact on the health of people and plants;
- oil leaks and spills from drill rigs;
- disturbance of terrestrial habitats from the creation of camp sites, drill holes, pits and tracks, which could result in the loss of topsoil, increased potential for erosion and damage to plant and animal life;
- aesthetic disturbance resulting from the creation of drill holes, pits camps and tracks; and
- pollution of land and water from litter, sewage, drill residues and drill water (diamond drilling).

What is ecological restoration?

Ecological restoration is the assisted recovery of structure (composition and diversity) and function (processes involved in the flow of resources and energy among ecosystem compartments) of a degraded ecosystem, based on ecological principles. It is an intentional activity that initiates ecological processes, placing the degraded ecosystem on a pathway towards a specified target, e.g. rangeland for stock farming.

Whilst the severity of impacts at each drill hole is usually small and contained, the scale of drilling programmes can be extensive, with multiple holes being drilled in a small area or multiple holes being spread out in a grid covering many square kilometers. However, the nature of the impacts are such, that with good planning and vigilance, most of the potential impacts associated with exploration drilling can be avoided, mitigated and managed. The most difficult impact to mitigate is **rehabilitation of habitats** once they have been disturbed. This means that there really has to be an emphasis on avoiding damage in the first place, particularly in areas of high biodiversity or in fragile habitats. Typically **rehabilitation** in the exploration industry has involved cleaning up disturbed sites, treating oil spills, filling in pits and holes and raking and sweeping disturbed sites and vehicle tracks to remove disturbance scars.

This approach has been very successful in remedying visual scars, and many landowners are satisfied with the way their land looks once exploration companies have completed rehabilitation. Unfortunately such activities do not necessarily contribute to the recovery of ecological function and structure of damaged habitats. People are placing more emphasis on ecological restoration of disturbed areas to prevent the ongoing erosion of natural capital from short-term activities. For example exploration drilling on the gravel plains in the central Namib results in the loss of scarce topsoil and disturbance of soil crusts. Raking gravel plains does not necessarily rectify these critical losses. The need to improve the effectiveness of restoration has been identified not only for exploration companies operating in sensitive areas but for other industries too such as the film and tourism industries. Unfortunately effective restoration is easier said than done.

Ecological restoration - an important challenge for people operating in sensitive environments

A number of sectors, such as mineral exploration, filming, tourism and recreational impact negatively on fragile ecosystems and wildlife, resulting in the need for ecological restoration. For example damage has been done in the Dorob National Park by quadbikes. Despite regulation quadbikes sometimes tresspass in the breeding grounds of an endangered species - the Damara Tern. The bird lays its eggs in the sand, and because of excellent camouflage, both egg and chick are at high risk of being destroyed by vehicles.

Reasons why successful ecological restoration is difficult to realise

- Damage to natural systems often takes decades or more to recovery yet it is often expected that rehabilitation will be completed within a year or two.
- Ecosystems are inherently complex and thus restoration must be based on adaptive management. This requires time and ongoing commitment.
- The odds (strict financial limits, unrealistically short time frames, and a lack of acceptance or understanding by the industry) are often stacked against the restoration practitioner.
- Scientific information is often lacking on how best to restore certain habitats, as not all habitats can be restored in the same way.
- Restoration cannot only be considered in the decommissioning stage of a project.

Tracks in the desert
(Source: G Schneider, 2010)

Tracks in the desert with newly hatched Damara Tern
(Source: R Braby)

The policy on mining and exploration in protected areas

Mining has been the biggest contributor to GDP after government services since the earliest discoveries of minerals in Namibia. At the same time, conservation initiatives have been gaining momentum since independence. Namibia's state protected areas cover some 17% of the total surface, and the rapid growth in communal conservancies, community forests, game farms and tourism concessions has increased the land under some form of conservation to some 44% of the country. Namibia's first Marine Protected Area was gazetted in 2009. With the high percentage of protected areas in Namibia, it is not possible to ban exploration and mining in National Parks. In fact, some 75% of government revenue from mining comes from mines located in National Parks, and 10.4% of mining's total GDP contribution of 12% is from these same mines. The Tsau//Khaeb (Sperrgebiet) National Park is host to diamonds and zinc; the Namib Naukluft and Dorob National Parks have deposits of uranium, dimension stone, gypsum, copper and salt; the Skeleton Coast National Park has diamonds, as does the Namibian Islands Marine Protected Area.

A Policy on Mining and Prospecting in Protected Areas has therefore been compiled by the Ministry of Environment and Tourism and the Ministry of Mines and Energy. It is to ensure that exploration and mining within protected areas is undertaken within the environmental and economic regulatory framework that exists and that mineral development only commences in these protected areas when reasonable restoration is guaranteed. The Policy further established no-go areas where exploration and mining is not permitted due to high conservation and/or aesthetic and tourism value based on the best available information and using the IUCN zonation.

Skorpion Zinc Mine in the Tsau// Khaeb (Sperrgebiet) National Park
(Source: G Schneider, 2013)

Feasibility of developing a mine

When a worthwhile orebody is found, feasibility studies will commence to establish the **viability of developing a mine**. Not all feasible ore bodies become mines because technological, financial or environmental constraints might prevent the development of the mine at that point. Potential developers have to comply with the provisions of the Environmental Management Act (Act No 7 of 2007). **Environmental impact assessments (EIAs)** have to be undertaken and must consider the nature of the mining operation, assess the impacts before and after mitigation measures are put in place and explore alternatives. The process must involve extensive stakeholder engagement. Based on the satisfactory completion of the EIA process, the Environmental Commissioner will then grant or deny an environmental clearance.

The developers of the proposed mining operation also have to provide a comprehensive **Environmental Management Plan (EMP)**, which outlines how all stages of the mine's life cycle (construction, operations and closure) will be managed. These management plans need to be reviewed regularly to ensure ongoing relevance. Many Namibian mines commit to implementing **ISO 14001**, a voluntary certification process, based on international best practice in environmental management.

Like exploration sites, the development of mines is likely to be in conflict with other land uses. However, as mining is so important for the economic development of the country, other land uses are usually forfeited in favour of mining (at least in the short-term). In comparison to large scale agriculture and forestry, the surface area permanently disturbed by mining operations is small, although the severity of that damage can be significant. Mining and processing areas usually occupy only a percentage of the mining license that is awarded and very often the mining company makes the remaining portion available for agriculture, stock farming or conservation.

Unfortunately, the geology that contains valuable mineral resources very often also houses high levels of biodiversity. All over the world, mines are being proposed in areas of high biodiversity value, both inside and outside of protected areas. This places pressure on the sustainable management of natural resources. Finding the right solution is not always straight forward. There is a need to maintain an extensive network of healthy ecosystems for a nation's long-term sustainability. But this needs to be coupled with economic development. Because of the substantial investment that is made in bringing a mine to its bankable feasibility stage, it is difficult not to grant an environmental clearance, if the developers have demonstrated that they have taken environmental impacts into consideration and have made the necessary commitments to close and restore the mining license properly. The option for 'no-go' always exists in legislation but needs to be supported by substantive, **scientific evidence**. Unfortunately, the scientific evidence supporting other forms of land use such as biodiversity conservation, tourism and agriculture is often scant and this hinders good decision-making. The next information box provides some insight on how progress has been made in Namibia in this regard.

Assessment of impacts on indigenous flora forms part of a feasibility study for potential development
(Source: G Schneider)

Landscape Level Assessment to guide sustainable land use in the Uranium Province of Namibia

In 2012 Fauna and Flora International (FFI) undertook a landscape level assessment (LLA) of biodiversity vulnerability and landuse in the Central Namib uranium province for the Ministry of Environment and Tourism (MET). Ecological and socioeconomic evidence and information was compiled for a detailed area of the Central Namib to create a strong scientific foundation, from which to assess the relative importance of different parts of the landscape for biodiversity and people. A systematic spatial conservation planning assessment was conducted, which involved translating information into spatial (map) layers. These were overlaid to determine the relationship between different land features and how they come together in the landscape and contribute to conservation goals. The outputs from the LLA provide a **live decision support tool** for MET to use when considering the impact of proposed developments in the uranium province (particularly in the Namib Naukluft and Dorob National parks). For example when a development such as a mine or hotel is proposed, it can be inserted into the decision making tool. The tool will indicate if the proposed development is located in a biodiversity priority area, will indicate with which land uses it conflicts and will provide an indication of how this proposed development will impact on MET's ability to meet its conservation goals and objectives for the area. Some habitats are well enough represented and protected so that the impact of one development will not hamper the long-term conservation of that vegetation type. However, placing a development in a biodiversity priority area could prevent conservation goals and targets for the landscape being achieved. In such instances the no-go option should be seriously considered. The decision tool should be used in conjunction with the Strategic Environmental Assessment for the Uranium Province (U-SEA) and the various assessments and strategies developed by the Namibia Coast Conservation and Management Project (NACOMA). The existence of these documents for the Central Namib mean that the information needed to support **strategic, sustainable, integrated development** is available. All that is required is the will to use it and the commitment to make decisions that benefit Namibians in the long-term rather than focusing on short-term prosperity. The LLA was very well received, in particular by the Ministry of Mines and Energy (MME) and there has been a drive to develop a similar decision making tool for the entire country. Unfortunately this has not yet happened but it is hoped that sometime in the near future this initiative will proceed.

Managing impacts throughout the life cycle of a mine

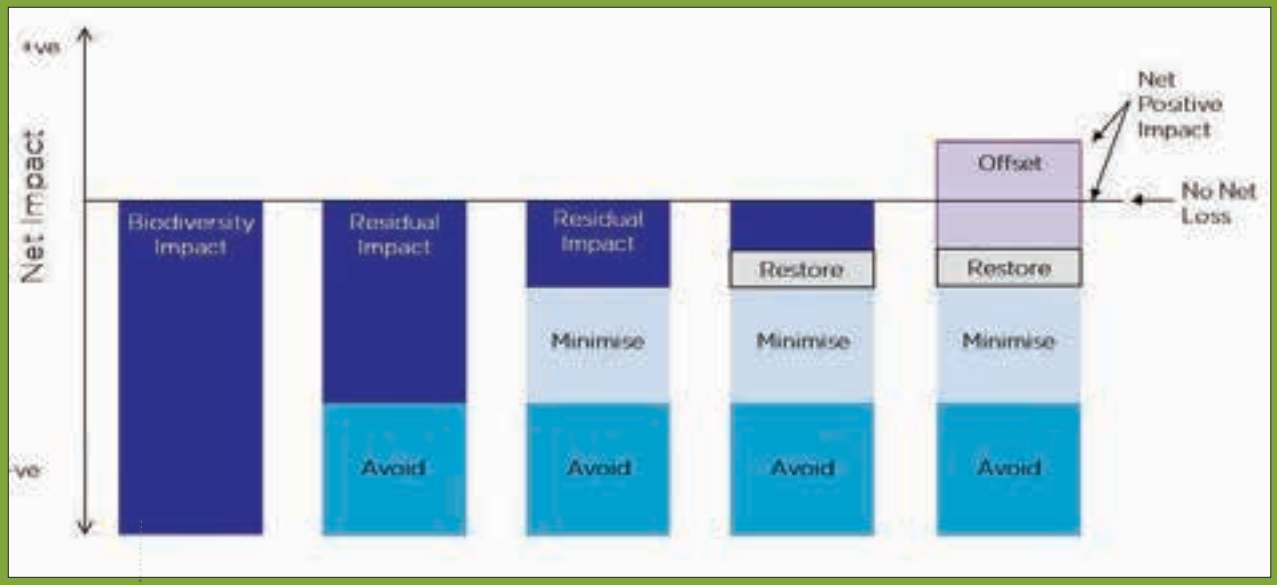
The **life cycle of an operational mine** starts with the **construction phase**, which depending on the size of the mine can take up to three years. The **operational phase** can vary from a few years to decades, and is followed by **mine closure**, which requires time depending on the extent of restoration and the implementation of long-term management programmes for permanent waste facilities, such as tailings dams and dumps.

There are a variety of positive and negative impacts that need to be managed throughout the life of mine. These days it is generally accepted that mines should only be given a license to operate if they can demonstrate that at mine closure the net result of their impacts on biodiversity (the natural environment as a whole), will be zero or even better by demonstrating a net gain. If this is not realised, mines would continue to erode the natural capital of a country, also diminishing the options for other land uses once mining has finished.

Many Namibian mines started operating before this approach to biodiversity was adopted. However, huge efforts are made and exemplary research and rehabilitation has been conducted for example by Namdeb, to name but one example. The **mitigation hierarchy** is a useful tool that demonstrates how different management approaches might be adopted to achieve a no net loss (see information box on next page).

The mitigation hierarchy – how mines should ensure they leave a positive legacy

The mitigation hierarchy is a set of prioritised steps to alleviate environmental harm as far as possible through **avoidance, minimisation (or reduction) and restoration** of detrimental impacts to biodiversity. **Biodiversity offsetting** is only considered to address residual impacts after appropriate avoidance; minimisation and restoration measures have been applied. Mines should apply the mitigating hierarchy as early on in the **planning and design phase** as possible so that as many impacts as possible can be avoided by applying best available technology, finding the most appropriate locations for permanent structures, choosing most efficient processes etc. Mitigation and restoration measures that are put in place once the mine is in operation should, if implemented properly, reduce the impact of the mine even further. Unfortunately it is impossible to avoid and mitigate all impacts. The impact that remains is known as the **residual impact** and is the impact that society inherits when a company closes and walks away from a mine. Mines that have not been managed well leave huge residual impacts that have to be dealt with by the government often at exorbitant cost. Responsible mines ensure that this residual impact is as small as possible. In trying to achieve **no net loss on biodiversity** some mines are exploring the feasibility of offsetting the residual impact. Whilst this is feasible in theory, it is extremely difficult to realise on the ground.



Mitigation hierarchy

(Source: divyanarain.wordpress.com)

Operational mines in Namibia

The vast majority of Namibian mines **are open pit mines and quarries**. Open cast mining creates a large cavity in the ground that, in most cases, remains behind when the mine closes. Large amounts of rock have to be mined to access the ore bearing material. The waste rock is discarded on a **waste rock dump**, which also becomes a permanent feature of the landscape.

Ore bearing material is transported to the processing plant where the ore is extracted. The metallurgical processes adopted depend on the type of mineral being extracted. Once the ore is extracted, the processed rock (mixed with chemicals, water etc) is discarded onto a **tailings impoundment**, which can be dry or wet. This too becomes a permanent feature. In terms of structures or activities that will alter the land use potential of an area forever, these three are the main ones, so the design, management and restoration of them require considerable attention. However, there are numerous other impacts that arise from mining that have the potential to impact on people and biodiversity. The most prevalent potential impacts associated with terrestrial mining in Namibia include:

- Over utilisation of scarce water resources;
- air pollution from dust, greenhouse gases, radiation and other toxic emissions;
- ground and surface water pollution from spillages, seepage and poorly managed waste facilities;
- soil and land pollution from spillages, poor waste management;
- loss of topsoil;
- impacts on productivity and functioning of ecosystems and/or specific species;
- noise from blasting, mining, vehicle activity, processing;
- vibrations from blasting; and
- visual pollution, including light and aesthetics.

In the Namibian **marine environment**, risks include:

- Biodiversity loss from both pelagic and benthic habitats;
- emissions into the air including greenhouse gases, pollution;
- impacts on the water column as a result of the tailings plume;
- impacts on the sea bed through drilling and dredging; and
- limited knowledge about the natural variability within the Benguela Current ecosystem.

To effectively **manage these risks**, mining companies not only need to commit to implementing mitigation measures, they need to:

- Conduct research to fill in information gaps about aspects of the environment they do not understand;
- implement monitoring programmes to gauge the effectiveness of their mitigation measures;
- evaluate monitoring programmes regularly and adjust management plans to ensure ongoing improvement and effectiveness of mitigation measures;
- document and share research findings and lessons learnt to improve the effectiveness of the entire industry;
- become active stakeholders at local, regional and national levels, helping to create an enabling environment in which effective environmental management can take place; and
- start planning for and trialling best closure methodologies as early on in the life of mine as possible.

Generally mines will set up an environmental management unit to continuously review and monitor the impacts arising from their operations and in relation to the commitments made in their EMP. Usually the first stage of environmental management undertaken by a new mine is to determine the **baseline conditions**. Specialist studies are commissioned and are likely to cover flora and fauna, archaeology, groundwater, air quality, noise and soil conditions. These studies built on the information gathered during the EIA phase.

Environmental monitoring at Areva's Trekkopje Mine
(Source: Areva, 2012)

The **monthly/annual monitoring** then builds on the database of information and provides a more detailed understanding of the surrounding environment. Usually mine site monitoring includes:

- Weather and dust (PM_{10}) monitoring (monthly);
- plant surveys and seed collection (monthly);
- groundwater quality and water level monitoring (monthly);
- wildlife and invertebrate surveys and counts (annually);
- flora surveys (annually); and
- soil analysis for nutrients and radionuclides (monthly).

As part of their social and corporate responsibly, many mining companies assist in the development of projects and initiatives to 'give back' to their surrounding communities. These can be in the form of donations, training opportunities, sponsoring of local organisations, contributing to local economic development, etc.

Mine closure

Modern mining and environmental legislation came into force in Namibia only after Independence in 1990. As a result, the country has a heritage of some **200 abandoned mine sites and quarries** that were not rehabilitated at the time of closure. Apart from being unsightly, some of them pose considerable environmental risks, such as dust pollution, acid mine drainage and structural hazards.

The Environmental Geology Division of the Geological Survey of Namibia has therefore developed a risk assessment technique, and is assessing these sites on an ongoing basis to identify those abandoned mines, that need remediation. Unfortunately the costs that these old mines have left for the country to bear are huge and it is not easy to find the funds to undertake rehabilitation. This has given mining a bad name, despite the fact that today there are better practices and more responsible operators.

Contemporary mines have **strict conditions for rehabilitation** under the current legislation, and must have **funded mine closure plans** in place. Those exploration and mining companies that are members of the Namibian Chamber of Mines are guided by the **Mine Closure Framework**, a detailed plan for responsible closure. Despite significantly more attention being given to mine closure and the long term liability of mine sites, mine closure faces many challenges such as:

- It is difficult to estimate the cost of closure and given that these sums are likely to be substantial, it is difficult for a mining company to put the money away up front. Whilst sureties are placed, it is not always guaranteed that sufficient funds will be available at closure.
- Rehabilitation methodologies are often not tested, so the success of ecological restoration is not guaranteed. The only way to reduce this risk is if the mine adopts a very rigorous restoration programme that includes trials and research from early on in the mine's life cycle.
- It is not easy to get a full closure license from government as they do not have the standards in place to measure if closure measures have been adequately implemented.
- Mines are often sold and the liabilities and closure commitments are transferred to the new owners. However, as the new owners are often smaller companies, it is not always guaranteed that they will have the finances to meet the closure commitments. In addition, mines may also be sold to companies that do not hold the same standard of environmental management as the former one, which can jeopardise the long term success of mitigation measures.

The photos that follow provide a before (left) and after (right) example of an area at Bogenfels, that was previously mined and has now been rehabilitated. Namdeb has been doing some exciting work on ecological restoration in the Succulent Karoo Biome.

Mining at Namdeb's Bogenfels License Area
(Source: G Schneider, 2007)

Rehabilitation at Namdeb's Bogenfels License Area
(Source: G Schneider, 2009)

Small Scale Mining

Small scale or artisanal mining is an important activity in areas of Namibia where there is little other economic activity. Small scale miners mainly produce **semi-precious stones and mineral specimens**, but in some instances also **tin and tantalum**. They usually have very little access to mechanization and work with simple tools, more often than not in unsafe conditions. Marketing of their products along roads in remote areas makes them vulnerable to unrealistically low prices and poor living conditions. In addition, their activities often lead to environmental degradation.

They do not undertake environmental assessments before they start their activities, they do not plan their excavations (but rather follow a geological unit that promises to host what they are looking for) and they do not mitigate negative impacts. In part this is because small scale miners are not educated about issues such as conservation, biodiversity and waste management. Sadly, small scale mining is frequently an example of how poverty leads to environmental degradation. In many cases small scale miners do not have licenses, and are therefore strictly speaking operating illegally. Support to this part of the Namibian mining sector is therefore important, in order to improve working conditions, improve marketing, living conditions and environmental performance. The mining industry and government have joined forces in this regard.

The following section provides an overview of the Namibian mining industry and gives details about the various companies that are responsible not only for mining Namibia's mineral resources but for managing the impacts of their operations on the environment.

Namibia's diamond industry

Namdeb Diamond Corporation, a partnership between the Namibian government and De Beers, has long-term mining concessions along the coast in the southwest of Namibia both on land and offshore, adjacent to the Orange River and offshore in the shallow waters. All land based operations are open cast. Innovative mining methods now also allow for the diamonds that occur in shallow water to be mined. This is done through continuous discharge of sand into the sea, which causes the shoreline to move further out to sea and thereby recovers land from the sea. Namdeb produced 403 000 carats of gem quality diamonds in 2016.

As early as the 1960s it was concluded that diamonds should also occur in the seabed adjacent to the land based diamond deposits as the diamond deposits were formed from the Orange River washing diamonds from inland into the ocean, before they were concentrated in shoreline deposits. The existence of such submarine deposits was confirmed and the first production occurred off Namibia's southwestern coast in 1961. DeBeers Marine Namibia produced 1.17 million carats of diamonds in 2016, almost three times as much as the land-based operations.

Beach accretion during diamond mining

(Source: G Schneider, 2015)

Diamond Mining Vessel

(Source: DeBeers Marine Namibia)

Namibia's uranium industry

Uranium is another important Namibian mineral resource and the country is currently the 5th largest uranium producer in the world. The uranium deposits are located in the central western part of the country, in an area that has become known as Namibia's uranium province. There are currently three operational uranium mines in Namibia. **Rössing Uranium Mine**, located some 60 km east of Swakopmund, has been in operation for more than 40 years, and is the longest operating uranium mine in the world.

Rössing Open Pit

(Source: Rössing Uranium Ltd)

Langer Heinrich Uranium Mine went into operation in 2007. It is an open cast mine, located some 80 km southeast of Swakopmund in the Namib-Naukluft Park.

Langer Heinrich Mine

(Source: Langer Heinrich Uranium)

The latest development in the uranium sector is the establishment of the **Husab Mine** in the Namib-Naukluft Park. This mine will become the second largest uranium mine in the world once it assumes full production. The mine is currently ramping up to full production, which is expected in 2018, when some 8 000 tonnes of uranium oxide will be produced, almost tripling Namibian uranium production.

Husab Plant

(Source: Swakop Uranium)

Trekkopje mine located about 80 km east of Swakopmund commenced with construction in 2009 but due to the low uranium prices was put on care and maintenance before full production occurred in 2013.

Trekkopje operations

(Source: Areva)

In addition, there are a **number of uranium exploration projects**, some of which are in an advanced stage and ready to start producing, once the uranium price has recovered.

Uranium mining is often perceived to be especially detrimental to the environment because of the aspect of radioactivity. It is also sometimes associated with the issue of nuclear weapons. However, in Namibia there are a number of measures in place to ensure that Namibian uranium is only used for peaceful purposes in the generation of nuclear energy, and that mining takes place according to high environmental standards and international best practice when it comes to radiation safety.

Namibia signed the **Comprehensive Nuclear Test Ban Treaty** in 1996 and ratified it in 2001. The country acceded to the **Convention on the Physical Protection of Nuclear Material** in 2002, and acceded to the **Treaty on the Prevention of Proliferation of Nuclear Weapons** in 1992. Namibia adheres to the provisions of the International Atomic Energy Agency, and has a functional **Atomic Energy Board**. The Ministry of Mines and Energy has undertaken a **Strategic Environmental Assessment** for uranium mining in the Central Namib, which resulted in the implementation of a **Strategic Environmental Management Plan (SEMP)**. Annual SEMP reports are being published.

In addition, the desire of the uranium mining industry to ensure that uranium mining, processing and transport is undertaken in the most responsible and sustainable way possible, as well as the need to educate the stakeholders about issues such as uranium mining and radiation, led to the establishment of the **Namibian Uranium Institute** by industry (see the information box in Chapter 4).

