Sink or swim...

Water and the Namibian environment

An environmental resource book for Namibian teachers

Ministry of Education and Culture

Enviroteach

Sink or swim...

Water and the Namibian environment

An environmental resource book for Namibian teachers

An Enviroteach production

1995

Enviroteach
P O Box 1592
Swakopmund
Namibia

Written by:	Derick du Toit Teresa Sguazzin
Illustrated by:	Asser Karita
Additional illustrations:	Louise Clapham

Design, layout and photographs by Enviroteach

ISBN 99916-43-00-1

Acknowledgements...

Enviroteach owes many people and organisations thanks for help during the production of this package. We would like to thank: the steering committee of this project; Viv Ward; Shirley Bethune and Piet Heyns of the Department of Water Affairs; Martin Harris; Ginger Mauney for help with the glossary; Dave and Helen Boyer; Sven Jansson who we remember and miss and Tani Forbes-Irving.

Thanks to the Enviroteach Outreach team - Haroldt Maletzky, Silas Shakumu and Brendan Flannery - for testing these materials, and to the staff of the 25 pilot schools.

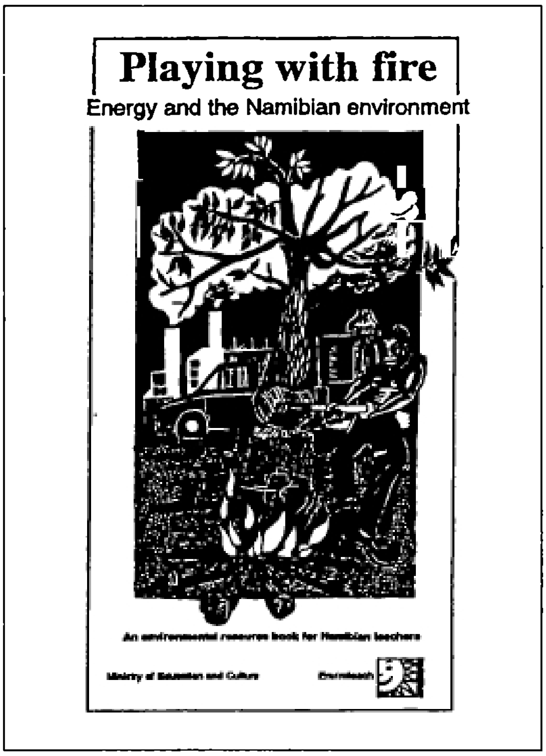
A special thankyou to SIDA for financial support, and to the DRFN, Mary Seely and everyone at Gobabeb.

1995

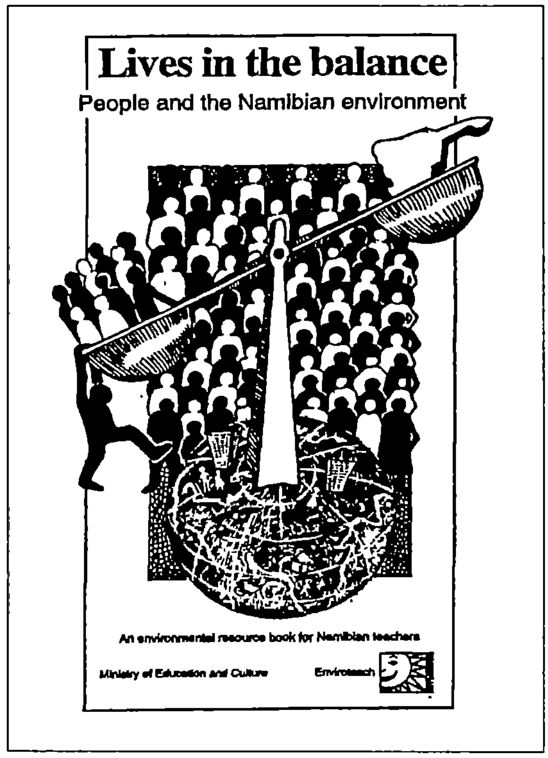
Table of contents

More Enviroteach resources...

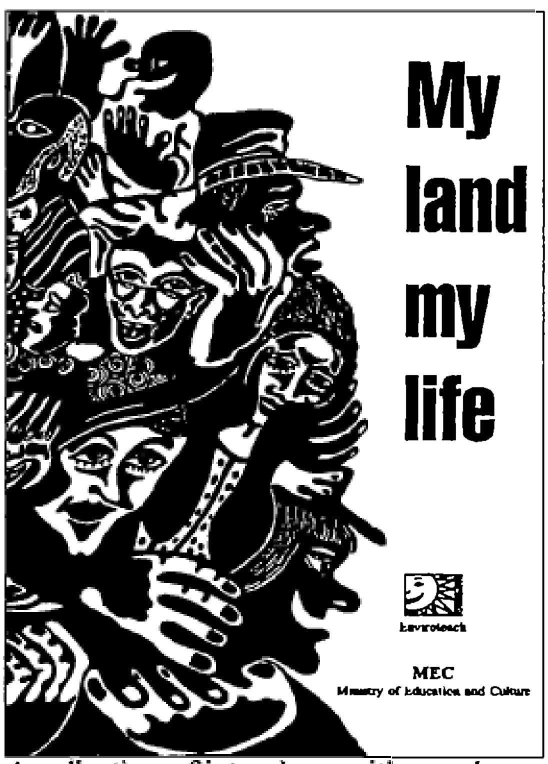
Sink or swim is one of five main Enviroteach resource books for Namibian teachers. The covers of the other four are shown below. There are also a number of supplementary booklets available to help you focus your teaching on environmental themes.



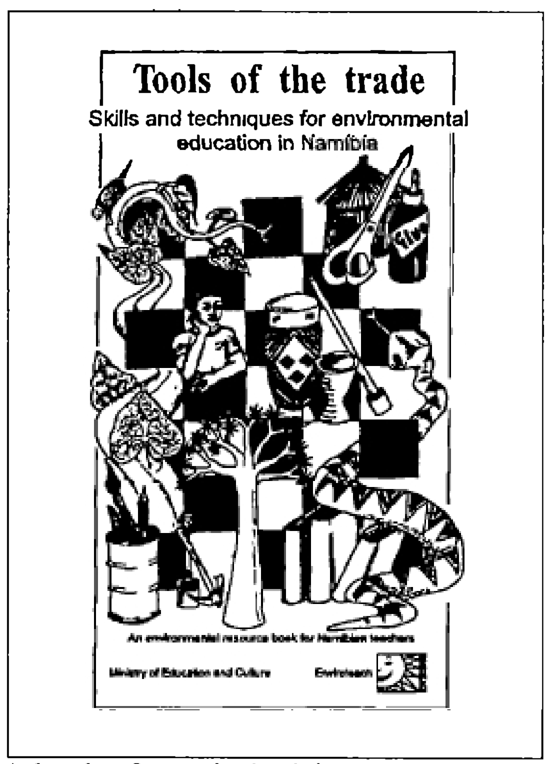
A book about energy with a special focus on Namibia



This resource focuses on people and their interactions with the environment



A collection of interviews with people using the Namibian environment



A book of practical advice on how to do activities and carry out projects

Notes to the teacher

This book is the second in a series designed to support the Enviroteach programme and provide information and ideas on themes linked to the Namibian environment.

It is NOT a textbook and is not meant to be used as such. The issues covered are there to provide background information related to water in our Namibian environment. More importantly, they are there to show that a number of subjects can draw on this topic, and that it can be used to increase awareness of and responsibility for our Namibian environment. At the same time, it can make both learning and teaching fun and more relevant. The activities pages are there to encourage learner-centred education.

Who can use this book? Any teachers interested in increasing environmental awareness amongst their learners, or in teaching in a way appropriate to Namibia's situation. Because the environment affects us in all spheres of life, it can be used as a teaching tool in any subject taught in Namibian schools.

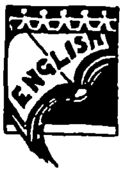
How can this book be used? This book forms part of a flexible resource pool that provides facts, figures, information and ideas to teachers. The blue activities pages at the end of each chapter will give you general ideas for ways to use the theme of water in your lessons and activities. These are merely suggestions and should be tailored to fit your specific region and to suit your learners. Add your own activities, and tell us about them if they are successful. Future editions of this book will include them and in this way you can share your ideas with other Namibian teachers. Let us know which of our suggestions you find useful, and which ones don't work. The address you should send this information and any other queries to is:

Enviroteach
Gobabeb
P O Box 1592
Swakopmund.

Finally, we believe that education should be relevant, stimulating and FUN! So, get the learners to participate in investigations, plays, experiments and demonstrations. Let them find some of the solutions to problems that they have to live with and their education will truly become relevant.

Symbols used in this book

The following symbols will be found on the blue **activities** pages. The activities that they mark may be of use to the following teachers:



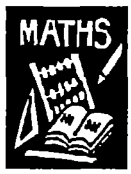
English and language teachers

religious and moral instruction teachers

art teachers

physical science teachers

geography teachers



maths teachers

history teachers

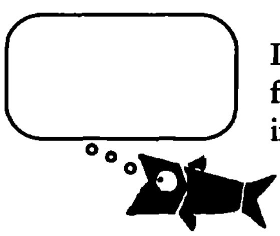
home economics teachers

life science and agriculture teachers

teachers of prevocational subjects such as wood-work, metalwork, etc.

Those activities tagged with two or more symbols may be useful in more than one subject. **General** activities can be adapted for use in many of the different classes.

This symbol, found in the margins throughout the book, marks a proverb related to the subject dealt with in the text. Use these in your language classes, or as points of interest in other subjects.



Italicised comments in the margins are "Did you know"s - interesting facts and figures that can be used as attention-getters or to capture the interest and imagination of your classes.

The water of life

"Water is life", but why?

Without water there can be no life. Some organisms can live without oxygen, but none can survive without this prcious liquid. It is an essential part in many of life's processes. We human beings ourselves are between two thirds and three quarters water.

In addition to this, water plays an important role in maintaining our climate. Agriculture, industry, some forms of transport and countless other things also need water to work. Water has often been taken for granted, but it has come to a point where we need to take care of our resources if they are to enable us to survive. Some areas - like arid Namibia - lack water, while others suffer from floods which can cause great damage and loss of life. As the world's population grows and our sources of clean water get scarcer, this liquid is becoming a more and more important issue.

But what exactly is water, and why is it so special?

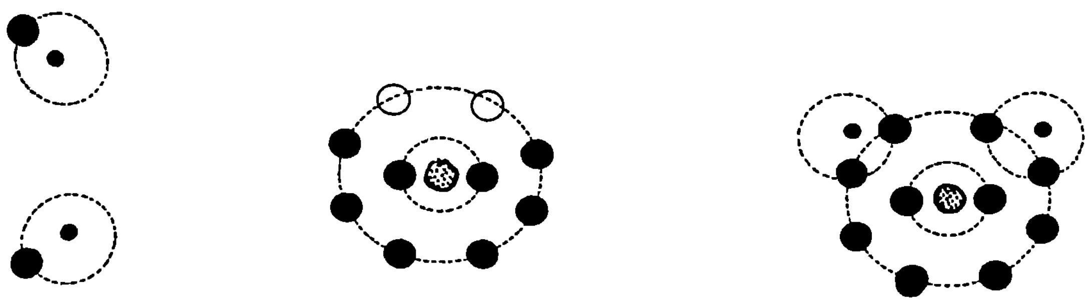
What is water?

Water is a chemical compound made up of two elements: hydrogen and oxygen. Pure water is odourless, colourless and tasteless. Bland as this may seem, water is a unique chemical and, due to its special properties, plays a vital role in almost all aspects of life.

Water is formed when hydrogen combines with oxygen, releasing huge amounts of energy which can even result in an explosion. The combination of two atoms of hydrogen with one of oxygen is a very strong one. Huge amounts of energy are needed to break the molecule apart. So strong are the bonds that link the atoms that as recently as 200 years ago water was believed to be a single element that could not be divided, rather than a compound.

Forming a water molecule

Two hydrogen atoms and an atom of oxygen fill their electron orbits by sharing electrons. Hydrogen atoms have only one electron spinning round their nuclei. They require one more electron to become stable. Oxygen has six electrons in its outer orbital, and needs two more to fill this orbital. When these three unstable atoms share their electrons the result is a very stable molecule of water.



$$2\,H \quad + \quad O \quad = \quad H_2O$$

Density

One of the most remarkable properties of water is that it expands when freezing. Almost every other substance will shrink in volume as its temperature drops. Water behaves as other substances do for the most part, shrinking for 96% of its way down the temperature scale. But at 4°C something happens. As water continues to cool, it expands, thus becoming less dense and lighter. Ice is 9% larger in volume than liquid water. This property has a very useful result: ice floats. This means that instead of much of our water being locked in permanent ice on the bottom of the sea or lakes, ice floats on the surface of liquid water, insulating the water below it from heat or cold, and enabling the water cycle to continue and organisms living in the water beneath the ice to survive.

Heat capacity

The internal energy possessed by a substance can be increased by raising its temperature. The amount by which the temperature rises is proportional to the amount of heat supplied. The amount of heat required to increase a particular mass of a substance varies from substance to substance. In chemistry we have a figure called the **heat capacity** of a substance that indicates how much heat is needed to change its temperature by a certain number of degrees. Substances with a large heat capacity need a lot of heat to raise their temperature even a little.

Water has a large heat capacity, which means that an enormous amount of heat is required to warm water, as anyone who has ever spent any time in a kitchen will know. This is why it is possible to burn yourself on a metal pot while the water it contains is hardly warm. The iron that the pot is made of heats up nearly 10 times faster than water does. Water's heat capacity means that large bodies of water, such as the oceans, can store huge quantities of heat. Because oceans have to gain or lose huge amounts of energy to change their temperature, and this takes time, they moderate coastal climates and prevent extremes of hot or cold. The same property that makes coastal climates less extreme than inland climates also means that water is indispensable in many industries where it is used for both heating and cooling purposes.

Latent heat

Latent heat is the energy required to change the state of a substance, for example, to turn ice to water or water to vapour. To convert one gram of water into steam requires 2260 joules of energy. This energy is usually supplied in the form of heat. Because such a large quantity of heat is taken up during the process of evaporation, evaporation is an extremely efficient way of cooling things down. A good example of how this works is how the human body cools itself through evaporation of sweat.

Water as a solvent

Water is so good at dissolving things that perfectly pure water is a very rare thing. Water is the most powerful general solvent known to people. Indeed, water is such a good solvent that water sipped from a glass may contain a very small number of glass molecules. Even the rain, as it falls through the atmosphere, dissolves materials such as atmospheric gases. If there is sulphur in the air, released by industrial or other processes, then this dissolves into rain to form sulphuric acid - acid rain. Seawater is quite a concentrated solution of dissolved solids. It contains hundreds of dissolved organic and inorganic substances. These substances give seawater its salty taste.

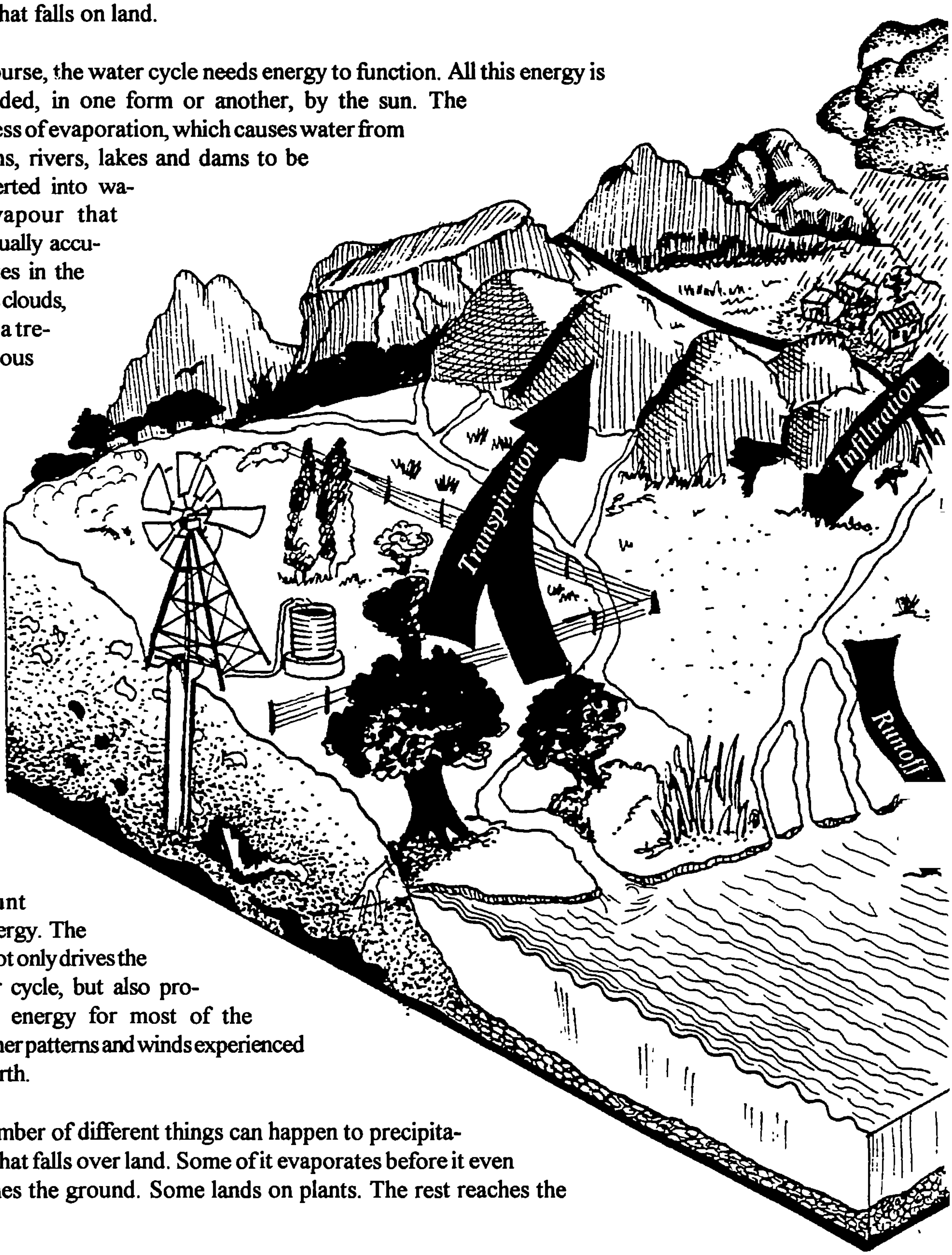
Some living organisms can live without oxygen but none can survive without water

All living organisms depend on water to dissolve and distribute the substances they feed on. People are no exception. The food we eat must be dissolved before it can be absorbed by our digestive systems and we rely on water to do this for us.

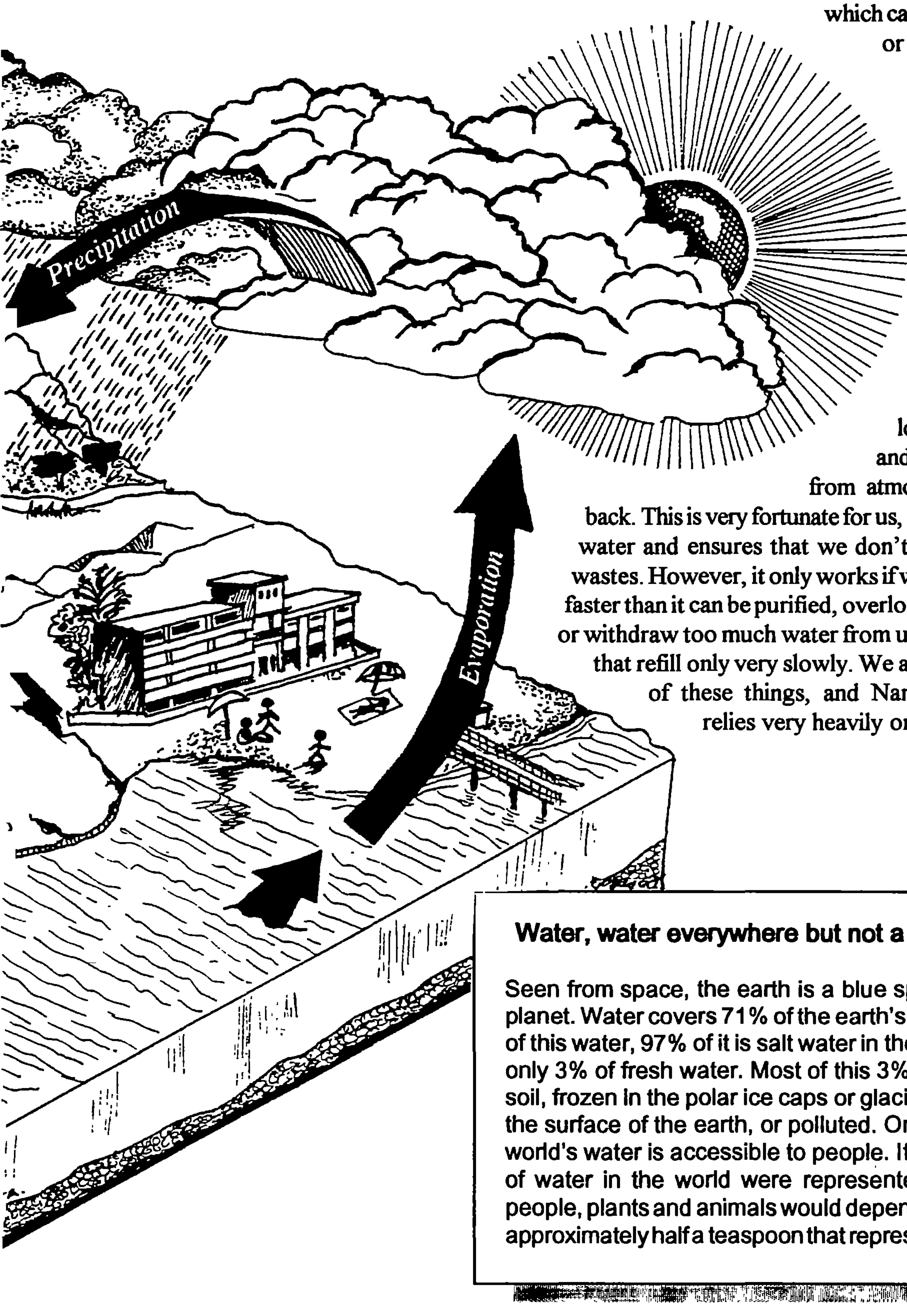
The water cycle

Water is in a constantly changing state. The **hydrological** or **water cycle** is the never-ending process by which water evaporates from oceans, lakes and land surfaces and rises into the atmosphere as vapour. This cools down, condenses to form cloud, and returns to the earth's surface in the form of **precipitation** - rain, snow, fog or hail. Much of this precipitation falls back into the sea, but some of the vapour is blown across land, where it produces the much-needed rain that falls on land.

Of course, the water cycle needs energy to function. All this energy is provided, in one form or another, by the sun. The process of evaporation, which causes water from oceans, rivers, lakes and dams to be converted into water vapour that eventually accumulates in the sky as clouds, takes a tremendous amount of energy. The sun not only drives the water cycle, but also provides energy for most of the weather patterns and winds experienced on earth.



A number of different things can happen to precipitation that falls over land. Some of it evaporates before it even reaches the ground. Some lands on plants. The rest reaches the earth or areas of inland surface water (dams, rivers, streams and lakes). Much of the water that reaches the ground evaporates quickly and returns to the atmosphere. Most of the rest seeps into the earth. This water is often used by plants, eventually returning to the atmosphere through pores in plants' leaves. Only a small percentage of the water penetrates beyond the root zone and recharges supplies of underground water. Water which does not enter the soil or evaporate runs across the land in the form of streams or rivers which can run into lakes, pans or the sea.



People and many other organisms depend on the tiny proportion of all the water in the world (less than 0.01%) that is available freshwater. This water is part of the hydrological or water cycle and constantly moves from atmosphere to land and back. This is very fortunate for us, for this cycle purifies water and ensures that we don't choke on our own wastes. However, it only works if we do not dirty water faster than it can be purified, overload it with pollutants, or withdraw too much water from underground sources that refill only very slowly. We are guilty of doing all of these things, and Namibia, in particular, relies very heavily on its groundwater.

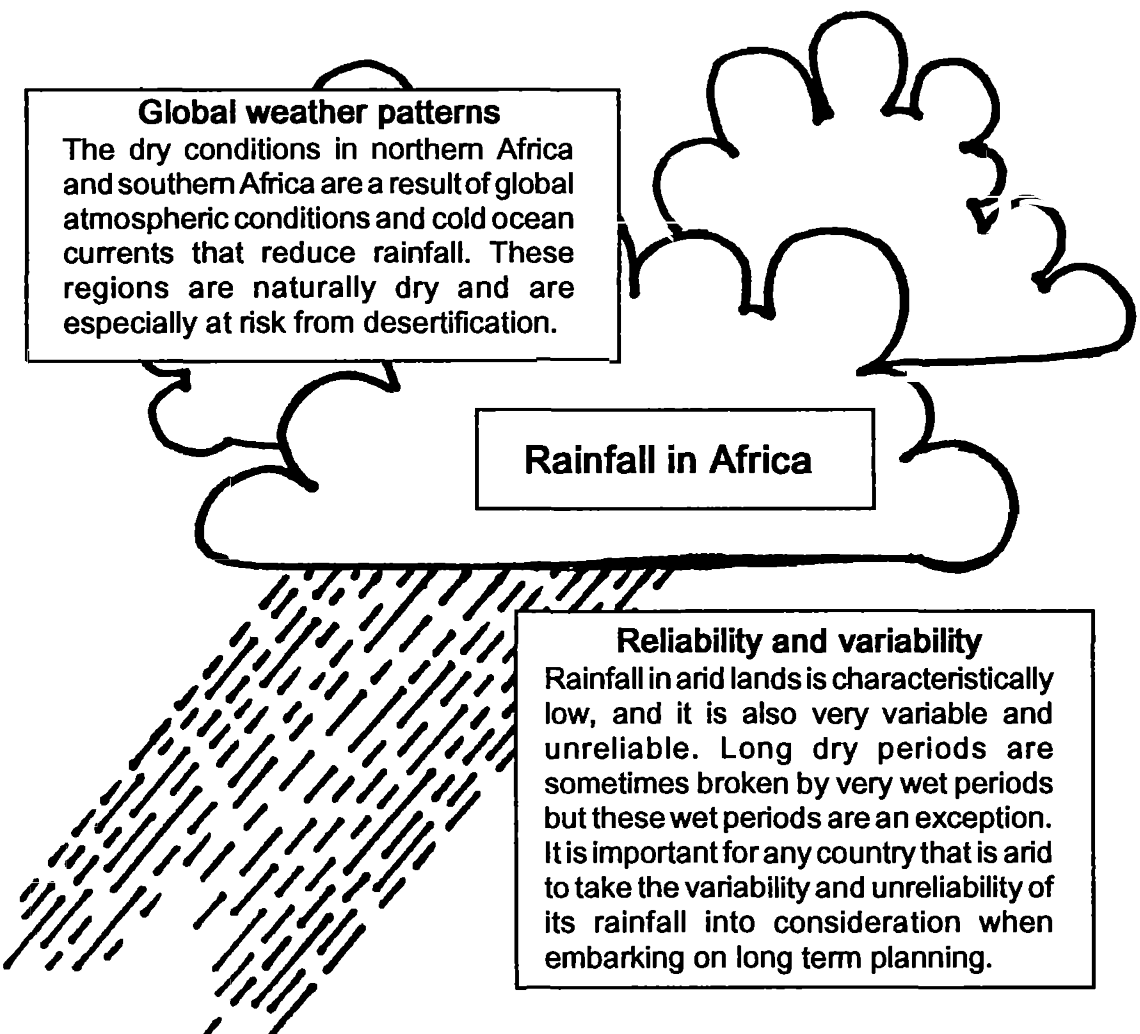
Water, water everywhere but not a drop to drink...