As Namibia does not have a nuclear power plant, all the uranium produced is exported. However, the Ministry of Mines and Energy has compiled a **Nuclear Fuel Cycle Policy**, which will also facilitate research into the opportunities for Namibia to utilise its endowment of uranium resources for its own electricity generation, as the lack of electricity and high dependency on imports is a major barrier to development and industrialisation.

Desalination - providing much needed water to the coast

The desalination plant at Wlotzkasbaken, 30 km north of Swakopmund, was commissioned by the owner of the Trekkopje Mine, AREVA, in 2010 to provide the mine with the large volumes of water it would need to treat its ore by heap leaching. The plant is connected to the mine via a 48 km long pipeline and is also linked to the NamWater pipeline system. The desalination plant can produce up to 20 Mm^3/a, much more than what is required by the Trekkopje Mine to carry out its care and maintenance operations. Hence the plant is currently supplying other industrial and domestic needs in the Erongo Region, and thereby making an important contribution to adequate water supplies for economic development in general. The plant has the capacity to double its output, and makes an important environmental contribution in saving the precious and long over-utilized natural aquifers in the area.

Wlotzkasbaken desalination plant
(Source: G. Schneider, 2011)

What is radiation?

Simply put, radiation is travelling energy. It is found naturally everywhere but is more concentrated in some locations than others. We come into contact with radiation every day from radio waves, microwaves, visible light and X-rays. Many forms of radiation are beneficial and essential to our survival. But some types of radiation can be hazardous and therefore pose risks to people. Nuclear radiation emitted by radioactive materials is an example of potentially hazardous radiation. Naturally occurring radiation in our environment is called natural background radiation.

Human exposure to radiation is measured in milli-Sievert (mSv), and 1000 mSv are equal to the energy of 1 Joule deposited into 1 kg of tissue. Natural background radiation in the Erongo region, where Namibia's uranium province is located, causes an average exposure dose of approximately 1.8 mSv per annum. In comparison, exposure to cosmic radiation on a flight from Windhoek to Frankfurt contributes approximately 0.4 mSv.

The International Atomic Energy Agency prescribes dose limits, and these also form part of the Namibian Radiation Protection Regulations. The occupational dose limit for people working in the uranium mining environment is 20 mSv per year. The annual dose limit for members of the public is 1 mSv per annum, excluding the exposure dose from background radiation. This difference is made because members of the public include especially sensitive groups such as unborn babies, infants and the elderly.

What radiation levels are people experiencing in uranium mines?

Ore grades in Namibian uranium mines are low, and the radiation exposure of mine workers is therefore **on average 2 mSv**, which is also relatively low and within international limits. Only workers handling concentrated uranium can be exposed to higher radiation levels, but in most cases **not more than 8 mSv per year**, and therefore well below the prescribed limits of 20 mSv per year. However, ongoing exposure monitoring is critical in order to ensure that these low levels are maintained. Mining personnel therefore wear a **dosimeter**, which is a personal device measuring their exposure to radiation. In addition, dust emissions and **radon** gas – a decay product of uranium which can be breathed in – are measured at monitoring stations close to the mines. Additional monitoring stations were put up by government in Arandis, Swakopmund, Henties Bay and Walvis Bay. Radiation monitoring forms part of the Strategic Environmental Management Plan.

Working in a uranium mine
(Source: Areva)

Strategic Environmental Assessment (SEA) and Strategic Environmental Management Plan (SEMP)

A Strategic Environmental Assessment (SEA) was undertaken in response to a 'uranium rush' that began when the spot market price for uranium started rising in 2005 and reached over US$130 per pound in 2007. Though the uranium price quickly dropped to US$40-60 per pound in the following years, a number of companies continued with exploration, feasibility studies, process development and applications for mining licences. Government and industry were concerned about the cumulative effect that uranium prospecting and mining could have on the environment and affected communities, and also about Namibia's reputation as a responsible uranium supplier. It was felt that the Erongo Region did not have the infrastructure and social services to accommodate a massive influx of job seekers. An SEA was therefore undertaken to address these concerns, provide vision and generate a culture of collaboration among the mining industry, government, and the public. This exercise was the first of its kind worldwide, and nowhere else has a mineral province undergone a SEA before. As part of the SEA process, a Strategic Environmental Management Plan (SEMP) was developed based on the issues raised during the SEA.

The SEA concluded that the uranium rush presented significant opportunities for Namibia in terms of growth and development. The benefits would, however, come at a price because the uranium deposits are partly located in proclaimed national parks and popular tourist hotspots. Unless it was well managed and the necessary safeguards put in place, the uranium rush would negatively affect the environment and tourism on which livelihoods depend. To enhance the benefits and overcome major challenges, government and mining companies must implement the necessary measures outlined in the SEA and the SEMP. The overall desired outcome of the SEMP is that the utilization of Namibia´s uranium resources significantly contributes to the goal of sustainable development for the Erongo region and Namibia as a whole.

The SEMP is an over-arching framework to address the cumulative impacts of existing and potential new developments. It consists of 12 Environmental Quality Objectives (EQOs), and each EQO articulates specific aims, desired outcome, targets and key indicators that need to be monitored. The EQOs cover the areas of socio-economic development, employment, infrastructure, water, air quality, health, effect on tourism, ecological integrity, education, governance, heritage and future, and mine closure and future land use. The SEMP Office at the Geological Survey of Namibia ensures that monitoring is carried out and data on environmental performance indicators are collected. The office prepares annual SEMP reports in co-operation with the Namibian Uranium Association, which are publicly accessible. The annual reports consist of a set of matrices, in which the desired outcomes, targets and indicators spread across the 12 EQOs are assessed. Each indicator is evaluated in terms of whether it has been "exceeded", "met", "in progress" or "not met" (Geological Survey of Namibia, 2016).

Air quality monitoring for the SEA study

(Source: G Schneider, 2009)

Otjikoto Gold Mine plant
(Source: G Schneider, 2017)

Gold mining

Two gold mines are currently operating in Namibia. Navachab Gold Mine is an open pit mine located close to Karibib. Since 1989, it has been producing gold bars, which are refined for onward sales to the Rand Refinery in South Africa. 1 890 kg of gold were produced in 2016. Navachab Gold Mine pays particular attention to the rehabilitation of its disused tailings dam, and a number of tests for re-vegetation have been carried out. In order to save on Namibia's most precious resource water, the mine recycles between 35 and 75% of the water used. Namibia's second gold mine, **Otjikoto Mine**, is located some 70 km northwest of Otjiwarongo. The mine came into production in 2014, and produced 4 714 kg of gold in 2016, thereby more than tripling Namibia's gold output. In addition, the mine produced 147 kg of silver. Like Navachab, Otjikoto is an open pit operation. The mine has installed a solar plant thus reducing its use of energy consumed from the grid. It has acquired some additional farms on which it has established an environmental education centre.

Zinc mining

Skorpion Zinc Mine near Rosh Pinah in southern Namibia is an open pit operation, which produces Special High Grade Zinc. The zinc ingots are exported via the harbour of Lüderitz. In 2016, Skorpion Mine produced 85 427 tonnes of zinc. Located close to Skorpion, **Rosh Pinah Mine** extracts zinc and lead. Rosh Pinah is one of the few underground mines in Namibia. After crushing and milling, the ore is subjected to flotation, and a zinc and a lead concentrate are produced and exported. In 2016, the Rosh Pinah Mine produced 80 560 tonnes of zinc concentrate, and 14 862 tonnes of lead. **Namib Lead Mine** is located close to Swakopmund. From 1965 to 1992 it produced zinc and lead. Extensive exploration around this underground mine has now identified sufficient ore to re-open the mine, so the possibility exists that Namibia will soon have another mine producing zinc and lead.

Skorpion Zinc electrolytic plant
(Source: G Schneider, 2015)

Copper mining

Tschudi Mine near Tsumeb is Namibia's chief copper producer. The mine opened in 2015, and achieved full production of 16 391 tonnes of copper in 2016. Weatherly Mining Namibia, the parent company of Tschudi Mine, also owns the **Matchless and Otjihase Copper Mines**, west and east of Windhoek respectively. The two

underground mines were put on care and maintenance in 2015 because of the low copper price. Historically, they have contributed substantially to Namibia's mineral production. In the east of the country, near Hochfeld, the **Omitiomire Copper Mine** is currently under development.

Salt mining

The availability of an endless supply of sea water, coupled with high evaporation rates generated by the sun and the wind as well as low rainfall, makes the Namibian coast an ideal location for the production of **salt through solar evaporation**. The company **Salt and Chemicals** operates large evaporation pans south of Walvis Bay. Coarse salt is produced and sold to the chemical industry in South Africa, and part of the coarse salt is also refined for human consumption and sold to local and other markets. The company was established in 1964, and produced 698 590 tonnes of salt in 2016. North of Swakopmund, the Salt Company has a similar, but smaller operation. It produced 120 000 tonnes of salt in 2016. Salt has also been produced intermittently at Cape Cross. In fact, in the 1880s, the first railway line in Namibia was operational from Cape Cross. The first salt that was mined near Cape Cross was not obtained from a solar evaporation operation, but was based on rock salt. **Rock salt** forms in the same way as solar evaporation salt, but over millions of years and through natural processes. Salt mining at Cape Cross is currently being revived, and both, mining of rock salt and solar evaporation production now occur in Namibia.

Harvesting Salt at the Walvis Bay Salt Pan
(Source: G Schneider, 2015)

Evaporation ponds – a great habitat for marine birds

Solar evaporation pans provide excellent habitat for a plethora of sea birds. At any given time, large numbers of flamingos and pelicans, as well as other birds can be seen here. With the Walvis Bay lagoon being a Ramsar site, the salt pans play a vital role as a resting place for migratory species. At the Swakopmund salt works, large platforms were built for the sea birds, where they deposit valuable guano, which is subsequently harvested.

Seabirds at the Walvis Bay salt pans
(Source: G Schneider, 2015)

Cement production takes place at the **Ohorongo Cement Plant** close to Otavi, which is the most modern cement plant in Africa. With an investment of N$ 2.5 billion, Ohorongo Cement represents one of the largest foreign investment projects in Namibia. It opened its doors in 2010. All raw materials required in the production process are sourced in Namibia, including the lime which Ohorongo Cement mines from a limestone quarry in the vicinity of the plant. It produces over 700 000 tonnes of high-quality cement annually. From the onset, Ohorongo Cement has tried to reduce the use of hard coal to fire its kiln, and undertook to use wood derived from debushing. However, security of supply of this fuel turned out to be problematic, so tests are now being undertaken to identify other alternative fuel sources.

Iron mining

Loadstone Namibia operates the **Dordabis Iron Mine** east of Windhoek.The mine opened in 2015, and produced 8 478 tonnes of iron ore in 2016. **Okanjande Graphite Mine** is currently under construction south of Otjiwarongo. The open pit operation will produce its first graphite concentrate in 2017. Mined ore is transported to the closed Okorusu Fluorspar Mine, where the existing flotation plant is used to treat the ore and recover the graphite.

Extensive exploration has led to the discovery of a **rare earth element deposit** at Lofdal, west of Khorixas. Rare earth elements are used in electronics and mobile phone technology. It is estimated that some 1 500 tonnes of separate rare earth oxides can be produced annually. Current world production of rare earth elements is almost exclusively from China, and it can therefore be expected that a mine will soon be developed at Lofdal in order to diversify sources of supply.

Phosphate is present in quantities that can be economically mined on the seafloor of the Namibian shelf, and two areas have been explored sufficiently to delineate mineable deposits. A pilot plant has already been successfully tested in Lüderitz. Apart from phosphate, such plants can produce gypsum and energy as by-products.

A **copper smelter** was first established at Tsumeb in 1906 in order to smelt the ores of the Tsumeb Mine. The existing copper smelter, operated by Dundee Precious Metals, is a much more modern operation, with state of the art gas filtration systems. As Tsumeb Mine is no longer in operation, the smelter produces blister copper from imported ores.

The output in 2016 was 40 869 t. Unfortunately more than a decade of smelting activities, using mostly ore from Tsumeb, which contained toxic heavy metals such as arsenic and antimony, have left soils in the area contaminated. Continuous upgrading of the operation in the last twenty years has ensured that today's smelting process has significantly fewer impacts on the environment. For example, the sulphur dioxide gas released during the smelting process is today used to

Concerns over sustainability of marine phosphate mining

Despite the rather small footprint of the proposed phosphate mine on the huge Namibian shelf area, numerous concerns have been raised by stakeholders regarding the impacts of this untested mining on the environment. There have been fears of a potential negative impact on the Namibian commercial fish species and therefore the Namibian fishing industry. Just how this mining will impact on biodiversity is disputed and there has been a **call for studies** to help provide some clarity and facilitate informed decision making. Phosphate is a valuable Namibian mineral and it needs to be established whether the benefits from mining this resource will be justified in the light of any environmental impacts and costs. Worldwide there is unfortunately very little information about the environmental impacts of marine phosphate mining. Namibia has therefore issued a **moratorium** halting development to allow for further research. Taking into consideration that the Namibian mineral resources should be developed to provide for economic development, this is an important measure in order to assure that marine phosphate mining only goes ahead if it can be done in an environmentally acceptable way.

The Tsumeb Smelter

(Source: Dundee Precious Metals)

produce sulfuric acid as a by-product, which is used by Rössing Uranium Mine and Tschudi Copper Mine in their extraction processes. Almost 200 000 tonnes of acid were produced in 2016 alone.

Beneficiation – a priority for Namibia

The full potential of any given mineral resource is only realized when there is also at least some value addition. However, historically, Namibia has always exported its mineral resources without any beneficiation. Recent years have seen some changes with the opening of a number of diamond cutting factories, and advanced recovery methods at Skorpion Zinc Mine and Tschudi Copper Mine, producing refined zinc and copper respectively. Nevertheless, the majority of Namibia's minerals are still exported in the form of concentrates, and the value addition is taking place outside the country, denying Namibians the opportunity to participate in the value chain.

Beneficiation in the diamond industry – a huge benefit for Namibia

Since 2007 the Namibian Diamond Trading Company (NDTC) in Windhoek has carried out the sorting, valuation and sales of Namibia's rough diamonds. Selling of diamonds is an intricate business, as the stones are not sold individually, but in parcels containing a number of diamonds.

Polishing and polished dealing add some 18% of value to a rough stone, while jewellery manufacture attaches another 33%, and this value is basically doubled in the retail stage. It is therefore important for Namibia to participate in the so-called diamond pipeline, which generates more value and provides jobs. The establishment of diamond cutting and polishing factories in Namibia and the use of Namibian cut diamonds in Namibian manufactured jewellery is therefore a welcome development in order to realize value addition of this important Namibian mineral resource.

Diamonds

(Source: Diamond Trading Compan)

3.5 FUNCTION OF SOILS

In Chapter 2 we mentioned that soils have four important functions. The ecosystem services provided by soil are linked to these functions and are outlined in the box below.

Most of these services take place within the biologically active zones within soils. These are the **detritusphere** (zone of decaying litter), the **porosphere** (the pores and channels between soil particles containing water films), the **aggregatusphere** (the tiny pores and channels within the soil aggregates), the drilosphere (earthworm burrows) and the **rhizosphere** (the rooted zone), with the rhizosphere being the zone where the most activity takes place. Thus it is that soil biodiversity, rather than the soil alone, which is critical to ecosystem functioning and sustainable land management. It is **soil functional diversity** rather than **genetic diversity** that plays a key factor.

The condition and type of soil determine its ability to function and to provide ecosystem services. Thus some soils have higher functionality than others. When soils become degraded their ability to provide ecosystem services is reduced. There are four main factors that can impact negatively on the soil, namely:

- **Wind and water erosion**, which transports soils from the landscape and deposits them somewhere else.
- **Compaction**, which is when the pores between the clumps of soil and soil grains become squashed and are unavailable for water or air uptake.
- **Loss of organic matter**, which takes place when the ability for the soils to support vegetation is reduced and when decomposition of organic matter does not take place.
- **Urbanisation**, which is responsible for removing large tracts of arable land from the system.

These activities lead to **soil degradation**. Degraded soils exhibit the following characteristics:

- A decline in soil fertility;
- a decline in soil organic matter and organic carbon content;
- loss of biodiversity;
- loss of water retention capacity;
- disruption of water, nutrient and gas cycles;
- reduced capacity to degrade contaminants; and
- reduced capacity to sequestrate carbon.

As soil is usually viewed as a lifeless medium for growing plants, most people do not actively manage the soil. The result is that changes in soil condition usually go undetected until soil degradation is well advanced. It should be the mission of our generation to **regenerate the soil**. This is not an easy task given that too few people truly appreciate how important the soil is.

Semi-arid landscapes are strongly patterned landscapes made up of separate **patches** of different sizes and shapes. These patches, which vary in size and make up (e.g. tree thickets, rocky outcrops and fallen tree trunks) support spatially diverse patches of biodiversity. Research has shown that resources are concentrated in these patches with the result that important functions, which the soil offers, such as water retention, soil fertility, nitrogen and carbon cycling is much higher in these areas. Observations also indicate that semi-arid landscapes which are in good condition efficiently capture, retain and utilise scarce resources within the landscape.

Ecosystem services of soils

Regulating services: water storage, supply and purification, reduction of soil contamination (e.g. pesticides are degraded by soil biota), remediation of soils contaminated by airborne pollution (soil biota metabolize contaminants), flood regulation, carbon sequestration, regulation of greenhouse gases (carbon dioxide, methane and nitrogen oxides).

Supporting services: basis of all terrestrial ecosystems – life support, nutrient cycling, support plant growth, habitat for organisms, foundation for human infrastructure.

Provisioning services: sand for building, clays for pottery and cosmetic industry, source of biochemicals and pharmaceuticals (e.g. penicillin is a soil bacteria).

Cultural services: protection of archaeological heritage, use in traditional ceremonies.

Erosion
(Source: G Schneider, 2017)

Patchiness of an open Mopane woodland
(Source: G Schneider, 2007)

However, if the patchiness of a specific landscape is disturbed (e.g. from ploughing or overgrazing), then its capacity to capture and store scarce soil-water and nutrients declines, and it tends to lose the nutrients and water it has accumulated over time. The system becomes 'leaky' and there is an accelerated loss of these resources out of the landscape to other places (e.g. dams). The reason is that there are no traps, such as grass tussocks, shrubs and log-mounds to catch and retain water. Semi-arid landscapes are also more prone to wind and water erosion than other landscape because plant cover is naturally low and soils are often very dry, whilst other landscapes such as floodplains have less tendency to 'leak'. Some reasons for this are that floodplain soils are often highly cohesive, cracking clays, floodplains are very flat and, being low in the landscape, tend to receive run-off and deposition of sediments from landscapes located at higher altitudes.

The Namibian situation

Namibia is an arid to semi-arid country. About 97% of the country's soils have a clay content of less than 5%, and thus have a very low water holding capacity. They are generally deficient in most of the major nutrients, as well as micro-nutrients such as manganese, iron and zinc. In addition, many of the soils are also saline. Despite this, **agriculture** (both crop and stock farming) plays a fundamental socio-economic role in Namibia. Agriculture contributes around 5% of the national Gross Domestic Product (GDP), and a large percentage of the Namibian population depends on agricultural activities for their livelihoods, in the form of subsistence farming and pastoral grazing. **Subsistence farming** is mainly confined to the 'communal lands' situated in the north-east of Namibia, whilst two-thirds of the country supports **pastoral grazing**. **Commercial cattle** raising is predominant in the central and northern regions south of the veterinary fence, while karakul sheep and goat farming are concentrated in the more arid southern regions. If one takes rainfall and soil fertility into account, then only about 1% of Namibia's land is considered to have medium to high potential for rain fed and **irrigated crop production**. Most of this area is found within the communal areas in the north-east of the country.

Inappropriate and unwise agricultural practices have been employed over most of the country for many years and have led to significant degradation of the soils on which this vitally important agricultural sector depends. However, all is not lost. Management approaches such as conservation agriculture (for cropping) and rangeland management (for cattle farming in particular), both of which are based on regenerating ecosystem functions, are taking hold in Namibia and are demonstrating that soils can be restored, albeit slowly, and that productivity of these landscapes can improve as a result thereof.

Rangeland management

In Namibia the rangelands utilised for commercial and communal stock farming as well as game farming and wildlife conservation are all in some state of landscape dysfunction and need to be restored to increase ecosystem functioning, reduce vulnerability in the face of climate change and improve productivity. The main factor that results in rangeland degradation is overgrazing.

Working the soil

(Source: WWF)

Overgrazing is a major factor causing rangeland degradation

(Source: G Schneider, 2010)

Overgrazing is not only caused by stock consuming too much vegetation. It is also caused by the abundance of artificial water points, keeping stock in areas that are too small, and the loss of predation and improved disease control, both of which decrease natural mortality of stock. The reason overgrazing is so destructive is that it removes patches from the landscape, causes a decline in soil and surface condition, increases erosion and results in a loss in productive capacity of that rangeland. This leads to desertification, a loss in biodiversity and ultimately failure of the pastoral sector.

It is important to understand that how well a rangeland functions from an ecological point of view is not always equal to the **condition** of that rangeland. The reason is that condition is a 'worth' value determined by the land user and will vary depending on the land use (e.g. pastoralism versus game farming). For example, a rangeland with medium ecosystem functionality may be judged to be in relatively good condition by a stock farmer while conservation rangers may judge this same landscape to be in poor condition for wildlife conservation. However, regardless of the species being farmed, rangeland management requires a change in mind set that removes the focus from large heads of stock to the conservation of scarce water, nutrients and soil.

How do large herds of grazers affect wild rangelands?

- Perennial grasses need to be grazed to grow optimally.
- Hoof action of large herds breaks up the soil cap and facilitates the permeation of water into the soil and water retention.
- Dung and urine from large herbivores helps improve soil fertility and water retention.
- Trampling of vegetation from large herds of grazers creates a protective layer over the soil which helps protect soil from erosion and modulates soil temperature.
- Large herds of grazers graze, trample and fertilise a specific area for a short period of time, then move on, not returning for a long time, thus giving plants time to replenish their root reserves from which new leaves can grow and giving the soil a chance to build up.

Sustainable rangeland management requires farmers to try and implement grazing patterns of large wild grazers, as best they can, with an **emphasis on intensive grazing followed by long rest periods**, taking the growing and non-growing seasons into account.

Sharing of watering point with wild game

(Source: www.Solutions-site.org/artman/uploads/grazing/_h_440.jgeg)

How have people translated this theory into action? From 2010 to 2013 Namibia carried out a Community Based Rangeland Management (CBRLM) pilot programme in the communal areas (Kunene, Omusati, Oshana, Oshikoto, Ohangwena and Kavango). Learning from successful initiatives seen in other parts of the Southern African Development Community (SADC), this programme combined modern rangeland science with indigenous traditional practice.

Essentially it encourages farmers utilising the same watering points to combine their herds into one large herd and then plan and manage where the herd moves within their defined grazing area, using trained herders. All 50 of the grazing areas in the pilot programme showed an improvement in rangeland functionality and stock productivity with the result that communities and government are now working to mainstream this approach.

Bush encroachment is defined as 'the invasion and/or thickening of aggressive undesired woody species resulting in an **imbalance of the grass to bush ratio**, a decrease in biodiversity, and a decrease in carrying capacity, causing severe economic losses for Namibia – in both the commercial (freehold) and communal (non-freehold) farming areas.

According to a comprehensive study that was undertaken in 2004, **bush encroachment** is one of the most important factors contributing towards desertification in Namibia and has had a huge impact on ecosystem functioning, biodiversity, productivity and the socio-economic welfare of farmers. In addition to decreasing the carrying capacity of the land, it results in lowered ground water tables, which further impacts on national security.

The causes of bush encroachment are complex but are directly related to the way that dynamic savanna ecosystems operate. In natural savanna systems the ratio between grasslands and thickets is constantly changing and is mainly affected by rainfall, soils and nutrients, grazing, browsers and fire. The **soil to moisture balance** has an overwhelming effect on vegetation structure, composition and productivity thus playing a major role in determining whether or not grasses will dominate.

Herders are important managers of our natural resources

One of the main challenges in mainstreaming CBRLM is to change the perception that most people have of herders. For too many years people have been using children and school dropouts as herders, which have resulted in herders being held in low regard. Yet one of the pillars of successful communal rangeland management is effective, skilled herders. There is therefore a focus on improving the status of herders so that they become recognised as natural resource managers, who play an essential role in the sustainable management of Namibia's soil, water and biodiversity resources.

Bush encroachment
(Source: G Schneider, 2011)

The reason that bush encroachment has become uncontrolled is mainly due to the decrease in soil quality caused by droughts and grazing, followed by above-average rainfall years with frequent rainfall events, which favour mass tree recruitment. There are many **secondary causes of bush encroachment**. Some of the main ones are listed below.

Fire suppression, which has been a fundamental part of rangeland management supported by the current legislation. Yet fires have always played a role in maintaining open savannahs and the suppression of high intensity, cool fires that kill seeds and saplings but not the mature trees, has promoted bush encroachment.

Replacement of most indigenous browsers with grazing livestock. Increased grazing results in a decrease in perennial grasses, which in turn decreases the effectiveness of the root zone within the soil. This results in the lowering in concentrations of CO_2 together with poor competition for available moisture in the upper layers of the soil. This creates a favourable environment for woody seedlings to establish themselves. In addition, bits of grass that are left lying on the ground by grazers contain chemicals that can inhibit seed germination. In the absence or scarcity of grass fragments on the soil surface, a favourable environment is created for woody seedlings to germinate.

Unwise stocking rates. Very high stocking rates were applied in the past. Although farmers have reduced their stock, the bush encroachment has not be reversed, despite many years having passed. This indicates that even at low stocking rates of 1 large stock unit per 10 ha, grazing pressure is too high, leading to a vicious cycle of further degradation followed by further loss in productivity and a decline in livelihoods and economic output.

Poor socio-economic policy. These factors are often beyond the control of farmers and impact the way they have to operate. For example immediately after the outbreak of foot-and-mouth disease in the late 60s, the vast majority of cattle were trapped behind the veterinary cordon fence which was erected at the time. Severe restrictions on the movement of animals were introduced. Farmers could not market their animals and the accrual of livestock during the ensuing years, until the veterinary restrictions were lifted, caused substantial damage to rangelands in the affected areas.

However, as savannahs are dynamic systems, **bush encroachment can be turned around**, if it is done within the constraints of functioning ecosystems. There is a suite of approaches that have been adopted to try and remove bush and encourage the regeneration of grasslands. These include the physical removal of trees either manually, mechanically or using fire, and by chemical means where poisons are applied manually to individual trees or as a blanket poison over an entire area.

How warped or unintegrated legislation has impacted negatively on sound rangeland management

The Soil Conservation Act, 1949 (No. 6 of 1949; implemented in the then SWA in 1952; as amended in 1969), prohibited the burning of veld applied in commercial farming areas and therefore actively promoted bush encroachment.

The government offered drought subsidies, which encouraged farmers to keep more animals during periods of grazing scarcity. We have seen that the long term impacts such as soil degradation and bush encroachment far outweighed the short term benefits of this scheme.

Rehabilitation of rangeland through clearing of invader species

(Source: M Schneider, 2014)

Given the hundreds of thousands of hectares that are affected and the desire to reverse this problem as quickly as possible, it is tempting to resort to mechanical clearing and blanket chemical treatment. However, the risks involved in semi-arid environments are large. Once an area is cleared, aftercare is therefore essential to protect newly exposed soils from erosion, facilitate the establishment of perennial grasses and manage the regrowth of invasive shrubs and trees.

Agriculture

Agricultural systems are characterised by soil degradation, including loss of organic matter and a decrease in the natural nutrient cycling and nutrient provision services made by soil and its associated living organisms. For many years these losses have been replaced by using chemical fertilizers. This resulted in ongoing improved agricultural production levels in the short term. But because adding chemical fertilizers does not address the root causes of soil degradation, this resulted in changes in soil structure and functioning. This has decreased the soils' ability to offer important ecosystem services such as water infiltration and retention, and nutrient holding capacity, purification of pollutants and decomposition of organic matter. The result of this is huge amounts of fertilizers, pesticides and other contaminants that should be kept in the soil leaking into the groundwater, and soils are transported by run-off into dams, lakes and oceans causing severe siltation and nutrient problems.

Because farmers are becoming aware of the impacts that certain farming practises have, and because the prices of chemical fertilizers and pesticides are so high, there is a growing drive to return to a more sustainable way of growing crops – one that fosters **increased reliance on the soil food web** - to maintain and boost crop productivity through nitrogen, phosphorous and other macro- and micro-nutrient cycling, and pest and disease control. This is not a quick process as soils take time to regenerate, but initiatives all over the world from conservation agriculture to permaculture demonstrate that this can be done.

Like so many other successful initiatives in Namibia, passionate NGOs, large funding organisations and communities have been working with Government to bring about change. In conjunction with numerous stakeholders and specialists, the Ministry of Agriculture, Water and Foresty developed a Programme called 'Comprehensive Conservation Agriculture Programme for Namibia, 2015-2019'. Conservation Agriculture (CA) aims to improve both macro and micro patch dynamics within the agricultural landscape by focusing on three main things:

- **Conservation tillage**, which minimises or eliminates manipulation of the soil for crop production. It includes mulch tillage, which leaves crop residues on the soil surface. Such practices generally reduce soil erosion, improve water use efficiency, and increase carbon concentrations in the topsoil.
- **Permanent organic soil cover** which prevents compaction and erosion. This is achieved by cover cropping - use of crops such as clover and small grains for protection and soil improvement between periods of regular crop production.
- **Diversification of crop species** by practising **crop rotation** and growing crops in sequences and/or associations. This helps to balance nutrients and increase the biodiversity of soil organisms.

Permanent soil cover

(Source: https://pbs.twimg.com/media)

Cultivation of maize

(Source: WWF)

Conservation Agriculture is not only a solution for subsistence, communal farmers. A few commercial farmers in the maize triangle (Grootfontein-Tsumeb-Otavi) are trying various CA approaches.

Sand mining

We have looked at the role that sustainable agriculture can play in restoring and maintaining soil functioning in Namibia. However, soil does not only provide agriculturally related provisioning services.

Sand is also mined so that it can be used in the construction industry to make concrete, and in the manufacturing industry as an abrasive, to make glass and bricks. Clays are mined for use in the pottery and cosmetic industries. In addition, some sands are mined so that valuable heavy metals can be extracted for use in industry or 'borrowed' from open pits for use in the construction of roads, railways, airstrips etc.

Sand mining is carried out on beaches, coastal and inland dunes, and river beds, most often as open pits. **Sand is perceived as a public good**, which means that everyone has a right to utilise it and use by one individual is not supposed to reduce the amount available to others.

But sand is not a public good and in many parts of the country this unrenewable resource is being utilised unsustainably. Of course there are always exceptions to the rule. In some communities in the north, the value of good quality clay for pottery is recognised and the fair distribution and sustainable use of it is managed to ensure that all households have access and that it is not over utilised.

Sand mining in the Klein Windhoek River
(Source: T Wassenaar)

Unregulated sand mining in the Swakop River resulting in a large pit which interferes with the flow of the river when it floods
(Source: G. Schneider, 2009)

Brick-making boom in the north – unsustainable use

Due to the rapid population growth in the northern regions of Namibia, the demand for bricks to build homes, kuka shops, schools etc. has increased substantially. This has provided many local entrepreneurs with a business opportunity. If you visit the north, you will see both small and large brick-making businesses everywhere. Bricks are made by mixing sand with cement, or clay with water and either baking them in a kiln or in the sun. Sometimes stabilisers and coagulates such as coal ash are added. Small businesses pour the bricks by hand, and larger ones utilise brick making machines. Larger brick making businesses provide employment opportunities as staff are required to make, stack and load the bricks. However, there are environmental impacts associated with brickmaking that can offset the advantages. These include but are not limited to:

- Many people do not know the difference between topsoil and subsoil and utilise valuable topsoil to make bricks.
- Sand and clay are seen as free resources (public goods) so everyone uses it indiscriminately but no one takes responsibility for managing it. This is unsustainable.
- Sand excavation results in the creation of large pits. This results in both soil and landscape degradation.
- Broken and sub-standard bricks are discarded on waste heaps that can become very large and unsightly. These are often located on top of functioning soils, which are subsequently lost from the system for there is no requirement for these brick makers to discard their waste in a more environmentally friendly way.
- Where electricity is not available trees have to be cut down to fire the kilns. This contributes to deforestation, which in turn impacts negatively on soil functioning and fertility.
- Sand and clay is an essential ingredient for this industry and if not managed sustainably will impact negatively on the long term viability of this industry and many people.

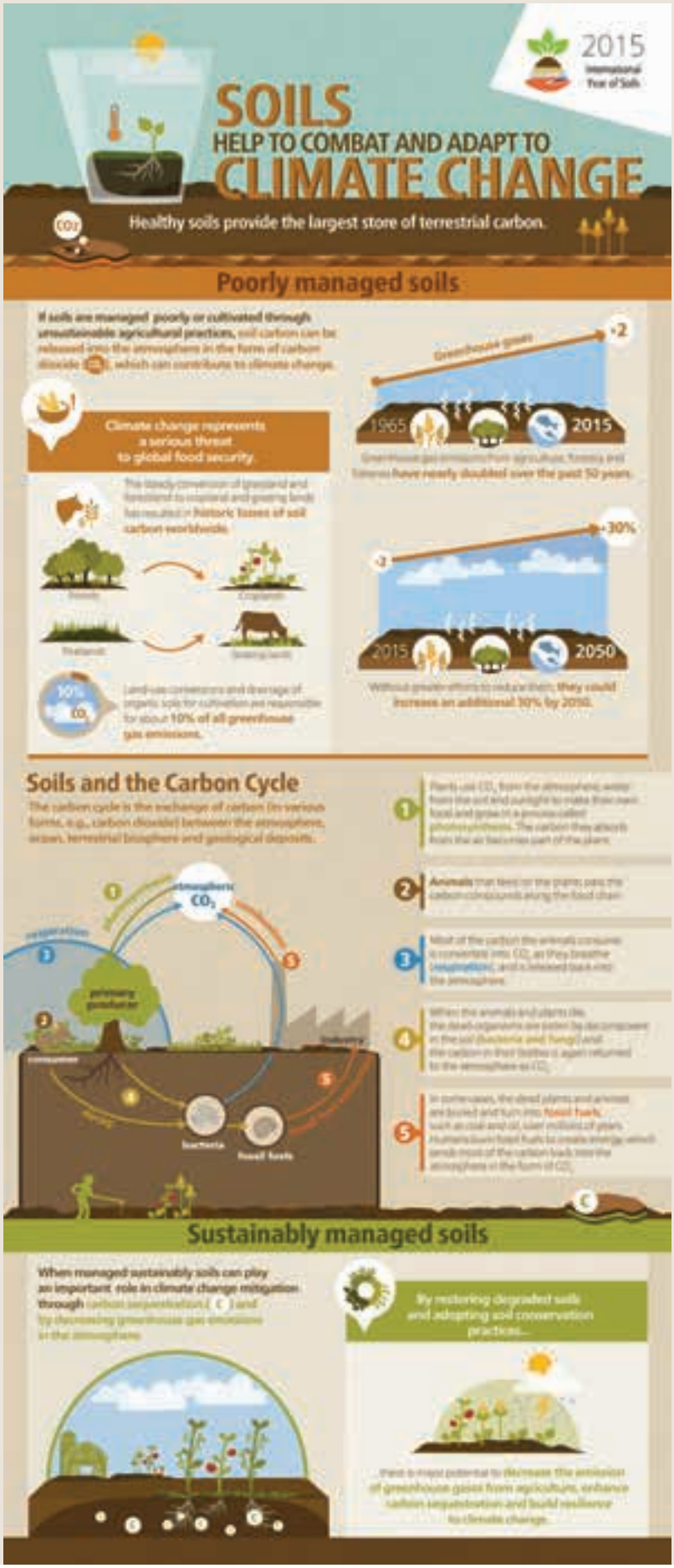
Brick making by a medium business enterprise
(Source: Ohorongo Cement)

Regulating Services offered by soil – carbon sequestration

The excessive amount of carbon in the atmosphere (mainly as carbon dioxide and methane), is believed to contribute significantly to global warming, which is driving the changing climatic patterns being observed all over the world. But the amount of carbon on our Earth is fixed. So where was it before human activities started releasing it into the atmosphere? We know that some carbons were tied up in coal, but by far the most carbon was sequestrated (stored for long periods of time) in the rocks, ocean, soil and plants, especially forests.

Activities such as deforestation, overgrazing and burning of grasslands have released large amounts of the carbon that was sequestrated into the atmosphere. The inappropriate agricultural methods that we have been applying for so many years, also move large masses of carbon from the soil, where it is stored as soil organic matter, into the atmosphere. Carbon has the potential to be stored in soils for millennia. A dedicated effort to regenerate the soils so that it could support healthy plant life would result in atmospheric carbon starting to make its way back into the soils via photosynthesising plants. And carbon in soils and plants is good for the planet because it is the building block of life.

The techniques adopted in conservation agriculture, namely conservation tillage, cover cropping and crop rotation work aim at increasing carbon concentrations in the topsoil. In addition, this less mechanised approach can also reduce the amount of fossil fuel consumed by farm operations.



(Source: fao.org/assets/infographics)

3.6 THE VALUE OF LIVING RESOURCES

The biosphere has a multitude of services that functional ecosystems are able to provide. A few of them are listed in the green box. Many Namibians are benefiting from and trying to manage ecosystems to ensure that they continue to function and benefit current and future generations. Almost all regions of Namibia are increasingly benefiting from the services provided by their natural ecosystems, as well as becoming valuable custodians of Namibia's biodiversity.

This has been made possible by the emergence of **community based natural resource management (CBNRM)**, communal conservancies and community forests. Together these constitute a democratic resource management approach that has provided economic opportunities to a sector of society that was previously excluded from the cash economy due to limited economic opportunities.

CBNRM was pioneered by Integrated Rural Development and Nature Conservation (IRDNC) in the 1980s, in response to the threat of rhino poaching. However, it has since grown into a model that not only allows rural populations to derive economic benefits from wildlife, indigenous plants and the landscape, but has had the added benefit of reducing habitat loss and conserving biodiversity due to improved rangeland and fire management practices. This has not only benefited wildlife but the communities too. By adding wildlife and high value indigenous plants to their rural farming economies, these communities are better able to weather drought and are less vulnerable to the impacts of climatic change, given that indigenous species are adapted to unpredictable rainfall and extreme dry cycles.

By the end of 2015, almost 20% of Namibia was committed to community conservation, with:

- 82 registered communal conservancies;
- 19 concessions in national parks or on other state land held by 23 conservancies (some conservancies share concessions);
- 32 registered community forests;
- one community conservation association in a national park (Kyaramacan Association – managed like a conservancy); and
- two community fish reserves.

Ecosystem services of living resources (single celled organisms, fungi, plants and animals)

Regulating services: water purification (e.g. reeds in wetlands), erosion and flood control (riverine vegetation), carbon storage and climate regulation

Supporting services: pollination of crops and wild plants, nutrient cycles, decomposition of dead organic matter

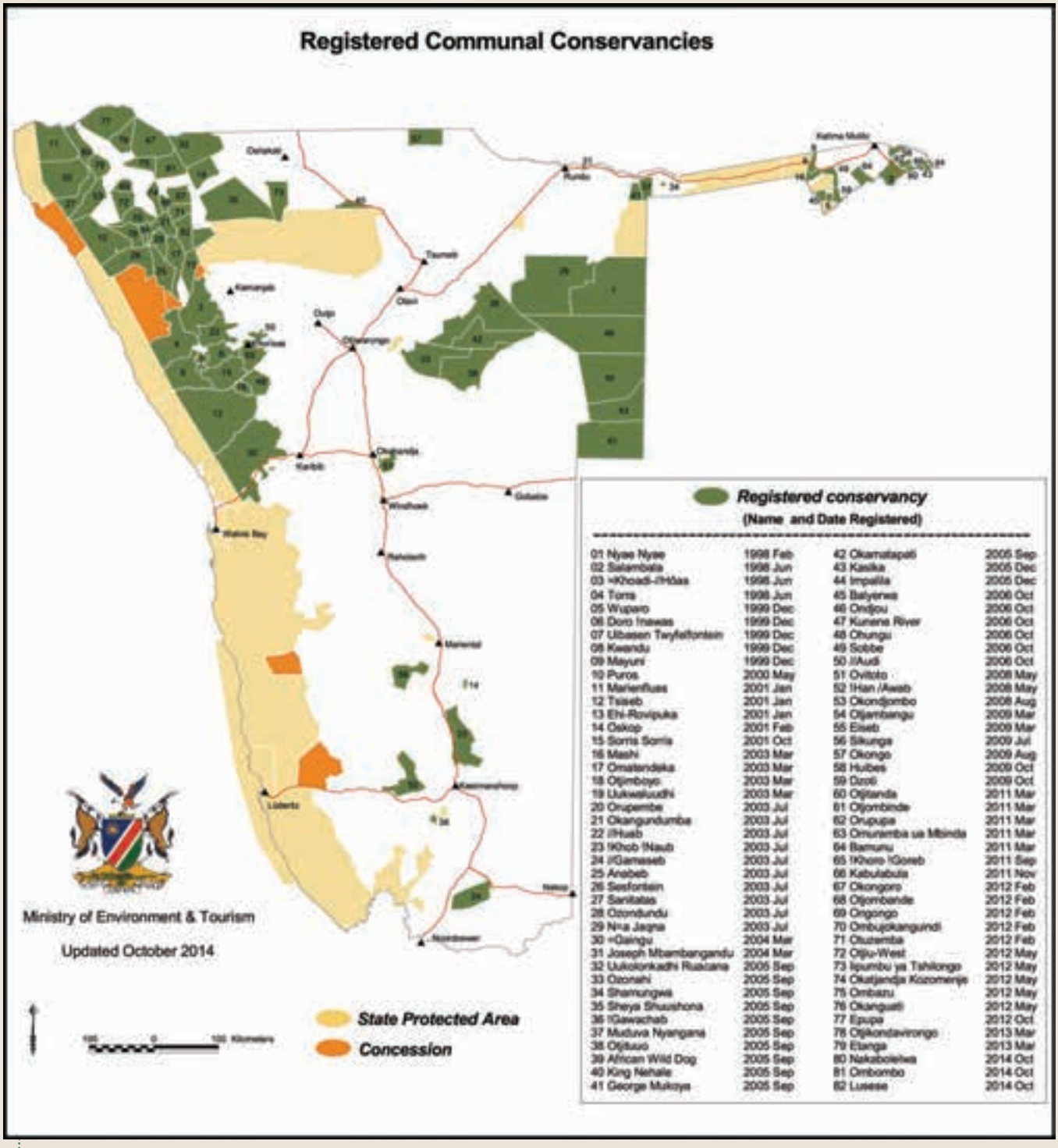
Provisioning services: food (meat, fish crops, spices, seafood), raw materials (wood, skins fertilizer), genetic resources, biogenic minerals (coal, limestone, pearls, silk, amber)

Cultural services: Spiritual connections to plants and animals, recreational (horse riding, hunting, whale watching)

In 2015 alone, communal conservation generated approximately N$ 102 million in returns for local communities. This approach to management of resources has been so successful that it is now recognized as one of the national development goals.

Twelve of the fourteen regions in Namibia have registered communal conservancies and community forests. Khomas and Kavango West are the regions that do not. Kunene was the first region to establish a communal conservancy and pilot community based natural resource management. It is an arid, hilly region boasting dramatic landscapes and large tracts of open land where wildlife still roam, small communities of livestock farmers and semi-nomadic herders live, and where infrastructure is limited and agriculture is marginal. In the Kunene region there are currently 36 communal

conservancies supporting approximately 50 455 people. Activities include trophy hunting, anti-poaching, meat harvesting, plant harvesting, and eco-tourism. Some community members have benefited directly by deriving an income from jobs (e.g. game guards, or employees in tourism camps and lodges) or from selling products (e.g. curios and indigenous plant parts). However, one of the most tangible benefits has been the small but meaningful returns that all community members qualify for, such as meat rations and a profit share at the end of each financial year.



Registered Communal Conservancies in Namibia

(Source: Ministry of Environment and Tourism)

Rhino poaching in Namibia

Since the early 1980s, when a couple of small NGOs (IRDNC and Save the Rhino Trust) initiated a campaign against the poaching of Namibia's rhinoceroses (rhinos), the population has tripled in number. Namibia is now home to almost 40 % of the world's black rhino population. The majority of the population lives in the Kunene region, in communal conservancies, or in the Etosha National Park.

In 2012, the first rhino in many years was poached in the Kunene region, but thanks to community members, who supported the conservation of their rhinos, the poacher was caught and eventually imprisoned. To understand why rhino poaching has reared its ugly head again and to see how the Kunene Conservancies were in a position to play a positive role, one must first understand the context.

There are five species of rhino in the world. The black and white rhinoceroses are found in Africa, the other three in Asia. Globally rhino populations are under extreme threat. Currently the demand for horn comes primarily from Vietnam and China, where they are used for medicinal purposes or as status symbols for the wealthy. Rhino horn is more valuable than gold and diamonds, having reached a peak value of N$ 65 000 per kilogram in 2012.

Rhino poaching was rampant in Namibia and South Africa from 1970 to the early 1990s, but as a result of mammoth conservation efforts, the onslaught died down and rhino populations were given an opportunity to increase. Then in 2007, poaching in South Africa, mostly from National Parks, recommenced and quickly escalated from 13 in 2007 to 1 215 in 2014. Anti-poaching efforts resulted in a slight decrease in 2015 and 2016, but this was offset by an escalation in poaching in neighbouring Zimbabwe and Namibia.

After that first poacher was caught in a Kunene conservancy, the poachers, who were not from the area, shifted their activities to places where no or few locals were living and to Etosha. The number of kills started to escalate. Worried that rhino poaching in Namibia would escalate as quickly as in South Africa, the Ministry of Environment and Tourism (MET), the national police and some NGOs, took control, adopting a militaristic approach to managing the crisis. By early 2015 10% of Kunene's rhino had been killed, (despite de-horning efforts) and no arrests had been made.

IRDNC and Save the Rhino Trust have been taking a different approach to government. They raised funds to re-activate traditional leader and community support for anti-poaching efforts in the Kunene region, to work with MET to recognise the positive role that communities can play and to bolster funding for the rhino conservancy ranger project. Communities have come to the party and the results have been encouraging. Whereas 20 rhino were killed in conservancies in 2014, only three were poached in 2015 and one in 2016, in comparison to the large number that were poached inside Etosha during the same period. Locals have blown the whistle on poachers operating in conservancies, as well as thwarted poaching attempts. The result is that a number of poaching related arrests have been made.

Grootberg Rhino Track
(Source: WWF)

OvaHimba collecting resin from an Omumbiri
(Source: T Nott)

CBNRM has been able to deliver results because the people of an area take responsibility and are given the authority to manage their own resources. For many this has resulted in a new or rekindled ethic towards the land. The previous case study on rhino poaching in the Kunene region shows how people who are empowered to manage their resources, and who value them, will make greater efforts to conserve them.

Commercial utilization of indigenous plants

For thousands of years, hunter gatherer, pastoral and agronomic communities have used indigenous plants for a plethora of reasons including food, medicines, fire, construction of houses and kraals and construction of utensils such as furniture, baskets, bows and arrows and axe handles. Today many people living in rural communities still depend on these natural resources for all of the reasons listed above. Whilst the conservation of these resources for local needs is a convincing argument, it is the up-scaling of certain crafts and practices to a commercial scale that has provided a very strong rational for sustainable conservation of these resources. Today there are increasing opportunities for rural woodcarvers, potters, weavers, jewelers and artists to sell their products both locally and overseas, if the quality of their workmanship is good enough.