Seen from space, the earth is a blue sphere - the water planet. Water covers 71% of the earth's surface, but of all of this water, 97% of it is salt water in the oceans, leaving only 3% of fresh water. Most of this 3% is trapped in the soil, frozen in the polar ice caps or glaciers, too far under the surface of the earth, or polluted. Only 0.003% of the world's water is accessible to people. If the total amount of water in the world were represented by 100*l*, then people, plants and animals would depend for their lives on approximately half a teaspoon that represents this 0.003%.

Water in Africa

Most of the African continent lies with a region of the earth called the tropics. Of all the places on our planet, the tropics receive the most intense energy from the sun. This has a major impact on the weather patterns within them. How and where rain falls are determined by such phenomena. For example, the countries that occur along the Equator experience high humidity and rainfall throughout most of the year while countries that occur along the Tropic of Cancer (northern hemisphere) and Tropic of Capricorn (southern hemisphere) experience much drier conditions.

This map on the opposite page shows surface water on the continent of Africa. Only rivers that flow all year round are shown. A glance at the map will give you a good idea of where the most rainfall occurs on our continent. Pay special attention to Namibia. You will notice that there are no perennial rivers within the borders of our country. The two main factors that cause our country to be arid are the cold Benguela ocean current associated with the Atlantic Ocean along the coast; and the dry air that descends on us, having lost its moisture over the equator.



Rainfall in Africa

Global weather patterns

The dry conditions in northern Africa and southern Africa are a result of global atmospheric conditions and cold ocean currents that reduce rainfall. These regions are naturally dry and are especially at risk from desertification.

Reliability and variability

Rainfall in arid lands is characteristically low, and it is also very variable and unreliable. Long dry periods are sometimes broken by very wet periods but these wet periods are an exception. It is important for any country that is arid to take the variability and unreliability of its rainfall into consideration when embarking on long term planning.

Droughts are natural

The dry conditions that occur in north Africa and countries such as Namibia and Botswana are normal and not caused by unusually dry periods, often called droughts. These countries are naturally dry.

Perennial and ephemeral rivers

Rivers that flow constantly, all year round, are called **perennial** rivers. Rivers that flow only when there has been enough rain are called **ephemeral** rivers. Their riverbeds are usually dry for most of the year. The map below shows only Africa's perennial rivers.

- *Regions along the Tropic of Cancer fall into a naturally dry zone, hence the low number of perennial rivers*

- *A warm ocean current allows more rain to fall along the east coast of southern Africa*

- *Dry conditions and, consequently, few perennial rivers are associated with regions along the Tropic of Capricorn*

- *Note the high number of perennial rivers in the equatorial regions of Africa*

Source: Beadle 1981. *The inland waters of tropical Africa*. New York, Longman.

Water in Namibia

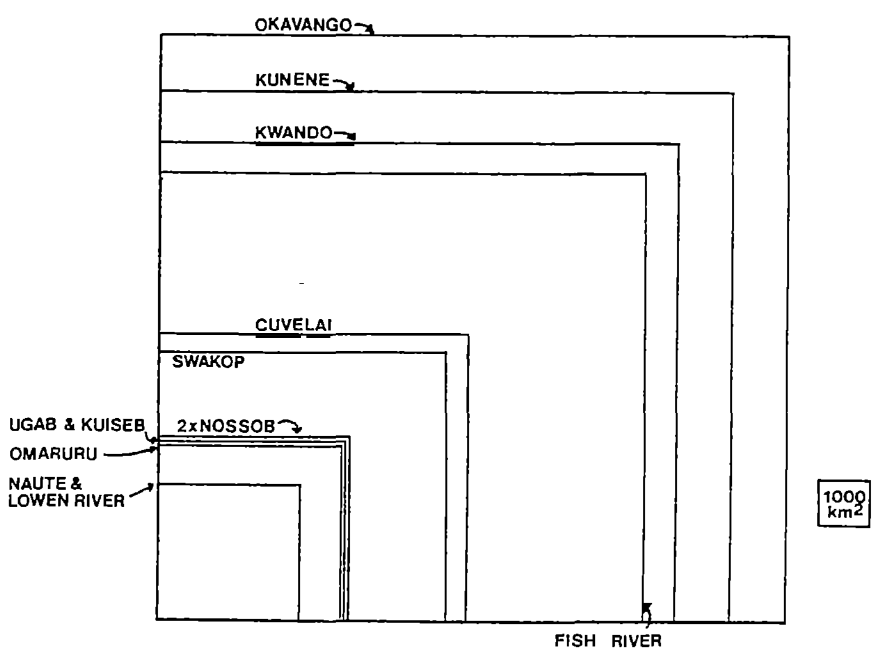
Namibia is one of the driest countries in the world. It is therefore not difficult to understand why water is such a precious commodity here. It is the single most important limiting factor influencing the productivity of our country, especially as regards agricultural and industrial activities. Water - its presence or its absence - governs all Namibian life, and determines where and how we can live.

All water in Namibia comes from rain, whether it has been trapped under the earth's surface for thousands of years or whether it occurs on the surface in the form of rivers or pans. But rainfall is scarce in our country and the rivers within our borders are dry for most of the year. The low rainfall we receive and the increasing demands for freshwater mean that all Namibians need to work towards conserving this precious resource.

Namibia's water resources can be divided into the following categories:

1. rainwater
2. rivers, pans and wetlands
3. groundwater
4. seawater.

River catchment areas in order of size

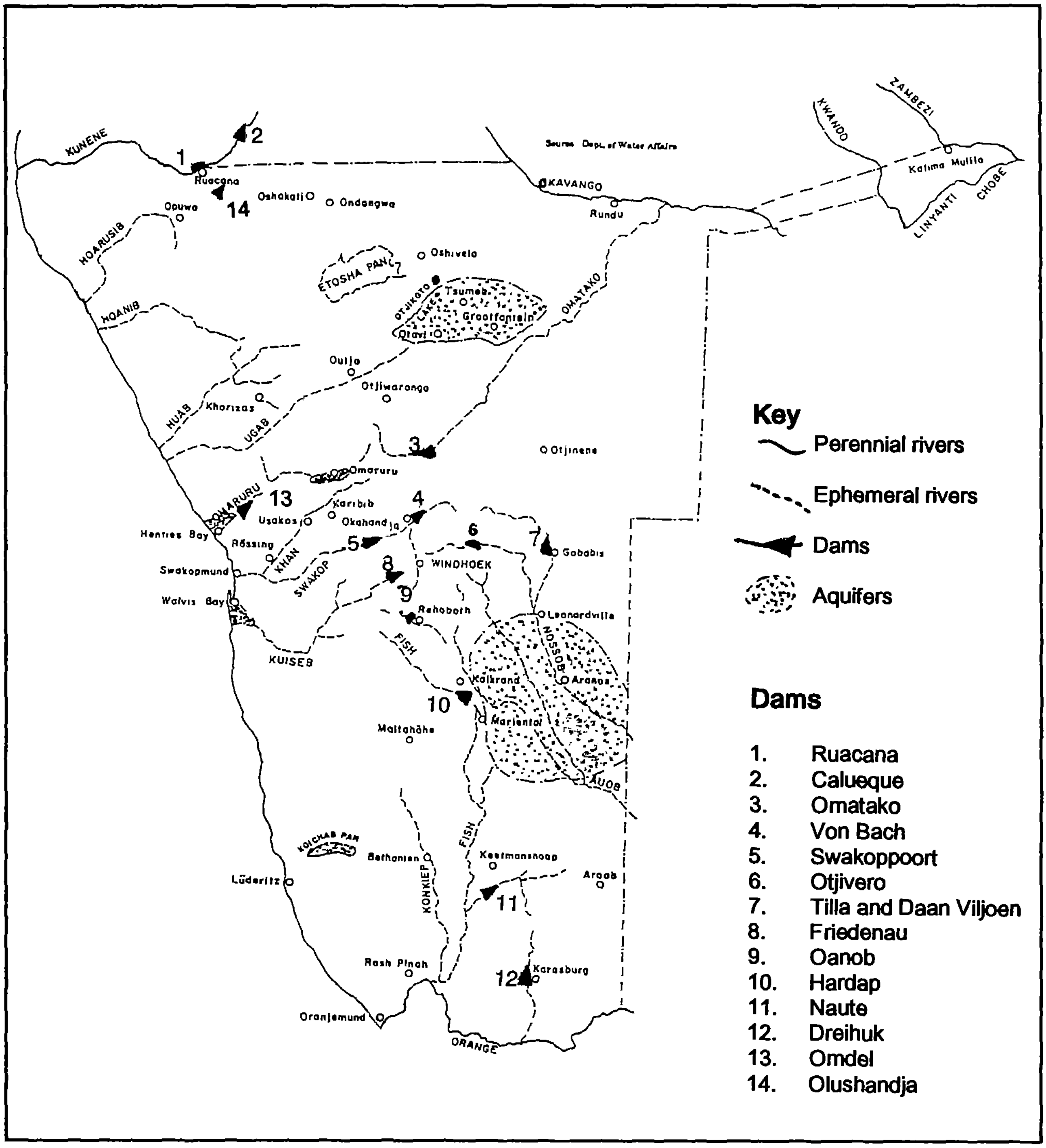


After Stengel, 1963

Okavango at delta	*152 000km²*
Kunene at mouth	*128 600km²*
Kwando at Caprivi	*112 000km²*
Fish	*91 000km²*
Cuvelai	*37 200km²*
Swakop	*31 000km²*
Kuiseb	*16 200km²*
2 x Nossob	*16 000km²*
Ugab	*15 500km²*
Omaruru	*14 050km²*

The diagram shows the relative sizes of catchment areas for a number of Namibian rivers. Remember that the size of the catchment does not tell you anything about the amount of water that flows in the river. A measurement called the mean annual runoff (MAR) is used to indicate this.

Namibia's water resources

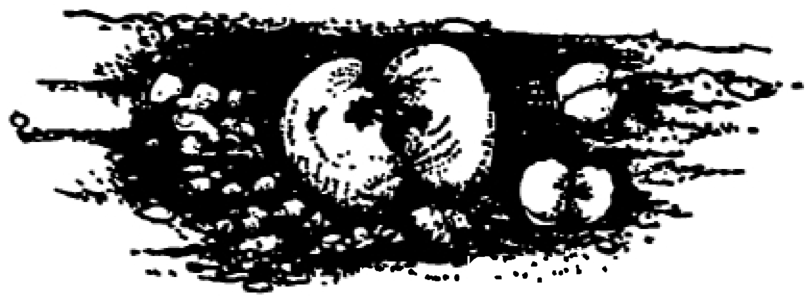


People who live in Namibia know that this is a dry country, but one factor they often forget about is that arid lands, which are characterised by low rainfall, are also characterised by very variable rainfall that differs greatly in amount and place from year to year. As we move towards the more arid western and southern parts of our country, we find that this variability increases.

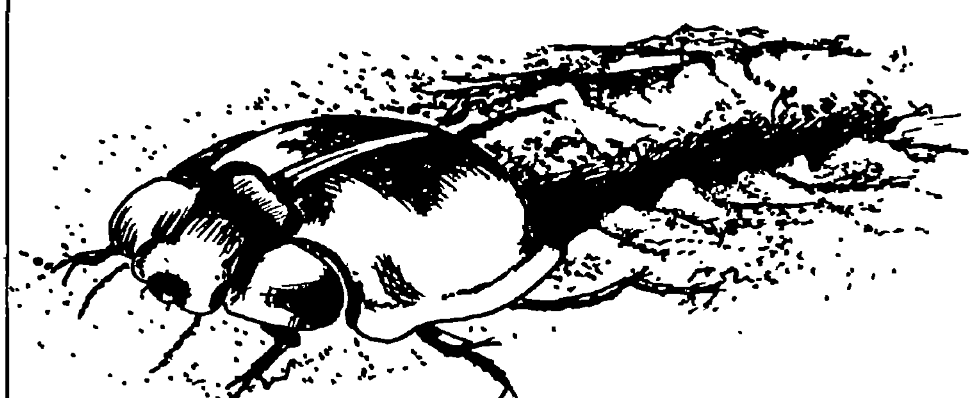
Nature's water-efficient wonders

The lack of water in Namibia has resulted in many plants and animals developing special adaptations to help them to survive in an environment where water is hard to come by. Some of the most striking of these adaptations are found among organisms living in Namibia's Namib desert.

The *Lithops*, or stone plant, is extremely well adapted for survival with little water. Almost the entire plant grows beneath the surface of the soil where it is protected from heat and evaporation. Only the peculiar tips of its leaves appear above the ground's surface. These tips are rounded and speckled, looking just like the pebbles among which this succulent grows.



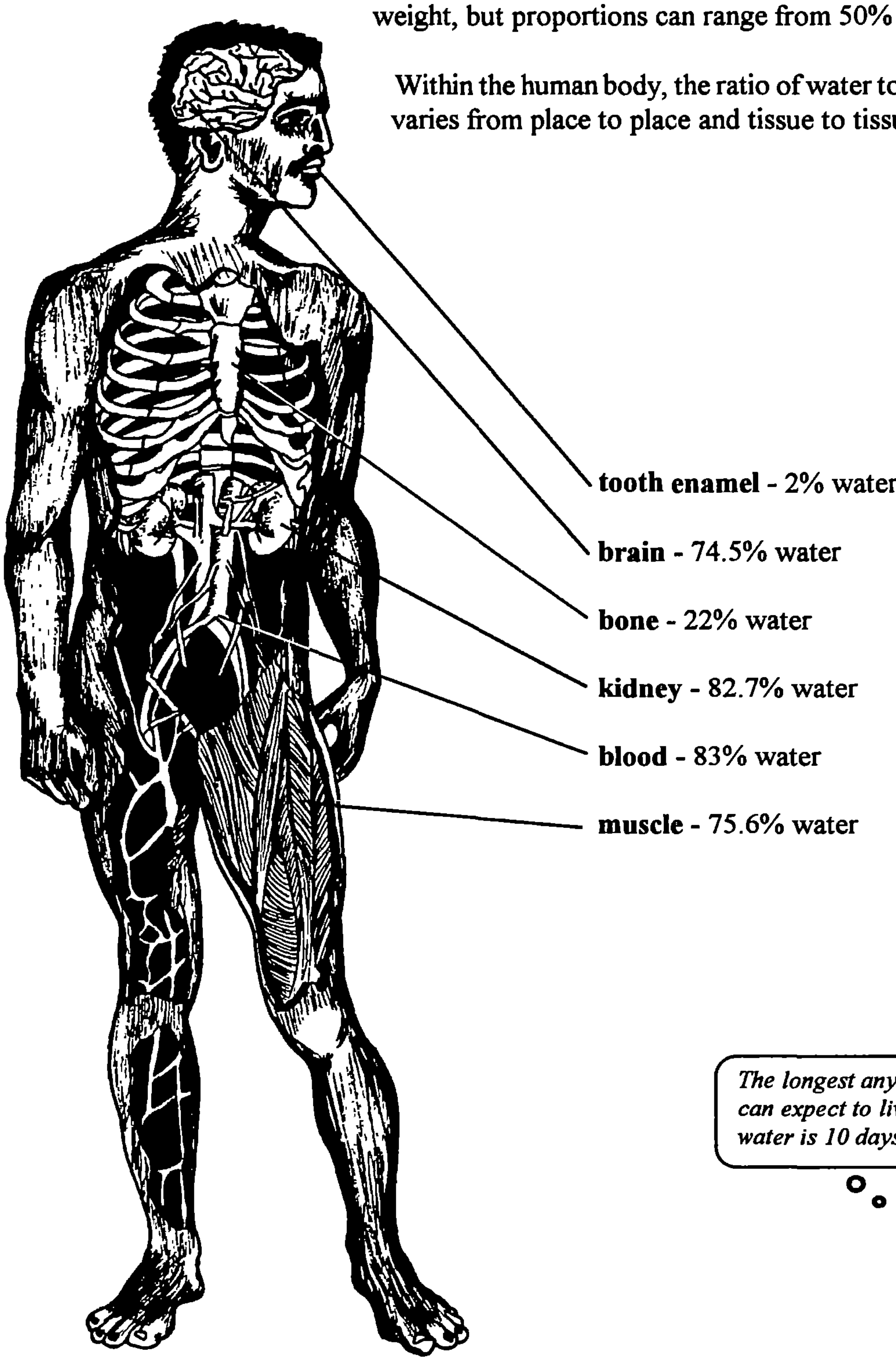
In the Namib dune sea lives an extraordinary beetle that has developed an ingenious way of trapping fog water - which is the only regular source of moisture in an otherwise very dry environment. This type of beetle, one of several species of *Lepidochora* found in our country, builds narrow trenches on the dunes at right angles to the wind bringing fog in from the coast. The ridges of these trenches collect more water than the surrounding sand, and the beetles move along these trenches harvesting this water. These beetles can consume up to 41% of their body weight in water on foggy mornings.



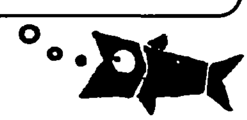
The watery world within us

You would probably object to being called a drip, but just how watery are you? The amount of water in a human body averages 65% of that body's weight, but proportions can range from 50% to 75%.

Within the human body, the ratio of water to body part varies from place to place and tissue to tissue.

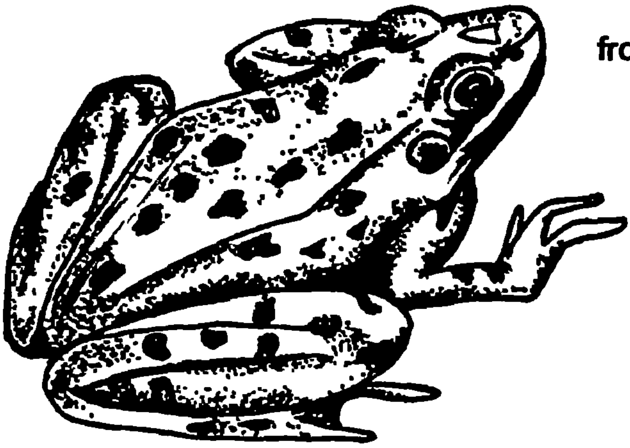


The longest any human being can expect to live without water is 10 days.

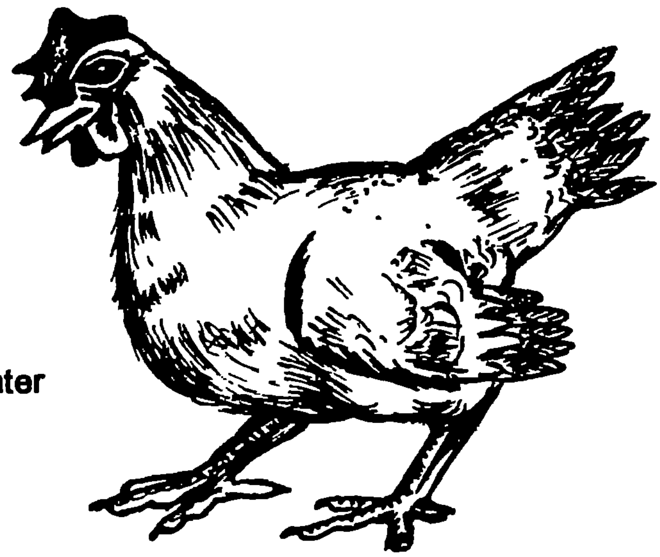


The human body gets its water from several sources. The most obvious way, drinking, supplies only about 47% of its needs. The body itself manufactures about 14% of its daily requirement as a side product of respiration. The remaining 39% of our water comes from the food that we eat. Most foodstuffs contain at least as much water as human cells - for example, meats are 50-70% water, and bread is about 35% water.

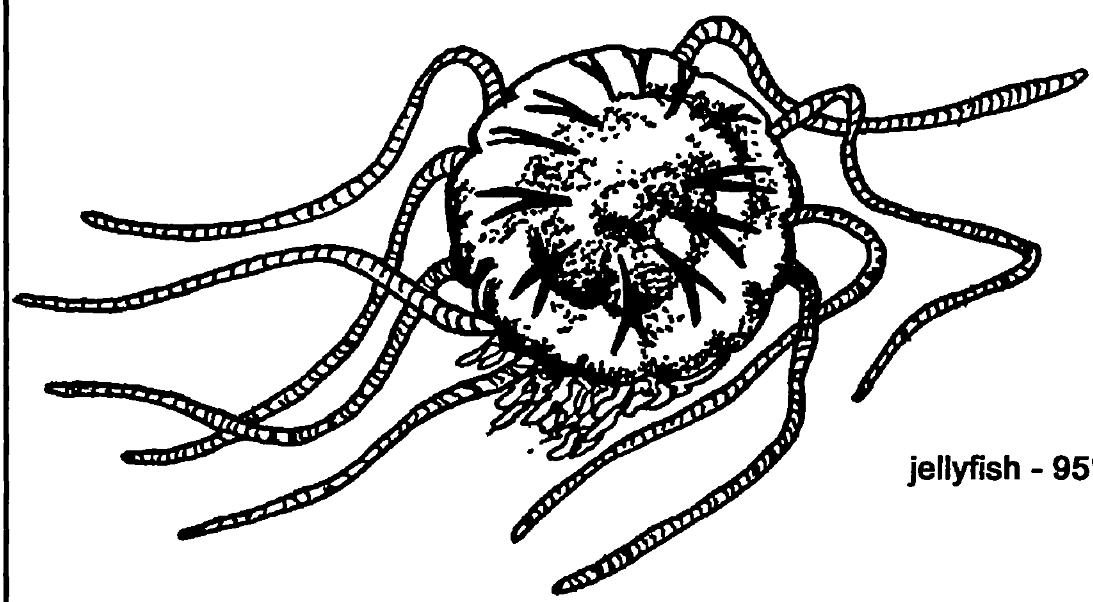
Water in animals



frog - 78% water

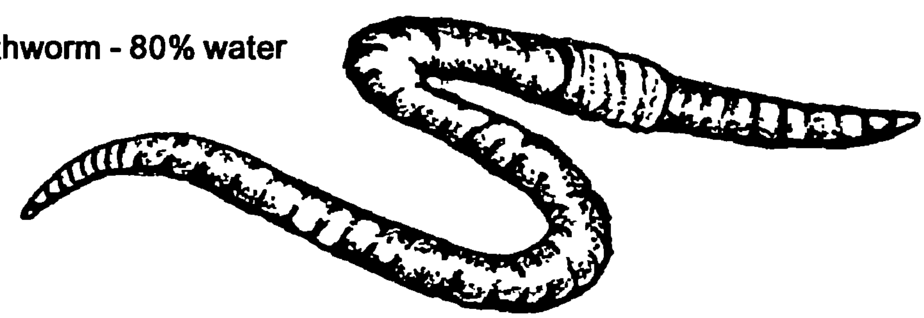


chicken - 74% water

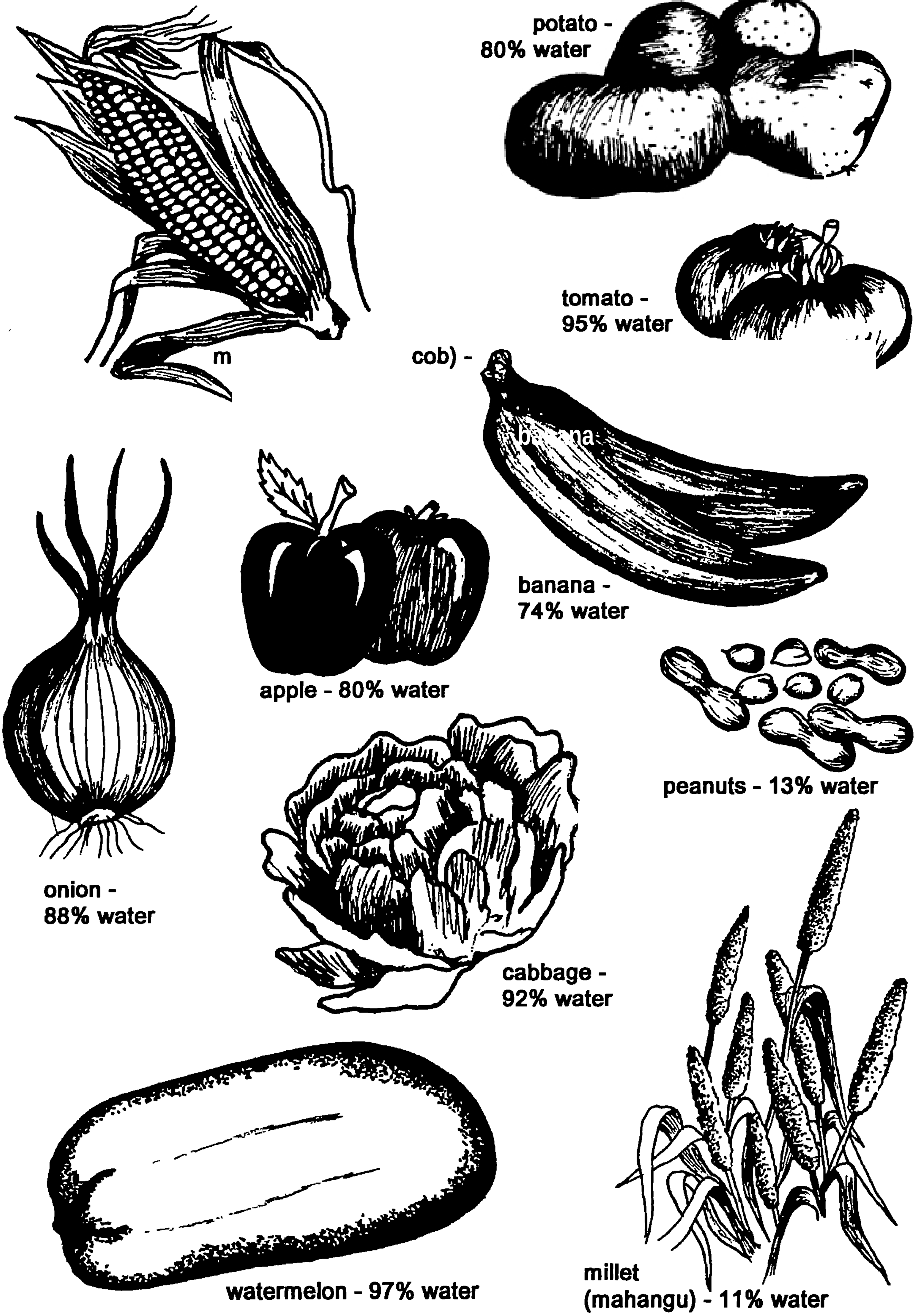


jellyfish - 95% water

earthworm - 80% water



Water in food



"Who owns the rain?"

Water is one of the most common natural resources on planet earth. Yet as we approach the year 2000 we are starting to realise that there is a crisis. Will there be enough freshwater to supply the needs of all people, plants and animals in the future?

One of the biggest causes of the problem that we now find ourselves facing is that water developments have masked the fact that freshwater is in scarce supply. More and greater projects have been embarked upon in order to meet ever increasing demands for water. Cheap and easy access to water creates the false impression that water is in plentiful supply, with the end result that water is used without considering the limitations that our rivers, wetlands, dams and groundwater sources will eventually impose on us. The question is no longer if but when will the "well run dry"?

The increase in the world's human population, new industries, agricultural schemes and economic development have resulted in a vast growth in the demand for water all over the world. Sometimes, technology has responded to the crisis by proposing massive water supply schemes that can cost billions and may result in a number of environmentally harmful side effects. Technology and engineering projects have given people greater access to water, although they cannot increase the actual amount of water available.

Water is essential for all forms of life, but we seem to have forgotten this in our attempt to supply people with as much water as possible. Sharp conflict has arisen between humans and nature in many parts of the world in recent years. In many cases nature is fast losing out. In Namibia many indigenous plants and animals are being threatened by people's poor farming practices and uncaring use of water. These plants and animals have evolved over tens of thousands of years to withstand the natural dry conditions experienced in most parts of our country. Not only do we risk losing these organisms forever, we also risk endangering entire ecosystems. The ultimate effect of this destruction on people is unknown, but it is unlikely to be positive.