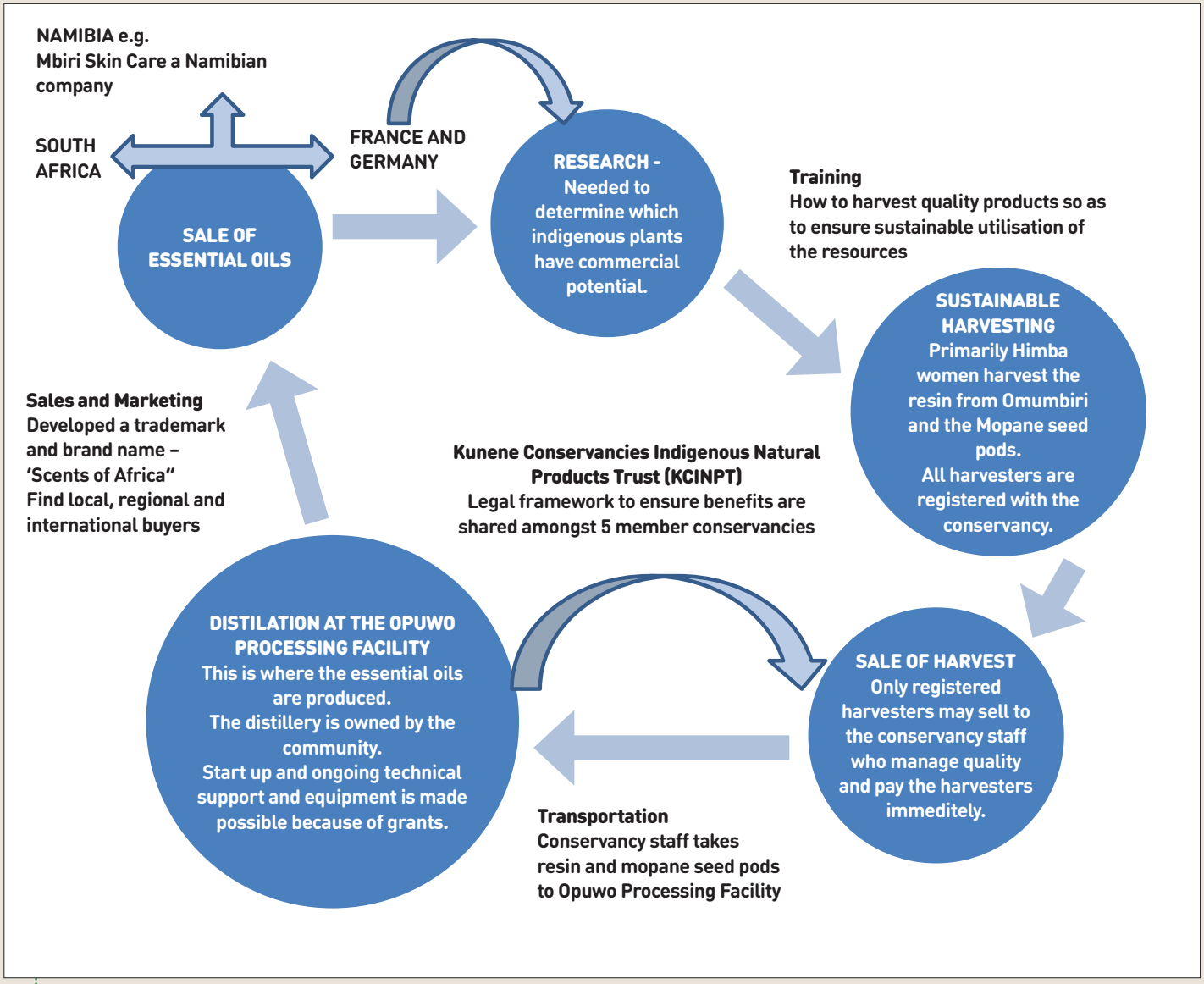
Typically the poorest people live in the rural areas of Namibia and the sustainable harvesting of indigenous plants (INPs) for commercial use has allowed them (in particular the women) not only to improve their food security, especially in times of drought, but has contributed to an improved standard of living. It has also provided a strong incentive for conservation of natural resources.

Until the late 1990s the trade in INP was limited to the local, informal trade sector. However, a group of dedicated communities, together with a few NGOs, specialists and grant funding, worked very hard to develop a viable commercial enterprise. There are at least eight indigenous plants that are currently being harvested on a commercial level in Namibia. These are !nara, devil's claw, marula and ximenia oils, commiphora and mopane essential oils and the morama bean.

It is estimated that the commercial sale of INPs contributes between N$ 30 to 50 million towards the Namibian gross domestic product and has the potential to increase substantially as the global demand for natural ingredients for use in the medicinal and cosmetic industry grows.

The success of the INP industry depends on a number of factors; the most important being an enabling legal environment, good baseline research into the feasibility of potential plants as commercially options, establishment of a sustainable business model, equitable distribution of profits, access to markets (both regional and international) and sustainable management of the plants on which they depend.

For example Omumbiri *(Commiphora wildii)*, and Mopane *(Colophospermum mopane)* come from the Kunene Region. Both of these plants produce essential oils that are processed at the Opuwo Processing Facility, a distillery that was built specifically to develop these essential oils as commercial products. The diagram below shows how commercialisation of Omumbiri and Mopane works.



Flow diagram showing the commercialization of essential oils in the Kunene Region

(Source: D Cole, 2014)

Basket weaving - an ancient skill with modern appeal

For millennia people have woven baskets to fulfill a range of tasks from winnowing grains, making beer and storing and carrying fruits, berries, fish and other products. In the northern and north-eastern parts of Namibia, where grasses, reeds and palm fronds can be found, the women wove these baskets. Different communities boasted different styles of baskets, developed to meet the particular needs of the users and designed and decorated in different ways. With the advent of cheap plastic and aluminum containers and changes in perception regarding the value of handmade versus manufactured products, the art of basket weaving was almost lost in Namibia, in particular amongst the !Kwe.

However, due to the dedicated work of organisations such as IRDNC and the Omba Arts Trust, this sophisticated skill has not only been revived but has been taken to new heights. Good quality baskets, with interesting designs and a variety of colours are in demand by tourists, in particular, but also from lodges and other local establishments who like to showcase and use Namibian products. Since the late 1990s, IRDNC and Omba Arts Trust have been working with the older women to teach the young woman how to prepare the grass and palm leaves, prepare the dyes and weave the baskets. They have also provided training in quality control and marketing and have helped to set up both governance and administrational structures that provide the potential for all who participate to derive benefits. Because the palm fronds and some of the dyes come from indigenous plants that grow in specific places and are not always in great abundance, the women were also given courses on the sustainable utilisation and conservation of these valuable resources, to ensure that they are not damaged during harvesting and that they are not over harvested. The basket weaving industry in Namibia has contributed positively to poverty alleviation and social upliftment in East Caprivi, the Kavango and Owambo regions. Last but certainly not least, the revival of this skill and the success that it has created has improved self-esteem and pride, both of which contribute hugely towards productivity in a community.

Harvesting reeds for weaving

(Source: WWF)

Basket weaving

(Source: WWF)

Trophy hunting - a mainstay of the Namibian economy

Trophy hunting (or conservation hunting as it is often referred to in Namibia) is a contentious activity that is abhorred by some and actively promoted by others. In 2016 there was an enormous campaign globally to ban trophy hunting, in particular endangered animals such as lions or animals under pressure from poaching, such as rhino and elephants. Namibia is a nation that is pro-hunting and despite global pressure it is likely that Namibians will continue to lobby for trophy hunting. The reason is that Namibians have seen that hunting is good for business and is good for conservation of wildlife. Statistics show that the introduction of conservation hunting was one of the most successful wildlife conservation initiatives in Namibia because:

- Commercial farmers realised that wildlife is an asset rather than a liability in direct competition with livestock.
- Large tracts of farm land have been bought up and consolidated into private hunting farms and nature reserves that offer both hunting and eco-tourism activities.
- Many neighbours have amalgamated to form conservancies, which provide economy of scale in wildlife management.
- The shift from practicing conservation to sustainable utilisation of natural resources contributed to the rapid growth of wildlife utilisation.
- Livestock has been removed or is farmed with wildlife, in much lower numbers which are more compatible with the carrying capacity of the land.
- Vast areas of overexploited veld have managed to recover due to the introduction of game management practices, and the introduction of more holistic approaches to veld management.
- Private landholders and communities on communal land have been given custodial use rights over their wildlife. This has resulted in considerable investment in wildlife stocks in these areas.
- The sustainable utilisation of wildlife in communal areas is a lucrative way for poor, rural communities to derive a livelihood, and conserve their natural resources.

The hunting industry is a carefully managed, regulated industry. Commercial rights over wildlife and plants were given to freehold farmers in 1967 and to communal farmers in 1996. There is a strict hunting season, as shown in the table below.

DATE	TYPE
1 May to 31 August	Farms of at least 1 000 hectares, enclosed with a registered game-proof fence (dates may vary slightly from year to year).
1 June to 31 July	Farms of more than 1 000 hectares and enclosed by a normal livestock fence, or on specific registered conservancies where quotas have been approved (dates may vary slightly from year to year).

Hunting season dates

(Source: www.namibian.com.na (2005-04-15)

On a hunt

(Source: theconservation.com)

In addition, there are strict rules and guidelines dictating how hunting is carried out, by whom, and how much may be bagged. Conservation hunting may only be done under the supervision of registered professional hunters. The Namibia Professional Hunting Association, NAPHA is very active, works closely with the Ministry of Environment and Tourism, and is well respected worldwide.

In 2010, approximately 90% of wildlife was located outside formally proclaimed conservation areas, with more than 80% of the numbers of the larger wildlife species found on privately owned farms (about 44% of the total land area of the country).

Tourism based on the sustainable use of wildlife, particularly trophy hunting, is the leading income source for communal conservancies. It is a key pillar of Namibia's broader approach to the conservation and sustainable utilisation of natural resources. So whilst it is not always easy to see magnificent creatures like lions and elephants being killed for pleasure, it is important to realise that if hunting was stopped, then wildlife conservation in communal conservancies (especially those behind the veterinary fence) would no longer remain viable and could be replaced by other forms of land use more damaging to arid ecosystems. It could also result in increased levels of poverty, an increase in illegal wildlife trade and cases of poaching, and an increase in people and wildlife conflicts especially from lions and elephants.

Namibia is one of the most preferred hunting destinations in Africa and conservation hunting earns more foreign currency for Namibia than it does for South Africa. Most conservation hunting is on private land where primarily plains game species are offered. Smaller quotas, mostly involving high value species, are offered on communal land and in concessions on state-owned land. In 2010 conservation hunting contributed about 14% to the total tourism industry with revenue of at least N$ 134 million per annum.

Strong support of hunting from local leaders

Chief Mayuni is the Chief of the Mafwe people and patron of the Mayuni Conservancy, located in the Linyanti Constituency, in northeastern Zambezi Region, along the eastern bank of the Cuando River. He is a passionate conservationist, who persuaded his people to move from the river side and make more space for wildlife. He believes that trophy hunting is an important conservation tool that is essential to sustain his people and wildlife populations.

In an interview done for the IRDNC website, he explained that whilst both hunting and tourism provide direct benefits to conservancies, living with wildlife can be dangerous. For example farmers suffer severe losses from wildlife, such as elephants trampling crops, lions taking stock and humans being killed every year by elephants, hippos and crocodiles. Income from hunting and tourism helps pay for human-wildlife conflict mitigation measures, such as chilli smoke bombs and lion proof kraals. Compensation is also paid to farmers who have suffered losses, and sadly to families who have lost loved ones. Chief Mayuni, like many other people engaged in communal conservation in the Zambezi Region, believes that without hunting, conservation would come to an end in the region.

Chief Mayuni
(Source: WWF)

The lobby against trophy hunting will not go away and the countries who engage in this industry will always be under scrutiny. If the business case for conservation hunting is to remain viable and Namibia's wishes to maintain its reputation as a top conservation hunting destination, then unscrupulous practices need to be kept under control. Examples of such practices include allowing illegal hunts, unwise allocations of trophy animals, the hunting of too many mature males in relation to females and young males, and the poaching of endangered animals. Maintaining a meticulous conservation hunting ethic and ensuring both wildlife and people benefit, is the key to a sustainable industry in the long term.

Namibia's game meat industry

Over the years there has been a realisation that non-consumptive utilisation of wildlife (i.e. photographic tourism, bird watching, and game watching) and hunting are not the only ways to utilise wildlife. Within Namibia wild game numbers are large enough that they can be commercially harvested. This has enabled the development of a game meat industry, whereby free-ranging wildlife are harvested sustainably, processed locally and exported to South Africa and Europe.

As the number of health-conscious consumers seeking meat, with a low fat content and a more favourable fatty acid composition than beef or lamb, has grown, so too has the demand for game meat products. In the early 1990s game meat exports to Switzerland commenced on a small scale. However, it was soon closed after the Chernobyl accident, which resulted in a perception in Europe that all game meat was contaminated with radioactive substances.

In 2003 exports of game meat started up again when the Farmers Meat Market Mariental Abattoir (Pty) Ltd got approval from the European Union (EU) to export deboned springbok meat to the EU and Norway. Between 2003 and 2008, the overall value of game meat exports almost tripled, from less than N$ 11 million to N$ 31 million.

Exports slowed down between 2009 and 2012 and then spiked in 2013. Over 1 000 tonnes of game meat products worth more than N$ 50 million were exported, the majority went to South Africa, followed by Belgium, Botswana and Norway. Since 2014, there has been no facility exporting meat from game species to overseas markets, and export activities have been largely confined to small amounts of processed products (biltong and droëwors) going to South Africa. The result is that meat export quantities plummeted to 86 tonnes in 2014 and 38 tonnes in 2015. However, regional demand for game meat products is on the rise, as the middle class in Africa is growing and gaining more purchasing power to spend on items such as meat and meat products and there is an opportunity to bolster exports by focusing more on regional markets. Namibia's domestic market is relatively small, primarily because of its small population.

The most relevant consumer segments, for both meat cuts and processed products, are private households, the food catering and hospitality industry, i.e. restaurants and lodges catering to both local costumers and tourists. The consensus is that the game meat industry has not yet reached its full potential. If the demand for game meat continues to rise, particularly from discerning customers looking for a healthy alternative to conventional meats and for an ethical and ecological alternative to industrial factory farming, then opportunities for growing this industry exist. This has the potential to increase the area of land used for wildlife, will create employment and generate revenue for the country.

Game biltong - a popular product

(Source: thesaffa.com.hk)

Fishing in Namibia

Namibia is fortunate in that it has access to both marine and freshwater fisheries. Both are valuable in economic terms (in particular the marine resource) as well as socio-economic terms (particularly the fresh water resources that support the subsistence fishing communities in the northern parts of the country).

The Ministry of Fisheries and Marine Resources (MFMR) is responsible for the management and development of fisheries and aquaculture in Namibia. The fishing industry is the second biggest export earner of foreign currency after mining, contributes significantly to GDP, as is shown in the table below, and provides thousands of jobs, the majority of which are permanent, others seasonal.

In 1995 research was undertaken to establish how many Namibians benefited from fishing. The findings revealed that the number of people benefitting from marine fishing was only marginally higher than the number of people who benefitted directly from fresh water, subsistence fishing. As marine fishing is a major contributor to GDP, it puts into perspective just how valuable the inland fisheries are too.

PERCENTAGE CONTRIBUTION OF MARINE FISHERIES TO NAMIBIAN GDP					
YEAR	2009	2010	2011	2012	2013
Percentage [GDP]	4.5%	3.2%	3.6%	3.9%	3.45%

Percentage contribution of marine fisheries to Namibian GDP

(Source: MFMR/Namibian Statistics Agency, 2013)

Marine Fishing

Namibia has sovereign rights over a large section of the coastline that is influenced by the **Benguela Current**. The Benguela Current Large Marine Ecosystem boasts rich populations of fish that swim in the open ocean (pelagic) and live close to the sea floor (demersal). These fish populations are supported by plankton production driven in by intense costal upwelling. It is the **second most productive eastern boundary upwelling system in the world**, after the Humboldt system located along the western coast of South America. For this reason fishing has been a mainstay of the Namibian economy for many years. Unfortunately, many of the marine resources have been heavily exploited, particularly since the Second World War.

Prior to independence in 1990, Namibia was ruled by South Africa but exercised some control over the inshore fisheries. However, there was little control over the more lucrative offshore fisheries because no country would acknowledge South Africa's jurisdiction over Namibia's 200-mile Exclusive Economic Zone (EEZ). The result was that the offshore fisheries were dominated by foreign fleets, mainly those of Spain, South Africa and the former USSR with no one taking responsibility for managing the resource. This resulted in severe depletion of fish stocks with very little economic benefit for Namibia.

Research compiled in 2001 showed a **substantial decline in annual marine** catches from a peak of about two million tonnes in the late 1960s to less than a million tonnes in the 1990s. This was largely due to the collapse of the sardine stock in the 1970s, which was due to

Fishing vessels in Walvis Bay harbour

(Source: d3rp5jatom3eyn.cloudfront.net/assets/images/3454/stormy-seas-ahead2017-07-060.jpg)

over-exploitation of resources but was also influenced by major environmental variances such as wide-scale advection of low oxygen water and the Benguela Niño of 1995. Unfortunately due to adverse environmental conditions and ongoing fishing the sardine stock has never recovered. Because so many other valuable fish species depend on sardine for food, this has had a huge impact on the fishing industry as a whole.

Since independence Namibia has been working to establish a more sustainable fishing industry. Regular monitoring of fish stocks and surveillance of operators is in place to try and minimise overutilisation of marine resources. Annually the state of Namibia's main fish stocks is reported on.

Hake *(Merluccius capensis and M. paradoxus)* - Annual swept-area (trawl) biomass surveys are conducted to assess the size of the hake stocks in Namibian waters. Since 1990 the total biomass of hake in Namibia has increased from about 600 000 tonnes to about 1 000 000 t. More than 50% of the total biomass is made up of fish less than 35 cm, and are immature and therefore non-fishable.

Monkfish *(Lophius spp.)* - The total biomass of monkfish in Namibian waters is assessed annually through swept-area surveys and stock assessment models. The total biomass of monkfish was estimated to be 72 000 tonnes in 2016, which is lower than the total biomass estimated during 1990.

Horse mackerel *(Trachurus capensis)* - Annual acoustic surveys are used to estimate the total biomass of horse mackerel. The total biomass of horse mackerel estimated during the survey in 2016 was 1 450 000 t, which is slightly higher than the biomass estimated in 1990.

Pilchard *(Sardine - Sardinops sagax)* - The sardine stock in the northern Benguela was estimated at around 11 million tonnes in the mid-1960s. There was a rapid decline by the late 1960s following intense fishing and low recruitment. By 1971 the stock was estimated to be over a million tonnes and has fluctuated at low levels since then. The total biomass of sardine is assessed annually by acoustic surveys. During 2015 and 2016 the biomass has been so low, that the surveys could not reliably assess the sardine biomass, indicating that the stock is currently at a critically low level.

How does Namibia manage its marine resources?
Namibian fishing policy is based primarily on:

- The promotion of commercial exploitation of marine resources;
- minimising subsidisation;
- 'Namibianising' the fishing industry; and
- utilising this national resource for the broader benefit of all.

Harvesting of tuna
(Source: BCLME)

Fish processing plant
(Source: G Schneider, 2016)

Although this policy is both progressive and ambitious, achieving all of these goals is not an easy task. Some of the tools that Namibia has adopted to manage its fisheries more sustainably include issuing **permits**, annually setting **total allowable catches** (TAC) for some fish stocks (e.g. hake, monk and mackerel), based on findings of scientific research and estimation and allocating TACs for large pelagic stock such as tuna and shark based on allocations given out by international organisations, such as The International Commission for the Conservation of Atlantic Tunas (ICCAT). The government also established a system of quota levies and the industry has invested substantial resources into **value addition** within the fishing sector, such as fish processing factories.

Fishing rights

The public has to apply for the right of exploitation of various fisheries. The criteria for allocation of rights of exploitation favour Namibian ownership. In 2012, a total of **338 fishing permits** were awarded. The duration for the right of permits varies from 7, 10, 15 to 20 years.

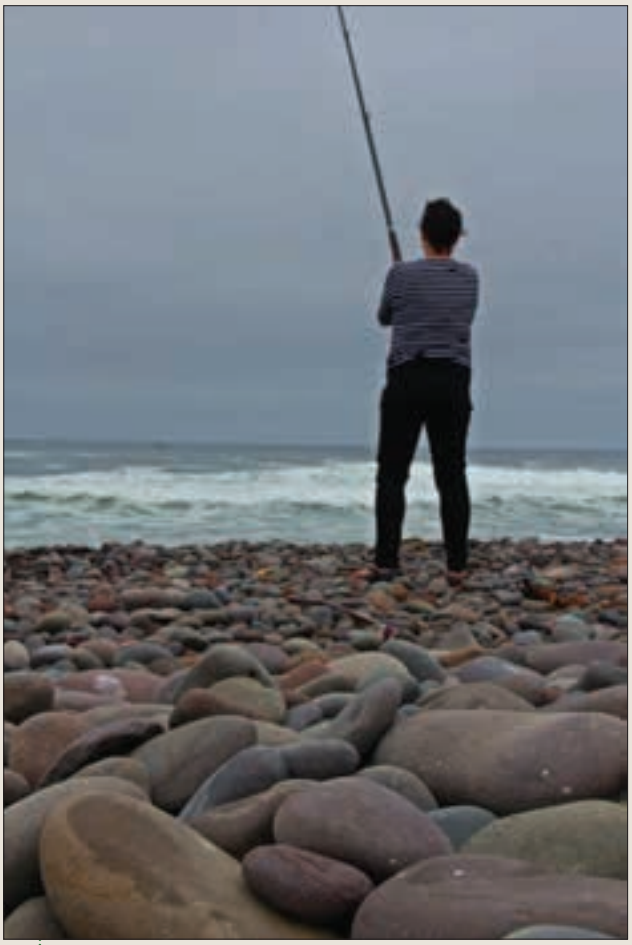
Total allowable catch

TACs are allocated annually for vulnerable species and are based on the results of fish stock monitoring. Whilst there is evidence that over the years TACs have sometimes been issued that contradict scientific recommendations and that TACs are exceeded, overall, Namibia has been making an effort to manage its marine resources.

Recreational fishing

In addition to industrial fishing Namibia has a successful recreational line-fishing industry. A study done for the Ministry of Environment and Tourism estimated that in 2012, 8 300 anglers spent a total of 173 000 days angling. The aggregate direct expenditure by anglers was between N$ 23 million and N$ 31 million and the gross value added represents some 3.6% of the whole fisheries sector. The findings indicate that recreational marine fishing not only has significant value within the sector but also needs to be managed to ensure sustainability.

The long-term sustainability and profitability of Namibia's fishing is extremely vulnerable to factors beyond the control of government, such as marine environmental events, international markets for fish and costs of imported inputs like fuel. However, the management of TACs, and allocation of permits and quotas is in the hands of government, as is effective monitoring of natural resources and strict control of operators and illegal harvesting.



Recreational Fishing
(Source: M Pfaffenthaler)

Namibian Chamber of Environment holds Ministry accountable for sustainable management of an invaluable resource

In March 2017, in response to the Minster of Fisheries and Marine Resources announcement to allocate a sardine quota of 14 000 t, the Namibian Chamber of Environment issued a statement calling for the Minister not only to reassess his decision but to implement some urgent measures to promote the recovery of the sardine stock. The NEC suggested that these measures should include:

- A moratorium on sardine fishing (including fines on sardine caught as bycatch) until the stock has recovered to sustainable levels – for at least three years - as per the Namibian Constitution, national policies and international commitments.
- Rigorous scientific research on stock size and related ecosystem aspects to be continued and intensified.
- Implementation of agreed EAF management principles, including long term sustainability.
- Ecological (including biodiversity), economical and social wellbeing.
- Development of Marine Protected Areas, specifically to protect key spawning and nursery areas.
- An agreement with Angola on the sustainable management of shared sardine stocks, ideally via a joint sardine/ pilchard management plan.

The fear is that should sardine populations reach a critically low threshold they will be unable to recover. This will have disastrous repercussions for the entire Benguela Current Large Marine Ecosystem, as well as for the people whose livelihoods depend on healthy, sustainable populations.

In addition to managing the exploitation of marine resources there are a range of other factors that have to be considered as part of a sustainable integrated management approach. These include:

- Conservation of fish breeding areas such as rocky shores, lagoons and estuaries.
- Conservation of the algae and krill, the base of the Benguela food web.
- Management of beach and water from pollution;
- Continued inflow from rivers and groundwater into the sea, delivering valuable nutrients and minerals into the marine environment.
- Conservation of islands which provide valuable habitat to marine birds and seals in particular.
- Management of the seabed which is home to a multitude of organisms and the source of nutrients and minerals.
- Management of the Benguela Current system.
- Research into the relationship between and knock on effects of different activities taking place in the ocean (e.g. fishing and phosphate mining, impacts of fishing on shark numbers and the effect it has on seal populations, which in turn impact on the commercial fishing stocks etc.).
- Ongoing research to learn more about marine ecosystems, some of which are poorly understood.

If current and future generations are to benefit from marine resources, disciplined and careful management of these resources are required.

Marine islands are an important habitat for birds such as gannets

(Source: BCLME)

The Benguela Current Commission (BCC) is an intergovernmental (South African, Namibian and Angolan) organisation responsible for implementing the Benguela Current Convention, which aims to promote the vision of the Benguela Current Large Marine Ecosystem (BCLME) sustaining human and ecosystem well-being for generation after generation.

Making a living from broken shells

Most people visiting the beaches of Namibia perceive the mounds of broken shells that litter the beach as waste. This is not the case for some women in Swakopmund who collect the shells in order to make necklaces. Beads play an important role in Oshiwambo culture and due to an ongoing demand for shell necklaces in the north of Namibia and even Angola this small group of previously unemployed women have been able to make a livelihood from these 'discarded' marine resources. The work is not easy as they have to collect and sculpt the shells by hand. But it is sustainable, has improved their standard of living and given them a sense of purpose and well- being.

Woman crafting necklaces from shells
(Source: K Retief, 2014)

Woman collecting shells from the beach near Swakopmund
(Source: K Retief, 2017)

Freshwater fishing

Freshwater fishing takes place throughout the year in Namibia's perennial rivers and dams and seasonally in the oshanas of the Cuvelai system. Subsistence fishing continues to play an important role in food security and livelihoods of rural communities and has both cultural and recreational value. The monetary value of this industry is difficult to calculate because most of the fish is not sold. However, in 2012, 1 963 tonnes of fish were sold at the Katima Mulilo fish market alone (approximate value of N$ 15 million) and it is estimated that the yield from the Zambezi floodplains (especially the Liambezi) is 5 340 tonnes (approximately N$ 41 million).

Fishing in inland waters is governed by 'The white paper on the responsible management of the inland fisheries of Namibia', which places an emphasis on the management of the resource by the communities themselves.

Unfortunately inland fisheries have been under considerable pressure for many years, due to an ever increasing demand and ever diminishing supply. Fair access to these resources as well as sustainable management of them is very complex due to the following reasons:

- Wide range of users such as subsistence communities, recreational fishermen and illegal fisherman (local and international);
- political considerations (the perennial freshwater rivers of Namibia are all borders, so resources must be shared with other countries;
- differences between various aquatic ecosystems and the complexity of them;
- differences in management approaches (management by government institutions versus community based management of resources); and
- illegal fishing.

Managing fresh water fish stocks is not only important from a food security perspective. If fish stocks collapse it will have a knock-on effect that will affect people's standard of living in so many ways. One example is that the number of mosquitos, black flies and other problem insects will increase because the fish that usually eat their larvae no longer exist. This will give rise to an increase in disease and health issues. Another issue is that without fish, numerous animals such as birds, otters and crocodiles will die and this will impact hugely on the general health of the riverine ecosystems as well as impacting on ecotourism, a major source of employment and income in the north of Namibia.

Managing fisheries in the Zambezi – the big picture

The Zambezi is the fourth longest river in Africa. It originates in Zambia and flows through Namibia, Zimbabwe, Malawi and Mozambique to the Indian Ocean. It is subjected to both subsistence, commercial and recreational fishing. The entire river has been overexploited with some sections worse off than others. For example in some areas, e.g. Liuwa Plain National Park in Zambia and conservancies in Namibia, community based resource management initiatives have potential for success, but other fisheries, e.g. Lake Malombe in Malawi, are so severely over-fished that there is no prospect of recovery without radical restructuring of exploitation patterns coupled with habitat restoration.

Research on catches at Lake Liambezi

(Source: NNF)

Poaching of fresh water fish to meet a growing demand in the Congo

For many years the Namibian sections of the Zambezi, Kwando and Kavango Rivers have been utilised for subsistence or recreational means. Recently poaching of fish for profit has developed due to a large demand in the Congo. This has resulted in many unlicensed, migrating fishermen - some contracted by Congolese businessmen coming into the area to fish. The catch is then exported. This demand has elevated the value of the fish, which makes it tempting for locals to become involved too. At the moment the majority of the poaching takes place on the Zambian side, but the impact is felt by Zambians and Namibians alike. This activity is very difficult to manage because Namibia does not have the resources to police such a large area (about 4 000 km^2) and customs are struggling to control these exports.

Managing fresh water resources for local Namibians

In the last few years excessive overexploitation of the resources in the Kavango and Zambezi rivers has taken place, which has put the entire ecosystem at risk and threatens the livelihoods of thousands of rural Namibians.

- Research has shown that there is a direct correlation between the use of monofilament nylon nets and the collapse of fish stocks and this must stop. The reason is that monofilament nets are cheaper and more efficient but less durable which means that they have to be replaced often. Unfortunately most of the old nets are discarded in the river where they drift in the water and continue to catch fish, become snagged on the river bank, entangling other animals as such birds and snakes or are eaten by hippos. When the nets degrade the micro-plastics of which they are made, pollute the soils and water and are often ingested by the very fish we eat.
- Uniform control and management of the rivers' resources by the neighbouring countries is difficult to achieve.
- Fish stocks need time and space to regenerate. Therefore, fishing throughout the year cannot continue and some sections of the river, where fish breed or find sanctuary need to be off limits and designated as conservation areas.

In 2016 the Ministry of Fisheries and Marine Resources took a first important step at managing these issues:

- Banned the use and sale of monofilament nets;
- gazetted the Kasaya Channel as a Fish Protection Area (channel between the Zambezi and Chobe). This adds to the Sikunga Fish Protection Area;
- Zambezi/Chobe River system in the Zambezi region has been gazetted a fisheries reserve with a closed season between 1st of December to 28th of February (excluding catch and release by recreational fishermen in December and January). This coincides with the Zambian closed season and thus allows for simpler enforcement and greater protection.

However, legislation is not enough. More communities need to come on board to co-manage their fisheries and conservation of these vital ecosystems must be improved. Fortunately committed NGOs such as the Namibia Nature Foundation (NNF) are working with communities.

Monofilament nets are very efficient but have had a negative impact on fishing. They have recently been banned.
(Source: NNF)

4

ENVIRONMENTAL MANAGEMENT -

HOW PEOPLE TACKLE THE TASK OF MANAGING NATURAL RESOURCES SUSTAINABLY

4.1 ENVIRONMENTAL MANAGEMENT – TAKING ACTION

Environmental management is not easy to define. It can refer to the following:

- A goal or vision;
- a process;
- the application of a set of tools;
- a philosophical exercise that seeks to establish new outlooks towards the environment and human societies.

Environmental managers are a diverse group of people including academics, policy-makers, non-governmental organisations (NGOs), company employees, civil servants and a wide range of individuals or groups who make decisions about the use of natural resources. Indeed, environmental management **involves all people** to some extent because all human activities ultimately have some sort of environmental impact. However, the extent to which individuals are involved in environmental management varies hugely (e.g. for some it is a profession for others a hobby or a way of life). As the field is so diverse, not everyone is involved in the same aspect of management. Some people utilise resources directly, whilst others are more interested in how those resources are exploited.

Because the environment is so diverse and people have different values, individuals and groups involved in environmental management often hold conflicting - and even directly opposing – views. Environmental management therefore involves many **stakeholders** and requires a multidisciplinary perspective, because there is rarely one right approach.

Sound environmental management seeks to find a balance that meets the needs of the environment and stakeholders. To do so, the process must consider **spatial scales**, ranging from local to global, **time scales**, from current to future needs, and **duration**, from short term to long term. It must involve many, diverse goals, such as the desire to control the direction and pace of development, to optimise resource use, to minimise environmental degradation, and to avoid environmental disaster.

The challenge is to find ways to integrate the management of all these goals.

Despite a diversity of approaches, in general, environmental management is concerned with the **understanding of the structure and function of the Earth System**, coupled with the ways in which humans relate to their environment. It is also about **decision-making**. Those decisions are seldom neutral or objective; on the contrary, they are value laden, reflect the exercise of power by particular groups over others and are often guided by incomplete information. It is therefore naïve to think that environmental management is simply about 'the management' of the natural environment. Instead, it is more accurate to suggest that it is the management of human activities and their impacts rather than the management of the natural environment per se.

Namibia's key environmental management legislation is the **Environmental Management Act (No. 7 of 2007)**. Its main objective is to prevent and mitigate the significant effects of activities on the environment in accordance with a set of environmental management principles as listed under Section 3(2). They are:

a. **Renewable resources** must be used on a sustainable basis for the benefit of present and future generations.
b. **Community involvement** in natural resources management and the sharing of benefits arising from the use of the resources, must be promoted and facilitated.
c. **The participation of all interested and affected parties** must be promoted and decisions must take into account the interest, needs and values of interested and affected parties.
d. **Equitable access** to environmental resources must be promoted and the functional integrity of ecological systems must be taken into account to ensure the sustainability of the systems and to prevent harmful effects.
e. **Assessments** must be undertaken for activities which may have a significant effect on the environment or the use of natural resources.
f. **Sustainable development** must be promoted in all aspects relating to the environment.

g. **Namibia's cultural and natural heritage** including its **biological diversity**, must be **protected** and **respected** for the benefit of present and future generations.
h. **The option that provides the most benefit or causes the least damage** to the environment as a whole, at a cost acceptable to society, in the long term as well as in the short term, must be adopted to reduce the generation of waste and polluting substances at source.
i. **The reduction, re-use and recycling of waste** must be promoted.
j. **A person who causes damage to the environment must pay the costs** associated with rehabilitation of damage to the environment and to human health caused by pollution, including costs for measures as are reasonably required to be implemented to prevent further environmental damage.
k. **Where there is sufficient evidence** which establishes that there are threats of serious or irreversible damage to the environment, **lack of full scientific certainty** may not be used as a reason for postponing cost-effective measures to prevent environmental degradation.
l. **Damage to the environment** must be **prevented** and activities which cause such damage must be **reduced, limited or controlled**.

Environmental management can only be possible through a concerted effort amongst all echelons of society. Government has a responsibility to develop and implement policies, laws, checks and controls so that activities are managed in a transparent and just manner. As a minimum, industry needs to comply with the legal requirements of the country under whose jurisdiction it operates. Some companies choose to manage environmental issues voluntarily or as a result of funding requirements or public pressure.

The degree to which communities and individuals do and can get involved depends very much on the governmental regime. In democratic countries where individuals are afforded personal freedom, civil society often plays an active role in implementing environmental action. In fact, there is a school of thinking that suggests that the state should be prevented from undertaking tasks that would be better performed by citizens. The approach to dealing with the environmental challenges then is to have a policy that recognises the role of individuals and permits private initiatives. In this approach, civil society is free and encouraged to find local solutions, leaving government to deal with the larger problems. For it to work, it requires civil society to take responsibility for being part of the solution.

The following sections will look at the roles that government, industry, NGOs and the public can take on to effect good environmental management; government through their policy making and regulatory framework; industry through their corporate governance and responsibilities; NGOs through their community programmes and finally all individuals through their daily decisions and actions.

Students learning about lichen in the Namib Desert during the annual Gobabeb Training and Research Internship Programme, supported by Langer Heinrich Uranium Mine

(Source: Oliver Helsey, 2016)

4.2 ACTIONS OF GOVERNMENT

There is an on-going debate about the appropriate involvement of government for solving environmental problems, with many environmentalists calling for increased government intervention and others calling for less. For example, issues such as global warming and the loss of biodiversity require much more government intervention than had previously been assumed. This is not to say that government intervention cannot rely on the private sector, but it is generally agreed that top-down regulation is critical for effective environmental management. There is simply no way to adequately address these issues without a strong commitment from government.

Governments are swamped with a multitude of issues requiring urgent intervention, for example when facing increased probabilities of natural disasters (mainly due to global warming). Governments have a responsibility to implement risk management in areas prone to floods, droughts, epidemics, and other environmental disasters; especially given that they are directly or indirectly responsible for meeting the costs of natural disasters. Absolute limits on greenhouse gas emissions, government funding for alternative-energy systems, and coordinated efforts to protect biodiversity are some of the many issues that need the implementation of government policy.

Generally there is a conflict between the protection of the environment and the economic development of a country, and the environment is most often afforded the lowest priority in terms of manpower and budget. Despite this, Namibia is known as one of the most progressive countries in Africa due to the environmental legislation that has been put in place. Effective and consistent implementation of this legislation and revision of old, redundant legislation continues to be a challenge. Despite this, the Namibian government has been proactive in finding ways to address some of these challenges.

Environmental protection can be achieved by different means and there are various tools that the government uses to govern the country. These tools make up the **regulatory framework** and consist of the constitution, bills, acts, regulations, policies, and guidelines.

The **Namibian Constitution** or 'Mother of all Laws', as Namibians have come to call it, is linked to the founding of the Namibian state. It came into force on 21 March 1990, the day of Independence. It has been hailed as one of the most democratic and liberal constitutions in the world. It shows a strong commitment to the rule of law, democratic government and respect for the fundamental human rights and freedoms. Namibia was also the first country in the world that has made environmental protection an integral part of its Constitution.

Under Article 95 (l), the Constitution actively promotes and maintains the welfare of the people by adopting, inter alia, policies aimed at the following:

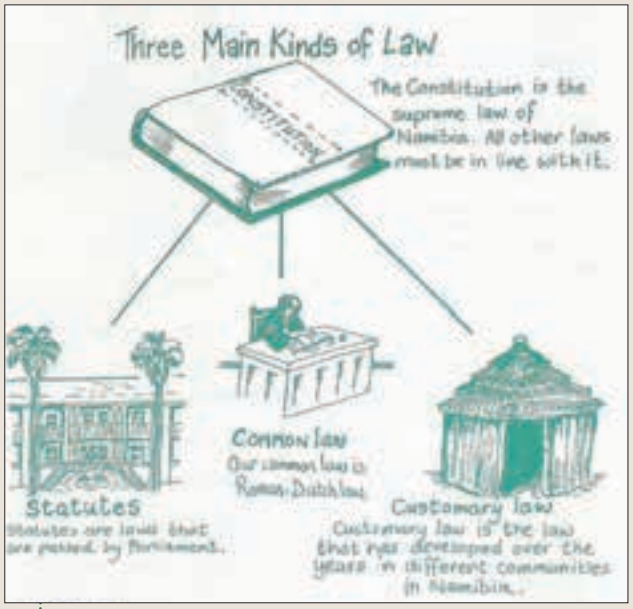
"Management of ecosystems, essential ecological processes and biological diversity of Namibia and utilization of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future."

Through this Article, Namibia not only recognises the importance of healthy ecosystems for the welfare of its people, but is obliged to protect its environment and to promote sustainable use of its natural resources.

The Constitution is the supreme law of Namibia. All other laws in the country must be developed in accordance with it. A **law** is a set of standards, procedures and principles that must be followed. There are three kinds of laws in Namibia, namely statutes, common law and customary law.

Statutory laws are the laws that are passed by parliament. Other words for statutes are 'legislation' or 'Acts of parliament'.

Common law is the Roman Dutch Law which was inherited when Namibia was a colony of South Africa. The Namibian Constitution recognises common law as it exists, but only as long as it is not in conflict with the Constitution. Common law is found in written form as reported court cases and in text books. Parliament can change common law by issuing statutes which say something different to the common law. Common law is important when an issue is not addressed in either statutory or customary law.



Laws of Namibia
(Source: Legal Assistance Centre Windhoek, 1996)

Customary law has developed over the years in different communities in Namibia. Questions over customary law are decided by the chiefs, headmen or other traditional leaders. As customary law is not written down, it can lead to different interpretations by community members. Parliament can change customary laws by passing a statute that applies to all communities of Namibia. Despite national laws being in place, customary law is very effective, especially in communal areas.

Bills, acts, regulations, policies, and guidelines form key components of the regulatory framework and these are described here:

Bills form the first stage in the law making process. A bill is a proposal for the making of a law. It can be suggested by the president, cabinet, parliament, or even a non-governmental agency or interested member of the public. A bill does not become law until it is passed by the legislature process which includes approval by the national assembly, national council and the president. The bill only comes into force as an act on the day it has been published in the Namibian Government Gazette.

Acts are promulgated ('approved') by parliament, signed by the President and published in the Government Gazette. The Act enters into force or becomes legally binding on the date determined by the Minister by notice in the Gazette.

Regulations are issued by various government departments and provide the means for the intentions in an Act to be implemented. Regulations are enforced by a regulatory agency or Ministry. If laws are not followed, those responsible for breaking them can be prosecuted in court. A number of key Namibian environmental acts are listed in the following table.

A **policy** outlines the goals of a government ministry or department and the activities it will use to achieve them. A policy document is not a law but rather guides actions to achieve a desired outcome. Policies will often identify new laws that are needed to achieve its goals. Many policies have been drawn up by the Namibian government. A number relating to environmental management include the Environmental Assessment Policy, National Land Use Planning Policy, National Water Policy, Water and Sanitation Policy, Policy for Prospecting and Mining in Protected Areas, Namibia's Drought Policy and Strategy, and the Water and Sanitation Policy.

Guidelines and action plans are aimed at guiding the management of various issues or activities. Following a guideline or action plan is not mandatory and cannot be enforced. However, it is recommended good practice and government, the private sector and the public are encouraged to apply the actions laid out in these documents to plan, develop, implement and monitor activities to protect the environment. A number of key Namibian environmental action plans include the National Biodiversity Strategy and Action Plan, Namibian's Proposed Climate Change Strategy and Action Plan, Aquaculture Strategic Plan and the Strategic Action Plan for the Implementation of Renewable Energy Policies. Key legislation that has influenced the way the environment is managed is listed in the table on the next page.

NAME OF ACT	DEFINITION OF ACT
The Environmental Management Act (No. 7 of 2007)	The Act provides a set of principles which give effect to the provisions of the Constitution for integrated environmental management. The Act is considered a model legislative initiative, not only in the African context but especially for a developing country. This law acknowledges Namibia's responsibility to protect and maintain its own environmental and natural resources for future generations. The Environmental Impact Assessment Regulations 2012 list the provisions which guide the implementation of EMA 2007.
Nature Conservation Ordinance No 4 of 1975	This piece of legislation governs the conservation of wildlife and protected areas and is one of the major biodiversity related laws in Namibia. It was amended in 1996 to take the establishment of conservancies and Wildlife Councils into account. Rural communities are required to form a conservancy in order to have a use-right over the wildlife. In doing so it has given communities custodianship of their natural resources.
Legislation on Water	The Water Act (No. 54 of 1956) consolidates and amends the laws relating to the control, conservation and use of water for domestic, agricultural, urban and industrial purposes. It further controls the disposal of effluent. The Water Resources Management Act, 2013 (No. 11 of 2013) provides for the management, protection, development, use and conservation of water resources; and provides for the regulation and monitoring of water services. The old Water Act will be repealed by the Water Resources Management Act once it is approved by the Minister.
Legislation on Fisheries and Marine Resources	The Marine Resources Act (No. 27 of 2000) provides for the conservation of marine ecosystems and responsible utilisation, conservation, protection and promotion of marine resources on a sustainable basis. The Aquaculture Act (No. 18 of 2002) regulates and controls the aquaculture activities. The Inland Fisheries Resources Act (No. 1 of 2003) deals with the conservation of inland fisheries resources.
Legislation on Land and Agricultural Production	The Communal Land Reform Act (No. 5 of 2002) provides for the allocation and administration of all communal land and makes provision for the prevention of land degradation and mitigating the impact from mining, prospecting, road works and water provision on the natural environment. The Plant Quarantine Act (No. 7 of 2008) provides for preventing, monitoring, controlling and eradication of plant pests. The Soil Conservation Act (No. 76 of 1969) aims to consolidate and amend the law relating to the combating and prevention of soil erosion, the conservation, improvement and manner of use of the soil and vegetation.
Legislation on Energy and Mining	The Minerals (Prospecting and Mining) Act (No. 33 of 1992) makes it illegal for any person to prospect or mine without a licence. The Petroleum (Exploration and Production) Act (No. 2 of 1991) covers all activities with respect to the exploration and mining of petroleum resources and the requirement of licences. The Diamond Act (No. 13 of 1999) covers the mining for diamonds and includes provisions for protecting the environment.
Environmental Legislation in Preparation	The following pieces of legislation are still in preparation: Protected Areas and Wildlife Management Bill of 2001; Pollution Control and Waste Management Bill; Access to Biological Resources and Associated Traditional Knowledge Bill.

Key Namibian legislation on environmental management

(Source: O Ruppel, 2016)

Namibia has also become a member of many multilateral environmental agreements (MEAs). These international agreements emphasise Namibia's commitment to strong environmental protection as well as to improved environmental governance, transparency, participation, accountability and conflict resolution. By becoming a member, it also allows Namibia to be a recipient of financial assistance in addressing environmental problems as well as facilitating assistance through knowledge and technology transfers. Some of the most important MEAs are listed in the following table.

NAME OF MEAS	NAMIBIA'S COMMITMENTS UNDER THIS MEA
1971 Convention on Wetlands of International Importance Especially as Waterfowl Habitat	Required to designate one national wetland for inclusion as a RAMSAR site (i.e. a wetland of international importance) and to conserve and manage this area as well as waterfowl numbers in accordance with international responsibilities.
1972 Convention Concerning the Protection of the World's Cultural and Natural Heritage	Required to identify, protect, and conserve cultural and natural heritage of outstanding universal value for the benefit of future generations. These aspects of national heritage must be submitted for approval as a 'World Heritage Site' and funding must be made to the World Heritage Fund.
1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (SITES)	Required to protect certain endangered species from over-exploitation by means of a system of import-export permits.
1982 United Nations Convention on the Law of the Sea (UNCLOS)	Required to assist in the establishment of a new legal regime for the sea and oceans and establish rules for environmental protection and pollution control of the marine environment.
1997 Law of the Non-Navigational Uses of International Watercourses.	Required to use, develop, and protect international watercourses in an equitable and reasonable manner. Participation in this law allows both the use and a duty to cooperate with other participants to protect and develop these watercourses.
1985 Vienna Convention on the Protection of the Ozone Layer	Required to protect human health and the environment against adverse effects resulting from the modification to the ozone layer. This includes cooperating and implementing measures to control activities as well as exchanging scientific, technical, and socioeconomic information relevant to the Convention.
1992 United Nations Framework on the Convention on Climate Change	Required to regulate levels of greenhouse gas concentrations in the atmosphere to avoid the occurrence of climate change. National inventories have to be prepared and programmes and policies for control as well as education and training should be implemented to increase public awareness. The Convention recognises that developing nations should be given assistance in achieving these terms.
1992 Convention on Biological Diversity (CBD)	Required to conserve biological diversity, promote sustainable use and encourage equitable sharing of benefits arising from the use of resources. CBD confirms the principle of national sovereignty over domestic natural resources but also promotes a duty of care over resources that fall outside a state's jurisdiction.
1994 United Nations Convention to combat Desertification in Countries experiencing serious Drought and/or Desertification, particularly in Africa	Required to implement a framework for integrated management of issues associated with desertification. The Convention promotes public involvement in decision making, facilitates national and local action and cooperation to ensure the sustainable use of land and water resources.
2013 Benguela Current Convention	The Benguela Current Commission is a permanent inter-governmental organisation of Angola, Namibia and South Africa. It promotes the vision of the Benguela Current Large Marine Ecosystem (BCLME) sustaining human and ecosystem well-being.