Water plays a crucial role in economic growth by supporting greater agricultural productivity, industrial expansion and urban growth. There is a limit to the expansion of all of these, particularly if they are developed with no thought of our limited water sources. We may be reaching the stage where our water is the crucial limiting factor of our current course of development. This may mean that this course will have to change, or that we will have to move away from our present water sources in favour of others. For example, in future the desalination of seawater might have to be investigated in order to supplement our supplies of freshwater.

Water is also an issue of political concern that is likely to affect countries and their neighbours. Nearly 40 percent of the world's people live in river basins shared by more than two countries. Namibia is no exception. Our perennial rivers all originate outside our country. Bad management and pollution of water sources upstream are passed on to users further down the river. It is for this reason that our neighbours must be drawn into sound water use policies. For example, the Okavango River, which originates in Angola, flows through Namibia and drains into the Okavango Delta in Botswana. Bad practices along the river may have negative effects on all forms of life in more than one of these countries. This set of circumstances is also true for the Orange and Kunene Rivers.

Now that water scarcity has become a cause for concern there is greater potential for conflict to arise due to irresponsible use of river water, excess pumping of shared water resources and pollution and the use of pesticides along rivers. It is generally accepted that the owner of a piece of land has the right to use the resources on that land, but with water the situation is not quite so clear as water flows across borders and boundaries. A variety of regulations, laws, international agreements and traditional rights control the way water is distributed amongst people, depending on a particular geographic location or culture. However, some of these regulations controlling the water sharing may be outdated and not based on current understanding or scientific evidence.

The demand for water in some parts of the world is so extensive that conflict situations are arising with regard to the right to use surface and groundwater. Using water from international boundary rivers, pumping groundwater and damming rivers are current areas of focus. In some situations people are even demanding the right to certain percentages of rain that falls. The question we must all ask is "Who owns the rain?"

Major river basins and flows		
River	**Flow (cu km)**	**Countries**
Zambezi	212	Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, Zimbabwe
Orange	12	Lesotho, Namibia, South Africa
Okavango	8	Angola, Botswana, Namibia
Kunene	7	Angola, Namibia

Source: *State of the environment in southern Africa*. 1994. IUCN

Water is a shared responsibility

Things to do...

Water's gravity-defying act

Using hydrogen bonding, water sticks to most substances containing oxygen in their chemical structure (**adhesion**), including itself (**cohesion**). It is this that enables it to defy gravity and creep upwards if it is in a narrow tube shape such as the spaces between soil molecules. This ability is called **capillarity**.

If a narrow tube is inserted into water, water molecules in contact with the tube form hydrogen bonds with the molecules of the tube (adhesion). These bonds, although weak, are strong enough to allow water molecules to be raised up along the surface of the tube. Because water molecules also stick to other water molecules, (cohesion) the water molecules near those that have bonded with the tube are also raised. In this way water rises in the tube without any suction being applied to it and will continue to rise until the downward forces of gravity balance the upward capillary forces.

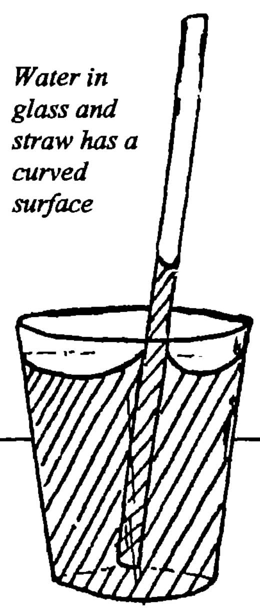
Teachers can set up the following demonstration to show how capillarity works:

You will need:

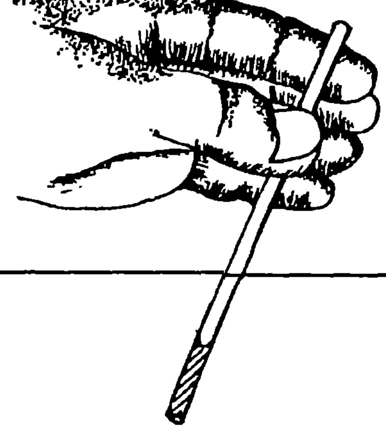
a very thin drinking straw or glass tube
a glass of water

Place the straw in the glass of water. Hold the straw completely still or let it rest against the edge of the glass. Note how the water in the straw rises slightly in the straw, without you having to suck on it. Remove the straw from the glass carefully. If the straw is thin enough the adhesive forces might be strong enough to hold water molecules in the straw.

Explain to your learners that adhesive and cohesive forces play an important role in moving water through the soil and within plants.



If the straw is thin enough, forces of cohesion and adhesion may be strong enough to keep the water in the straw



Chapter 1
Activities

1. Look at the picture of the water cycle in the first chapter. Use the words in the cycle to demonstrate how some words can be changed from a verb to a noun.

condense	→	condensation
precipitate	→	precipitation
evaporate	→	evaporation
infiltrate	→	infiltration

How many words like this can learners think of? Use this as a vocabulary-building exercise.

Consider the origins of the word "water" in as many different languages as you can think of. What languages use similar roots?

for example: English	- water
Afrikaans	- water
German	- Wasser
Swedish	- vatten
Dutch	- water
Danish	- vand
Nama	- //gam-i
Otjiherero	- omeva
Otjihimba	- omeva
Oshiwambo	- omewa
Lozi	- mezi
Kwangali	- mema
Italian	- acqua
French	- eau
Portuguese	- agua
Spanish	- agua

Does the list tell you anything about the history and development of these various languages?

1. Look at the map of Africa's perennial rivers and then look at a population distribution map or a map of towns and cities in Africa. How have the positions of perennial rivers affected the settlement of people in Africa?

1. **Why does Namibia have the Caprivi Strip?**
Did you know that the Germans who colonised Namibia wanted to be able to get to the Zambezi River for trade purposes so the Caprivi region was included in Namibia?

What role have rivers played in the location of national boundaries in Africa? What are the river boundaries of Namibia?

See the lesson card entitled "What is a country?" for more information and ideas for teaching about borders.

1. We know that the early exploration and colonisation of Africa often occurred along large rivers. Read about some of these expeditions and discuss how rivers provided a path for the early colonisation of Africa. Use this to introduce what colonisation is and how the people and cultures of Africa have been affected. You may deal with a variety of effects: cultural, dietary, political, leadership, environmental, etc.

1. **"What provides energy for the water cycle?"**
Fill a container, such as a bucket, with water. Ask for a volunteer from the class. The task of the volunteer is to lift the bucket of water and keep it at head height. It will be clear that the learner needs energy to lift the bucket. At this point ask the learners if they know where water gets the energy to lift water from the sea into the atmosphere. Of course the answer is... the SUN!

1. Most of our major religions originated in arid areas. Trace the origins of religions to various countries or regions of the world. What do these arid areas have in common with Namibia? Can you find any similarities between the environment described in the Bible and Namibia's environment? Consider wells, rivers, water storage methods, fishing methods, etc.

1. Consider the moisture content of a number of foods we get from plants. Where do plants that produce commercially sold fruits, etc. originate from? Do any of these plants grow successfully in Namibia? You may want to make a collection of tropical and indigenous fruits, grains, beans and roots for the class to look at.

"In and out of water!"
ke a study of amphibians. Introduce the study by asking learners to design a vehicle that can travel both and and in water. Let them introduce their designs to the class and make a written record of all the most ortant features that make a successful amphibious craft. You can then show pictures of, or tell learners out, amphibious animals such as frogs, crocodiles, hippo's, ducks, otters, etc. Are there any similarities tween these animals and the learners' amphibious vehicle designs?

You can build a mini-watercycle in your classroom!
uild a terrarium (plants growing in a closed container) in your classroom. Water the plants only once and seal container. Get the learners to observe how the water evaporates, condenses on the sides of the container runs down into the soil to provide water for the plants. The same water is used over and over again!

A terrarium made from a large glass jar

Use a glass tank for a terrarium but remember that you must have a sheet of glass to place on top

Look at the importance of water in the life cycles of a number of animals. How many animal species can e learners think of that are dependent on water for breeding and/or part of their life cycle? How many of ese animals occur in Namibia and where do they occur? Discuss how an understanding of life cycles can important in controlling pests such as mosquitoes and some flies.

1. Study the chemistry of water by making models of water molecules with plasticine and matchsticks.

2. **"If icebergs didn't float"**
Set this as a homework exercise under the topic of "density". Learners must study the reason why ice floats on water and consider the consequences for the planet Earth if ice did not float the oceans.

the learners to make simple magnifiers from drops of water, water in clear plastic bags or from water glass containers. Choose the best one and use it to introduce the concepts of refraction of light in water.

Challenge: "How can you change the density of water?"
nclude this as a challenge for learners when studying the topic of density. After having introduced the arners to the concept of density, set them the task of changing the density of a liquid. They should design experiment that shows how they can change the density of water. More advanced learners can be allenged to work out a way of determining the percentage change in density.

w to do it: freeze water in a plastic container (glass containers will crack) and you will notice that the ume increases when it turns to ice while the mass stays the same.

In order to demonstrate how the evaporation of water has a cooling effect, get learners to sit in the sun a wet sock on one foot and a dry one on the other. Let them feel the difference for themselves. If learners not wearing socks they can wet one sleeve and keep the other dry.

Design a study unit called "Chemistry and Water". In it plan a number of lessons and experiments that w how a variety of chemicals react with water. Consider chemicals such as acids, alkali-earth metals, When dealing with these discuss the effects that modern industry is having on the environment by rivers and the ocean with chemicals.

1. Study the phenomenon of capillarity using drinking straws and other tubes and pipes with a variety of small diameters. Remember to mention the importance of capillarity in the movement of water in between soil particles and inside the roots and stems of plants.

1. Set up an experiment to measure the latent heat of water. You will need some source of heat, a thermometer and a container that can be heated. Record in a table the temperature changes as the water heats up, boils and then evaporates and then plot the results on a graph. Remember to work carefully with the thermometers - do not leave them in the container while the water boils.

ater is the only substance that occurs naturally in all three states on earth. The greenhouse effect is osed to result in an increase in global temperatures and so result in large amounts of ice melting at the s. Discuss with the learners how the shift in the balance between ice, water and vapour is likely to affect ife on earth.

MATHS

1. Use the information in chapter 1 on page 5 to make a graph or pie diagram showing what percentage of the world's water is available for use by people.

1. **Make a fridge.**

Design and construct a cool box or a "fridge" that works on the principle of evaporative cooling. Your design must use water as efficiently a possible.

General.

1. Pretend that you are an explorer travelling down a river by boat. Describe your journey in a logbook. Record information about the people that live along the river, their habits and diet, the types of animals and vegetation that you encounter and any other things that you think are worthy of entering into a logbook. You may make sketches to add interest to your logbook. There should be a page for Science, History, Geography, Art, English, Home Economics, Technical Subjects, Agriculture, etc. Logbooks must be handed in to the respective teachers for marking.

2 The river of time

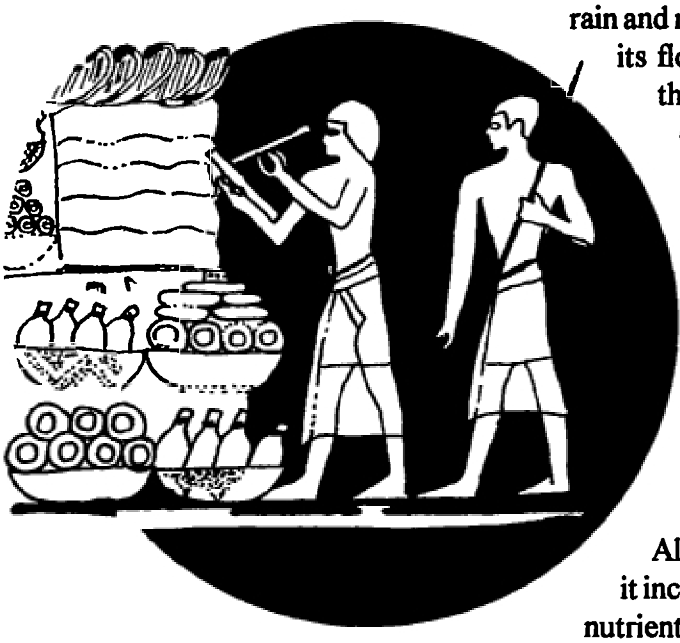
The passing of time is often compared to water flowing under a bridge, but time is not the only thing that flows through our history. Because people cannot live without water, the history of humanity also includes the history of our interactions with water. Without access to and some degree of control over water, human life is impossible. Over the ages people have used water to irrigate their crops, raise great civilisations, power their machines and spread their cultures and trade over the face of the earth.

Early civilisations were, to some degree, defined by their ability to control and use water. In Africa the ancient Egyptians built their pyramids close to the Nile, while in the Middle East the Mesopotamians developed a network of canals for irrigation and transport. Water was one of the first sources of energy that people learned to harness, and even today it is the source of much of our electricity. In Namibia where and how people lived was determined by the availability of water, and our course of development and present economy were dictated by the scarcity of this precious resource.

Ancient Egypt - "*Gift of the Nile*"

"Egypt is the gift of the Nile", said Herodotus (a Greek historian) 2 400 years ago, for the ancient Egyptian civilisation owes its existence to this mighty river. The most important achievement of Egyptian civilisation was its control of the Nile's annual floods.

It is believed that, in ages past, the climate of the Egyptian region was much wetter than it is today. However, with the end of the ice age in Europe there was less rain in Egypt, and people of the region moved nearer to the river, living off its water and fertile farming land. Every late June the lower Nile, swollen by tropical rain and melting snow in the river's upper reaches, rises to cover its flood plain. When the waters recede they leave behind them a rich silt which provides nutrients for crops grown on the floodplain.

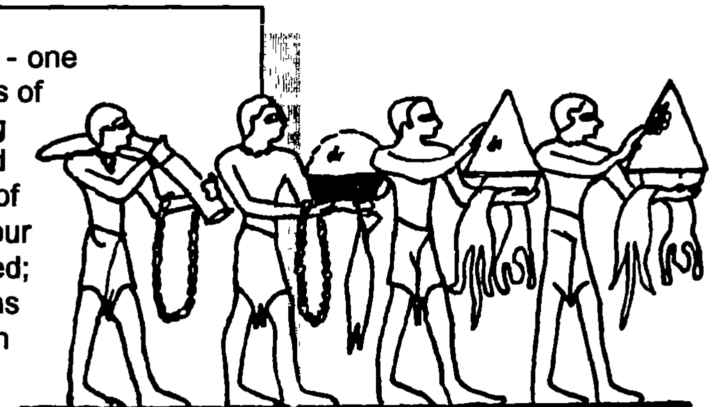


The ancient Egyptians saw the Nile River, on which they depended for life, as a god. They called this god Hapi, and he was plump and well-fed and liked to give and receive gifts. Most ancient Egyptian pictures of him show him carrying ripe crops. In return for his bringing life to the fields with the annual floods of the Nile, the Egyptians gave him gifts of food, precious ornaments and jewels.

Although the Nile's annual flooding is very important as it increases the fertility of the flooded land by bringing down nutrient-rich silts, it can also bring destruction. So, the ancient Egyptians invented methods of controlling this flooding, using canals, earth banks and walls. Using these same methods, the ancient Egyptians also developed the system of irrigation which lies at the root of Egyptian civilisation and which ensured their survival in an environment that was becoming drier and drier. A system of flood basins, which controlled and distributed water and silt inside earth embankments, meant they could grow more than one crop a year. The ancient Egyptians mostly grew wheat and barley. Water from the river was also used to grow vegetables, fruit trees and grape vines all year round.

This yearly cycle of life-giving floods has now been broken by the construction of large dams such as the Aswan, but the fertile floodplain of the Nile still provides modern Egypt with many valuable agricultural products .

The ancient Egyptians used two different calendars - one based on the moon, which they used to set the dates of religious festivals, and another based on the flooding of the Nile. Under this calendar, the year was divided into three seasons: *Akhet*, which saw the beginning of the flood and which covered the approximately four months during which the fields would be saturated; *Peret*, when the land finally coming out of the flood was ready for sowing; and *Shemou*, which was the season during which crops were harvested and stored.



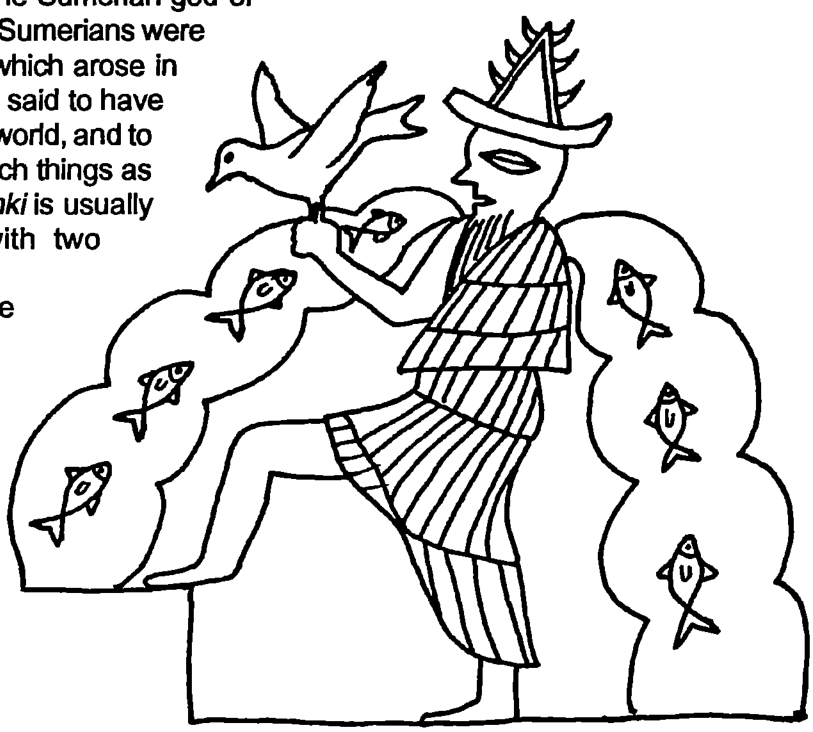
Mesopotamia - a civilisation founded on water

Even earlier than in Egypt, in the delta of the Tigris and Euphrates Rivers one of early people's greatest civilisations arose. Mesopotamia is a Greek name, meaning "between the rivers" for the land of the Tigris and Euphrates rivers - now ruled by Iraq and Syria. This area was, in ancient days, the birthplace of many of humanity's important achievements. For example, the earliest surviving form of writing comes from this region, preserved on clay tablets.

Mesopotamia was also very important in terms of the development of agriculture. Irrigated agriculture was carried out in Mesopotamia as early as the 4th or 5th millennium B.C. Barley, wheat and sesame were the main crops grown, although a wide variety of vegetables and fruits were also cultivated. In later years, more barley was grown than wheat because barley is a more salt-tolerant plant and continuous irrigation had raised the level of salinity in the soils of Mesopotamian farms and lowered their fertility.

The Mesopotamians were interested not only in irrigation, but also in controlling the flooding of the two great rivers, and with providing water for the large towns that had sprung up. Much of their effort also went into establishing a huge network of canals that provided transport for people and goods both within their cities and between them. The most famous human-built waterway in Mesopotamia was the 122m wide Nahrwan Canal, which was used mostly for irrigation. It stretched for more than 320km parallel to the Tigris.

Enki was the name of the Sumerian god of water and wisdom. The Sumerians were one of the civilisations which arose in Mesopotamia. *Enki* was said to have created the order of the world, and to have given the world such things as irrigation and fishing. *Enki* is usually pictured as a man with two streams flowing from his shoulders. These represent the twin rivers of the Tigris and the Euphrates. He was a very important god in the Sumerian heirarchy, as his waters fertilised the earth.

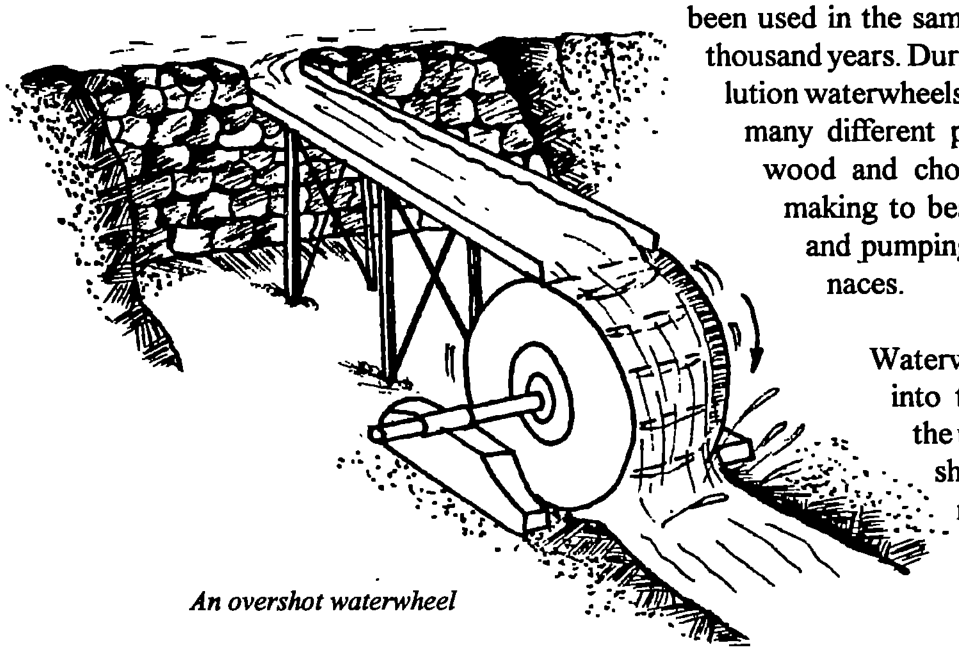


From waterwheels to steam power

For centuries people have used water to help them do their work. Even today, water is essential for most modern industries: if not as a source of energy then as a coolant, cleaner or for some other necessary part of the manufacturing process. Our progress in harnessing the force of water - from water wheels to steam power to today's sophisticated hydroelectricity schemes - marks our movement towards industrialisation.

Waterwheels

Waterwheels are one of the earliest ways in which people harnessed the mechanical power of nature to help them in their work. The most common uses for water wheels are crushing grain and raising water for irrigation. Waterwheels are used for these purposes in many areas of the world at present, and there are records of them having been used in the same way for at least two thousand years. During the Industrial Revolution waterwheels were used for a a great many different purposes, from sawing wood and chopping rags for paper-making to beating hides for tanning and pumping bellows for blast furnaces.



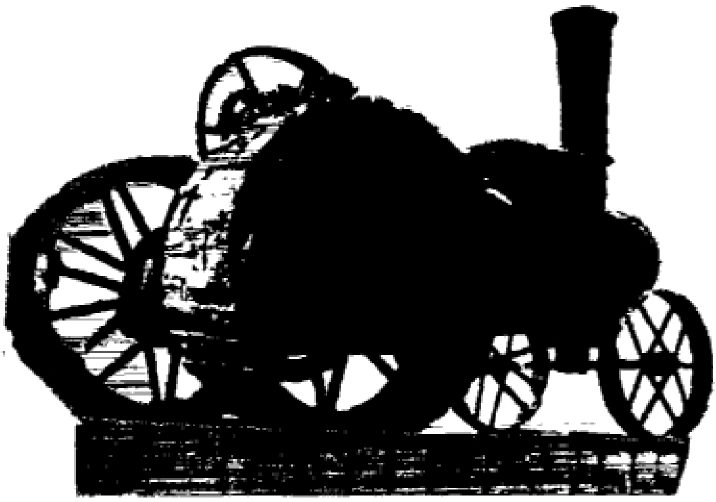
An overshot waterwheel

Waterwheels can be divided into two basic categories - the undershot and the overshot varieties. In both varieties work is done by the energy generated by the force of water turning the waterwheel.

Steam power

Water was actually the Industrial Revolution's major source of power - not through its use in waterwheels but by its use in a new invention, the steam engine. These engines utilised the peculiar physical properties of water (its fairly low evaporation temperature and its latent heat) to drive a piston that was capable of powering many different machines.

The 'Martin Luther', a steam tractor that stands near Swakopmund, was driven by this power source. Coal-fired power stations that generate electricity, like the Van Eck power station in Windhoek, use steam-driven turbines to do this to this day.

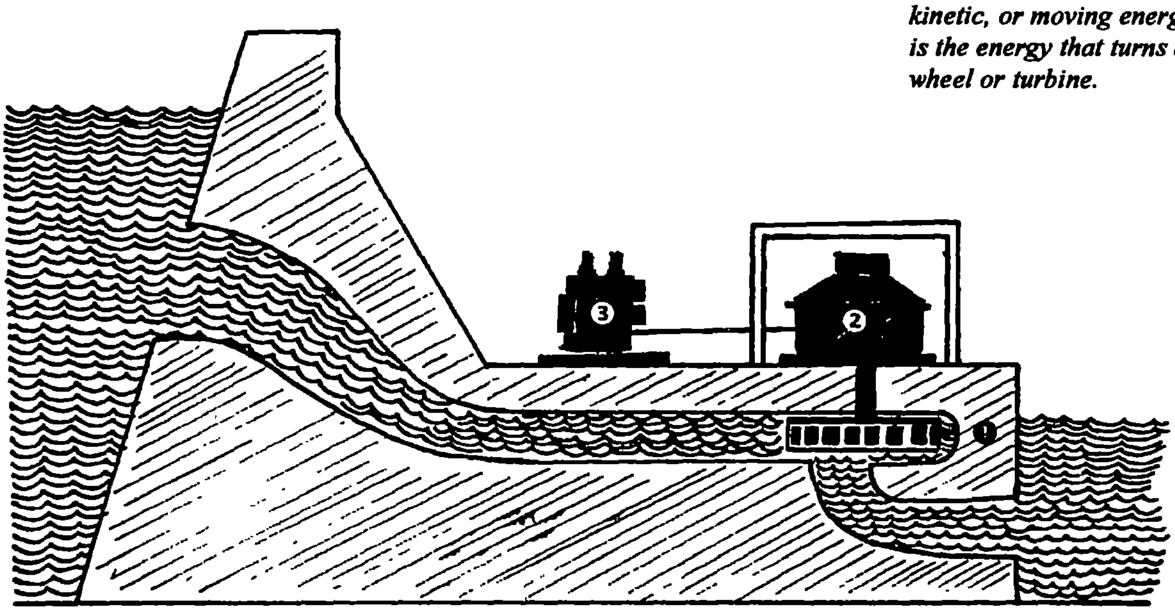


The "Martin Luther" which stands just outside Swakopmund is a steam engine which became immovably stuck in deep sand because of its driver's inexperience. It was named after Martin Luther who said: "Here I stand; I cannot do otherwise".

Hydroelectricity

Hydroelectric stations generate electric power from dammed up water. Water in a high dam has a huge amount of potential energy. This energy is released when the water rushes down a channel, and turns the rotary blades of a turbine ❶ - a modern form of the ancient waterwheel. Power generated in this fashion is converted into electricity by a generator ❷ and is used to provide the energy necessary for many facets of modern life. A transformer ❸ is used to convert the power into a form in which it can be supplied through long distance powerlines to its consumers. Namibia has a hydroelectric power station at Ruacana, on the Kunene River, which makes a substantial contribution to Namibia's supply of electricity. There are currently plans to build a second large hydroelectric power station at Epupa Falls.

Potential energy is energy that a body has because of its position. Dammed up water has potential energy because to flow down and out from a dam means it has the potential to do work. This potential energy is transformed into kinetic energy when the water is released, and this kinetic, or moving energy, is the energy that turns a wheel or turbine.