Some of Namibia's most important multilateral environmental agreements

(Source: O Ruppel, 2016)

In 2004, Namibia adopted **Vision 2030**. This key directive from the Founding President Dr Sam Nujoma gave the the nation a long term plan and vision for the country. The purpose was to unify the nation and provide it with a common ideal to work towards. President Nujoma stated in the document:

'A national vision is a perception of the future. .....The goal of our Vision is to improve the quality of life of the people of Namibia to the level of their counterparts in the developed world, by 2030. .....Vision 2030 presents a view of where we are, were we want to go, and over what time frame.'

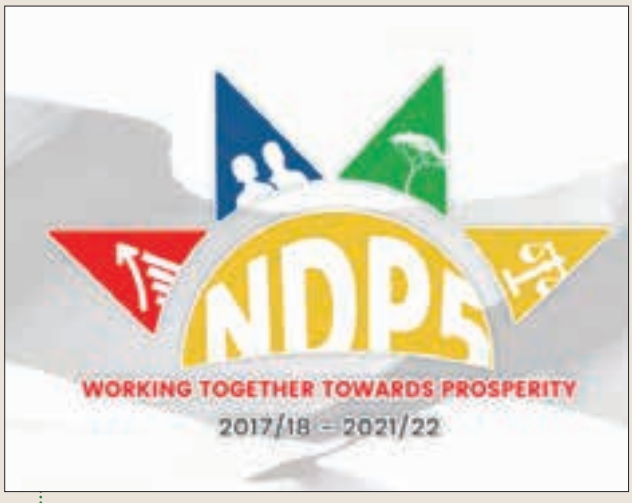
Vision 2030 was designed to guide the five year **national development plans (NDP)**, from NDP2 to NDP7, as well as provide direction to government ministries, the private sector, NGOs, civil society and regional and local government authorities. The aim was to create policy synergies to effectively link long-term perspectives with short-term planning. One of the key requirements of sustainable development as outlined in Chapter 6 of Vision 2030 was the need to ensure **environmental protection** and **limit biodiversity loss**. The loss of biodiversity impacts on Namibia's ability to develop by disrupting ecosystem stability and the functions that underpin the country's very survival (e.g. provision of clean air, water, the control of soil erosion and floods, the assimilation of wastes).

In 2016, President Hage Geingob launched the **Harambee Prosperity Plan**. It is an action plan driven by the Namibian Government to achieve prosperity for all. It is based on five pillars; namely effective governance and service delivery; economic advancement; social progression; infrastructure development and international relations and cooperations.

Both Vision 2030 and the Harambee Prosperity Plan are important vision statements and plans to drive the development framework for the country and improve the living standards and well-being of all Namibians. These goals are relevant and critical to ensure the long term sustainability of the country. However, key to ensuring these long term goals is the need to recognise and promote environmental sustainability.

The development of economic and social structures and the creation of a just, moral and safe society are only possible within a healthy environment.

The fifth **National Development Plan (NDP5)** includes the environment as one of its main goals. NDP5 will be implemented from 2017 to 2022. NDP5 builds on the successes as well as recognises the challenges of the four previous plans. It was informed by the global, continental, regional and national development frameworks and underwent extensive consultations with stakeholders.



Logo for NDP5
(Source: National Planning Commission, 2017)

Namibia has embarked on a proactive environmental management course. Approximately 44% of the country's land mass is under some form of conservation management. Namibia continues to champion high levels of community participation in the management of its natural resources and communal conservancies have increased from 66 in 2012 to 82 by the end of 2015, covering over 54% of the communal lands. However, poaching, human wildlife conflict and unsustainable use of natural resources are threats to environmental sustainability. Hence, NDP5 sets out the following goals to achieve a sustainable environment and enhance resilience by 2022:

NDP5 Strategies and Outcomes for Natural Resource Use and Conservation

(Source: National Planning Commission, 2017)

In summary the responsibilities of government are to:

- Represent Namibia in the international arena and ensure that the commitments to international treaties and conventions are honoured.
- Develop and enact new laws and review old laws, in conjunction with relevant stakeholders.
- Implement Namibian laws in a transparent and effective way.
- Work together with other government departments to iron out issues relating to conflicting legislation. Without this collaboration, sustainable management of environmental resources is often difficult to achieve.
- Work with civil society and industry as a stakeholder or to help implement projects at ground level.

Government is guided and controlled within very prescriptive boundaries that often have a strong political influence. Government is responsible for the high level frameworks that are required to establish an enabling environment and these frameworks should not be jeopardised by political agendas. Namibian citizens have a responsibility to not sit back and let politicians and bureaucrats develop these frameworks alone. Citizens need to be vigilant and ensure that the Government develops policies and laws that meet the needs and expectations of its citizens.

Launch of NDP5

(Source: The Namibian, 2017)

Namibia, Angola and South Africa cooperating under the Benguela Current Commission to manage a shared marine resource

(Source: BCC, 2016)

4.3 ACTIONS OF INDUSTRY

Legal and voluntary compliance

Industrialisation, while important for economic growth and the development of society, is known to have had a detrimental impact on the environment. Amongst other things, industrial processes cause pollutant emissions, resource depletion, land-use changes, extinction of species, and more. Degradation of environmental quality can, in turn lead to adverse human exposures and eventual health effects.

Tailings dam failure

(Source: G Schneider, 2003)

Acid mine drainage

(Source: G Schneider, 2003)

The following table lists some types of emissions that are generated by various prevalent industrial processes and the possible environmental impacts that can arise.

SECTOR	TYPES OF LIKELY EMISSIONS	POSSIBLE IMPACTS
Chemicals (industrial inorganic and organic compounds, excluding petroleum products)	Many and varied types of gaseous, liquid and solid emissions depending on processes used and chemicals manufactured. Emissions include particulate matter, SO_2 NO_x CO, CFCs, volatile organic compounds and other organic chemicals, odours, heavy metals (cadmium, mercury).	Risk of explosions and fires, of spills that can pollute groundwater or surface water. Permanent loss of habitat from footprint of factories. Pollution of soils and land due to incorrect disposal of waste from the chemical processes.
Paper and pulp	Emissions of SO_2 NO_x methane, CO_2 CO, hydrogen sulphide, mercaptans, dioxins, suspended solids, organic matter, chlorinated organic substances, toxins (dioxins).	Permanent loss of habitat from footprint of paper mill. Risk of pollution to groundwater and surface water from release of effluent containing chorine, used in the bleaching process, and dioxins, persistent organic chemicals known to be toxic.
Cement, glass, ceramics	Cement dust, NO_x CO_2 chromium, lead, CO. Glass emissions of lead, arsenic, SO_2 vanadium, CO, hydrofluoric acid, soda ash, potash.	Permanent loss of habitat from footprint of factories. Contamination of surface waters if process water contaminated by oils and heavy metals are released or spilled. Soil contamination if heavy metals and waste are not disposed of correctly.

SECTOR	TYPES OF LIKELY EMISSIONS	POSSIBLE IMPACTS
Mining of metals and minerals	Emissions of dust from extraction, storage and transport of ore and concentrate. Emissions of metals (e.g. mercury) from drying of ore concentrate.	Contamination of surface water and ground water by highly acidic mine water containing toxic metals (e.g. arsenic, lead, cadmium), and chemicals used in metal extraction (e.g. cyanide). Major surface disturbance and erosion. Land degradation and loss of habitat by large tailings dams and ore stockpiles.
Iron and steel	Emissions are extensive and consist of SO_2 NO_x and hydrogen sulphide, heavy metals like lead, arsenic, cadmium, nickel chromium, mercury, organic compounds, particulate matter, hydrocarbons, acid mists, tars and oil, benzene, phenols, acids, ammonia, cyanides, thiocyanates, thiosulphates, fluorides.	Permanent loss of habitat from footprint of factories. Risks of explosions and fires. Unless treated, large quantities of toxic fumes (e.g. naphthalene, coke dust) and greenhouse gases (e.g.CO_2) emitted. Soil contamination and waste disposal problems if solid wastes and slag are not handled and disposed of correctly.
Non-ferrous metals	Emissions of particulate matter, SO_2 NO_x CO, hydrogen sulphide, hydrogen chloride, hydrogen fluoride, chlorine, aluminum, arsenic, cadmium, chromium, copper, zinc, mercury, nickel, lead, magnesium, PAHs, fluorides, silica, manganese, carbon black, hydrocarbons, aerosols. Scrubber water containing metals. Gas scrubber effluents containing solids, fluorine, hydrocarbons.	Permanent loss of habitat from footprint of factories. Soil contamination and waste disposal problems Contamination of surface waters and groundwater if process water containing many toxic compounds are released or spilled.
Refineries, petroleum products	Emissions of SO_2 NO_x hydrogen sulphide, hydrocarbons, benzene, toluene, CO, CO_2 particulate matter, mercaptans, toxic organic compounds, odours, hazardous waste, sludges from effluent treatment, spent catalysts, tars.	Permanent loss of habitat from footprint of refinery. Risk of explosions and fires. Risk of contamination if hazardous sludges are not disposed of correctly and toxic gaseous emissions (e.g. benzene, toluene, xylene) are released. Combination of volatile hydrocarbons and oxides of nitrogen contribute to ozone formation.
Leather and tanning	Gaseous emissions, including leather dust, hydrogen sulphide, CO_2 chromium compounds, arsenic. Waste contains a complex mixture of toxic organic and inorganic substances (e.g. chromium, chlorinated phenols, and cadmium).	Permanent loss of habitat from footprint of tannery. Contamination of surface waters and groundwater if process water are released or spilled. Soil contamination if heavy metals and waste are not disposed of correctly.
Fish processing and aquaculture	Release of organic and inorganic nutrients together with chemicals associated with medication, from intensive marine aquaculture, odours, putrid waste.	Permanent loss of habitat from footprint of either fish processing facility or aquaculture. Contamination of surface waters from high organic loading. Odours from poorly managed waste handling and cooking.

Some potential environmental emissions and impacts arising from industries

(Source: Improving the urban environment and reducing poverty, 2000)

Industry has long been criticised for sacrificing the environment in the pursuit of profits. Slowly, however, things are changing. Industries are beginning to actively implement environmental management as part of their design and operations. Stricter legislation has in many instances triggered this change. However, public pressure and shareholder value have also played a role. There are many companies who are voluntarily adopting a more proactive approach to managing environmental impacts, or who are choosing to go beyond compliance. These are the industry champions who set the standards for **best practice** and push those sectors towards improved performance.

In the past, the aim was to target the major polluters and focus on the most harmful pollutants. Physical improvements were generally verified using relatively inexpensive monitoring and on-site inspections. In the early stages of pollution control, **'end-of-pipe'** technologies, favoured by companies, targeted the pollutant rather than the root of the problem; often changing the form of the pollution rather than eliminating it. For example, taller stacks merely displaced air pollution over greater areas, while scrubbers, removed pollutants from the air but then created sludges that required treatment and disposal. Such technologies helped reduce exposure levels for surrounding communities but in the end did not provide long-term solutions for environmental degradation.

By making technological/process improvements to industrial plants, some companies were able to demonstrate an improved efficiency with regard to energy and water consumption and use of materials. This reflected positively on the environment and operating costs. However, taking small steps in pollution control and focusing on operational efficiencies did not reduce the negative impacts to acceptable levels. It was clear that a more holistic approach was needed.

Hence, the concept of **lifecycle management** was developed i.e. taking into account all the environmental burdens associated with every phase of a product's lifecycle. This approach favours changes in production processes from early on in the design and planning phase, over traditional methods such as end-of-pipe measures, long-term containment of dangerous waste, widespread dispersal of airborne gases or remediation once pollution has occurred. Lifecycle management changed the way that companies looked at the environment because it focuses on preventing impacts from arising, rather than trying to manage them once they have occurred.

End-of-pipe treatment – wastewater treatment plant to treat pathogens, nutrients and chemicals contained in municipal effluent

(Source: watertechonline.com)

Similarly a preventative approach called **cleaner production** was developed. Cleaner production is the continuous application of an **integrated, preventive strategy** applied to not only the processes, but also the products and services in pursuit of economic, social, health, safety and environmental benefits. It aims to reduce waste, environmental and health risks; minimise environmental damage; use energy and resources more efficiently; increase business profitability and competitiveness; and increase the efficiency of production processes. Often, higher efficiency brings greater productivity along with waste reduction. Cleaner production is applicable to all businesses, regardless of size or type.

Technology advancement is seen by industry as a key tool in promoting its license to operate because it reduces the impacts on the environment and provides new ways to repair the damage that has been done. The application of improved technology and the introduction of cleaner production and lifecycle management have

had a positive effect. Some industries are beginning to change their image from environmental villains to partners in the search for environmental solutions and this has promoted a level of trust between the public and these operations. Running a 'green' business is one of the fastest growing areas of opportunity for businesses. Those who have adopted environmental management processes and thinking have realised that not only does it help the environment, it also makes business sense. The rationale for adopting sound environmental practices, over and above looking after Earth's natural capital on which current and future generations depend, include:

- Improved access to financial assistance and grants from banks, international funding agencies and governments;
- reduced spending on inputs (raw materials, energy and water);
- improved public image (e.g. recognition through environmental awards) and shareholder value;
- access to new market opportunities for 'green' goods and services;
- improved workplace safety through reduced exposure to industrial chemicals and toxic wastes; and
- more motivated workforce who are proud to represent the company and enjoy working in a healthy environment.

Unfortunately, despite the progress made by some industries, overall, much still needs to be done to reduce industry's current often negative impact on the environment. The reasons for this are:

- Despite a shift towards lifecycle management, environmental sustainability is not always effectively integrated into business practices.
- Many environmental impacts need to be managed over the long-term, but businesses generally operate with short term life cycles. More often than not, the positive benefits are realised in the short term, whilst the negative impacts are realised in the medium or long term, when budgets are no longer available for managing them.
- Companies often focus on developing and maintaining policies, programmes and systems rather than emphasising their on-the-ground implementation. This means companies can show that they are thinking about environmental issues but actual change on the ground is slow.
- Environmental sustainability is not properly integrated into national planning, so in many countries, many industries are given the license to operate despite not having sufficient environmental management plans and safeguards in place.
- Many countries do not have resources to properly administer environmental compliance. There is still a focus on the big polluters whilst thousands of medium and small polluters have no environmental management practices in place.

Sound environmental practises should be an integral part of any Namibian business
(Source: Areva)

Environmental management in Namibia

Prior to the enactment of the **Environmental Management Act in 2007 (EMA 2007)**, Namibia was guided by the **Environmental Management Policy**. Environmental compliance was enforced on the mining and petroleum sector, and large, high profile projects, whilst developments in other sectors were largely ignored. But activities such as agricultural projects, fish factories, aquaculture farms, dam and road constructions and tourism developments all have the potential to eat away at Namibia's natural resource base by creating more negative impacts than positive ones. Fortunately, this situation has started to change since the enactment of EMA 2007.

In terms of the Act, many industries are listed activities. In order to obtain permission to carry out exploration activities and/or construct and operate an industrial facility, the proposed developer must apply for an **environmental clearance certificate** (ECC) from the **Ministry of Environment and Tourism (MET): Directorate of Environmental Affairs (DEA)**. To obtain an ECC these industries are required to commission an **environmental assessment practitioner** to complete an **environmental impact assessment (EIA)** and produce an **environmental management plan (EMP)** in accordance with the conditions set out in the Environmental Management Act (No. 7 of 2007). The EMP will then guide the activities of the operations to ensure that continued environmental management is applied throughout the life of the business. Many of the conditions under the EMP stipulate on-going stakeholder engagement, auditing and monitoring of key pollutant emission sources. For large operations, an annual report summarising these activities must be submitted to MET:DEA for their review and approval. Similarly, MET:DEA must undertake annual site visits to review the implementation of the EMP and any other conditions stipulated under the ECC. An ECC is only valid for three years. Following this, companies are required to apply for a renewal.

Namibian companies contributing to civic responsibility

As part of their corporate social responsibility commitments and/or due to a lifecycle approach to the management of environmental impacts, many companies in Namibia are helping both government and civic initiatives to manage a range of environmental initiatives including research, monitoring, waste management and education. These local, voluntary initiatives often make a significant impact on the ground. A good example pertains to waste management. In general, the responsibility for waste management has been deferred to local government. However, many municipal landfills are not properly designed or managed and are rapidly reaching maximum capacity. Hundreds of dumping sites exist throughout the country, for which no one claims responsibility. Limited budgets, lack of management and large volumes of waste are contributing to the growing waste crisis in Namibia. There have been a number of projects to promote recycling, many of them driven by private companies and individuals. **The Recycle Namibia Forum (RNF)** is the result of such an initiative.

What is a listed activity?

A listed activity is any activity listed under Annexure of Schedule 29, 2012, and may include activities in respect of the following sectors:

- Energy generation, transmission and storage;
- waste management, treatment, handling and disposal;
- mining and quarrying;
- forestry;
- land use and development;
- tourism development;
- agriculture and aquaculture;
- water resource developments;
- hazardous substance, handling and storage;
- infrastructure; and
- other activities.

Recycle Forum Namibia

Recycle Namibia Forum (RNF) was formed in June 2011 with the backing of Namibia Breweries Limited, City of Windhoek, Rent-A-Drum, Collect-a-can, 4H-Namibia, Plastic Packaging and Nuevas Ideas Consulting. Its aim is to coordinate projects to promote recycling, and the reduction and reuse of so-called waste. Many recycling projects have been initiated across Namibia; a few are mentioned here:

- Model Pick n 'Pay partnered with RNF to introduce reusable plastic grocery shopping bags.
- Namibia Breweries Limited (NBL) teamed up with a number of companies and allowed them to drop off recyclable material such as paper, glass, plastic and tin at NBL depots near them which are then transported to Windhoek. B2 Gold and Namibia Wildlife Resorts rest camps at Halali and Okaukuejo are among the companies that deposit material at these NBL depots.
- Grow Namibia is a recycling project in Omaruru that aims at better management of waste and is motivating Namibians to not carelessly dispose of their waste. From discarded paper and glass, the project manufactures crafts such as gift cards, boxes, writing paper, wine glasses and much more.
- In many of the towns in Namibia, people, mainly women, are earning an income by collecting discarded bottles at the dumpsite and selling them to recycling companies.
- The Schools Recycling Project was set up by RNF in 2013 and was aimed at schools in Windhoek, at the coast (Swakopmund, Walvis Bay and Henties Bay) as well as in the north (Oshakati/Ondangwa). Schools are encouraged to participate in this initiative whereby they are given four bay stations and RNF partner Rent-a-Drum services keeps track of the recyclables collected. Schools are not only in line to win a cash prize for their recycling efforts, but also are rewarded for the actual recyclables collected.

Collected plastic is recycled into plastic pipes in Okahandja

(Source: G Schneider, 2017)

The following three examples describe partnerships that have been formed between private companies and non-governmental organisations to promote and develop conservation activities in Namibia.

'Go Green Fund' partnership between Nedbank Namibia and Namibia Nature Foundation - Nedbank Namibia initiated the Go Green Fund in 2001 together with the Namibia Nature Foundation. The objectives of the Go Green Fund were to conserve threatened species and habitats and to promote environmental education, sustainable use of natural resources, and adaptation actions for climate change. Since its inception, grants totalling around N$ 3.2 million have been awarded to over 30 conservation projects across Namibia The projects range from environmental education programmes in the south to fresh water fisheries research in the north east. Here is a list of some of the current projects:

- Population and Conflict Assessment of the African wild dog with a focus on the Greater Mangetti Complex, Kavango Region, north-east Namibia;
- Namibia Giraffe Conservation Status Assessment;
- Assessment of offshore fisheries dynamics in Lake Liambezi: potential for development of an offshore fishery;
- The Desert Science and Research Training (DeSeRT): An ecology field course for young environmental leaders;
- Building Environmental education capacity in Hardap Region Secondary schools; and
- Namibianising biodiversity information – enhancing the in-country usability of the Namibia Biodiversity Database (NaBiD).

A recent project recipient of the Go Green Fund is The Cheetah Conservation Fund (CCF) which was awarded around N$ 147 000. This support has enabled CCF to start implementing a three year project to determine the distribution, density and human-carnivore conflict areas for cheetah *(Acinonyx jubatus)*, African wild dogs *(Lycaon pictus)* and other key large carnivores across the Greater Waterberg Landscape. The current distribution and densities of these carnivores are unknown. However, previous studies have shown that a high level of retaliation killing of carnivores due to livestock loss is occurring within this area. In addition, the project aims to go further by quantifying the level and spatial distribution of human-carnivore conflict. By mapping these conflict zones, resources can be targeted through education, which in turn reduces the level of human-carnivore conflict and secures the future of large carnivores across the area.

The positive development impact that has come from this partnership showcases how private corporations can work with civil society to bring about greater change and contribute to Namibia's sustainable development based on sound research.

'India India Mike' takes to the skies for conservation - In August 2017 Westair Aviation (Pty) Ltd signed a Memorandum of Understanding with the Namibian Chamber of Environment (NCE) to make a surveillance aircraft available to the NCE and its members. The aircraft, a four-seater Cessna C182, also known as 'India India Mike' has already spent many hours of service for the Save the Rhino Trust in aerial surveillance. All 50 environmental non-governmental organisations that are members of NCE, can use the aircraft to support their wildlife protection and conservation activities in Namibia. They just need to pay for the fuel and landing fees. Westair has offered to sponsor the aircraft's flying hours and maintenance costs, whilst Welwitschia Insurance Brokers and Specialised Risk Management Ltd will cover insurance costs. In the event that an NGO does not have its own pilot, Westair will help find an experienced pilot who will volunteer to fly the Cessna, as a contribution to conservation. Such initiatives, by private businesses, are important and provide a valuable contribution in sustaining commitments made towards Namibia's environmental conservation and in fighting poaching within the country.

'Managing wildlife-power line interactions' a NamPower and Namibia Nature Foundation Partnership - The power line network coverage across Namibia is increasing rapidly, especially in terms of providing power infrastructure for new mining developments as well as many new private sector developments. This increase in coverage raises the risk of bird mortalities through collisions and electrocutions, in particular

Bird of prey on a power line
(Source: travelnewsnamibia.com)

for large birds of prey, bustards, cranes, storks and flamingos. At the same time, these wildlife-power line interactions cause inconvenient blackouts, with high maintenance and repair costs for both NamPower and regional electricity distribution (RED) agencies. Smaller birds including sociable weavers, red-billed buffalo-weavers and crows also use power line structures for roosting and nesting and are a further source of wildlife-related faulting. These impacts are a concern as they are both preventable and can be reduced with appropriate planning and mitigation.

In 2008, NamPower and the Namibia Nature Foundation (NNF) joined forces to form a strategic partnership to address power line/wildlife conflicts in Namibia. The initiative was funded by the European Investment Bank and its mission is to address wildlife/power supply interactions in Namibia. The objectives are to:

- Monitor, report and manage wildlife/power supply interactions;
- conduct research and incorporate bird/wildlife mitigation into existing power supply networks, and into the planning of future networks;
- promote awareness and comminicate the risks that the power supply poses to wildlife, and wildlife poses to the power supply; and
- develop an over-arching, easily accessible environmental information service to assist with achieving the above objectives.

This initiative has continued successfully for the last nine years, with regular newsletters and updates being made available to the public. Many stakeholders have actively contributed towards the ongoing monitoring of the wildlife- power lines interactions and the development of the GIS database. This increased knowledge and awareness has helped to inform management measures to mitigate the impact on birds and wildlife.

Recognising sustainable environmental management

Tourism is one of the fastest growing industries in Namibia and is a massive industry worldwide. As with all economic activities there are positive and negative impacts. On one side tourism brings employment, generates opportunities for local people, contributes towards foreign exchange, and funds conservation projects. On the other side, it creates environmental and social costs such as over consumption of resources like water and the creation of large volumes of waste. Proactive management of the tourism sector has been improving with potential developers and existing operators, an increase in voluntary environmental initiatives within the sector, and the establishment of national initiatives to promote sound environmental practises.

Logo for EcoAwards
(Source: jaroconsultancy.com/ecoawards)

Eco Awards Namibia - a national initiative to motivate improved environmental practices in the Tourism sector

Due to the raised awareness and public concern around the negative impacts associated with the tourism industry, the World Commission on Sustainable Development has urged that all countries should work against illegal, abusive and exploitative tourist activities and find ways to minimise the negative and support the positive impacts of tourism. In 2005, in response to this call, Namibia created a programme called the Eco Award Namibia. Eco Award Namibia is a non-profit organisation, which is made up of an alliance between the private sector and government and runs a tourism certification programme. Its aim is to encourage sustainable development by creating more awareness of the environment as well as uplifting local staff in terms of employment and training. Having the certificate is a mark of distinction for accommodation establishments that are planned and managed according to eco-friendly principles. Each applicant gets re-evaluated every two years.

Establishments, from campsites to hotels, can apply for the award and depending upon the number of points achieved are awarded from one to five flowers. Various areas are evaluated and include conservation, water, waste and energy management, construction and landscaping, guiding, staff development and social responsibility. For example, the evaluation team looks at what sort of water management policies are in place, whether reduce, reuse, and recycle actions have been applied and whether natural building materials such as natural stone and shadow roofing were used for construction. In order to increase opportunities for rural communities, the award promotes the hiring and training of local staff, rather than bringing in trained employees from outside.

Wolwedans scored five flowers in its last evaluation in 2015

(Source: A. Engelhardt, 2014)

Recycling in Namibia
(Source: rentadrum.com.na)

Finding business opportunities that promote a green economy

The growing interest in greener economies has created a variety of new opportunities for entrepreneurs. Namibia has seen an increase in the number of companies working in the 'clean energy' sector, developing permaculture initiatives, establishing small businesses that sell local goods, establishing facilities that manage recycled waste and plants that utilise biowaste for power generation.

An important Namibian initiative recognising the efforts of industry is the Sustainable Development Award which was implemented by the Environmental Investment Fund of Namibia and the Sustainable Development Advisory Council in 2014. Monetary prizes are issued annually. Initiatives such as this demonstrate that Namibia is committed to development within the ambit of sustainable environmental management and despite the numerous challenges that development brings, industry, government and civil society have paved the way for improved environmental performance, education and better integration of environmental issues into the business life cycle and day to day activities of Namibians.

Recycling efforts climb to a new level due to investment from the private sector

In 2010 the Namibian business Rent-a-Drum erected and commissioned a material recovery facility (MRF) in Windhoek, the first of its kind in Namibia. In the past the sorting had been a time-consuming and labour-intensive process as each piece of waste had to be sorted manually. The establishment of the MRF meant that the company could now sort large volumes of mixed recyclables. In 2015 Rent-A-Drum, in partnership with the Swakopmund Municipality, began operating an N$ 7 million sorting facility. Approximately 65 people are employed; many of them previously landfill scavengers.

The soft plastics are reduced into pellets and sent to Namibia Polymer Recyclers in Okahandja to be made into plastic pipes and tanks. Other recyclable materials such as cans (aluminium and tin), bottles, plastic shopping bags, and milk and juice containers; are sorted, compressed and baled for reprocessing in South Africa. Newspapers, magazines and paper are also collected through the File 13 system, and processed. File 13 is a cardboard box which you can purchase from Rent-a-Drum and fill with unwanted paper, newspaper, magazines etc. They will empty it free of charge. One tonne of recycled paper collected is equivalent to saving 17 trees.

Plastic collected for recycling
(Source: G Schneider, 2017)

Ohorongo Cement wins sustainable development award

Ohorongo Cement (Pty) Ltd is based just outside Otavi and is the only company in Namibia producing cement. It commenced operations in December 2010 and at peak production will turn out more than 700 000 tonnes of high-quality cement per annum for both local consumption and export purposes. Prior to its construction, Namibia had to import all of its cement. During the manufacture of cement, a mixture of limestone and clay is heated in a cement kiln to temperatures of up to 1 450 °C. At these high temperatures, chemical reactions take place that form a material called clinker, which is ground to make cement. Usually coal is used to fire the kiln and achieve the required temperatures. At Ohorongo Cement, an effort was made to implement waste management, and at the same time reduce the use of coal with its associated emission of greenhouse gases, by utilizing various alternative fuels.

In partnership with Rent-a-drum, non-recyclable refuse from Windhoek's Kupferberg landfill, redundant pallets shredded into a suitable size, waste charcoal fines, and cattle and chicken manure from NAM Poultry and the Okapuka feedlot outside of Windhoek are re-used as an alternative to coal. This has already resulted in a reduction of 80 % in the use of coal. The company is also investigating the use of old tires, and has started the construction of a 5 MW solar power plant. Ohorongo Cement sources all of its raw materials locally. Even the limestone used within the process is quarried on site. Because of all these measures, the plant is able to meet one of the lowest CO_2 emissions rates worldwide. The companies' Corporate Social Responsibility Programme focuses on education, healthcare and infrastructure. ISO 14001 has been implemented and the company is committed to caring about the environment and ensuring a lasting legacy.

Their environmental management practices and application of innovative technologies were recognised in 2016 when the company won the award for 'Environmental excellence in industry', one of the categories in the Sustainable Development Award.

Ohorongo Cement Plant
(Source: Ohorongo Cement)

The Namibian Uranium Association – working towards sustainable development of the Namibian Uranium Industry

The Namibian Uranium Association (NUA) was formed in order to promote and ensure the Namibian uranium industry's adherence to strong sustainable development performance and product stewardship. Members of NUA include all Namibian uranium mining operations, most of Namibia's leading uranium exploration companies, and associated contractors. NUA members accept the responsibilities of uranium stewardship through building partnerships throughout the life cycle of the product to ensure that production, use and disposal are consistent with global sustainable development goals. NUA also seeks to balance environmental protection values with exploration for and mining of uranium. It addresses the social and cultural needs of its employees and local communities and promotes the principle of zero harm and universal adherence to the World Nuclear Association's policy document on uranium mining standards. It is actively involved in the Strategic Environmental Management Plan implemented by the Namibian Ministry of Mines and Energy. NUA has established the Namibian Uranium Institute to promote knowledge and capacity building in specialized skills in the fields of environmental management, radiation safety and health.

Uranium Institute training session

(Source: G Schneider, 2017)

The Otjikoto Environmental Education Centre

The Otjikoto Gold Mine of B2Gold near Otavi has made a special investment in conservation, in order to support sustainable development that will benefit Namibians long after the mine has closed. The company established the Otjikoto Environmental and Education Trust, which runs the Otjikoto Environmental Education Centre, located on a Game Farm adjacent to the mine. School children with their teachers from all over the country are hosted at the Environmental Education Centre, where they can learn about Namibian flora and fauna while experiencing camping in the bush. The Centre also offers an experimental science laboratory. The Game Farm has been carefully stocked with Namibian wildlife, and offers a good opportunity for the school children to observe the animals at close range. It is the Centre's mission to instil a passion for conservation in the children by giving them the chance to experience nature at first hand.

School children at the Otjokoto Environmental Education Centre
(Source: B2Gold)

4.4 THE ROLE OF NON-GOVERNMENTAL ORGANISATIONS (NGOS)

Governments, industry and individuals have responsibilities that, if embraced fully, would go a long way in improving environmental stewardship. Unfortunately, governments and businesses are driven primarily by economic and political motives and individuals are often focused on personal well-being. The result is that the sustainability agenda is often placed on the back-burner and not afforded the priority it deserves.

NGOs have played a pivotal role in the field of sustainable development, by focusing on the long term issues, such as climate change and environmental education, as well as bringing these issues into the spotlight in both the international and national arenas. They have targeted both governments and powerful corporations whose actions (or lack thereof) are having significant impacts on the environment and society.

In response to such pressures, many businesses and government departments have adopted a more proactive stakeholder engagement process to dealing with issues and integrating sustainable development into their decision-making processes. Public surveys reveal that NGOs often enjoy a high degree of public trust.

Generally NGOs act as **implementers** who mobilize resources in order to provide goods and services to people/animals/habitats in need, **catalysts** who drive change by inspiring, facilitating and contributing to improved thinking and action, so as to promote change, and **partners** who work alongside government, big businesses and other organisations in order to tackle problems and address sustainability needs more effectively.

In Namibia, there are a host of NGOs working to bring about change within the sustainable development sector. Because this sector covers every aspect of society from health to environment to education, the mandates and approaches of these NGOs vary widely.

Non-governmental organisation (NGO)
NGOs are not-for-profit organisations that are independent from states and international governmental organisations. They are usually funded by donations but some avoid formal funding altogether and are run primarily by volunteers. NGOs are highly diverse groups of organisations engaged in a wide range of activities such as human rights, environment, improving health, education and development work.

Operational NGOs seek to "achieve small-scale change directly through projects". They deal with a wide range of issues, but are most often associated with the delivery of services or environmental issues, emergency relief, and public welfare. The focus of operational NGOs is on implementation of projects.

Campaigning NGOs seek to "achieve large-scale change promoted indirectly through influence of the political system". They often deal with issues relating to human rights. As opposed to operational project management, these organisations typically try to raise awareness, acceptance and knowledge by lobbying, using the press and activist events.

Some NGOs like the **Giraffe Conservation Foundation and Cheetah Conservation Fund** focus all of their activities around the sustainable conservation of a threatened species, whilst others, like **Integrated Rural Development and Nature Conservation (IRDNC), the Namibia Nature Foundation (NNF) and World Wildlife Fund Namibia (WWF)** work with rural communities to improve sustainable utilisation of resources and in doing so conserve wildlife and their habitats.

The **Legal Assistance Centre (LAC)** is a public interest law firm that aims to protect the human rights of all Namibians, whilst the **Namibian Animal Rehabilitation Research and Education Centre (NARREC)** works towards the rescue, care and rehabilitation of injured, orphaned and misplaced wildlife, in conjunction with public education. Each and every NGO fills an important niche and helps society to achieve some of the goals that governments and businesses cannot/ will not do on their own. The information boxes highlight how some of Namibian NGOs are contributing to the sustainable utilisation and conservation of the environment.

Cheetah and giraffe conservation efforts in Namibia

(Source: cheetah.org; giraffeconservation.org)

Helping Namibians increase agricultural production

Conservation Agriculture Namibia (CAN) is a Namibian non-governmental organization (NGO) that was formed for the purpose of increasing agricultural production in Namibia. CAN is operational in seven northern communal areas in Namibia and focuses on climate change strategies in the livestock and cropping sector. They work in 33 grazing areas within seven regions and are piloting improved rangeland and crop production, as well as starting to facilitate the development of local land use plans.

CAN works closely on the ground with farmers, helping them to find solutions to challenges such as drought, grass poaching, limited grazing areas due to fencing issues, and no legal framework to apply grazing plan. In addition, CAN are working closely with an international NGO called HMI, which has worked in the field of regenerative agricultural practices and holistic management for 33 years. HMI will be supporting CAN with the training and capacity building of key implementing partners such as the Ministry of Agriculture, Water and Forestry (MAWF) and the Namibia National Farmers Union (NNFU), farmers and key stakeholder operating in their project areas.

The Hanns Seidel Foundation's (HSF) three-year Environmental Awareness and Climate Change Project includes a national information campaign called the **ThinkNamibia Environmental Awareness Campaign** and the **Eco-Entrepreneur Training and Mentorship Programme**.

One of the elements of the Project elaborated the Eco-entrepreneur programme spearheaded in partnership with the Namibia Business Innovation Institute (NBII) at the Namibian University of Science and Technology (NUST). In 2017, 3-day workshops were held, followed by mentorship sessions, field trip excursions and an award for the best business plan. The aim was to provide participants with insight on how to start up their own businesses as well as to inform small and medium enterprises on the importance of seizing green business opportunities that contribute to the realisation of the Namibian Green Economy. One hundred and six Namibians participated in the programme aimed at supporting a greater uptake of eco-business opportunities, adapting existing businesses to become more environmentally-friendly, reducing carbon footprints, and/ or improve the lives of communities through job creation and the provision of affordable green products.

Entrepreneurs who completed the Eco-Entrepreneur Training and Mentorship Programme participate in an excursion to an aquaponics gardening project in Windhoek to learn more about sustainable agricultural practices and business opportunities for Namibian start-ups

(Source: HSF Namibia, 2017)

Logo for Think Namibia

(Source: enviro-awareness.org.na)

Education for sustainable development – a foundation for sustainable living

No matter what the topic, or the sector, environmental programme developers across the world identify awareness, education and training as critical activities, without which meaningful change will not take place. Since it opened its doors in 2003, the **Namib Desert Environmental Education Trust (NaDEET)** has been running week-long programmes for primary and secondary school learners, communities and educators. These programmes provide participants with an opportunity to not only hear about sustainable living, but to actually live it. Their environmentally efficient and attractive centre is nestled amongst the sand dunes and camelthorn trees of the NamibRand Nature Reserve. For a week participants are immersed in a culture that fosters thoughtful and gentle interactions with their environment, educators and fellow participants. Bucket showers are used and water consumption measured, food is cooked using solar equipment and recycled fire bricks are made to feed the fuel efficient stoves in the event of a cloudy day. The hands on learning and the opportunity to spend time in the dunes and under the stars provides a positive impact on all participants – for some it's a life changing experience.

Learning about biodiversity at NaDEET
(Source: NaDEET, 2016)

The fully sustainable NaDEET centre
(Source: NaDEET, 2016)

EduVentures is run from the National Museum of Namibia. It takes children, primarily from disadvantaged communities, on two-week long expeditions to remote areas to participate in data collection, and to gain further knowledge about Namibia's natural and social history. They also have an educational laboratory at the museum where learners can work on research projects. An exciting mobile classroom called the Ombombo bus travels to schools all over Namibia. The EduMobile programme focuses on educating secondary school learners on environmental concerns such as climate change and biodiversity loss in rural areas. In addition, educational material is continually being provided, in particular to support individual ex-participants.

Other environmental programmes being run in Namibia include the **AfriCat Foundation Environmental Education Programme** and the **Wilderness Safaris' Children in the Wilderness Programme**, both of which aim to expose the youth to wildlife and wilderness areas, to help them to understand the issues threatening conservation and to inspire them to care for their natural heritage.

There are also a few environmental education centres such as the **Namutoni Education Centre** located in the Etosha National Park and the **Cheetah Conservation Funds Educational Centre**. All of these centres offer displays for the public, whilst some go further to include activities or programmes for visiting schools and / or outreach programmes which are taken to schools.

These NGOs play a pivotal role in promoting the long-term sustainability of Namibia's environment, but they are all small and can only reach out to a few lucky Namibians every year. There is an obvious need to integrate sustainable development into the curricula of primary, secondary and tertiary institutions.

The Desert Research Foundation of Namibia (DRFN) is a Namibian NGO that has served communities and government for the 27 years since Namibian Independence. DRFN was established to support research but also to address sustainable development throughout arid lands. The DRFN tackles issues ranging from water to energy to land from a human and a basic biophysical perspective, as well as undertaking awareness and capacity building necessary to support this approach. In order to strengthen DRFN's capacity to address climate change related issues in a more holistic manner together with other institutions locally and within the Southern Africa Region, DRFN became the accredited National Implementing Entity (NIE) for the World Bank's Adaptation Fund in Namibia.

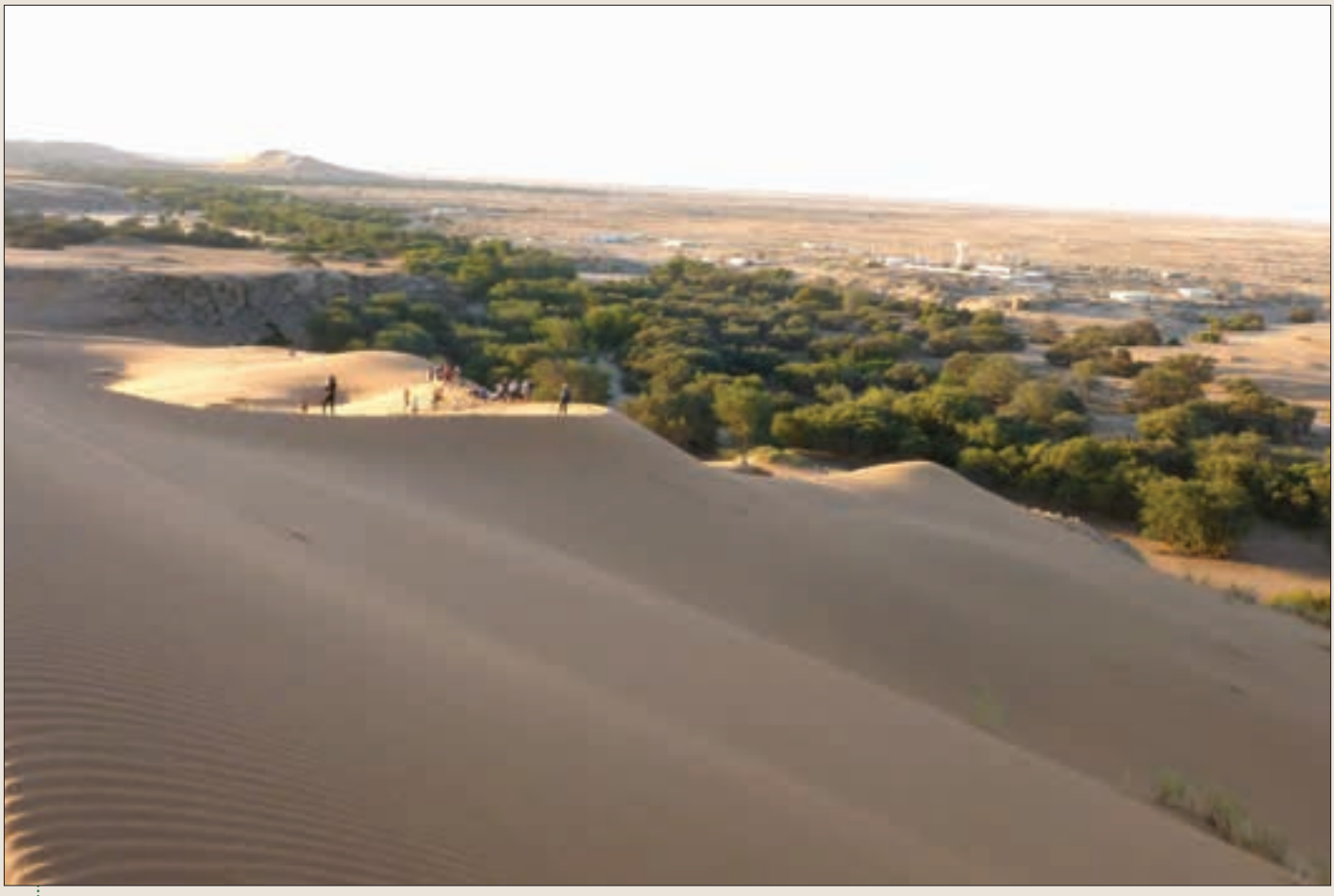
DRFN implements projects within the thematic areas of energy, land and water and utilizes a combination of institutional knowledge, field experience and the relationships it has developed over the years to contribute to policy development, planning and implementation. The main activities of the DRFN are:

- Research;
- training;
- mentoring and capacity building;
- promotion of integrated water management;
- promotion of sustainable land management;
- development of monitoring methodologies; and
- awareness raising.

DRFN conducts climate change adaptation awareness campaigns together with other civil society organizations in Namibia, and recently produced an Environmental, Social and Gender Policy based on the Adaptation Fund's policies in these areas that strive to incorporate human rights, gender equality, biodiversity and habitat conservation in projects.

The Gobabeb Research and Training Centre is a Joint Venture between the Ministry of Environment and Tourism and the Desert Research Foundation of Namibia. The Centre is located in the Namib Naukluft Park, on the north bank of the Kuiseb River within the buffer zone of the UNESCO World Heritage Site, in an area that is characterized by the occurrence of three ecosystems, namely the Namib Sand Sea, the ephemeral Kuiseb River, and the rocky desert to the north of the river. It is also located within the traditional area of the Topnaar people. Gobabeb was established in 1962 and long-term ecological research serves as the backbone against which all other research is integrated. Meteorological measurements have been the foundation against which all other research is calibrated. Fog, as the basis of life in the Namib dunes, has received particular attention. Long-term observations of dune vegetation and dune fauna, particularly the common and obvious tenebrionid beetles, provide an idea of the long-term changes over the past half century.

Gobabeb maintains a small staff augmented by a variety of interns. The research itself is predominantly carried out by a diverse array of visiting scientists from all over the world collaborating with the resident staff. To date approximately 1000 publications addressing a wide variety of topics have been published. Training and education is receiving high attention both in-house and for the Namibian nation. This ranges from post-graduate degrees, to resident programmes for tertiary students, to visiting school classes from all levels, to a diversity of community groups. A series of Enviroteach books (on inter alia energy, population, water) based on Gobabeb experience and addressing the requirements of the Namibian curriculum were prepared and are available for distribution. The Gobabeb Research and Training Centre provides an excellent example of how Namibia's resources, in this case the Namib Desert, can be exploited for the benefit of all Namibians present and future.



View of Gobaeb showing the three ecosystems

(Source: G Schneider, 2013)

Urgent help needed – NGOs lobby for public support

Not all NGOs have an operational focus. Some of the most well-known NGOs like **Green peace** and **Friends of the Earth** focus on **campaigning** and take a confrontational role to engineer change. **Earthlife Namibia** has been active in Namibia in raising awareness and causing change. One of **their** most well-known drives has been the ongoing campaign to gain compensation for environmental damage caused by Ramatex, a textile factory that opened in 1990 and left dangerous chemical waste in the outskirts of Windhoek. Another is their campaign against the expansion of uranium mining, where they brought attention to the perceived health and environmental impacts of this type of mining, and raised concerns about mining in National Parks in general.

4.5 INDIVIDUAL ACTION – THE ROLE OF THE PUBLIC

The previous sections have already discussed the role that governments can play in helping to address environmental degradation as well as the measures companies and NGOs are taking. What remains are the personal contributions that people can make every day, to become agents of change and shift the balance towards a more environmentally conscious society. There are four key areas where individuals can play an active role in reducing environmental degradation. These are the responsible use and saving of energy, valuing water, reducing waste and protecting biodiversity.

Saving energy

There is no such thing as clean energy. In the section on energy use it is pointed out that even wind and solar technologies are not 100% clean because metals need to be mined, equipment and cement needs to be manufactured and redundant or broken equipment needs to be discarded. But it is cleaner than burning fossil fuels. Reliable access to sunlight means that all Namibians could start **substituting solar energy** for some of their existing energy needs.

This involves capital input upfront but results in personal and environmental savings down the line. An easy substitution is using solar lamps and torches instead of battery powered torches, paraffin lamps or electric reading lamps. There are excellent products on the market these days that are able to run for at least 12 hours and can even substitute as a cell phone charger.

Solar cooking (using solar ovens and parabolic cookers) is a wonderful solution not only for reducing dependency on electricity or fire wood but for reducing the cost of cooking – a huge boon for the thousands of poor Namibians that are living off meagre budgets. The capital cost of this equipment is beyond the budget of many Namibians, but the potential for schemes in partnership with government or companies exists.

Shirking our responsibility – the easy route out

There was once a mother, who purchased a fashionable fur coat. Her young daughter, who supported the anti-fur campaign, was dismayed when her mother arrived home with the coat. The Mother's response was that as the animals had already sacrificed their lives it would be sad not to wear it. She also said that she did not see why she should forfeit wearing a fur coat when so many others continued to do so.

Her answers did not satisfy the young girl but she had not yet developed the critical thinking skills required to analyse her mother's logic and pinpoint what was wrong about it. The girl never forgot that episode, because her mother only wore the coat a few times, after which it hung in the cupboard and because she heard that refrain so often throughout her life.

"Why should I stop doing it when everyone else does it?" or "Why should I deny myself and be the only one to go without".