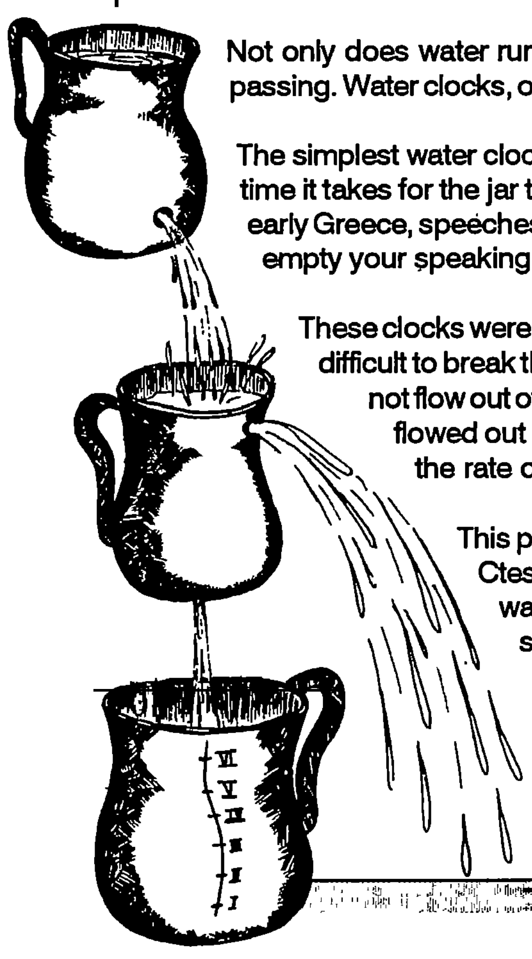
Water in Namibian history

Namibia has always been a dry country, and for this reason water has played a very important part in our history, plays an essential role in our present, and is vital for our future.

The early inhabitants ofNamibia were pastoral nomads or hunters and gatherers. They lived off the land. Pastoral nomads drove their livestock to areas where grazing was good and water was available, shifting from place to place depending on conditions. This type of lifestyle is called transhumance. Hunters and gatherers fed on game and wild plants. Their patterns of movement were also determined by weather, veld condition and availability of water. These early Namibians obtained their water from rivers, springs and shallow wells that they dug in the beds of ephemeral rivers. When the water dried up they simply moved on to new spots where water, grazing and game were available. Permanent settlements were only possible in places where there was a reliable supply of water, such as on the banks of Namibia's perennial rivers or near permanent springs.

For example, archaeological evidence shows that people have lived in the catchment areas of Namibia's western flowing ephemeral rivers for thousands and thousands of years. This evidence includes the area's rich heritage of rock paintings and engravings. Agricultural development here began about two thousand years ago, when nomadic hunter gatherers in the area began keeping livestock that were introduced from northern Africa. Their hunter gatherer lifestyle changed to one of nomadic pastoralism, and to this day livestock play an important role in the lives of the people in this area.

Water and time



Not only does water run through history, it has also been used to measure its passing. Water clocks, or clepsydras, were used as long ago as in Ancient Egypt.

The simplest water clocks are jars with one or several holes in their bases. The time it takes for the jar to empty through these holes becomes a unit of time. In early Greece, speeches in court were limited by these devices - when the jar was empty your speaking time was up.

These clocks were useful for measuring one or more units of time, but it was difficult to break these units down into smaller sections because water did not flow out of the jars at a constant rate. When the jar was full the water flowed out fast because the pressure was high. As the jar emptied, the rate of flow grew slower as the water pressure decreased.

This problem was solved in about 250 B.C. by a Greek barber, Ctesibus. His device consisted of three containers. The first was the source of water. From it water dripped into the second container, the level in which was kept at a constant height by an overflow outlet in its side. The third container could be marked off into levels which measured the passing of time.

Herders are governed by the availability of water. In times past, when herders and their beasts moved between pastures their movements depended on the location and state of waterholes. Since boreholes and other forms of water supply have been developed, fences have been built and the numbers of both people and animals have increased, many of these seasonal migrations are a thing of the past.

Nomadic pastoralism, throughout Namibia, began to disappear with the arrival of Namibia's colonisers in the 19th century, although remnants of it are still found today. Many people consider that nomadic pastoralism is one of the systems of farming best suited to our arid land. It takes our dry and variable climate into account, and the movement of livestock helps prevent overgrazing in any one area. However, this system can only function where there is a lot of land and few people and livestock. In many areas of our country there are now simply too many people and animals for this system to work. Rotational grazing is a modern system of livestock farming based in part on this ancient practice, and is one that benefits both our livestock and our land. All farmers' lives revolve around water - without it there could be no crops as well as no livestock - so our future depends on careful management of our water and our environment.

Evidence of Namibia's earliest farmers includes sheep dung found at the Mirabeb inselberg in the central Namib Desert. This dung is thought to have come from livestock in the area more than 1 500 years ago. Sheep herders would have brought in their livestock following good rains, when grazing and water were available. In dry years, or when the grazing was exhausted, they would have grazed their animals in other areas.

Since time immemorial, patterns of settlement have been very closely linked to the availability of water, whether it be in the form of rivers, rainfall, warm or cold springs, or easily accessible groundwater. Places where water is available have been inhabited for centuries. Windhoek was one such place, relying on springs to provide water for those who lived there. These springs have now vanished - the city's growing population has abstracted so much water from the area that the groundwater table has dropped below the level necessary to keep those springs flowing. Other settlements built around water sources include those at Waterberg, Rehoboth, Warmbad, Klein and Gross Barmen, Omburo and Omapju.

As people in Namibia settled permanently in areas and these settlements grew and grew, more and more demands on our water sources were made. Farm dams were built and boreholes drilled. Larger dams were built to ensure reliable sources of water for towns. And the rate of groundwater tapping increased, in many cases to levels too high for the available resources. With modern systems of water supply, people are able to live in areas that would not formerly have been able to support them due to lack of water. Artificially supplying areas with water is costly not only in water but also in the finances needed to build and maintain water supply systems.

Thirst will move nations - Sudan

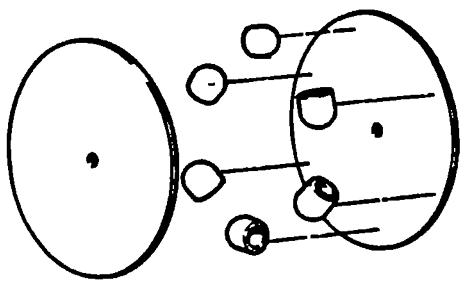
Our modern ability to manipulate water and supply areas with water they would not normally have does bring with it some problems. In areas where lack of water used to limit the number of livestock able to live in them, grazing is now the limiting factor, and overgrazing is a serious threat to the environment. Also, it must be remembered that water is in short supply all over Namibia, and that we cannot rely on modern technology and water carriers to provide ever increasing amounts of water without considering ways of eliminating wasteful practices from our lifestyles - there is simply not enough water for this to be possible.

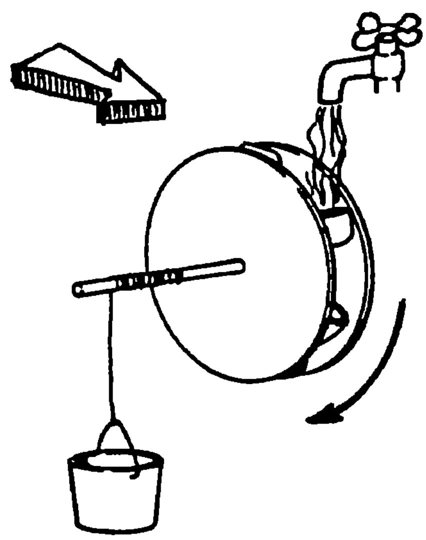
Things to do...

Make your own water wheel

Water wheels are fun to constuct and can be used to demonstate how water can do work. Let learners experiment with different materials and designs.

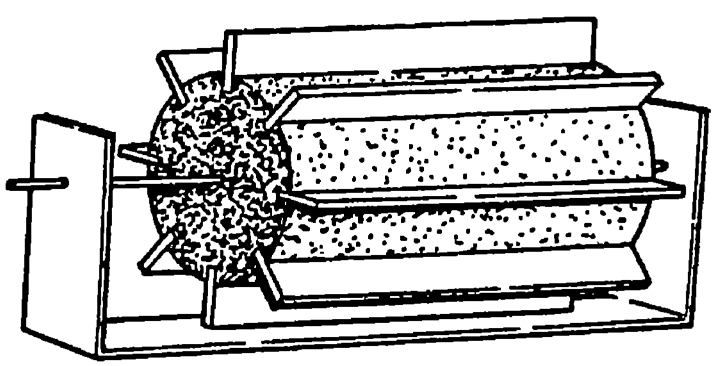
Schools near rivers or canals can build models that harness the energy of the flowing water. If you are using a tap to drive your water wheel, **please** remember to be conservation minded and catch the water to use on the vegetable garden or other plants.





A water wheel made with plastic cups

A water wheel made from a wooden pole with plastic or wood slats



Chapter 2 Activities

1. Through the ages pots have been an important way of storing water. Make a study of the pots used throughout history for the storage of water and beverages. Were any special designs used to decorate them? Compare these with traditional and modern storage vessels.

1. The Egyptians were a highly organised culture that owed a lot to one of Africa's largest rivers, the Nile. They also developed a very sophisticated form of art and writing. If you have access to reference books or a library, study their art, writing and architecture.

Are there any rivers that played an important part in the lives of ancient Namibians? How have things changed with time?

1. Briefly look at the Egyptians' use of symbols in their peculiar form of writing called hieroglyphics. What symbols were influenced by the environment? What symbol was used to represent water? Is a similar symbol used to represent water on maps, road signs, etc. in the modern world? Can you think of a better sign?

1. The Mesopotamians and the Egyptians believed that the elements of water, sun, fire, earth, etc. where controlled by gods. Great respect was paid to these gods. Find out more about the water gods and what significance they had in the spiritual life of these people.

1. Construct a water wheel that can be used to lift objects or do some form of work. Study ways in which water wheels and turbines are still used in the modern world. What advantages and disadvantages do water wheels have for the environment ?

1. Design and build a water clock that can be used to tell the time. Make the water clock as efficient as possible so that water is not wasted.

1. Many wars and battles have taken place at sea. Choose a battle and discuss what the political motives for the battle were.

2. Building up powerful navies is often seen as a priority in many countries with long coastlines. Discuss the good and bad effects that military activities can have on the environment. Try to find examples from the past that support your point of view.

3. Future wars may well be fought over water rights. Discuss this. Find evidence in newspapers and magazines to support your point of view.

1. In the past, the settlement patterns of people were largely determined by the availability of water and landforms created by water. How has the availability of water affected the settlement of people and what water-created landforms are ideal as places for communities to settle? Say why. Useful examples include alluvial valleys, caves, floodplains, springs, etc.

1. Consider what types of plants and crops where grown in different parts of the world in the past. How did the availability of water play a role in determining what was planted? In the past people of Namibia used to depend on what grew naturally when there was rain. Name some of the important harvests of days gone by.

Studies have shown that the fertility of the soils of the Nile Valley has decreased steadily ... the years. Make a study of agricultural practices that can harm soil fertility and write a small pamphlet ... can be distributed to farmers to help them to stop soil fertility from decreasing. Do you know of places ... Namibia where soil fertility has decreased? Why has it happened?

The ways of water

Water is the commonest liquid on planet earth. It is therefore hardly surprising that it plays a major role in shaping the earth's surface. Where water flows over the surface of the earth it causes a number of changes. Erosion, changing the shapes of rocks, depositing sand and stones, and even forming massive river valleys like the Fish River Canyon are all part and parcel of the dynamic processes that water is involved in. Without water the surface of the earth would look very different from the way it presently does.

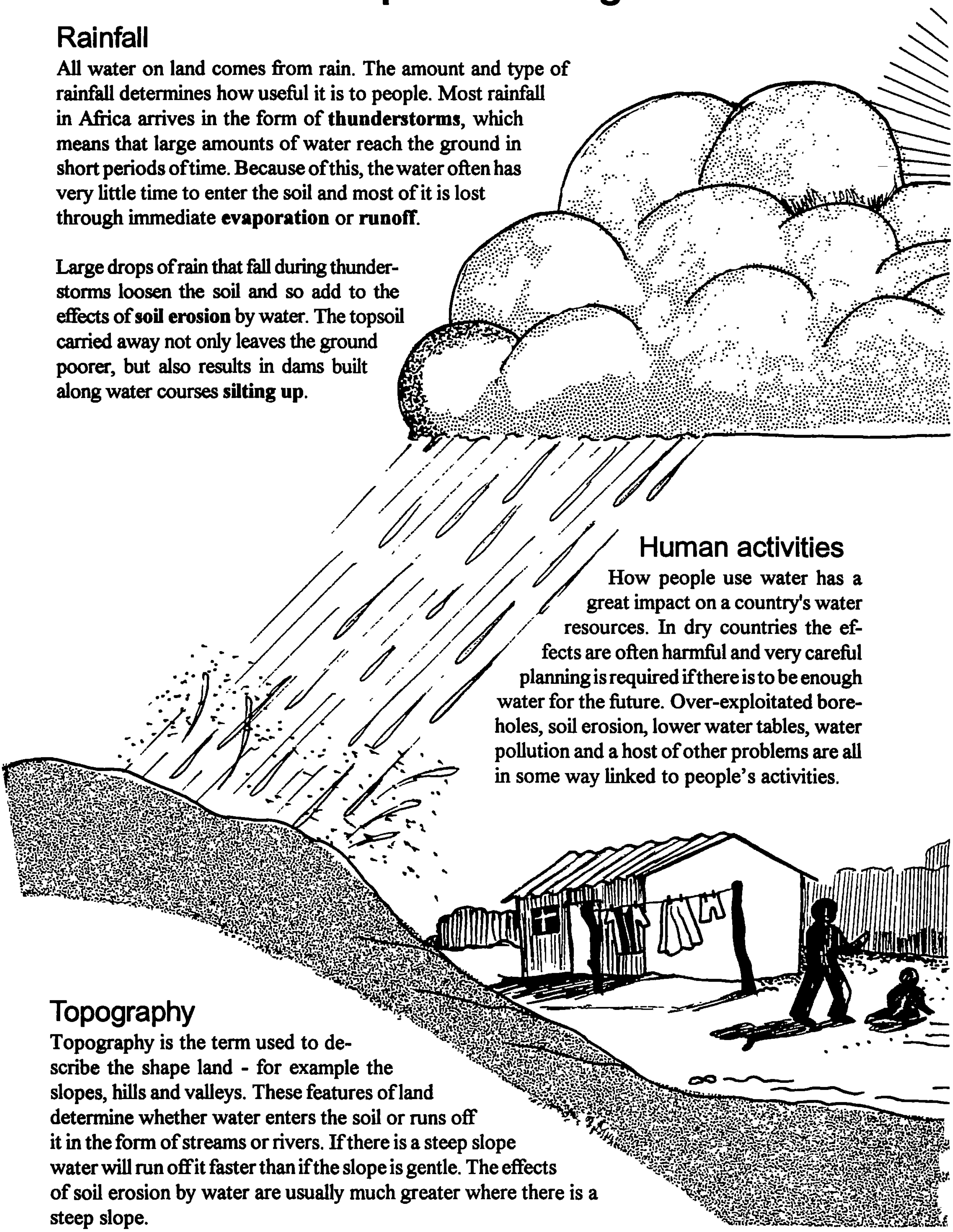
In order to understand the dynamic processes of water it is necessary to spend a little time learning about the distribution of water, where it accumulates and how it moves.

Important things to know...

Rainfall

All water on land comes from rain. The amount and type of rainfall determines how useful it is to people. Most rainfall in Africa arrives in the form of **thunderstorms**, which means that large amounts of water reach the ground in short periods of time. Because of this, the water often has very little time to enter the soil and most of it is lost through immediate **evaporation** or **runoff**.

Large drops of rain that fall during thunderstorms loosen the soil and so add to the effects of **soil erosion** by water. The topsoil carried away not only leaves the ground poorer, but also results in dams built along water courses **silting up**.

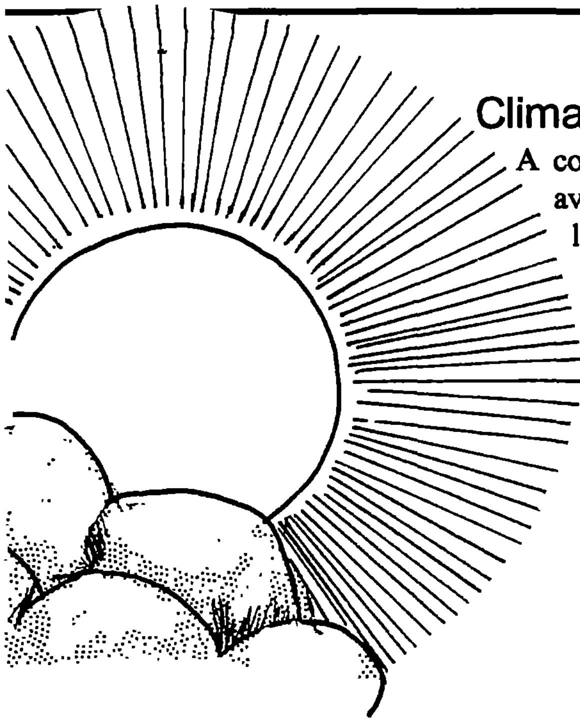


Human activities

How people use water has a great impact on a country's water resources. In dry countries the effects are often harmful and very careful planning is required if there is to be enough water for the future. Over-exploitated boreholes, soil erosion, lower water tables, water pollution and a host of other problems are all in some way linked to people's activities.

Topography

Topography is the term used to describe the shape land - for example the slopes, hills and valleys. These features of land determine whether water enters the soil or runs off it in the form of streams or rivers. If there is a steep slope water will run off it faster than if the slope is gentle. The effects of soil erosion by water are usually much greater where there is a steep slope.

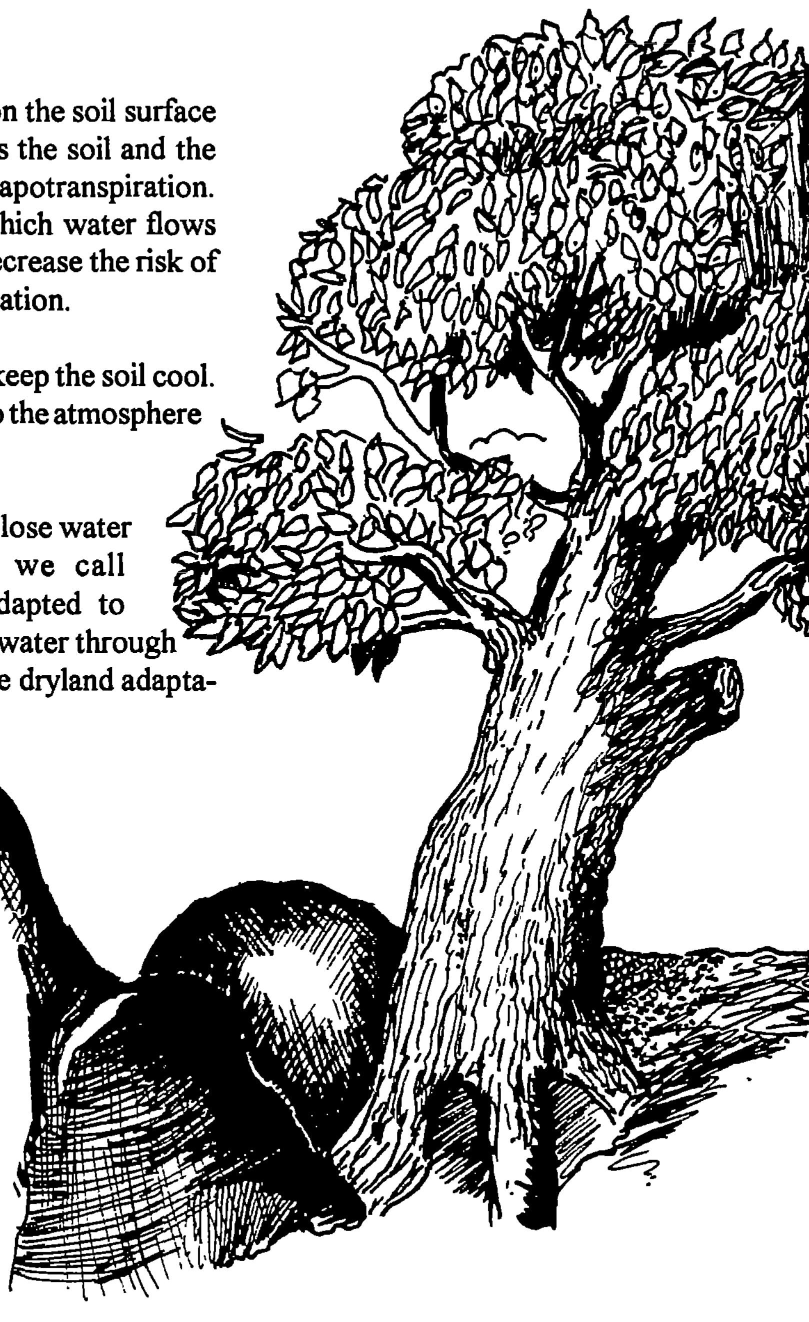


Climate

A country's climate determines the amount of water that is available in that country for people to use. Hot, dry climates, like our Namibian climate, result in large amounts of water evaporating from soil, rivers, lakes, pans and dams, leaving very little water to recharge the groundwater supply or for people to use. Climate also determines the amount of moisture that is available in the soil for plants to use. Hot, dry climates increase the loss of moisture from open water surfaces and soil.

Vegetation

The number and type of plants growing on the soil surface influence the amount of water that enters the soil and the quantity of water lost from the soil by evapotranspiration. Because plants reduce the speed with which water flows over the surface of the soil they help to decrease the risk of soil erosion as well as encouraging infiltration.



Plants also provide shade which helps to keep the soil cool. This can reduce the amount of water lost to the atmosphere through evaporation.

As part of their natural growth, all plants lose water through their leaves in a process we call **evapotranspiration**. Plants that are adapted to living in dry climates usually lose far less water through evapotranspiration than those do not have dryland adaptations.

Geology

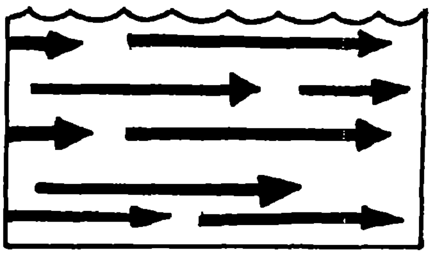
The types of rock found in an area greatly influence the quantity and distribution of groundwater there. The shapes of the rocks; their composition; the way in which they were formed; and the position of cracks, contact zones and faults all influence how water moves through the soil and where it accumulates. Gravel, sand, conglomerates and sandstone are different to shales, igneous and metamorphic rocks when it comes to **porosity** and the way they interact with water.

Rivers and streams

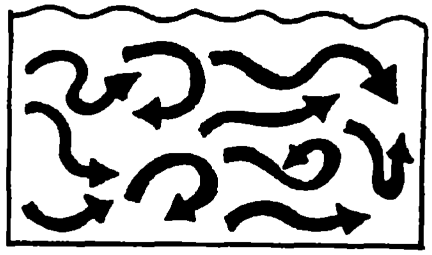
When rain reaches the ground it can either enter the soil, evaporate back into the atmosphere or run over the surface of the land in the form of a river or a stream. Below are some important things to consider when studying river flow.

Types of water flow

The type of river flow will have an important effect on whether or how a river erodes the land it is flowing through. Turbulent flow is highly erosive.



Laminar flow *occurs at low velocities.*



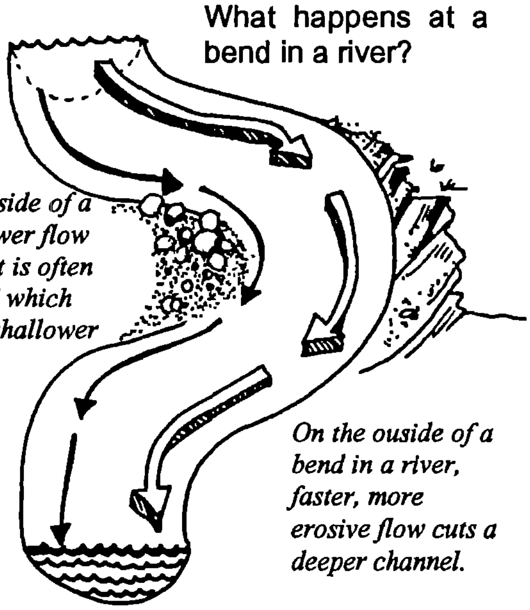
Turbulent flow *occurs at high velocities.*

River energy

The amount of work that a river can do depends on the **energy** of the water in it. The energy of a river can be used to to do work such as turn waterwheels or turbines. Using the energy of flowing water is one of the cheapest and most pollution-free ways of generating electricity. Hydroelectric power schemes are usually built where water flows quickly down steep slopes or over waterfalls, like at Ruacana on the Kunene River.

Going round the bend!

What happens at a bend in a river?



On the inside of a bend, slower flow means silt is often deposited which makes a shallower section.

On the ouside of a bend in a river, faster, more erosive flow cuts a deeper channel.

Erosion

As rivers flow over land they erode the surface of the land they flow over. Particles of sand and rock are carried away by the river. These particles are usually deposited later in the river channel, or in the sea. A river's ability to cause erosion is a function of the velocity and quantity of water in the river.

Highly erosive rivers transport tonnes of soil to the sea each year and cause the loss of fertile soil from land. Slow flowing sections of a river, on the other hand, deposit the materials that are being transported. **Deposition** can result in problems such as dams and hydroelectric schemes silting up, but it can also enrich the soils of some areas - for example floodplains.

River discharge

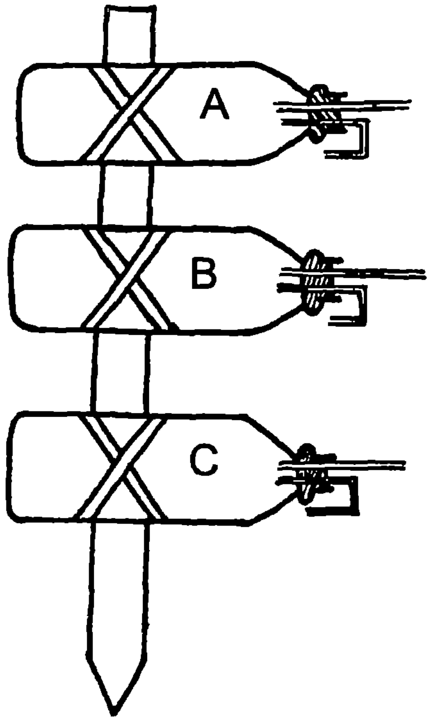
This is a measurement of the amount of water flowing past a certain point in a river in a certain amount of time: usually the amount of water passing one particular point in one second in a particular river. There are many ways of measuring river discharge, but a simple method can be seen on the following page.

A weir across the Kuiseb River provides an accurate cross-section for calculating discharge.

River loads

Rivers can carry at lot of material with them as they flow. The amount and types of material that a river carries depend on the energy that the river has. The material that makes up river loads can be divided into the following groups:

1. floating materials - leaves, branches and even trees
2. dissolved materials - lime, salts, etc.
3. suspended materials - sand, small stones, pebbles, etc.



Make your own suspension sampler for sampling suspended materials in a river or canal near you. Bottles A, B and C will collect samples at different depths.

Things to do...

Measuring discharge from a pipe

Discharge = 10l / 40s = 0.25 litres per second

Measuring discharge of a canal or river with the help of a float

The discharge of a river or a canal can be calculated in a fairly simple way. You will need to take measurements of the cross-section of the river - an approximate answer will do. Remember to warn learners of the dangers of playing near water and make sure that there is an adult who can swim in attendance at all times. Keep a look out for crocodiles if they live in the river you are working on!

Take the appropriate measurements and use the following formula to calculate the discharge of the river:
***Q = A x V** (Quantity is equal to Area times Velocity)*

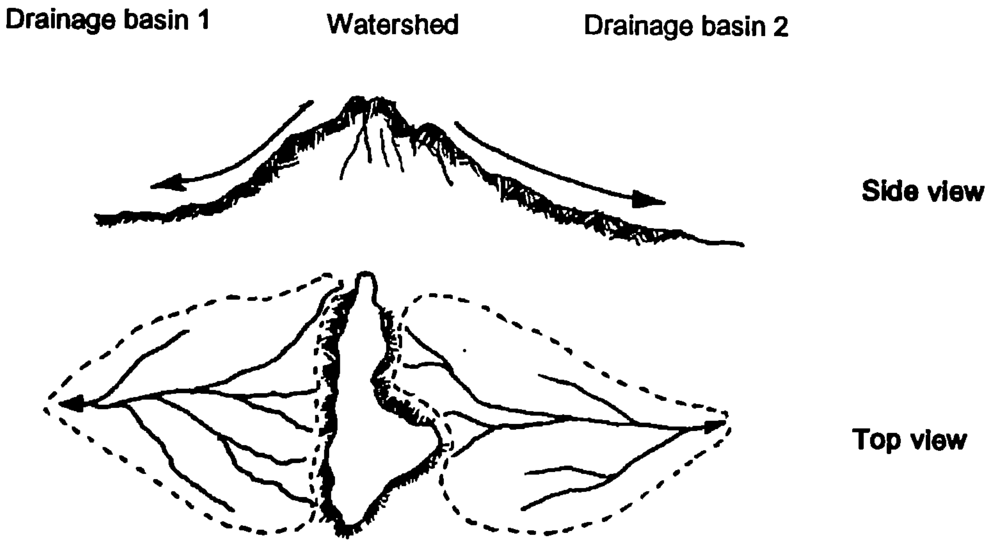
Calculating A:
Measure the depth = D
Measure the width = W
Calculate the area (A) : A = W x D

Calculating V:
Measure the distance: R to S
Take the time for the float to go from R to S
Velocity (V) = Distance ÷ time

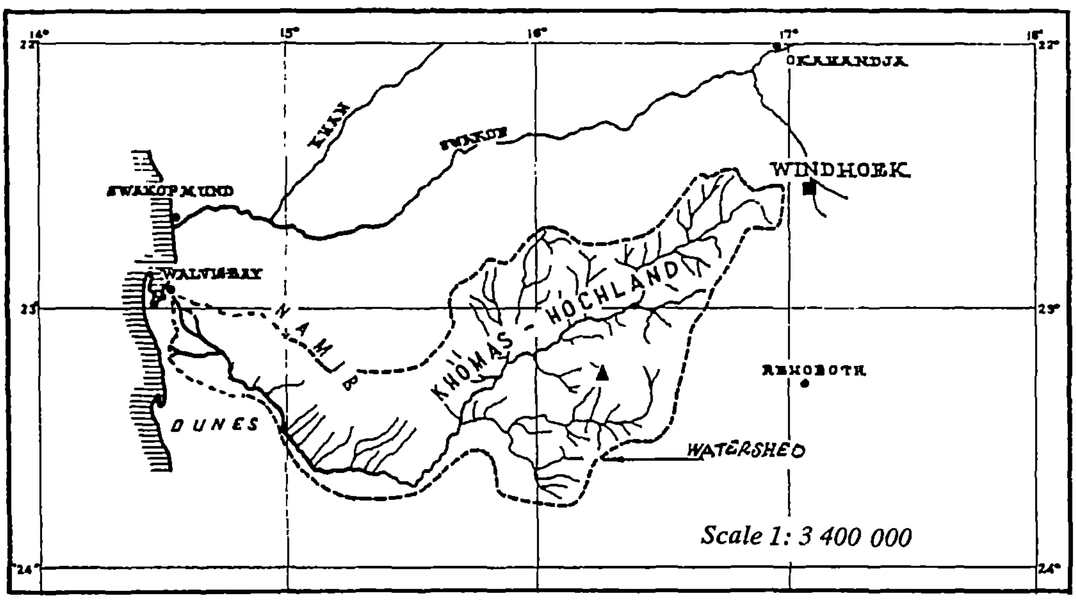
Here is an example:
Q = A x V
Q = 1.2m² x 3m/s
Discharge = 3.6m³ per second

Drainage basins and watersheds

A **drainage basin** is the term used to refer to an area that has a number of rivers and streams flowing across it. All these rivers flow into one main river. Drainage basins get their water, or **input**, from rain that falls over this area of land. Water leaves a drainage basin as its rivers flow on the surface or underground into the sea, a pan or swamp (**output**).



Drainage basins are separated by hills or mountainous areas. After rains, water flows down the sides of the hills and into the drainage basins. We call the hills or mountains that separate drainage basins **watersheds**. The size of a drainage basin depends on the position of the watersheds.



Map showing the drainage basin and river system of the Kuiseb. The whole drainage basin covers an area of 18 000km²

Source: Water in SWA by H. Stengel. 1963

Wetlands

Throughout history, wetlands have been seen as unproductive lands that are home to disease-carrying insects and dangerous animals such as hippopotamuses and crocodiles, but this is only one side of the story. In Namibia, wetlands support thousands of plants and animals and play an important role in the everyday life of thousands of people. In fact, the culture, habits, traditions and daily routines of a lot of people in Namibia are closely linked to our wetland systems.

The potential role of wetlands in our economic development still needs to be investigated. As mentioned previously, our wetlands currently support thousands of Namibians but there is the potential for these systems to play an even greater role in water purification, food production and income-generating activities such as tourism. Whether wetlands support development over the long term or not all depends on how we look after them.

Wetlands and culture

Communities that have grown up near a wetland often have a culture that is closely tied to it. Diet, transport, livelihood and lifestyle, dress and traditions are often closely linked to the wetland. Destruction or loss of wetlands leads to a loss of culture, heritage and traditions. In societies that rely on wetlands for fish protein, pasture, agricultural products and timber, severe problems arise when wetlands are drained or damaged. These communities have to spend more on food and other benefits they used to get that now have to be purchased, and consequently have less to spend on other necessities like education and housing. The quality of these peoples' diet also declines as there is a drop in the amount and variety of food eaten.

What types of wetlands are there?

The term "wetland" is used to describe a number of different places where water occurs naturally or artificially. Wetlands can occur inland or along the coast, which means that the water can be salty or fresh. Water may be found in a wetland all year round or for only part of the year. As a general rule, the water in a wetland is no deeper than 6 metres. Some examples of wetlands include estuaries, lagoons, flood-plains, freshwater marshes, lakes, pans and man-made wetlands.

Some examples of wetlands

Floodplains

When a river floods large areas of land on either side of itself we call these areas floodplains. Floodplains may be grassy marshes, flooded forests, or simply temporary pools of water. Many birds and wild animals depend on these floods which occur during the rainy season. Large numbers of fish can be brought down with the flood and can provide a source of food for people in the months to come. The Okavango floodplains and the oshana system in nothern Namibia are examples in our country.

Estuaries

The place where a river flows into the sea is called an estuary. The water in an estuary can be salty or fresh, depending on how stong the flow of the river is. Tides also play an important role in determining whether the estuary water is fresh or salty. At high tide seawater pushes up into the estuary making the water in the river mouth salty, while at low tide freshwater extends further down towards the sea. Because most of Namibia's rivers are ephemeral, this country does not have many estuaries within its borders. Our two main estuaries are found at the mouth of the Kunene River and the mouth of the Orange River.

Lagoons

Lagoons develop where a sand bank stops a river estuary from flowing directly into the sea. How salty a lagoon's water is depends on how close it is to the sea. Walvis Bay and Lüderitz are both built on lagoons.

Open coasts

Wetlands may develop along open coasts, even where there are no rivers. The **mudflats** along Namibia's coast are examples of open coast wetlands.

Swamps

Swamps are marshes that contain standing water for most of the year. The Linyanti Swamps provide a good Namibian example of this.

Freshwater marshes

When an area is often flooded by groundwater, springs or rivers , a freshwater marsh may form. Reeds, birds, fish and other forms of wildlife are usually found in such marshes.

Lakes

There are many different kinds of lakes, but one thing most of them have in common is that water in them can accumulate to a fairly great depth. Wetland habitats often develop on the edge of lakes where there is soil for plants to grow. Dams can be seen as lakes that have been made by people.

Pans

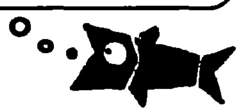
Pans are dips or depressions in the surface of the ground deep enough to hold water for part of the year. The water in pans often dries up in the dry season, leaving a salty layer behind it. Namibia has many large and small pans. Etosha Pan is an example of a very large pan. The soils of Etosha Pan are not as salty as one would expect them to be because wind blows the salt deposits away during the dry season.

What do wetlands provide us with?

Although many of Namibia's wetlands are dry for most of the year, they become areas of great activity after rains and flooding. Water in the wetlands allows grasses and trees to grow, and these provide grazing for animals, and thatch and fuelwood for people. People use reeds to build houses and make items such as mats and baskets for their homes. In some areas floods bring thousands of fish with them and these are an important source of food for people for a number of months in the year.

Wetlands provide raw materials for a number of crafts

Rice is a wetland plant that provides the staple diet of over half the world's population.



The effects of dams on wetlands

Although dams often create their own small wetland systems these are not as extensive or productive as natural wetlands. Dams may welcomed by people in urban settlements because they provide water and sometimes electricity, but their effects on wetlands and the people, animals and plants that depend on them for survivial are not always positive.

Large dams interrupt the natural flooding cycles of wetland areas, in some cases completely preventing water from reaching former wetlands. In Nigeria fish catches in the floodplains of the River Niger decreased by 50% in an area extending 200km downstream when the Kainji Dam was built. Without these fish, farmers and fishermen from the area had to leave home and find work in the cities and towns to support themselves and their families.

Why are wetlands important?

Wetlands are important all over the world. Human settlements have occurred near wetland systems since very early times as wetlands have been areas where people have been able to obtain food and water. The civilisations of Mesopotamia and Egypt owe a lot to the wetlands on which they based their agriculture and development.

A lot of Namibians live in our wetland areas. We should take great care of all of our country's wetland areas because they provide a valuable source of food and water. For example, most freshwater fish that we eat depend on wetlands, and cattle and wild animals are often supported by the grazing that wetlands provide. Wetlands also provide breeding grounds for many different bird species as well as water and nutrients to support trees and other vegetation.

Wetlands provide many other benefits too. They help recharge our groundwater by allowing water to filter down through the earth. They can help to stabilise shorelines and offer some form of protection from storms. They act as a sieve, retaining both sediment and nutrients and so purifying water at the same time as enriching farming land.

Changing wetland systems can have negative effects on local populations, plants and wildlife. There is international concern over the way in which wetlands have been poorly managed. In some places people have tried to convert wetlands into productive agricultural land. Other wetlands have been almost completely drained to provide irrigation water for crops or to provide more land for cattle to graze on. Wetlands have also been drained so that areas can be used for urban and industrial development.

Developments involving wetlands need to be carefully considered because wetlands are sensitive systems that, if damaged, may never recover. Destroying a wetland that serves many different functions to enable a single development that cannot fill the place of the wetland is something that should be strongly discouraged.

Poisons destroy wetlands

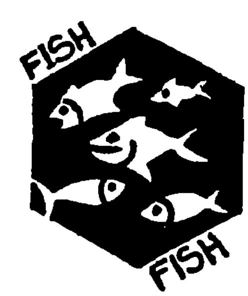
Pesticides used to control crop pests often end up in wetlands. These poisons, along with other chemicals used in agriculture, like fertilisers, can damage wetlands and the wildlife that depends on them. In Botswana, chemicals such as Dieldrin and Endosulphan are used to control tsetse fly. These flies breed and live in the wetland area of the Okavango Delta.

Although these poisons are aimed at tsetse flies, they can kill or harm fish and other non-target insects, many of which are beneficial to the ecosystem.The poison breaks down very slowly and because it is active for so long can enter the food chains of thousands of organisms. The overall effects on human health are unknown at this stage.

Wetlands provide us with:

Forest resources

Wildlife resources



Fish

Water

Water in the ground

Although it may seem unlikely, soil can hold a lot of water. Soil is made up of small particles with air spaces between them. When rain falls to the ground water enters the soil, filling these spaces. Because these air spaces are connected, water moves down through the soil until it reaches a rock or clay layer that does not allow water to pass through it. We say that this layer is **impermeable** to water. Water moving down through the soil will not be able to pass through this layer and will accumulate above it.

Aquifers

An aquifer is a fairly large source of underground water that can be abstracted for domestic, agricultural or industrial use. All aquifers store water underground in cavities in rocks or between soil particles. The water of an underground supply may be salty or fresh, acid or alkaline, hot or cold.

Different soils and rocks have different water-holding abilities depending on the amount of air space in them that can be filled with water. We call the ratio of open spaces to rock or soil volume **porosity** and we express it as a percentage. Porosity determines how much water can be stored in an aquifer.

An aquifer gets its water from one or more of the following sources:

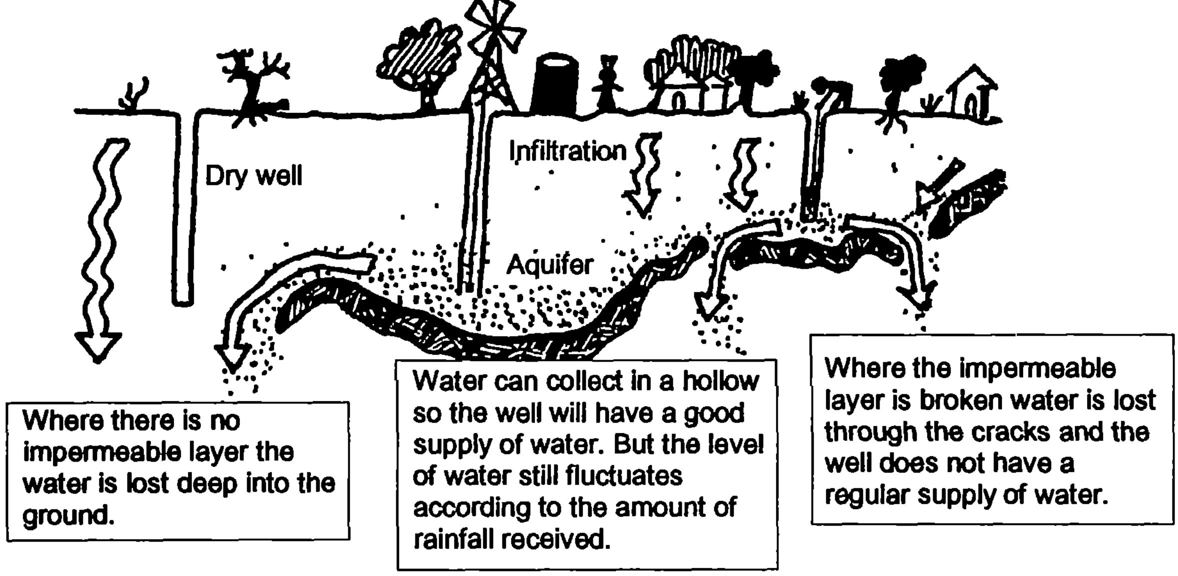
- water that was trapped underground many hundreds or thousands of years ago. This is often called **fossil water**
- water that filters horizontally through the soil from other groundwater sources
- rainfall that filters down vertically through the soil to the aquifer.

All of this water, at one time or another, comes from rainfall.

Water tables

A water table is the upper surface of an aquifer. A more detailed description would be that a water table is the boundary between the layer of soil in which the spaces between the soil particles are filled with air and the layer of soil in which the spaces are filled with water.

The presence and shape of the impermeable layer will determine how groundwater resources are distributed



Depth of water tables

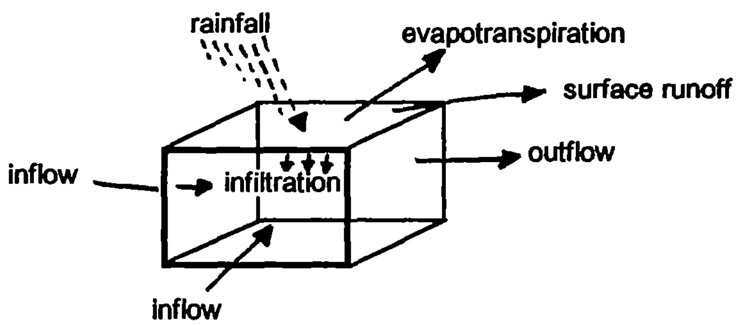
The depth of a water table depends on the amount of water that has filtered down into the soil and the depth of the impermeable layer of clay or rock that is trapping the water above it.

The water table is never a clear horizontal line, and its depth may fluctuate depending on the type of soil, the slope of a particular region, seasonal variations in rainfall, and the inflow and outflow of water from other underground sources. Levels rise and fall under natural conditions, but human activities such as abstracting water from wells and boreholes can play an important role in determining the depth of water tables.

Lowering of the water table can be caused by:

- capillary rise of water in the soil and the evaporation of this water from the soil surface
- plants taking up water through their roots
- the slow escape of water through a slightly porous layer or cracks in the impermeable layer
- abstracting water from the aquifer by means of boreholes and wells
- inappropriate farming practices which cause water to flow over the surface of the ground rather than entering the soil
- the outflow of water from an aquifer without an inflow of more water from other sources.

Diagram depicting movements of water in and out of a section of aquifer



Rainfall is responsible for recharging groundwater resources but large amounts of water are lost to the atmosphere long before they get a chance to reach the water table.

Recharge

When groundwater from an aquifer is pumped to the surface for use there will be a drop in the water table unless water is replaced in some way. We call this replacement **recharge**. Groundwater can be recharged in a number of ways, but ultimately the water all comes from rainfall. In countries like Namibia, where rainfall is very low, there is not much water available for recharge. However, the amount of rain that a piece of land receives does not tell us anything about the **rate of recharge** of the aquifer beneath it. Rate of recharge is determined by the silt load, water flow depth and flow velocity (turbulence) of water when it flows over the surface of the soil as run off. If very little water is able to penetrate the soil then the chances of recharge are decreased. It is estimated that only 1% of all the rain that falls on Namibia filters through the soil to recharge groundwater.

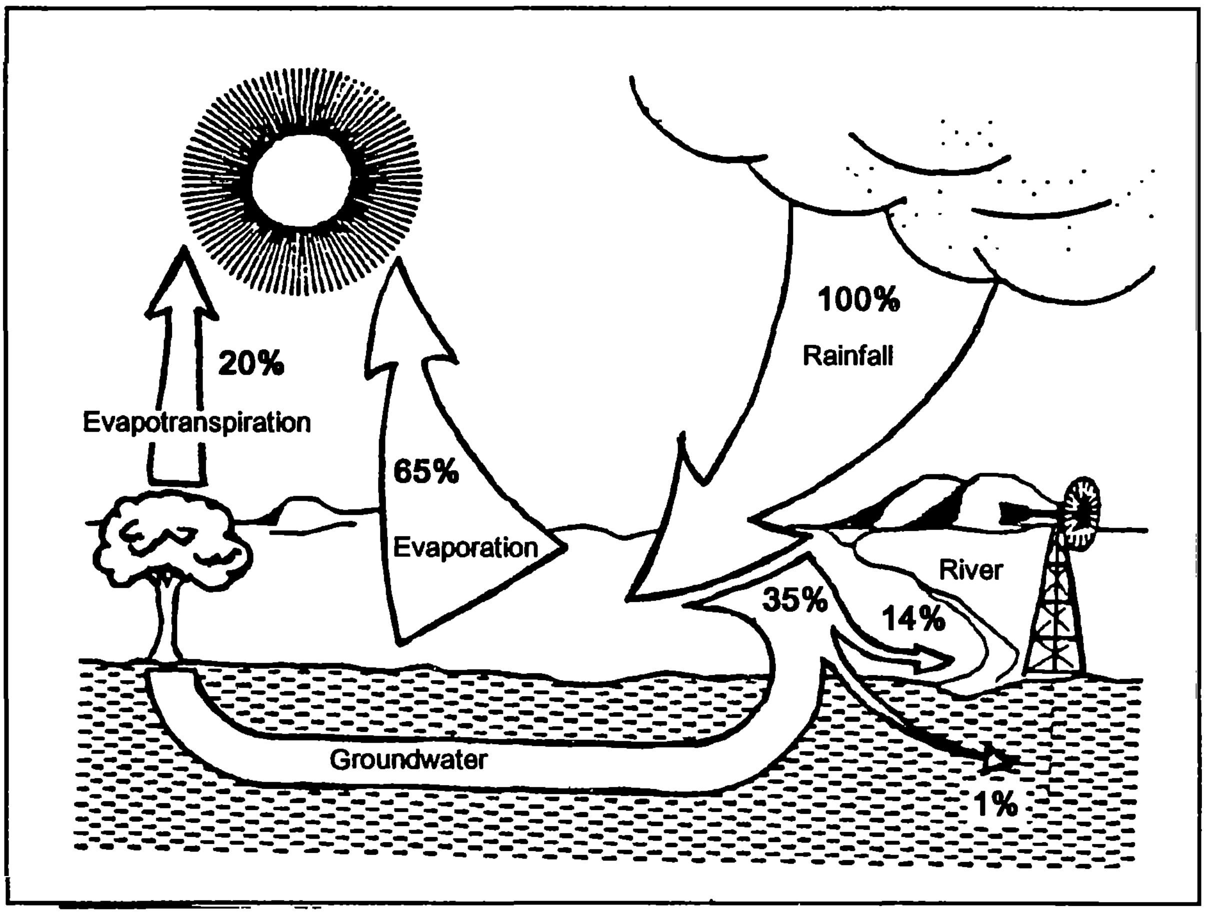
In cetain places, many thousands of years ago, water was trapped beneath the surface of the earth by an impermeable layer. We call this **fossil water**, and because it is trapped in cavities or fault zones it can never be recharged. This means that once this water is used up it is gone forever, and that boreholes into a groundwater supply of this type will all eventually dry up.

What happens to our rain?

When rain falls over land a number of things can happen to its water once it reaches the ground. Water can sink into the soil and be taken up and used by plants, or run over the ground and make its way into a stream, river, lake or pan. It may even penetrate the soil deeply enough to help recharge an aquifer. However, in Namibia, as in other hot, dry countries, most rainwater evaporates back into the atmosphere either through direct evaporation or evapotranspiration from plants. As much as 85% of our rainwater can be lost in this way.

Since on average only 1% of our total rainfall goes to recharge our groundwater, this adds up to very little water each year - especially in areas that receive very little rainfall.

The water cycle in Namibia



Department of Water Affairs, Namibia. 1993

The diagram above shows that of all the rainfall that Namibia receives, most (65%) evaporates back into the atmosphere immediately. Only 14% forms runoff that flows into rivers. Of all the water reaching the surface only 1% goes to recharge the groundwater resources.

Chapter 3
Activities

1. Under the topic of "topography", study how flooding of the earth's surface by rainfall is affected by the gradient of slopes and surface features. What are the effects of soil erosion likely to be in each case? Practice skills in map reading, working with contours, etc.

2. Look at a map of Namibia and decide which features are important watersheds that divide the land up into drainage basins. Once the learners have decided on a good way to divide the country into drainage basins, look at the rainfall, population density, water supply, river flow, etc. in each region.

1. **"Water - the Great Sculptor".**
Get the learners to find examples of landforms, shapes, textures, etc. in Namibia or near the school that are shaped by water. Some Namibian examples include: the Fish River Canyon, Mukarob, Kuiseb Canyon and Lake Otjikoto. How important are these things as tourist attractions?

1. Under colonial rule wars were fought over drainage basins that had a good supply of water. Can you find any links between the struggle for land and the availability of water in Namibia? Discuss the role that natural resources such as oil, water and minerals play in political struggles.

1. See the page on "Things to Do" in chapter 3. If your school is near any of the canals or a small river, visit it and calculate its cross-sectional area so that the discharge rate can be calculated later in geography classes.

1. If you live near a river or a canal, make a set of suspension sampling bottles to investigate what sorts of things are carried in the water as part of its load. Make a graph to show what percentage of its load is occupied by the different types of things that you find.

1. To show that objects such as rocks are porous you can set up a simple demonstration that will make the concept clear to the learners. Weigh a brick that has been left in a hot, DRY place for a few days (or left for a few hours in a warm oven). Submerge the brick in water overnight. Remove the brick from the water the next day, wipe off excess water and weigh it again. Compare the weight readings. Ask the learners to explain why the mass of the brick has increased.

Explanation: there are tiny air spaces between the particles that make up the brick. These spaces get filled with water and this results in an increase in the mass of the brick. We call the spaces in any solid object its porosity. Ask the learners if they can think of a way of calculating what percentage of the brick's volume is made up by air spaces.

1. Think of all the different food types supplied by wetlands. Rice is one of them. Make a list of all the different food types supplied by Namibian wetlands. Discuss the role that they play in daily nutrition and make a collection of some traditional recipes.

1. Consider the essential role of wetland vegetation (reeds, grasses, trees) in supplying materials for building homes. Look at traditional forms of housing in different parts of Namibia. How many of them depend on wetlands?Make a model of a traditional home built from wetland materials.

1. Many of our traditional arts and crafts depend on wetlands, for example, pottery and basket making. Not only are they culturally important, but they can also help families to generate income. If you live in or near a wetland have a member of your community teach your class one of these crafts. If the necessary materials are unavailable, pots and bowls can be made from papier mache, and mats and baskets woven from old plastic bags.

4

Rainfall

Rainfall is the ultimate source of all of a country's freshwater resources. Rain fills dams, makes rivers flow and infiltrates down through the soil to recharge groundwater. Even fossil water reserves, deep within the earth, are composed of water that was once rain. Rainfall is also an important component of the water cycle, maintaining the circulation of water and playing a vital part in its distribution.

Namibia is an extremely dry country with very little rainfall, so rainfall or its lack is important in determining where and how people live in our country. Because of this, stories and poems dealing with rain are often found in Namibian cultures.

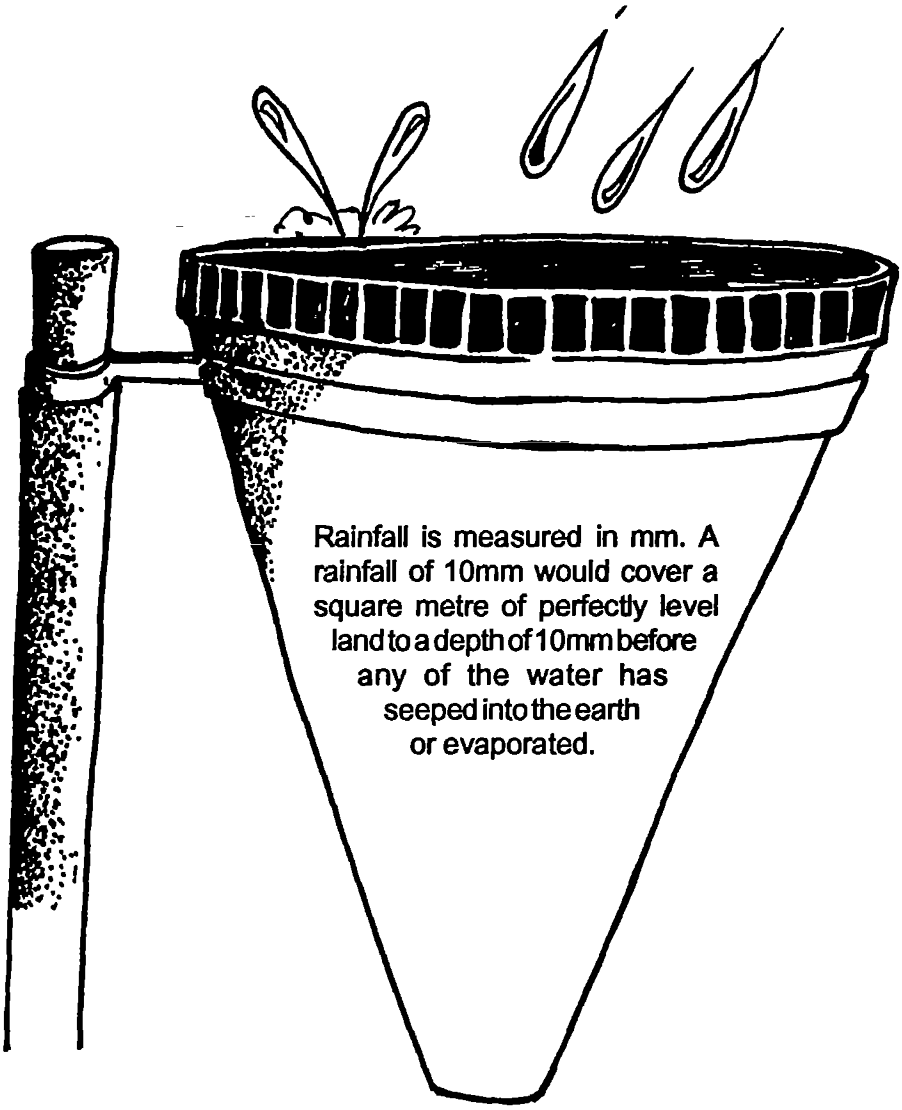
Since rainfall in Namibia is limited so are our water sources, and it is important that we do not use more water than enters the system each year if our lifestyle is to be sustainable. Namibia is an arid country, with a high evaporation rate and very variable rainfall. Drought and desertification are ever-present threats. We must manage the water we get from rainfall carefully if we are to obtain the full benefits from it. Rainwater and fogwater harvesting are one way of increasing our benefits from precipitation.