It is a sentiment that reinforces some of the most powerful notions of our current societies that (i) we deserve gratification regardless of the implications and (ii) that we as individuals do not have the power to affect change. In the face of large complex environmental issues that are being caused by millions of people it is so easy and defensible to take this stance. But can we afford to ignore the issues because other people are or because the problems seem overwhelming?

Solar lamp

(Source: WWF)

For example the Ministry of Mines and Energy actively promotes the installation of **energy appropriate technologies** especially for communities living in off-grid areas, but also for urban areas. The Solar Revolving Fund (SRF) is a credit facility that provides loans at subsidised interest rates to people interested in installing **solar water heaters, solar home systems or photovoltaic water pumps**. The end user is able to purchase the equipment, thus becoming the owner of the system and is responsible for the installation and maintenance thereof. The annual contribution of the Ministry of Mines and Energy to the fund is only about two million Namibian dollars, but it is a start.

Comparisons made amongst different types of hot water systems showed that solar-water heaters are five to seven times more effective than electric hot water geysers (including installation and running costs).

The Namib Desert Environmental Education Trust (NaDEET) is an environmental education NGO that teaches participants how to live more sustainably. The programme includes solar cooking. NaDEET is able to cook three meals a day for 40 people at a time only using solar cooking apparatus. To be successful you need to plan in advance and start cooking well ahead of meal times. You also need a person to watch over the cookers and change their position as the sun's position changes.

Solar cooking

(Source: NaDEET, 2011)

	ELECTRIC GEYSER (3 kW ELEMENT)	SOLAR WATER HEATER WITH 2 m^2	SOLAR WATER HEATER (2 m^2) WITH ELECTRIC BACKUP
Volume of water to be heated	100 litres	150 litres	150 litres
Operational hours per day	6 hours	12 hours	0.6 hours
Power consumption per day	18 kWh	0 kWh	1.8 kWh
Annual costs of water heating at 1.6 NAD/kWh	10,512 N$/year	0 N$/year	1,051 N$/year
Upfront costs, including installation	5,000 N$	15,000 N$	15,000 N$
Total costs of water heating over 15 years	162,680 N$	15,000 N$	30,768 N$

2014 Cost comparison of different hot water systems in Namibia

(Source: Namibia Energy Institute)

For hundreds of years farmers have been using windmills to pump ground water. Now some people living on farms have chosen to utilise **wind powered technology** to generate electricity. There are a variety of windmills on the market to suit both small and large electricity generating needs.

The other major source of energy that Namibians consume is **fuel for vehicles** – and these fuels (petrol and diesel) contribute significantly to local air pollution and global warming. The most significant change that Namibians could make right now would be to **use bicycles** when commuting, especially in towns. Alternatively one could investigate changing over to a vehicle powered by electricity. The **electric car** has not yet made its way to Namibia but even when it does, the likelihood of it catching on quickly is low due to the large distances between towns, the remoteness of many towns and farms, and the cost of these vehicles. However, **electric bicycles and scooters/mopeds** are viable options for daily commutes. It is important to remember that until Namibia shifts away from or decreases the percentage of fossil fuel based electricity, electric vehicles will not solve the problem. It simply shifts the pollution from Namibia to the place where the electricity is being generated. However, if you choose to invest in Solar-powered photovoltaic (PV) panels (which convert the sun's rays into electricity) for your own home or office then you could use your cleaner energy to charge your electric bike or scooter and you could zoom around town all day without loading your carbon footprint.

Most important of all, every single person that uses electricity should take action to **utilise it more efficiently**, thus **reducing** the amount of energy they use. One of the aims in Namibia's Energy policy is to become a more efficient user of energy. To succeed in this goal every one of its citizens needs to contribute, not just big business. This includes switching off lights and electrical appliances that are not in use, putting a timer onto the electrical geyser, insulating geysers and utilising LED light bulbs.

These things are not difficult or expensive to do. They just require a shift in mind set and will.

Solar water geysers on the roof of a private home in Windhoek.

(Source: G Schneider, 2017)

Creative ways to harness energy in cities

People are exploring numerous ways to capture energy or heat and convert it into electricity. A nightclub in Rotterdam hit the headlines when it revealed that it had installed piezoelectric materials under its dance floor, so that the pressure from the patrons' feet as they danced powered the lights of the club. The owners claimed that 60 percent of their energy needs were met by the technology.

Saving water in the garden

- **Develop xeriscape gardens** (landscaping for dry conditions). This includes proper planning and design, soil analyses, appropriate plant selection (where possible opt for indigenous plants, or water wise plants such as succulents) efficient irrigation, use of mulches and appropriate maintenance.
- **Shrink your lawn and water it only when it needs it.** This means changing your watering regime with the seasons and monitoring soil moisture.
- **Deep-soak your garden.** Water long enough for the moisture to soak down to the roots. A light sprinkling can evaporate quickly and tends to encourage shallow root systems. More, but less often is usually better than watering every day.
- Put a layer of mulch around trees and plants. This slows evaporation whilst discouraging weed growth.
- Use **water efficient sprinklers** and position your sprinklers so water lands on the lawn or garden, not on paved areas. Also, avoid watering on windy days and in the heat of the day. This reduces water loss via evaporation.
- **Don't run the hose** while washing your car, even better use a bucket. There are even waterless car washing systems on the market (e.g EcoTouch).
- Use a broom, not a hose, to clean driveways and sidewalks
- **Make your swimming pool more efficient.** During the construction of a swimming pool install a pipe to divert rainwater from the roof of the house into the pool. This harvested rainwater replaces water lost from the swimming pool through backwashing and evaporation. A pool cover (rolled up at the back) also reduces evaporation losses.

Xerophytic garden at Swakopmund municipality

(Source: G Schneider, 2017)

Rainwater harvesting from roof

(Source: G Schneider, 2017)

Valuing water

The period of late 2016 to early 2017 was a sobering time for all Namibians because the country was in a dire water crisis. In particular the dams supplying Windhoek had almost 'run dry'. Welcoming rains helped recharge the dams and brought relief to many farmers, but this is only a short reprieve.

Citizens cannot just expect the government to find alternative water sources because as has already been discussed, there are a limited number of water sources with increasingly more people needing to share it, and the cost of transporting water hundreds of kilometres is very expensive. Namibia is and always will be water vulnerable, so **conservative water utilisation practices** should become the norm for each and every one of us, rather than measures we practice when we are in dire straits. In this way individuals contribute positively to the water demand management of the country.

During the water restrictions, radio campaigns encouraged people to properly close taps and report leakages but there is so much more that individuals can do to become responsible water users. Some of these are outlined in the boxes provided.

Going to war against waste

Every Namibian should become a waste warrior and wage a war against waste because the management and disposal of waste costs local governments millions every year and is not keeping abreast with the problem. Daily both **hazardous** (e.g. medical waste, car batteries, chemicals, printer cartridges) and **non-hazardous** waste (e.g. paper, food, garden waste, and plastics) are generated and whilst a percentage of it finds its way to properly designed landfill sites, a large percentage does not. In addition, many of the landfill sites are not managed optimally, which means that they become sources of pollution in themselves. Namibia might be a sparsely populated, large country but evidence of this ever increasing mountain of waste is everywhere. The **3 R's refrain or reduce, recycle and reuse** is not a new concept, yet it is not ensconced in the minds and actions of individuals.

Saving water in the house

Shower Bucket. Whilst waiting for water to heat up, collect the cold water in a bucket rather than letting it run down the drain. Use it for watering plants, flushing toilets, cooking etc.

Re-use water. Collect used cooking water, let it cool down and use it on plants. Collect the distilled water from the dishwasher and save it for topping up the car battery.

Turn off the tap whilst brushing your teeth or washing your hands or face.

Do not wash dishes under a running tap. Fill up your sink with water, instead of letting it run the whole time that you're scrubbing.

If it's yellow, let it mellow. This tip might not be for everyone, but the toilet is one of the most water-intensive fixtures in the house. Do you need to flush every time?

Cut your showers short and skip the shower from time to time. Do you really need to shower multiple times a day or even daily? Skipping even one shower a week adds up to big water savings.

Choose efficient fixtures. Use smaller toilet cisterns, investing in a low-flow toilet, choosing efficient shower heads, and opting for a 'water sense' rated dishwasher and washing machine can add up to big water savings.

Use equipment optimally. Only run the washing machine and dishwasher if it is full.

Use less electricity. Power plants use thousands of gallons of water to cool. Do your part to conserve power, and you're indirectly saving water, too!

Re-use grey water. Check to make sure that re-using grey water is legal where you live, as in some municipalities you may not. But using grey water for watering the garden or for flushing toilets is a great way to save clean water. Design your new house to separate grey water from sewage. If it is illegal, then lobby your municipality to change the law.

For many years the emphasis has been on recycling and some exciting progress has been made in this regard but if humankind is going to turn the global waste problem around, the real emphasis must be on **reducing** waste. Our **throw away culture needs to change** and this is only going to happen when individual consumers start demanding more durable appliances, when it becomes un-cool to change our mobile phones and other electronic gadgets every two years and when we move away from 'take-away' plastics and polystyrene. A critical part of this process is that governments and individuals start insisting that the real cost of waste is properly accounted for because the cost has been externalised for too long. **Externalising environmental costs** means that the companies and institutions that create the products that will become waste, have not taken responsibility for managing the waste properly but have transferred some of their moral responsibilities as costs to the community and this has resulted in degradation of the environment. But it is not only the manufacturers. When people buy these goods they become liable for it, so when they do not dispose of it properly they too transfer an environmental cost to the community. Every time we throw a piece of paper out of the car window or use a plastic shopping bag we transfer the cost of managing this waste to the community. Making the **polluter pay** and enforcing a **cradle to grave** approach regarding the manufacturing, use and disposal of goods is critical if society is to turn the tide on waste.

Substitute disposable goods for funky, long lasting ones

Why not buy yourself a funky travel mug and take this to your local coffee shop instead of purchasing a throw away cup every day? And while you are at it, purchase a stylish water bottle, and carry that around with you instead of purchasing bottled water. It not only reduces waste but will save you lots of money as bottled water costs N$ 12.00 per liter whilst tap water costs only two cents per liter.

Metal Coffee-to-go-mugs are attractive, durable and much more environmentally friendly than disposable cups
(Source: bodum.com/gb/en/coffee/travel-mugs)

The first step in the process of reducing waste is **learning to say No!** Society is obsessed with packaging, much of it unnecessary. Individuals can prevent huge volumes of plastic and styrofoam packaging finding its way into the environment simply by choosing to buy products that have less packaging, and by using material bags instead of plastic shopping bags. Another way to make a big impact on the environment at very little cost to personal lifestyles is to cut down on the amount of disposable utensils that you use. They include take-away coffee cups, straws, and plastic crockery and cutlery. The short term convenience that take-away companies and the public get for using disposable utensils is offset by the economic and environmental costs that the community must bear in managing the mountains of waste created. You may not think such actions could make a difference but do the sums.

Electronic waste – A plague of our times

Why is it that electronic equipment, made thirty years ago, worked for over ten years whereas the products made today only last for a couple of years? Researchers and experts have put a name to this problem – **'planned obsolescence'**.

Planned obsolescence is a policy of planning or designing a product with an artificially limited useful life, so it will become obsolete (that is, unfashionable or no longer functional) after a certain period of time.

A hypothetical case shows how quickly waste escalates

An individual goes shopping once a week and takes 5 plastic bags. That means he uses 260 bags a year. There are approximately 50 000 people in the town of Swakopmund. If one third of that population (16 666 people) goes shopping and takes 260 bags a year that is 4 333 160 plastic bags in one year. Most of these bags are only used once before being discarded. If those same people only took 2 bags a week, instead of 5, the number of bags being thrown away would decrease to 1 733 264 bags a year. Even better if they used a material bag instead it would be a substantial saving for the environment with absolutely no change to the shoppers' quality or way of life except having to remember their material bags.

If you do take plastic bags they should be re-used as often as possible, therefore reducing the need for you to take more plastic bags or to purchase other kinds of packaging thus cutting down on waste.

Plastic bags trapped in thorny acacia

(Source: G Schneider, 2017)

The aim is to generate more sales in the long term by reducing the time between repeat purchases. This is a brilliant strategy for the company's manufacturing the electronic equipment ensuring a constant demand and huge profits. However, it creates a large cost for the consumer, who is forced to continually spend money on the same equipment, and an even larger cost to society as e-waste is hazardous for both the environment and human health. Not only does e-waste break down very slowly, but it contains dangerous substances such as lead, mercury and cadmium, which are hazardous and should not be dumped in a landfill. Unfortunately planned obsolescence permeates every niche of our consumer society, not just electronics. Just how much waste will dominate our landscapes in the future depends very much on how consumers choose to spend their money.

What can individuals do to decrease e-waste?

Put an end to early adopting. Ask yourself if you really need to buy the newest gadget or if you are just a victim of marketing and peer pressure? The best solution is to use what you currently have until it is no longer useful. Refrain from making impulsive buying choices, and always choose something you believe you will be able to use and enjoy for a long time.

Sell. Instead of throwing your old electronics away try and sell it, or give it to someone in need. Not only will you make money off your old stuff, you will also help reduce e-waste by extending the life of your electronics and keeping them out of landfills.

Recycle. Encourage your municipality or community to set up a legitimate electronic waste disposal site were the public can drop off redundant electronics, safe in the knowledge that the equipment will be properly recycled and disposed of.

Are we comfortable with constantly updating and changing our belongings or do we need to make a change?"

(Source: cdn0.tnwcdn.com)

What is Samsung going to do with all the defunct Note 7s smartphones it had to recall?

In 2016 when Samsung had to recall 4.3 million Note 7S smartphones after having problems with them catching on fire, Greenpeace along with other concerned citizens, campaigned for Samsung to dispose of these cell phones in an environmentally friendly way. The campaigning was a success and in early 2017 Samsung committed to:

- Refurbishing and selling any recalled smartphones or using them as rental phones;
- detaching salvageable components, such as semiconductors or camera modules, for reuse or sale; and
- extracting metals using environmentally friendly methods.

Samsung also committed to helping the European Union research and develop new environmentally friendly technology to recycle smartphones. It remains to be seen how well Samsung will implement these commitments but if it was not for concerned citizens standing up for their rights to a healthy environment, then Samsung may have gotten away with just dumping these phone on a landfill. Now the polluter is being forced to pay.

Respect for Earth's other creatures

Living things

Hurt no living thing:
Ladybird, nor butterfly,
Nor moth with dusty wing,
Nor cricket chirping cheerily,
Nor grasshopper so light of leap,
Nor dancing gnat, nor beetle fat,
Nor harmless worms that creep.
-Christina Georgina Rossetti

Everyday humans kill millions of creatures, ranging from other human beings to tiny bacteria. It is incorrect to think that all of this killing is wrong - humans are part of nature after all and in natural systems, death often results from both inter-specific (between individuals of different species) and intra-specific (between individuals of the same species) competition. However, it is people's lack of respect and disregard for life that has resulted in the unprecedented extinction rates we see today.

Across the globe the long term survival of millions of species ranging from sable antelope, to marine worms are under threat from human induced activities such as overexploitation, habitat destruction, inadvertent killings (e.g. dolphins are caught in tuna nets and if they cannot escape are drowned), inhumane treatment (e.g. animals used in laboratories) and lack of conscience (e.g. killing all creepy crawlies that are found in your home and garden).

What is so tragic is that many people are oblivious to the nature and extent of the problems. When people do hear about an issue and learn about the reasons for a creature's plight, many bury their head in the sand and hope that the problem will go away. However, some individuals lobby against the malpractice. Over the years civil society has fought for the cause of many beleaguered animals, resulting in improved management practices by companies impacting on the animals, an increased drive to protect natural habitats, and an increase in knowledge of thousands of species due to increased research. In some cases this action has brought species back from the brink of extinction (e.g. the southern right whale, the giant panda).

If every individual adopted a more reverent attitude to life and showed more respect for living things the **amount of unnecessary and incidental killings would decrease**. There are a number of things that individuals can do to become more respectful and caring stewards of life. The first and most important is to **think twice** before doing something that could hurt or kill living creatures. By considering why you wish to kill a particular organism, what the impact of your actions might be and what you could do to avoid it, you will be giving yourself time to make the right decision – one that has the potential not only to save lives but improve your own self-esteem. For example when driving off road, choose to avoid driving over vegetation, to stay away from sensitive habitats and to limit your impact by utilising existing tracks. And what about the spider you find in your house? Do not squash it. Rather pick it up using a piece of paper and a cup and take it outside. Then, because many spiders love to eat flies allow it assist you in keeping them at bay. Breaking old habits and adopting new ones take time and may require perseverance and discipline but it is possible.

Choose your fish dish wisely

Do you enjoy eating fish? If so, what is your favourite fish? Are you aware that many fish have been overexploited and their populations have either crashed to the point that they cannot recover or are very vulnerable?

When purchasing fish, or ordering it at a restaurant, consumers can contribute towards the conservation of vulnerable species by making **environmentally responsible seafood choices**.

Many countries have set up a 'traffic light' system to guide consumers.

The **best choice** are the healthiest and most well managed fish populations that can handle current fishing pressure or are farmed in a way that does not harm the ocean. This includes South African hake, monk, mussels and snoek.

Think twice indicates that there is reason for concern e.g. species numbers have become depleted from overexploitation and cannot handle current fishing pressures. It would be better if you did not purchase these species, or at least not all the time. Vulnerable species include Atlantic salmon, Namibian hake, various species of prawns and octopus.

Don't buy refers to those species from unsustainable populations that have extreme environmental concerns, lack of appropriate management or are prone to poaching. This includes the South African sardine, Bluefin tuna, silver kob and both red and white stumpnose. Make a choice not to buy these species even if they are your favourite. If we give these populations a break they have a chance at recovering. If not we will lose them forever.

(Source: wwfsassi.co.za)

How reading labels can save animals lives

In South Africa, honey farming is big business with an annual turnover of N$ 3.2 billion and most of the honey sold in Namibian stores comes from South Africa. The problem is that not only people love honey, honey badgers do too. And when they raid hives to get to the honey they can create substantial damage. This can have serious economic consequences for farmers so many farmers kill them. This has resulted in a dramatic decrease in honey badger populations.

Fortunately conservation NGOs have been working with beekeepers and the South African Bee Keepers Industry Organisation (SABIO) to develop badger friendly farming techniques. Farmers who are willing to adopt this approach can, through an audit system, become accredited as a badger-friendly beekeeper. This allows the farmer to use the badger friendly logo on his products. These interventions have resulted in a decline in badger mortalities.

If you choose to purchase honey that has this logo over the products that do not (even if they are slightly more expensive), you will be showing your support to those beekeepers trying to farm in a more sustainable way, and you will be contributing towards honey badger conservation.

There are a number of other logos out there that support the fair and sustainable farming or manufacturing of products. Find out about them and start making conscious decisions about what you purchase. It will save lives.

Badger friendly honey – environmentally conscious purchasing

(Source: flickr.com/photos/eudaimonia7/1725357910)

This book outlines just what valuable services functioning ecosystems provide humankind and that the irresponsible use of these services has resulted in extensive ecosystem dysfunction and deterioration in landscape quality, not only in Namibia but globally. When looking at damaged landscapes, it is very hard not to feel that degradation of ecosystems is unethical. And if it is unethical, then the impact is not only economic but spiritual because it symbolises what mankind has become.

The actions of one individual alone cannot turn the tide on environmental degradation but the cumulative actions of many individuals can make a big difference. When many people start to express their gratitude for the multitude of benefits that Earth provides and start to care for it, then we will start to notice a change for the better.

In his book called **"Green Philosophy, how to think seriously about the planet"**, Roger Scruton puts forward an idea that is worthy of consideration. He believes that if people are to change their impacts on the environment we need to generate Oikophilia (the love and feeling for home), for when people love and believe in something, they cherish it.

He recognises that implementing this is not straightforward as there are so many aspects of human society and economy working against it. But he suggests that if people started moving away from the global village and **rekindling local communities**, founded on strong families, which live and work together that 'Oikophila' could grow. It is easier to share motives, develop ideas and foster stewardship in supportive, cohesive communities. And such communities give rise to sustainable neighbourhoods, so the knowledge and effort the current generation invests can be handed down to a future generation that has an inherent sense of belonging and stewardship for their home.

Coupled with that, individuals need to start making wise decisions about what we eat, where we shop and how we utilise energy and water. Every individual has the power to create and change things, and to be part of the solution rather than the problem. It starts with us acknowledging where the challenges are and then taking responsibility instead of leaving it up to others, **with the aim of caring for our home and restoring the condition of the environment which supports and harbours our community**.

The world in our hands

(Source: powerfulviews.wordpress.com/2016/06/13/the-world-in-our-hands)

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7. ABOUT THE AUTHORS

Svenja Garrard

Svenja is an environmental impact assessment specialist with broad international experience. She obtained her honours degree in Chemical Engineering from the University of Cape Town. Initially she worked as an engineer but soon moved over to the environmental management field. For the next 15 years, she worked in South Africa, Australia, and United Kingdom, both for government and independent environmental consultancies where she gained extensive experience. Finally in 2006, Svenja settled back in Namibia and established Quivertree Consulting specialising in environmental impact assessments.

Svenja is passionate about working with industry to implement environmental change and sustainable development. She is a registered Lead Practitioner with Environmental Assessment Professionals of Namibia (EAPAN).

Piet Heyns

Piet is a professional civil engineer and freelance water management consultant. He has degrees in science and water engineering from the University of Stellenbosch. He started his career in the Department of Water Affairs in South Africa and retired in 2007 as the Head of the Department of Water Affairs and Forestry in Namibia.

Piet is a respected water expert in Southern Africa, participated in many local and regional water resource investigations, published more than 20 papers, and wrote numerous articles on water issues.

Michelle Pfaffenthaler

Michelle is an environmental practitioner with a passion for biodiversity and teaching. She has a BSc(Hons) Zoology from the University of Kwa Zulu Natal, and a MPhil Environmental Management from the University of Cape Town. She has spent most of her career working in the environmental field, with mining corporations and biodiversity conservation NGOs that run business and biodiversity programmes.

Raised in South Africa, Michelle came to Namibia in 2001, where she worked on the construction and operation of Skorpion Zinc mine. Three years later she left Namibia to work for the Botanical Society of South Africa. In December 2005 she returned. Since then she has worked for Lange Heinrich Uranium, Fauna and Flora International, NaDEET and as a consultant.

Gabi Schneider

Gabi holds MSc and PhD degrees in Economic Geology from Frankfurt University, Germany. She joined the Namibian Geological Survey in 1985 and served as its Director from 1996 to 2016. She currently is the Executive Director of the Namibian Uranium Institute. Her professional experience covers economic geology, exploration, and environmental geology, and management. She is a honorary life member of the Geological Society of Namibia, honorary fellow of the Geological Society of London, and registered with the South African Council for Natural Scientists.

Gabi serves on Namibia's Sustainable Development Council, Namibia's Geoscience Council, the Namibian Energy Institute's board, and on the Commission for the Implementation of the World Heritage Convention in Namibia. She played a leading role in the Strategic Environmental Assessment of the Namibian Uranium Province.

Namibia is a semi-arid country that boasts a magnificent array of landscapes and wildlife. All Namibians, but particularly the rural population, depend on a healthy environment to ensure both subsistence and economic livelihoods. The challenge is that semi-arid landscapes are fragile and once damaged take a long time to heal. This means that if natural resources are not appreciated and sustainably managed, the natural capital in the country will weaken and the ability of the environment to support both people and biodiversity will decrease. The current population in Namibia is expected to increase from 2.2 to 3.5 million by 2050. This presents significant challenges to a country that is already faced with many environmental difficulties such as limited water resources, infertile soils, bush encroachment and poverty. In this book the authors provide insight into how the environment functions, how people benefit from healthy ecosystems and how Namibian society is tackling environmental issues. The standard of living and socio-economic prosperity of current and future generations depends on the willingness of the whole population to understand and champion sustainable development. This book aims to inform and inspire everybody living in Namibia to take responsibility for caring for the environment and in so doing to contribute to a more sustainable future for all.

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