Precipitation

Any moisture deposited on the earth by natural means is called **precipitation**. It may be rain, snow, fog, mist, dew or frost. Precipitation is an important part of the water cycle - by means of precipitation water vapour in the atmosphere is returned to the earth.

The sun evaporates some half a million km^3 of water from the sea each year. However, worldwide less than 40 000 km^3 ends up falling as precipitation on land, and the usable runoff from this rain is less than a tenth of the total amount of water that has evaporated. A lot of the runoff water is also lost. For example, if precipitation causes floods much of the water may run off into the sea, leaving only a very small percentage of the total available for people to use. In Namibia most of our rainwater evaporates directly back into the atmosphere shortly after it reaches the ground.

The most common form of precipitation in Namibia is rainfall, although on the west coast precipitating fog occurs frequently and in the south of our country snow sometimes falls.



Things to do...

Measuring rainfall without a rain gauge

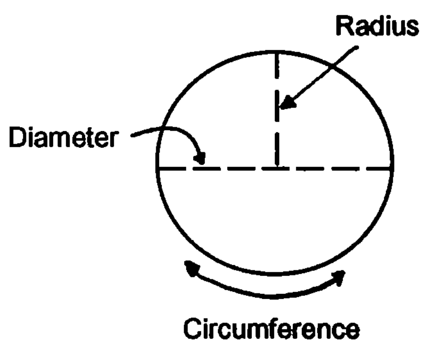
Rainfall can be measured quite easily and accurately without a rain gauge. In areas where there is quite a lot of rainfall, rain water can be collected in a straight-sided container and measured with a ruler. In areas where there is not much rainfall, it is sometimes helpful to use a larger container and perform the simple calculation below to give you your amount of rainfall. What is needed is a large collecting container, such as a plastic or metal bucket, and a small measuring container, such as a measuring cup used for cooking. Rainwater that is collected in the large container is poured into the small container and its volume is measured. This volume, in cm^3, is then divided by the area of the opening of the collection container in cm^2. For example:

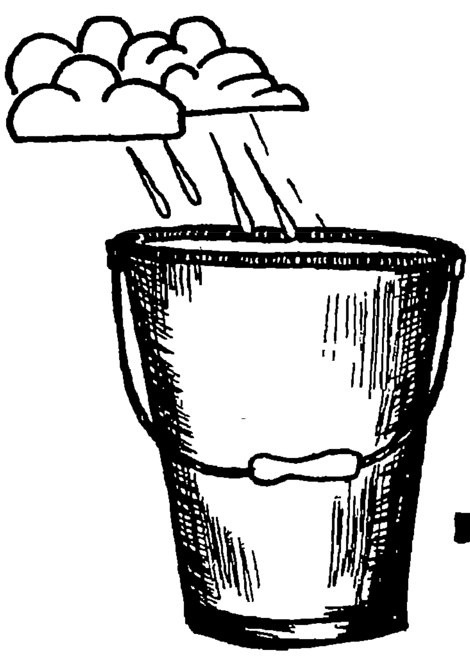
a bucket with a diameter of 26cm is set out to collect rain. The water collected is then poured into a measuring jug and comes to 191*ml*. For the calculation below you will need the radius of the bucket, which is half of its diameter.

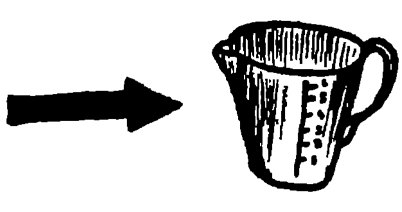
A (area of bucket opening) = Πr^2
= $3.14 \times (13cm \times 13cm)$
= $530.7cm^2$

Vol (volume of water) = 191*ml*
= $191cm^3$

P (precipitation) = **Vol ÷ A**
= $191cm^3 \div 530.7cm^2$
= 0.36cm
= 3.6mm of rainfall







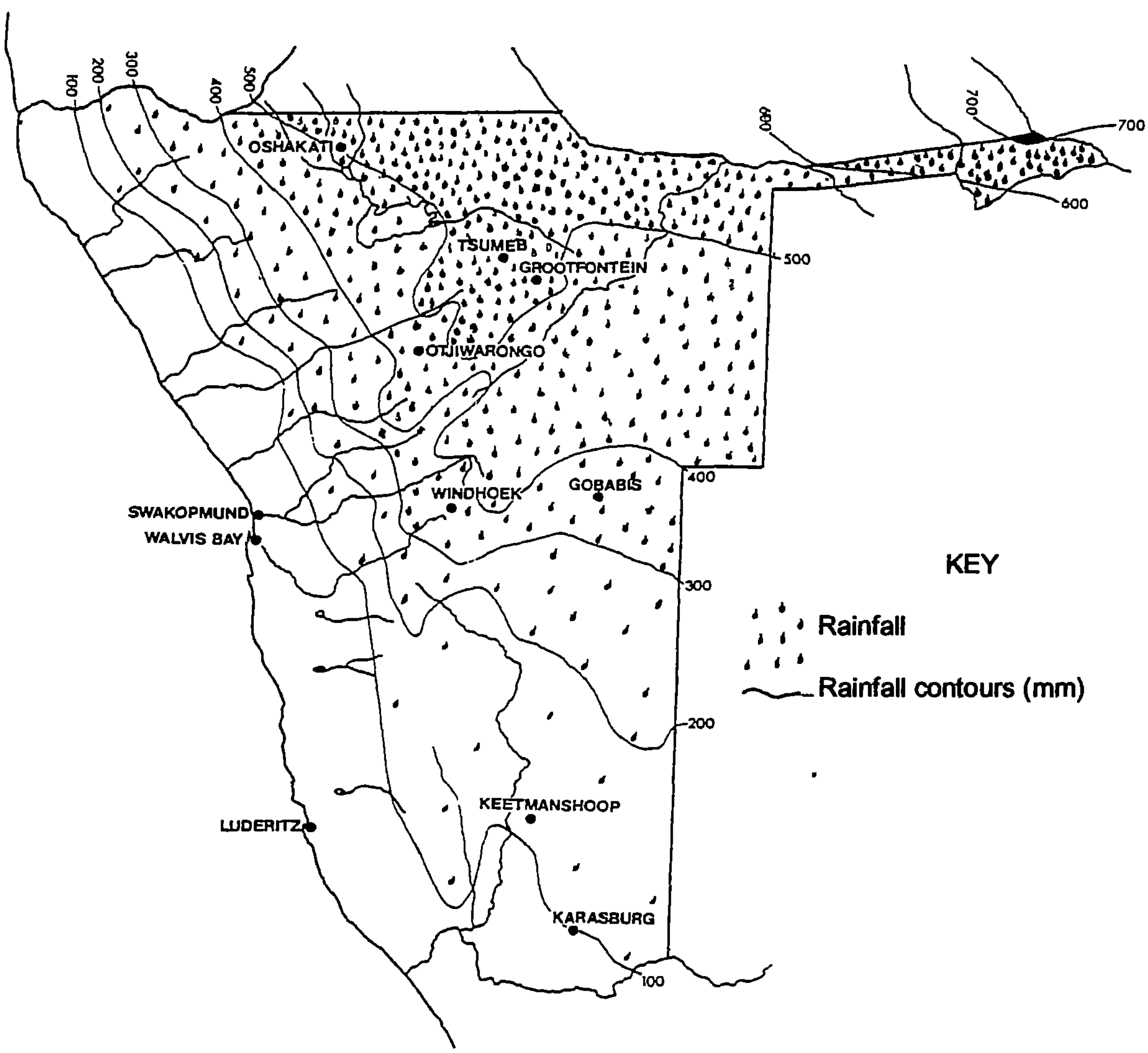
Rainfall in Namibia

When the rain ceases all people lament - Kimbundu

Namibia is a very dry country. Its overall annual average rainfall is around 300mm. This falls well under the annual world average of 860mm. Namibia's annual average figure is that of the whole country combined, but from place to place the amount of rainfall received varies. The general trend is for the amount of rainfall to increase from south west to north east. The dry south west receives virtually no rain on average, while eastern Caprivi receives an average of 700mm of rainfall per year.

Rainfall in Namibia occurs mainly in the summer months, between October and April, although the most southerly parts of our country receive rainfall in winter. In most of Namibia, there is usually a small

Map showing rainfall in Namibia



rainy season in October, when the rains start, followed by two months of hotter and drier weather up until December when the major rain season begins. Heaviest rainfall usually occurs in January, February and March.

Rainfall in Namibia often takes the form of intense scattered thunderstorms that occur in the late afternoon or night. Most of the water that falls as rain in Namibia comes from the Indian Ocean or from the moist equatorial regions. Having passed over much of the African continent on its way here, most of the water in the air has been dropped before it reaches Namibia. Very little water is brought in from the Atlantic Ocean in the west due to the pressure system over southern Africa and the generally low temperature of the Atlantic itself. Namibia's aridity is due to, among other factors, a fairly stable system of winds - none of which bear much moisture. This dryness is reinforced by the cold Benguela Upwelling off the western coast which intensifies the aridity in this region as it cools the air, for cool air is less capable of holding water than warm air.

The frogs come out of the earth and croak as soon as it rains on dead lands - Kenya

Swakopmund has one of the longest recorded rainless periods - no rain fell in the town for 15 years. It also has one of the largest annual rainfall variabilities, 1-148mm. In one year no rain was recorded for the town, and in the next, 148mm of rain fell.

How our ocean stops the rain...

Strong southerly winds along the coast of Namibia cause cold water deep in the ocean to rise to the surface. Because this cold water is rich in nutrients, a profitable fisheries has grown up along the coast of Namibia. But this same cold water also means less rain falls on nearby land. The Benguela system reduces rainfall over Namibia in two ways:

1. when cool winds blow from the sea onto the shore, they cool the surface of the land. A cool land surface prevents warm air from rising and creating the turbulence in the air that causes thundershowers. Even though there might be moisture in the air, it will not rain under these conditions

2. because - due to the Benguela Upwelling - the ocean water off our coast is cool, it cools the air above the sea. Cool air cannot hold as much moisture as warm air can, nor can it evaporate as much water. As a result of this, the air that is blown across Namibia from the Atlantic Ocean does not hold much water and cannot produce rain.

Aridity

Namibia is often spoken of as being an **arid** country. Most systems that define aridity are based on the concept of **water balance** - the relationships in an area between the amount of incoming water in the form of **precipitation,** and water losses due to **evaporation** and water given off by plants through pores in their leaves and stems **(transpiration)**. In arid areas there is an overall water **deficit**, that is, there is more potential for water loss than there is actual water entering the system. About one third of the earth's surface is arid, with 4% of the earth's surface being extremely arid, 15% arid, and 14,6% semi-arid. 49 million square kilometres out of the world's 135 million square kilometres fall into these categories. All of Namibia except for 3% of its land is either extremely arid, arid or semi-arid.

28% of Namibia = arid
69% of Namibia = semi-arid
3% of Namibia = sub humid

Evaporation

A factor that adds to Namibia's aridity is our high evaporation rate. So dry is our air that rain in the Namib can often be seen evaporating before it reaches the ground. The potential for evaporation in our country is many, many times higher than our rainfall. Namibia's annual average mean rainfall is roughly 300mm, but our average potential evaporation is over 3 000mm per year!

In Namibia the **evaporative potential** (the amount of water that would be evaporated if unlimited water were present) varies from about 3 700mm a year in the central southern areas to 2 600mm in the north. Compare these figures to those of Namibia's rainfall, and it soon becomes clear why much of Namibia is classified as arid.

Things to do...

The mystery of the disappearing puddle...

After a rainstorm take your class out in the schoolgrounds and look for a puddle on a fairly hard surface - tarmac or concrete would be best. Alternatively, make your own puddle with a bucket of water. With a piece of chalk, draw a line around the edge of the puddle. Later in the day, go out and see what has happened to the puddle. It will have got smaller. Draw a new chalk line around this smaller puddle. Continue this process until the puddle has completely disappeared. Where has all the water gone to?

Variability

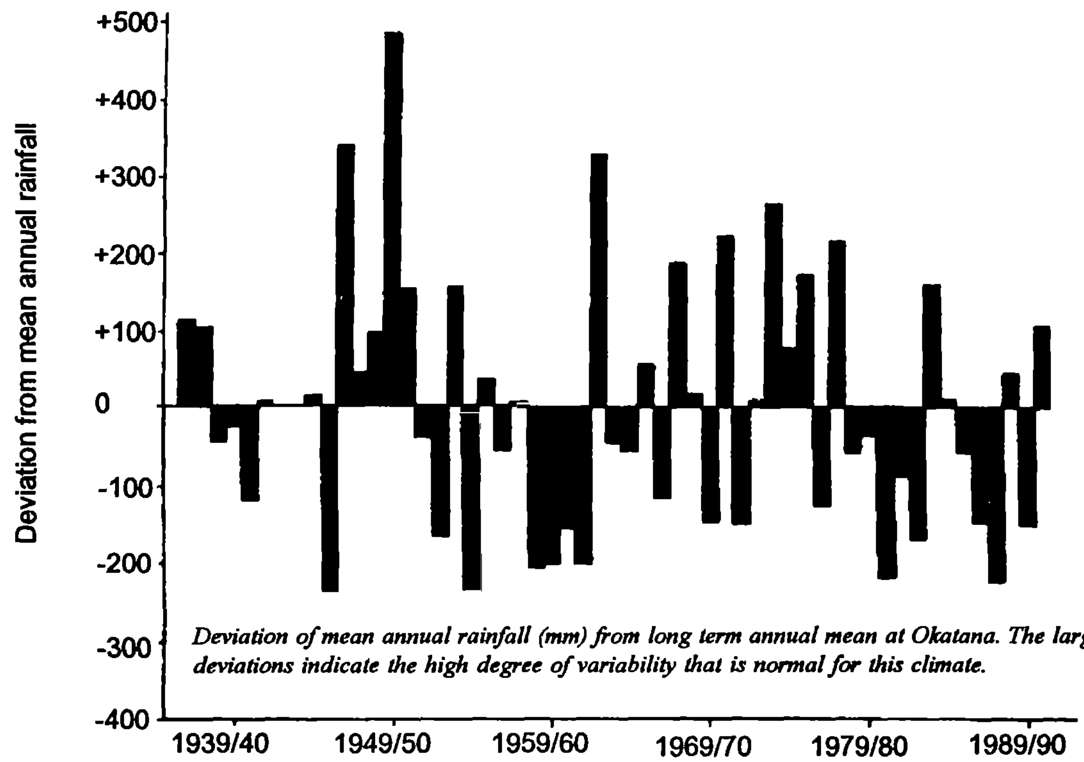
An important aspect of rainfall in arid countries is its **variability**, both in time and place. In most parts of our country it is impossible to predict how much and when rain will fall. Average annual rainfall figures give us very little indication of how much rain we can expect, and for this reason it is often more helpful to look at the range within which our rainfall is likely to be, rather than at a mean figure. Namibia's high amount of natural variability makes it very difficult to plan from year to year for farming or other activities that need a reliable source of water.

Namibian rainfall has a variability of as much as 80% of annual rainfall in the dry south west to as little as 20% of annual rainfall in the north east of the country.

If you have at least a few years worth of rainfall records, the equation below is a simple way to work out precipitation variability in your area.

$$\textbf{Variability(\%)} = \frac{\text{the mean deviation from the average}}{\text{the average}} \times 100$$

How many years of "average" rainfall has Okatana had in the last 50 years?



Deviation of mean annual rainfall (mm) from long term annual mean at Okatana. The large deviations indicate the high degree of variability that is normal for this climate.

Rainfall intensity

The term **rainfall intensity** describes the amount of water falling over a given period of time. For example, two days may each have a recorded rainfall of 45mm, but on the first day this rain may have fallen in 2 hours, and on the second day it may have fallen over 7. The first day's rain was intense and the second day's a much more gentle fall. The risk of run off and soil erosion is much higher during intense rainfalls, as the ground is compacted by the raindrops and has no time to absorb the water before it runs off. This is also the kind of rain that can cause flooding.

Money in Botswana is known as "pula", which means rain!

The Bushmen divided rain into two categories - male rain and female rain. He-rain is hard and violent and can cause destruction rather than growth and life. In other words, male rain has a high intensity. She-rain is gentle and soft and soaks deep into the earth - low intensity rainfall. Rainbows are often associated with she-rain.

The rain that is male

The rain that is male is an angry rain.
It brings with it lightning loud like our fear.
It brings water storming, making smoke out of dust.

And we, we beat our navels with our rigid fists.
We, we press a hand, flat to the navel.
We snap our fingers at the angry, male rain.

And we stand outside in the force of the water,
we stand out in the open, close to its thunder,
we snap our fingers and chant while it falls:

"Rain, be gone quickly! Fall but be gone!
Rain, turn away! Turn back from this place!
Rain, take your anger, be gone from our place!"

For we want the other, the rain that is female,
the one that falls softly, soaking into the ground,
the one we can welcome, feeding the plains -

So bushes sprout green, springbok come galloping.

From: *Return of the moon: versions from the /Xam* by Stephen Watson

Things to do...

Pool and puddle life...

When Namibia receives rain it is usually in the form of sudden thundershowers. Clouds build up over a short period of time, and there is a sudden downpour of rain. Then the clouds clear and the sun shines as if nothing has happened. The only reminder that there was rain are the puddles of water that remain behind on the ground. If an area receives large amounts of rain the puddles can be quite large and remain behind for a number of weeks. Some pools of water, such as the oshanas in the north, contain water for months at a time and are home to frogs, fish and a variety of smaller animals, including the malaria carrying mosquito!

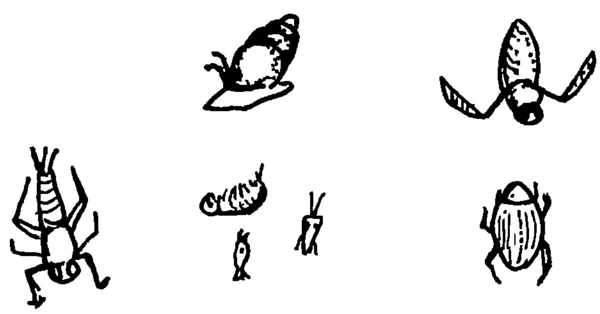
Puddles may appear to be lifeless pools of water but they are teaming with many life forms if you care to take a closer look. Puddles can provide a number of exciting outdoor lessons after a rain event that require very little time and almost no money. Here is some information to help you:

Wait at least a two days after a rain storm before you do this lesson. Then divide your learners into small groups. Take them out of the classroom to where there are a number of rain pools. Let each group spend at least 20 minutes observing what is in the puddle. They will need to look very closely as the life forms are usually very small. Avoid taking learners to large pools as they are often a form of distraction and they are not easy to collect life forms from. Take with you small glass containers to collect water and animal life forms. Each learner must make accurate observations and drawings of the life forms in his/her notebook. Some important things to observe include the following:

- *how many legs do the creatures have?*
- *what animal/insect that you are familiar with does each resemble?*
- *how do they swim?*
- *what size is each creature?*
- *where in the pond do they occur?*
- *how do they breathe?*
- *describe their behaviour*
- *what creatures are the most common/least common?*

Standing the container filled with a small amount of water on a white sheet of paper makes observation easier.Standing the container filled with a small amount of water on a white sheet of paper makes observation easier.It is best to visit the pond daily for a few days or until the pond dries, to see how the community changes.

If it is not possible to visit a puddle you can set up a lesson that requires only the mud of an old pool and some water. Collect some mud from the bottom of a rain puddle and place it in a large glass jar. Add water and make daily observations. Record any observations in the same way mentioned above.



NOTE: This hands on lesson provides a good introduction to concepts such as:

- adaptations to temporary water conditions
- aestivation
- lifecycles (insects, tadpoles)
- general adaptations to arid climates
- water and health

What happens when rain doesn't fall?

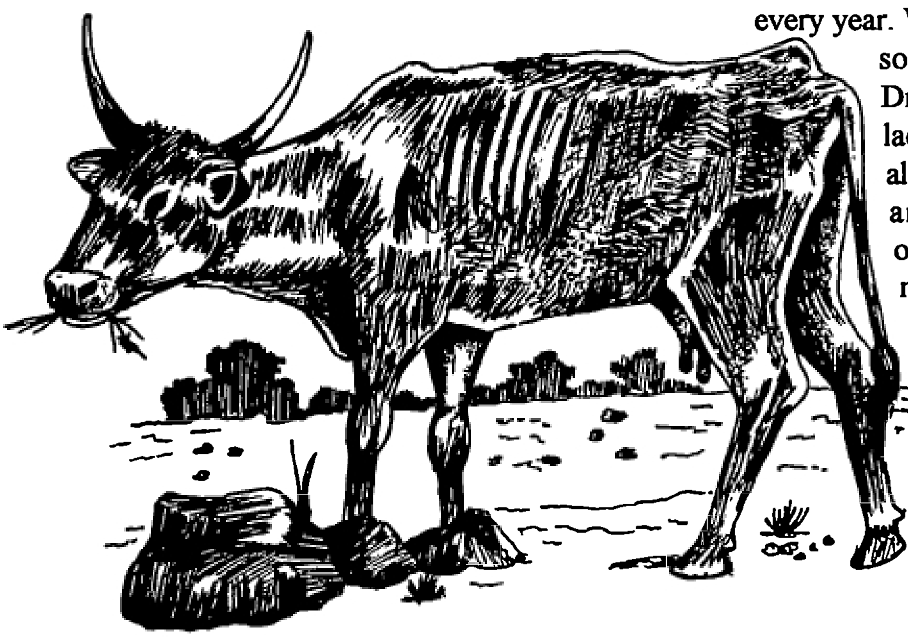
During the 1970s droughts affected an average of 24.4 million people a year world-wide, killed over 23 000 people a year, and resulted in huge numbers of environmental refugees - people forced to move from their homes because the environment could no longer support them. This trend continued through the 1980s and is continuing into the 90s. At least 80 arid and semi-arid countries, where nearly 40% of the world's population live, suffer from serious droughts from time to time.

Drought is a common - and normal - occurrence in Namibia. Droughts are a natural part of our environment, whereas high rainfall is not. For as long as history has been recorded in our country there has been mention of droughts.

The word drought has many meanings. One of these refers to an agricultural drought, when rainfall and temperature conditions result in crop failures or loss of grazing. Another is a hydrological drought, which is when lack of rain causes a reduced flow in rivers or causes them to stop flowing completely. Meteorologists usually say there is a drought when a particular region receives less than three quarters of its usual rainfall. However, due to the variability in precipitation over much of Namibia this definition is of limited use in our arid land.

Less rain, higher temperatures than normal or both usually trigger a drought. But rapid population growth and poor land use make the effects of a drought worse. In many underdeveloped nations people have no option but to try to make a living from land that is susceptible to drought. Drought is usually seen as a natural disaster, but it is often caused by people - the result of trying to support too many people and too many animals in areas that have prolonged droughts as part of their normal weather patterns.

Approximately 70% of the Namibian population is directly or indirectly dependent on agriculture, with a large proportion of the remaining 30% having strong links to it, so agricultural drought in Namibia can have disastrous effects. Many of these are a direct result of wrong farming practices or unsuitable stock and crops being farmed, rather than a shortage of water. Many farmers in Namibia farm as if there were going to be abnormally wet years every year. When we have a normally dry season, they then call it a drought. Droughts are not just the results of a lack of rainfall. Their occurrence is also influenced by the way land in an area is used. Overstocking, overcultivating and removing too much natural vegetation make drought more likely, and - if rainfall fails - more intense and damaging. In an arid country periods of dryness must be expected, and great care should be taken to cultivate animals and plants suited to our environment, and to use good farming practices.



The 1992/3 drought in Namibia

The 1992/93 rainy season saw one of the worst droughts in living memory - not just in Namibia, but all over southern Africa. There was massive crop failure throughout Namibia, and many livestock died. The livelihoods and food security of many rural households in our country were threatened. Although droughts are defined in terms of shortage of rainfall, many of their most serious effects are economic and nutritional, rather than in terms of water supplies.

You love your cow in the wet season, you hate her in the dry season - Oshiwambo

In 1991 the rains began well in our country, but had virtually stopped by mid-January of 1992. Crop production was devastated. For example, the maize harvest in Caprivi dropped from an estimated 11 900 tonnes in 1991 to approximately 1 000 tonnes in 1992. Mahangu and sorghum harvests in Kavango and the former Owambo regions dropped from 57 700 tonnes to only 16 400 tonnes. Elsewhere in Namibia, livestock were hardest hit. Average livestock mortality rates in communal areas ranged from 22% for cattle to 40% for sheep and goats.

During the 1992/93 drought in Namibia, 31 water tankers belonging to the Department of Water Affairs covered a distance of more than one million kilometres delivering water to schools, clinics and disadvantaged communities in the rural areas.

A national Drought Relief Programme was set up in May 1992 to tackle the problems caused by the drought and to try and lessen the impact of future droughts. Despite some serious problems, such as mistargetting of food and fodder relief, many of Namibia's more vulnerable people were helped (see table below). It is to be hoped that the lessons learned during these difficult times will help us to be more prepared for future dry periods in our arid land.

Registration of vulnerable groups (VGs) for drought relief in Namibia, January 1993 (in thousands)

Region	0-5 years	Pregnant and lactating mothers	Others	Total	Population	% registered as VGs
Caprivi	12,9	4,0	24,0	40,9	92,0	44,4
Kavango	26,2	14,9	51,8	92,9	136,0	68,3
Kunene	21,0	5,0	8,2	34,2	58,5	58,5
Otjozonjupa	9,3	3,2	12,4	24,8	85,0	29,2
Omaheke	7,9	0,9	6,8	15,6	55,6	28,1
Erongo	3,4	1,1	2,8	7,4	98,5	7,5
Hardap	5,7	1,2	5,6	12,5	80,0	15,6
Karas	3,9	1,8	6,4	12,2	93,0	13,1
Oshikoto	11,4	3,7	18,1	31,6	99,8	31,7
Ohangwena	25,6	7,0	31,8	64,4	184,2	35,0
Omusati	23,2	7,0	35,9	66,1	189,2	34,9
Oshana	10,8	3,3	20,7	34,8	98,4	35,4
Total	161,3	53,1	224,5	437,4	1270,0	34,0

Source: NDTF Secretariat, M & E Unit

Who says that drought was here?

With these green guests around
Who says that drought was here?

The rain has robed the earth
in vests of verdure
the rain has robed an earth
licked clean by the fiery tongue of drought

With these green guests around
Who says that drought was here?

Palms have shed the shroud of brown
cast over forest tops
by the careless match of tinder days
when flares flooded the earth
and hovering hawks talonned the tale
to the ears of the deafening sky

With these green guests around
Who says that drought was here?

Aflame with herbal joy
trees slap heaven's face
with the compound pride
of youthful leaves

drapering twigs into groves
once skeletal spires in
the unwinking face of the baking sun

With these green guests around
Who says that drought was here?

And anthills throw open their million gates
and winged termites swarm the warm welcome
of compassionate twilights
and butterflies court the fragrant company
of fledgling flowers
and milling moths paste wet lips
on the translucent ears of listening windows
and the swallow brailles a tune
on the copper face of the gathering lake
and weaverbirds pick up the chorus
in the leafening heights...
soon crispy mushrooms will break
the fast of venturing soles

With these green guests around
Who still says that drought was here?

Niyi Osundare, Nigeria

Desertification

Desertification, despite its name, has nothing to do with deserts. It is rather a process by which land irreversibly loses its productivity. Desertification is defined as "...land degradation in arid, semi-arid and dry subhumid areas resulting from various factors, including climatic variations and human activities" (Agenda 21, Article 12.2).

"Namibia: proud of its deserts but preventing desertification"

More than one third of the world's land surface is in danger of losing its productivity. Much of it is already well on its way. This puts the livelihoods and lives of millions of people worldover in danger. This huge loss of arable land is one of the most serious threats to the future of humanity. The area under threat is so big it almost defies the imagination. Together it adds up to more than the combined area of North and South America.

Only a little of this problem is due to natural forces. Low rainfall does help the process of desertification along, but most of the blame for it rests on people. The problem is not that the world's natural deserts are expanding, but that areas of formerly productive land are losing their productivity as land is overgrazed, overcultivated, deforested or ruined by salinisation due to poor irrigation practices. Desertification is mainly a people-caused process.

Five causes of desertification in Namibia

1. inappropriate provision of artificial waterpoints
2. sedentarisation of semi-nomadic and mobile human and animal populations without shifts in management practices and livelihoods
3. absentee farm management
4. fencing under some land use management practices
5. inappropriate crop cultivation practices.

Four symptoms of desertification in Namibia

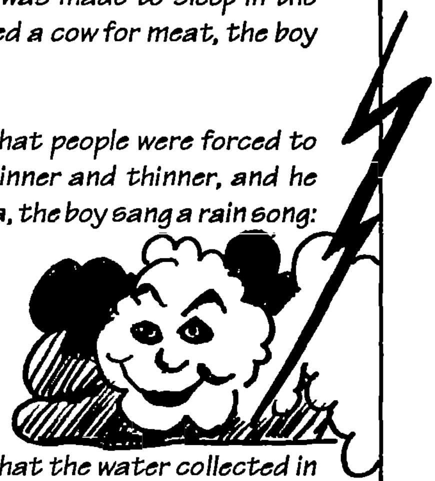
1. reduction in vegetation cover due to overgrazing
2. bush encroachment
3. deforestation
4. impoverished soils due to overcultivation.

The following story is told by the Tonga people, who live in the Zambezi Valley in Zimbabwe and in Zambia. Rain and rainmakers play a large part in their mythology because the area they live in is fairly arid, and they depend on rain for their agriculture.

Once upon a time, there was a man who had two wives. His first wife died, leaving behind a son, who the father and second wife treated badly. He was made to herd cattle on his own, although there were other children who could have helped him, and at night was made to sleep in the kraal. Although the boy looked after the cattle, when his father killed a cow for meat, the boy was not given even one piece.

One year, there was a terrible drought. There was so little water that people were forced to drink the urine of their cattle. The boy watched the cattle get thinner and thinner, and he himself got thirstier and thirstier. One day, in the cattle grazing area, the boy sang a rain song:

Mother may I have water
my throat and tongue are dry!
When my father kills a cow
I am given no meat.



When he had finished this song, it began to rain. It rained so hard that the water collected in pools on the ground. After he had washed and collected water to drink, and his cattle had drunk their fill, the boy sang:

Water go back,
Water go back.

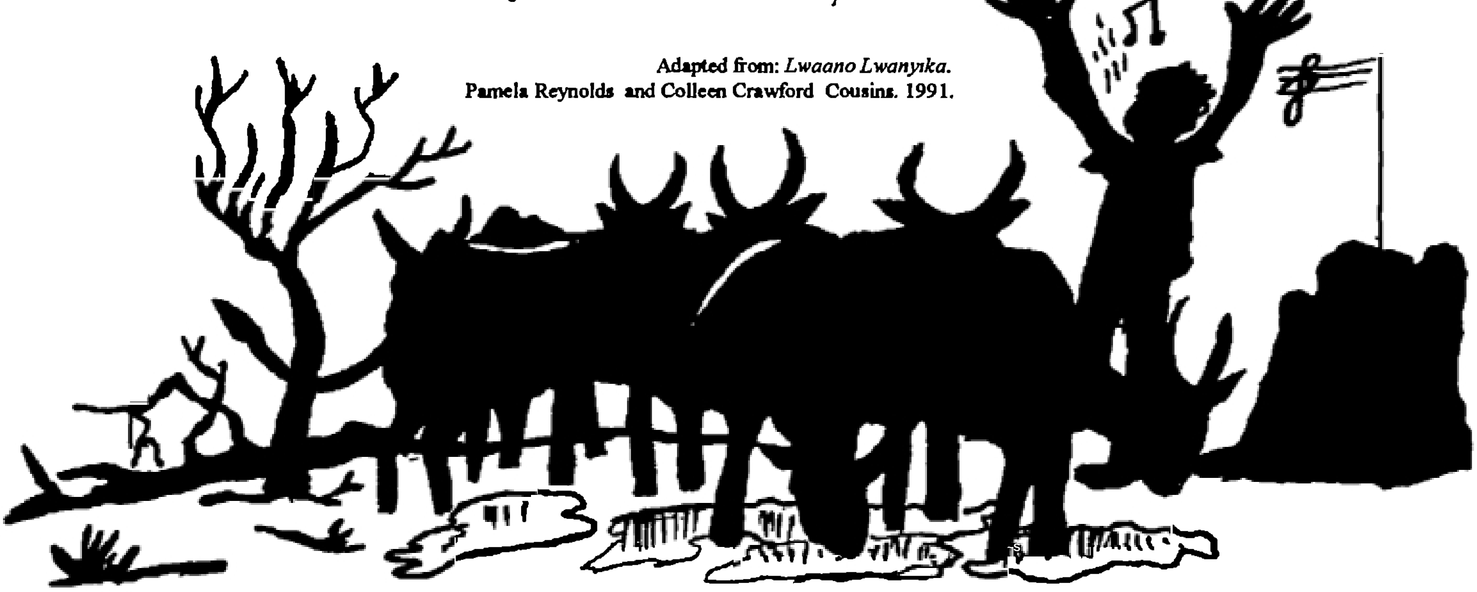
And all the water evaporated. He repeated this whenever he was thirsty and filled a dry and empty gourd with water to carry home with him.

One day, on his way home, with his gourd full of water, an old woman stopped him and asked him for a drink. When she tasted the sweet, fresh water, she became very curious. The next day she secretly followed him to the grazing grounds and hid. She was amazed to hear his song and see the rain. She told his father, who told the Chief.

The Chief called the boy to his homestead and kept him without food or water. When the boy could not bear his thirst any longer, he crept out to sing his song. The Chief followed him and saw the rain falling. His secret discovered, the boy called rain for the villagers, and due to his powers everyone survived the drought.

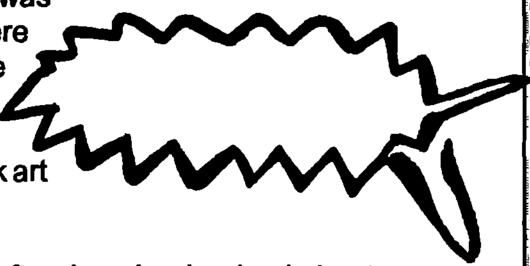
When the Chief died, the boy was elected to take his place.

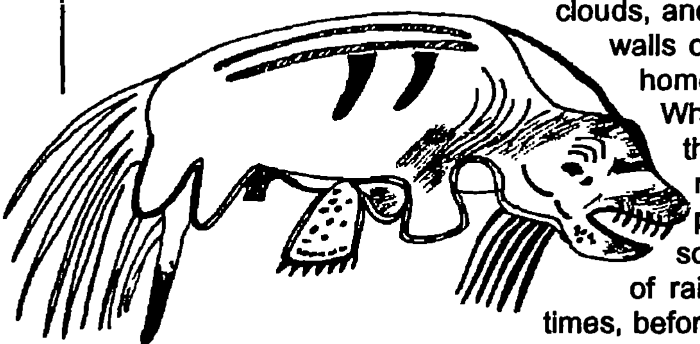
Adapted from: *Lwaano Lwanyika.*
Pamela Reynolds and Colleen Crawford Cousins. 1991.



Creatures of the rain

For many centuries Namibia has been occupied by Bushmen, who traditionally followed a lifestyle of hunting and gathering, living entirely off the natural environment. Being completely dependent on this environment, water, and especially rain, played a very big role in what there was available for them to live off. Rain to make vegetation grow was essential to their way of life, as without it there would be no animals to hunt and no edible plants to gather. The importance of rain is reflected in their traditions and myths. Evidence for this is found in much of the rock art these people have left behind.





The Bushmen often imagined animals in storm clouds, and drew these rain animals on the walls of the rock shelters they used as homes or for ceremonial purposes. When clouds with rain falling from them are seen from a distance this rain often occurs in well defined patches, and the Bushmen sometimes pictured these showers of rain as the animals' legs. In early times, before the introduction of cattle to this region, painted rain creatures usually looked somewhat like hippopotamuses, but in later years they resembled bulls or cows.

Snakes are often associated with water, and rain snakes are found fairly frequently in rock paintings. This is due to the fact that certain snakes are only found in moist places, and also that rivers and streams, which have their source in rain, have a snake-like form. In certain of the rock paintings showing rain snakes, human figures are making offerings to these rain snakes, hoping to ensure good rains and thus good hunting and the growth of edible plants.

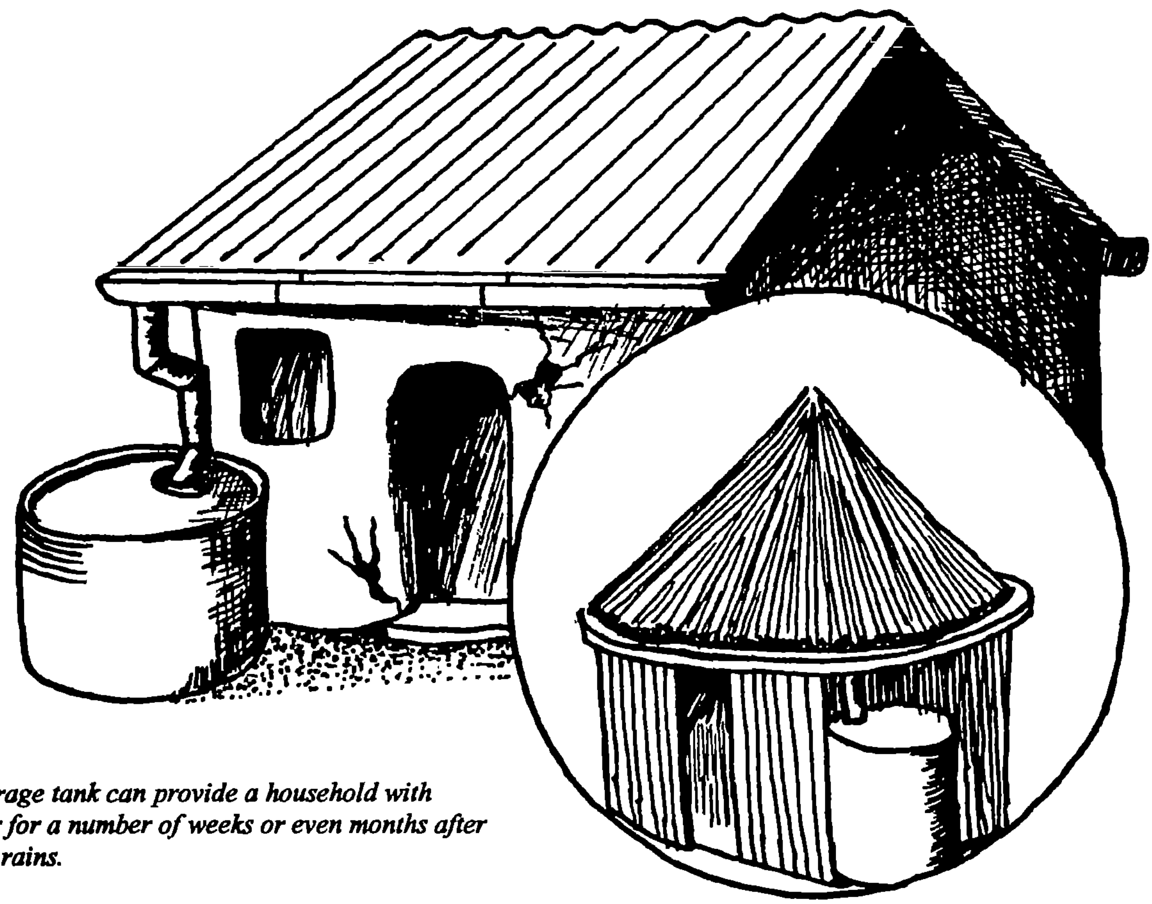
Rainwater harvesting

In countries such as Namibia, where much of our rainfall occurs in short but fairly intense storms, rainwater harvesting can be a useful way of supplementing water supplies - especially during the summer months. And rainfall is one of the cleanest types of water available, depending on the surface used to collect it.

Harvesting rainwater is not always practical. For example, one cow requires about 50 litres of water a day, which is 18.25 cubic metres a year. It would take a roof of 7m x 7m to collect enough water per year for one cow in a place the same rainfall as Windhoek.

Rainwater harvesting has been practised since early history. However, it is only recently that its potential for increasing water supplies, especially in the rural areas of developing countries, has been fully recognised. Stored rainwater can be a valuable addition to other, perhaps inadequate sources of water, and can be used both for domestic consumption and for agriculture (stock watering and irrigation). Because rainfall in Namibia is low, rainfall harvesting will not supply us with vast amounts of water. However, the water it can supply will certainly contribute to sensible and sustainable management of our water resources.

To harvest rainwater, three things are required: a **catchment area**, a means of **collection** and good **storage** facilities.



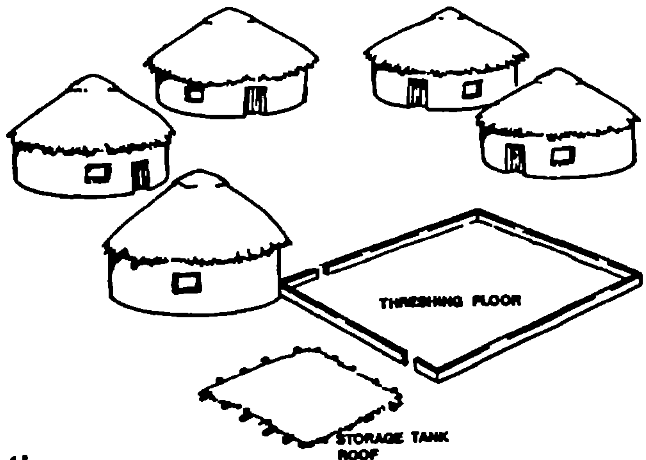
A storage tank can provide a household with water for a number of weeks or even months after good rains.

Catchment area

The most common areas used for catchment are roofs or the ground. Corrugated iron roofs are often used, but almost any type of roof - including tiles and thatch - will do. Runoff from thatch is, however, often discoloured and best used for irrigation. This problem can be solved by covering the thatch with a plastic sheet.

Flat or slightly sloping areas of ground can also be used to collect rain water, the water running off either compacted soil or some other smooth, hard surface such as tar or paving. This water tends to be much more contaminated than that collected from roofs, and can often only be used for irrigation.

The rainwater which first runs off a roof at the beginning of a storm will be polluted by dust, bird droppings and other dirt. If possible, this should be separated from the other, cleaner water.



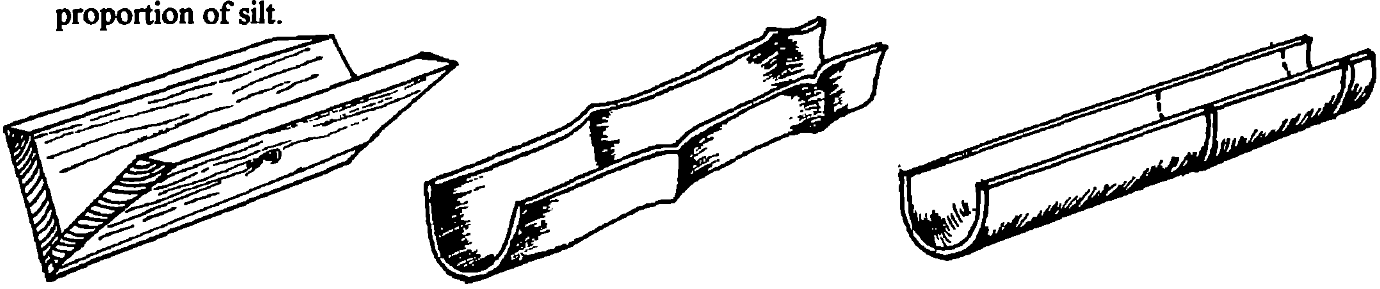
Areas such as a threshing floor can provide ideal catchments especially if they are covered in concrete or tar. Rainwater is channelled into a storage tank and can later be used for gardening. Keeping fish in such a tank will prevent mosquitoes from breeding and provide an extra source of food.

Collection

When rainwater is collected from roofs, this is often done by means of a gutter and downpipe system. Gutters can be made of local wood, bamboo, galvanised iron, or PVC. They must be big enough to carry the runoff from the roof during a heavy storm. Generally speaking, semi-circular gutters about 200mm wide should be able to cope. The gutters must be either firmly attached or strongly supported, for they can be very heavy when filled with water. They should be fixed in such a way that they slope slightly towards the storage tank to avoid water standing in them and becoming stagnant, forming breeding pools for mosquitoes and other insects.

When water is collected from the ground, the slope of the ground or specially built drains should direct water into an underground storage tank. Water collected in this way often contains a high proportion of silt.

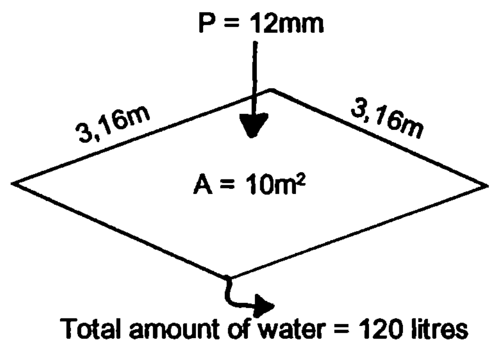
Gutters that can be used to collect rainwater from a roof



Calculating runoff percent

Runoff percent can be calculated by dividing the total amount of rain falling on a catchment area (P) by the volume of water collected in the container (R). For example, if it rains 12mm on a 10m^2 area, this is equal to 120*l* of water. If 45*l* are collected then the runoff percentage is equal to:

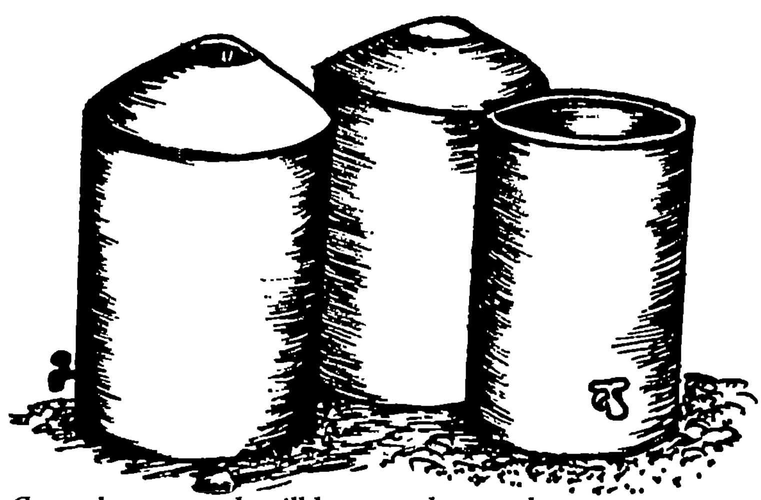
Runoff % = (R + P) x 100 = (45 + 120) x 100 = 38%



Storage

Rainwater can be stored either in underground or surface tanks of varying sizes. Whatever storage method is chosen, it is important that the tank is covered to prevent the entry of dirt and insects, and that there is an efficient and hygienic way of taking water out of the tank. The size of the storage tank will depend on the amount of rain, size of the roof, and rate of water use. Barrels make good storage vessels for rainwater harvested from roofs.

Storage tanks should be kept as clean as possible. Even so, some treatment may be necessary before the water is drinkable.



Covered storage tanks will keep your harvested rainwater clean and prevent it from evaporating

Fogwater harvesting

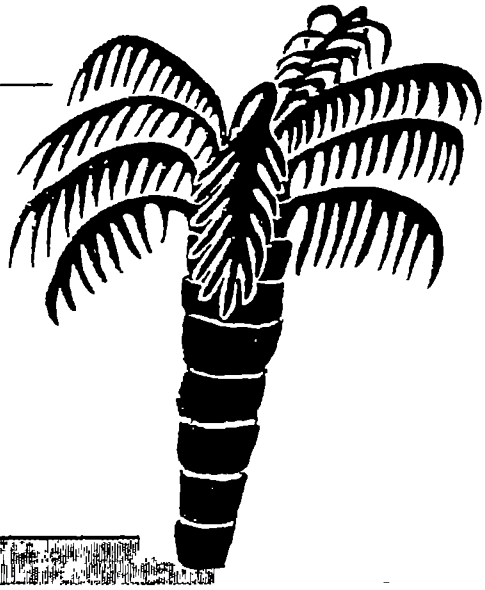
Just as rainwater can be harvested, so too can fog. Plants and animals in Namibia's hyper-arid Namib desert have been taking advantage of the moisture contained in fog for many thousands of years. On the west coast of South America where similar conditions to the Namib prevail, including a cold sea and frequent fogs, an idea is being tested that will enable people to use this source of water. Dozens of fog-collectors have been set up - long fence-like structures made of nylon net on which the fog condenses and trickles down to be collected. A substantial amount of clean water can be harvested in this way. This idea is being used in Chile, and perhaps in the future these nets will provide a source of clean, cheap and plentiful water for the inhabitants of our arid region.

A machine that mimics a beetle

Another device has been developed to harvest fogwater, based on the behaviour of the famous fog-drinking beetles found in the Namib Desert. This beetle stands on its head on the crest of a sand dune on foggy mornings. Fog condenses on its back and runs down towards the beetle's mouth. The device uses a hollow cylinder that stands on three legs. Fog condenses on the cylinder and runs down through the legs into a collection tank.

Water from plastic palm trees

Other means of capturing fog water in desert areas include the use of plastic palm trees that absorb water on cool, foggy mornings and release it gradually over the course of the day, thus making the climate less harsh, and encouraging the growth of plants. These plastic trees are being tested in certain parts of north Africa.



The Rain-man's Praise-song of Himself

No house is ever too thick-built
To keep me, the rain, from getting in.
I am well known to huts and roofs,
A grandson of Never-Been-There.
I am the mother of the finest grasses,
Father of green fields everywhere.
My arrows do not miss their aim,
They strike the owner of huts.
I am a terror to clay walls and the architecture of termites,
Fear-inspiring above and below.
When I pour in the morning, people say:
'He has cut off our lips and stopped our mouths,
He is giving us juicy fruits.
He has rained and brought mushrooms,
White as ivory.'

Aandonga (Angola and Azania)

Chapter 4
Activities

1. At the North Pole snow is so important to the Eskimos that they have many different words to describe different types of snow. In Namibia people often describe different types of rain in different ways.

Bring an object to class that the learners can describe. Divide the class into groups. Show each group the object separately and let them describe it in a short paragraph. Call the class together and pin the descriptions up on the board. Is it clear that the different groups were describing the same object? Why is accuracy important in language?

The "Rain Tree" is a tree found growing near rivers in the Caprivi region. There are many superstitions linked to this tree. It is called the rain tree because the tree itself is said to "rain" for a week or more during the hot, dry months just before the actual rains begin. Sometimes there may be pools of water beneath the tree, even though there has been no rain. The "rain" has a biological explanation and is in fact caused by the nymph stage of a small insect called a frog hopper (it is NOT a frog!). As protection from the sun the nymph covers itself with a foamy liquid. The insects get the liquid they need to produce this foam from the tree. They pierce the tree's bark with their sucking mouthparts and suck up the tree's sap. The foamy liquid drips from the backs of the insects and creates an impression of rain.

Are there any such stories connected with rain in your area? Record one or a few in the form of an essay or an article for a magazine. Make a collection of them in a class magazine.

Write a business letter to various organisations that are involved in the sale of water storage tanks asking them for a list of the water tanks they have available that are suitable for storing rainwater. Choose the best letter in the class and send it off to one of the companies. The reply could form the basis for a debate about the advantages of harvesting rainwater and whether or not such a system would benefit the school.

Write a set of instructions for people telling them how they can harvest rainwater in a safe and efficient way.

1. Write a poem about a mythical rain creature and make an illustration of it. Paste your poems and drawings up in the art and poetry corner of your classroom.

1. **"And now here is the weather report..."**
Divide learners into groups. Each group must choose a city from the world atlas and write a weather report. Learners must then present the weather report for their city as if for a television broadcast. While the "presenter" reads the report other members of the group have to act out the weather conditions, e.g. holding umbrellas for rain, shivering, fanning themselves, etc. Each weather report must include a rain forecast for the next day. Describe the type of rainfall expected and where it is likely to occur.

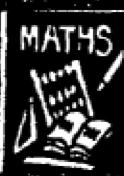
1. Study the rain creatures that exist in rock art in Namibia and in the rest of the world. Use the symbols, figures and patterns to inspire your own artwork.

2. On a cloudy day look at the clouds and imagine the different animals that the shapes of the clouds form. Use these images in a picture.

1. What rain creatures are depicted in Namibia's rich heritage of rock art? How many of these animals are still commonly found in Namibia and which ones are endangered by extinction? Why are these animals endangered by extinction and can you suggest ways that governmental legislation can be used to protect these important parts of Namibia's wildlife?

1. For an oral history project gather information about droughts and floods in your area in the past. Speak to elderly people about their memories of very dry periods and very wet periods. Ask them what the effects were. Plot these on a time line and try to work out if there are any trends or if they coincide with major historical events such as elections, Independence, etc.

2. Read about the "nyambi" ceremony in the Kwangari tradition. What other cultures have rain dances or celebrate the rain?



1. Use rainfall as an example when studying such things as averages, means, modes, medians, variability, etc. Use rainfall data to calculate some of these things.

2. **"What is the probability of rain?"**
The concept of probability is used in weather predictions to express the chance of rain occurring in a particular place. List various ways that probabilities can be expressed mathematically, e.g. fractions, percentages, ratios, etc. When everyone understands the concept of probability, allow each individual to predict the chances of rain for the next day in the form of a fraction or percentage. Check to see who made the most accurate predictions.

1. See the lesson card entitled: "*Build Your Own Weather Station*" for information on how to construct simple weather instruments.

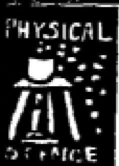
1. Build a tank that can be used to store rainwater in an efficient, healthy way.

2. If you live in a place that receives a lot of fog, design a piece of apparatus that can be used to harvest fog water. You may find the methods that some of the animals in the Namib desert use helpful in providing you with ideas.

1. Learners in the higher grades can study the chemistry and physics behind "cloud seeding". How does it work, what chemicals are used and what are the advantages and disadvantages?

2. Refer to *Playing with fire* for more information and activities that deal with acid rain.

3. Try making your own rain in the classroom by boiling a kettle and letting the steam condense on a plate or a cool object held above it. Colour the water in the kettle with some food colouring, observe the colour of the water drops that condense on the plate. Does this tell you anything about the role that the water cycle plays in the purification of polluted water?



1. Provide the class with 5 or 6 strips of old materials. Make sure to include some that are plastic or oiled. Divide the class into groups and ask them to design an experiment that will test the waterproof qualities of these materials. The aim of the exercise is to choose the best material for the making of a raincoat.

1. How are different homes in different rainfall regions of the world designed to withstand different types and amounts of rain? Compare homes in arid areas, tropical environments and places that receive snow. A collection of postcards or pictures cut from magazines showing different buildings in different places could be a useful aid. Can the learners guess what the weather is like in a certain place by looking at the design of the houses?

1. Make a short catalogue of all the major rain and drought events that occur in the Bible, e.g. Noah's ark, the drought during Joseph's time in Egypt, etc.

1. What animals are associated with rain? Make a study of animals that become active after rain as well as those that have names associated with rain, e.g. rainbirds, rain frogs, etc.

2. In Namibia the first rains signal the emergence of flying termites. Many Namibians use these insects as a tasty and protein-rich supplement to their diets. Make a study of one species of animal that has a life cycle that is dependent on rainfall e.g. frogs, termites and flying ants.

Rivers, pans and wetlands of Namibia

Namibia's rivers, pans and wetlands are our country's natural reserves of fresh water. They are important not only for people and human activities, but also because of the rich ecological systems they support.

But a glance at a map of Africa will reveal that Namibia is poorly blessed when it comes to water flowing across its surface. This lack of surface water has shaped all life forms in our arid land. The plants and animals, after hundreds of thousands of years, have adapted themselves to our harsh, dry environment. However, when water becomes available after an unusual rain event all living things take advantage of this life-giving liquid and the face of our dry land is briefly changed before rivers and pans dry and all returns to normal.

The origin of pans and riverbeds

The /Gwi clan of the Bushman people tell this story to explain how pans and rivers came into being:

Once there were two sisters who lived together in a village. The one sister was good and had many children, while the other sister was bad. One day the good woman went off to collect food in the veld and left the bad sister to look after her children while she was gone. While she was digging up tubers she had a feeling that her sister was not looking after her children well, so she returned home early. When she got home her children told her that their aunt had not given them any food, and that she had told them that they were ugly and that there were too many of them.

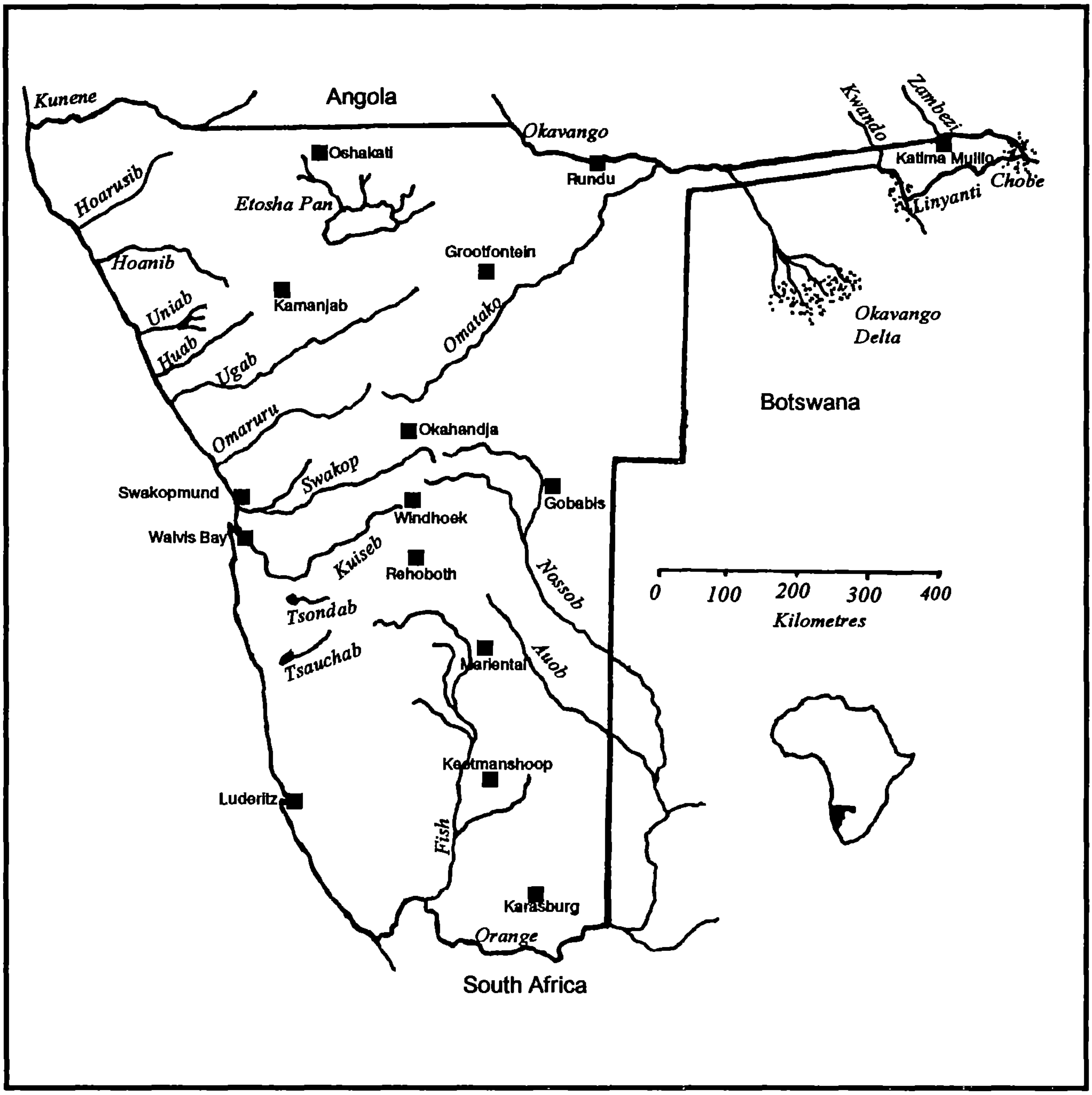
So the good woman decided to see for herself how her sister was treating her children. She said to herself: "I must find out why my sister is such a bad woman. I' ll bury myself in the sand, just like a puffadder does, and no one will see me."

So the good sister hid herself, just as she had said she would, and then called her children and told them to sing and dance a very good song. Their aunt came closer and closer to listen and to watch. Then she began to dance too. She danced closer and closer to the place where her sister had buried herself in the sand. When she got near to her buried sister, the good woman would hiss like a snake, and the bad sister would leap into the air and jump away from the spot. But then the children would sing louder and she would dance and come closer again. When she was close enough to where her sister was buried, the good woman grabbed her foot and bit her hard.

The bad sister thought she had been bitten by a snake, and she screamed and started running. As she ran she would stop and rub her foot on the ground and in the sand to try and get rid of the poison from the snake she thought had bitten her, then run on again and stop and rub. Every time she rubbed her foot on the ground a pan was formed. But she kept on running until she was so tired that she fell to the ground. In her exhausted state, she was still so panicked that she kept dragging herself across the ground, leaving deep furrows in the sand behind her. These deep drag marks eventually became riverbeds. She crawled on and on until at last she dropped dead, and this is how pans and riverbeds were formed.

Adapted from: ***Living legends of a dying culture*****. Coral Fourie. Ekogilde, 1994**

Map of major rivers in Namibia



Surface water

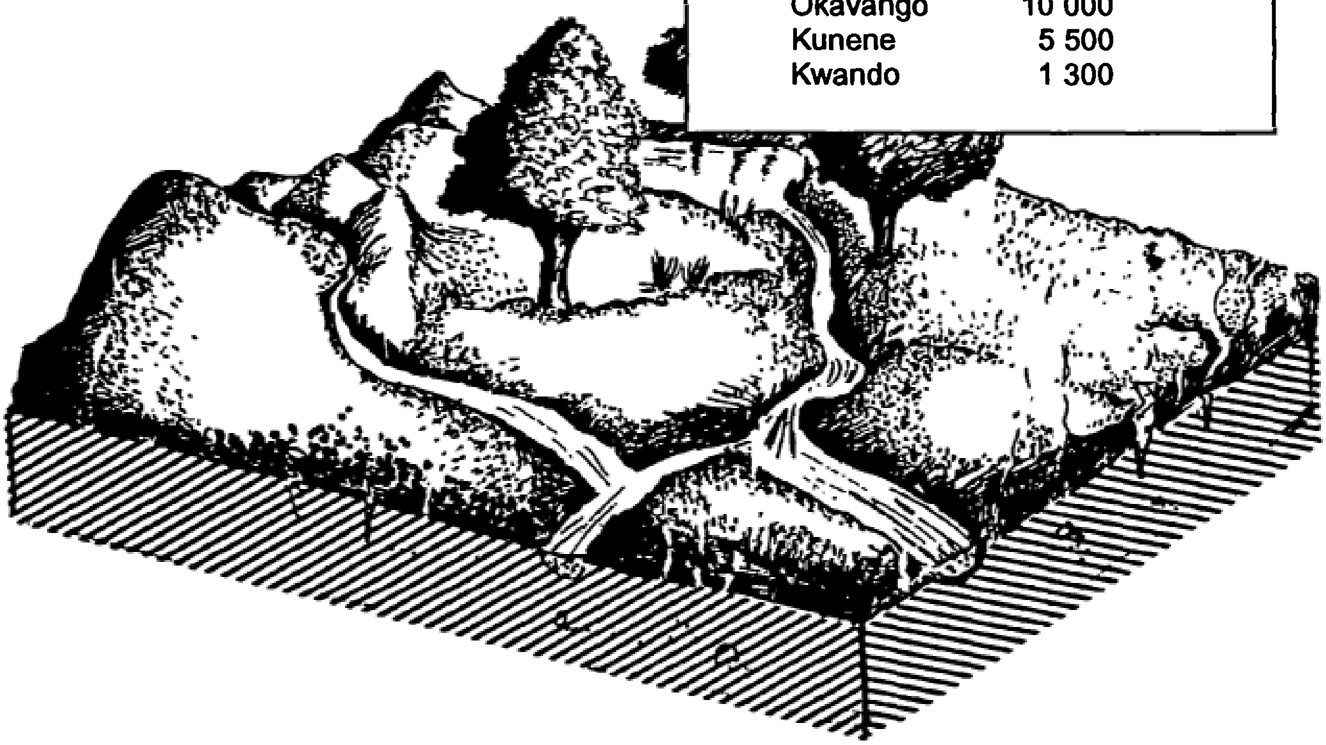
Rivers

The amount of rainfall we receive is important in controlling the flow of rivers in a country. Since rainfall is generally low, irregular and unreliable, river flow within the borders of our country is also irregular, unreliable and usually limited to a few days or weeks a year. There are even areas where rivers do not flow for a number of years.

Only the Orange River, in the south, and the Kunene, Okavango, Kwando-Linyanti-Chobe and Zambezi Rivers, in the north, flow all year round (**perennially**). Very little water that flows in these rivers comes from runoff that originates in Namibia.

Mean annual runoff in millions of metres cubed per annum (Mm³/a)

Zambezi	40 000
Orange	11 000
Okavango	10 000
Kunene	5 500
Kwando	1 300



The arid climate over Namibia means that there are no perennial rivers within the borders of our country. There are a number major ephemeral drainage systems that carry seasonal runoff across the landscape. The flow in these rivers is usually in the form of a flood that follows adequate rainfall over the interior. Other than at these times, water is absent from the surface of the river channels.

The irregular and unreliable flow of rivers in the interior of our country seriously limits the potential for development of surface storage facilities and for recharge of our groundwater. It is estimated that the safe yield of water from the ephemeral rivers is about 200Mm³/a, or 40% of the total water resources available in the interior of the country.

Pans

One of the largest pans in the world, the Etosha Pan, is found in Namibia. This pan is part of a very large network of pans and shallow riverbeds called oshanas that extend all the way down from Angola into Namibia. The oshanas and Etosha Pan fill with water only occasionally when heavy rainfall in Angola and over Namibia causes floods down across the northern part of Namibia, finally ending in Etosha Pan. Although the oshanas can be filled almost every year there is usually not enough water to flow south and fill the Etosha Pan. It is only occasionally that the pan has water in it.

It is not only the northern parts of our country that have pans. The eastern parts of Namibia, which are part of the Kalahari Basin, are characterised by shallow depressions or pans that fill with water when there is enough rain. As with the northern pans, the hot Namibian sun bakes down and evaporates the water away, leaving the pans dry for most of the year.

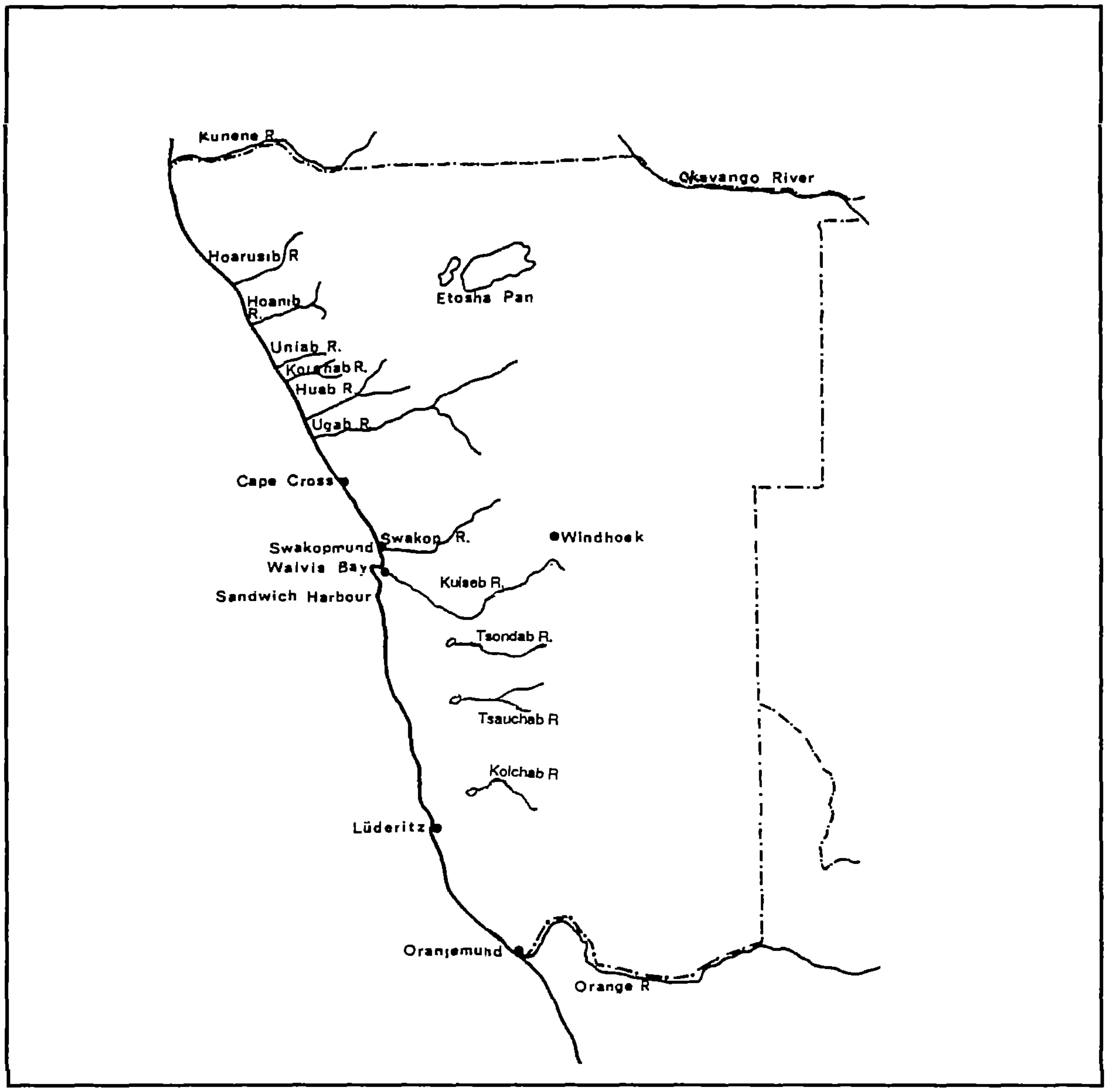
Wetlands

Because Namibia is such a dry country people often think that it has no wetlands, but this is not true. Two of Africa's largest wetland systems, namely the Etosha Basin and the Linyanti Swamp of the East Caprivi region, are found in Namibia. In addition to this, the Okavango River that runs through Namibia, enters the world's largest inland delta - the Okavango Delta in Botswana.

Namibia's wetlands are often taken for granted or even ignored, but thousands of people, plants and animals depend on them for survival. Because there are so few permanent rivers that can provide water all year round, people have become reliant on wetlands for food and water. In many cases their traditional lifestyles, habits and cultures are closely linked to the things that rivers and their wetlands can provide. The types of homes that are built, the foods eaten and the behavioural patterns of people are often influenced by wetlands.

But the wetlands of a hot, arid country such as Namibia are often dry for most of the year. It is only after good rains that they fill and during this time people, plants and animals use the water extensively. But this period is relatively short and evaporation soon leaves the wetland dry until the next rainy season.

The westward flowing rivers of Namibia



Most of Namibia's rivers run down to our country's west coast. With the exception of the Kunene and Orange Rivers, all rivers along our west coast are ephemeral. All these rivers flow through one of Africa's most arid regions - the Namib Desert. The rivers in the north western half of our country empty into the Atlantic Ocean, while most of those in the south western half are blocked from reaching the ocean by the large sand dunes of the desert.

Although we use the word "flow", water seldom flows on the surface in these riverbeds. Naturally dry conditions mean that the rivers may be filled with water for only a few days or weeks in a year. In some cases the riverbeds remain dry for a number of years. But even though the surface is dry, this does not mean that water does not flow underground. Beneath the dry surface of most of these rivers is a wealth of water. In some places the water is salty, in other places fresh. The water may be near the surface or buried deep in the sands of the river.

The rivers and wetlands in the western part of Namibia can be divided into three groups:

1. Rivers along the northern coast

Rivers along the northern coast (Skeleton Coast) include the Ugab, Huab, Koigab, Uniab, Hoanib and the Hoarusib. All are ephemeral and only flood if there has been enough rainfall in their catchment areas. When the rivers dry up pools of water remain behind, providing water for rare animals such as the desert elephant and rhino. Illegal wildlife hunting along these rivers is a serious problem. There are also clashes between wildlife and farmers. Between 1980 and 1983 many elephants were shot near Sesfontein because they destroyed crops. All the coastal lions of the Skeleton Coast have been shot by farmers - a sign of people's careless attitude towards and misunderstanding of Namibia's important wildlife heritage.

During the flooding of the westward flowing rivers, large numbers of seeds are carried downstream by the water. This may help to disperse indigenous seeds but it can also result in the dispersion of alien plant species along riverbeds. Seeds of alien plants such as wild tobacco, datura, Mexican poppy and castor oil plants may be carried from areas where the land is poorly managed to new areas where they compete with indigenous plants for nutrients and water.

2. Rivers in the central area

The central region contains the Kuiseb, Swakop and Omaruru Rivers. Although water flows on the surface in these rivers for only a few days each year, their aquifers provide large amounts of freshwater for human, animal, mining and industrial use. Groundwater from the Kuiseb and Omaruru riverbeds has enabled towns such as Swakopmund, Walvis Bay, Henties Bay and Omaruru to develop. The Rössing Uranium Mine relies heavily on water from these aquifers to sustain mining activities. Besides pumping water from the aquifers, surface water in the Swakop, Omaruru and Kuiseb Rivers is collected in a number of dams. The Von Bach and Swakoppoort Dams on the Swakop River supply the central region of Namibia with freshwater. The Omdel Dam on the Omaruru is a unique dam in that it does not store water on the surface but rather functions to encourage water to penetrate the soil and so supply the the Omaruru Delta Aquifer.

It is interesting to note that flows of the Swakop and Kuiseb Rivers have become less frequent in recent years. This is cause for concern since river flow is essential for recharging the groundwater of the alluvial aquifers. It is thought that reduced flow in the Swakop riverbed is a result of the Von Bach and Swakoppoort Dams preventing water from reaching places further downstream.

Mean annual runoff (Mm^3/a)	
Hoarusib	*20*
Omaruru	*12*
Ugab	*8*
Swakop	*6*
Kuiseb	*5*

There is currently only one large dam on the Kuiseb River: Friedenau Dam, not far from Windhoek. In addition to this there are an estimated 400 farm dams built along the Kuiseb and its tributaries. Although a single farm dam is too small to have a major impact on flow patterns in the river, the combined effect of hundreds of small dams may strongly influence the amount of water that reaches the lower parts of the catchment. Whether or not the large numbers of deaths of thorn trees in the Kuiseb delta area have anything to do with a decrease in river flow or a drop in the water table is unknown at this point in time, but the long term effects of building dams on rivers such as the Swakop and Kuiseb need to be carefully investigated.

3. Rivers along the southern coast

Rivers in this lower region of Namibia include the Tsondab and Tsauchab. Both are ephemeral and flow towards the Atlantic Ocean only after good rains. But we must not forget that each river is associated with an alluvial aquifer that occurs beneath the surface of the ground.

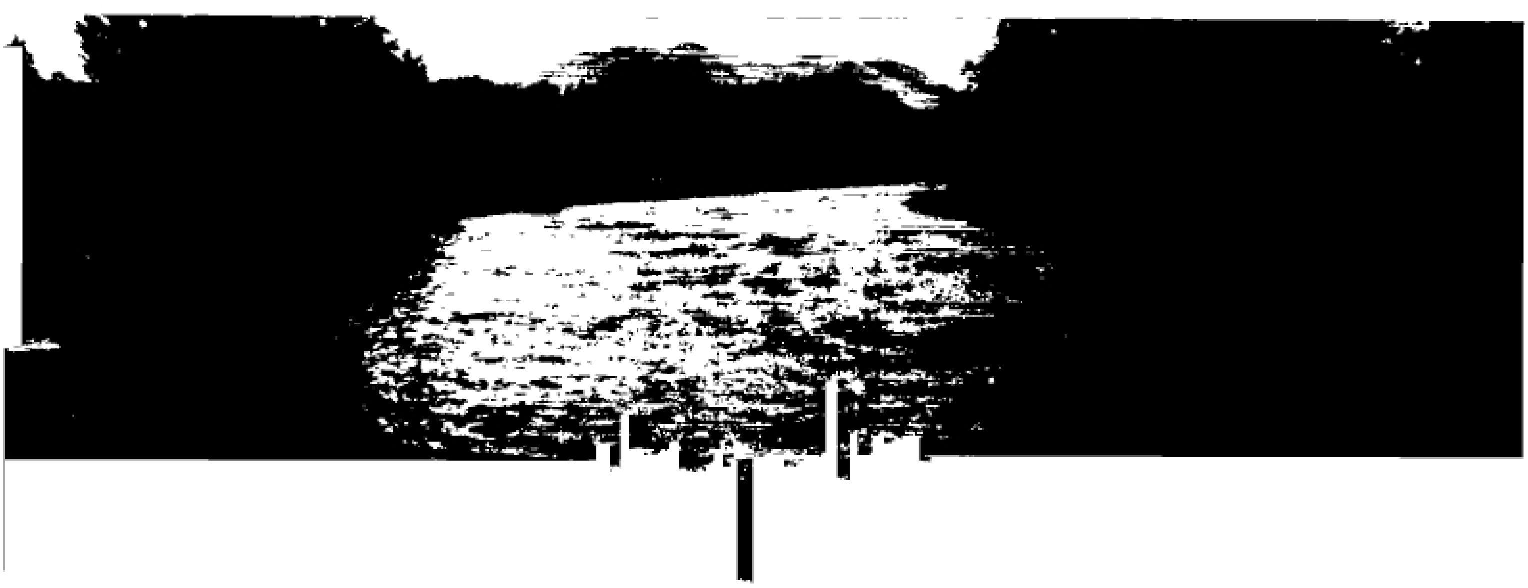
The linear oases and riverbeds of the westward flowing rivers are home to some of Namibia's important wildlife. Elephant, rhino and Hartmann's zebra make use of the riverbeds in the Kunune Region. Growth in human population and grazing pressure places these animals at risk.

The map on the previous page shows that the flow of these rivers is blocked from reaching the Atlantic Ocean by the dunes of the Namib Desert. These river channels end in *vlei's* or pans. Examples include Sossusvlei and Tsondabvlei. In years of above average rainfall the pans fill with water, providing an important habitat for wild birds and mammals. They also recharge the groundwater that sustains trees and other plants in the area.

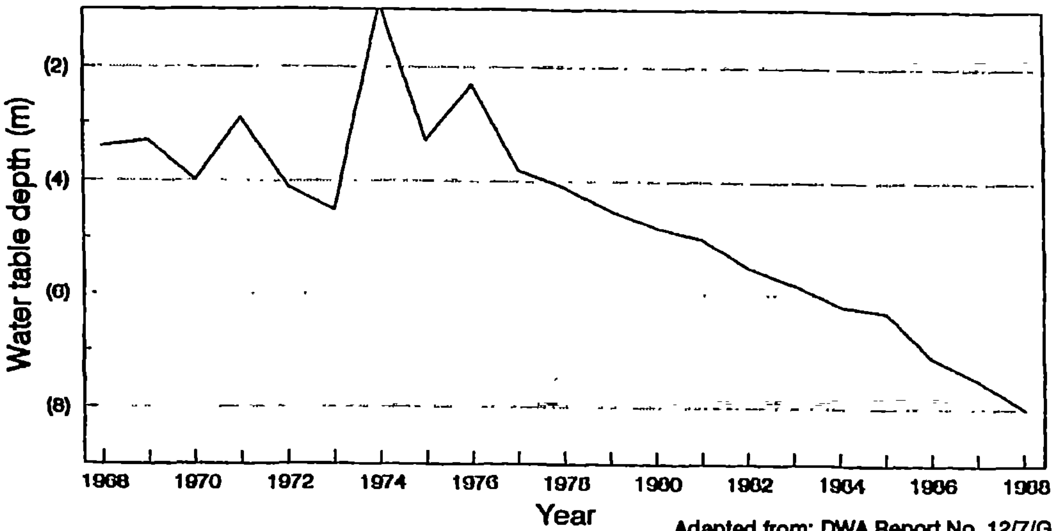
People make use of these pans too. Sossusvlei is one of Namibia's biggest tourist attractions, while Lüderitz's water is extracted from Khoichab Pan.

These catchments provide a vital source of water for some of Namibia's important economic centres - Windhoek, Swakopmund and Walvis Bay.

The Kuiseb in flood



Graph showing water table depth at Rooibank on the Kuiseb River



Adapted from: DWA Report No. 12/7/G10

At Rooibank Area Borehole No. 2.
Depth of borehole = 12.15 m

This borehole is one of a few used to supply Walvis Bay with water. Note the steady decline in the water table. The recharge effects of the 1974 and 1976 floods can be seen.

The major wetlands of the region

a) Sandwich Harbour

Sandwich Harbour is a wetland just south of Walvis Bay. It covers an area of some 5km² and is sheltered by a sand barrier. The area is rich in fish resources and is a great attraction for tourists and fishermen alike. The wetland supports a large bird population. Peak bird counts suggest up to 70 000 birds if the southern mudflats are added to this area!

b) Walvis Bay wetlands

These wetlands cover an area of between 35 and 40km² and include the Walvis Bay Lagoon, part of Pelican Point, the salt works and other flooded areas. The area is home to a large number of migrant birds and to more than half of southern Africa's flamingoes.

c) Cape Cross

The lagoons at Cape Cross have no fresh water supply but they still provide shelter and food for a large number of sea birds and seals. The birds deposit substantial amounts of guano (a very rich fertiliser made from bird droppings) which in earlier times was harvested from specially built platforms, while the seals use the area for shelter and breeding.

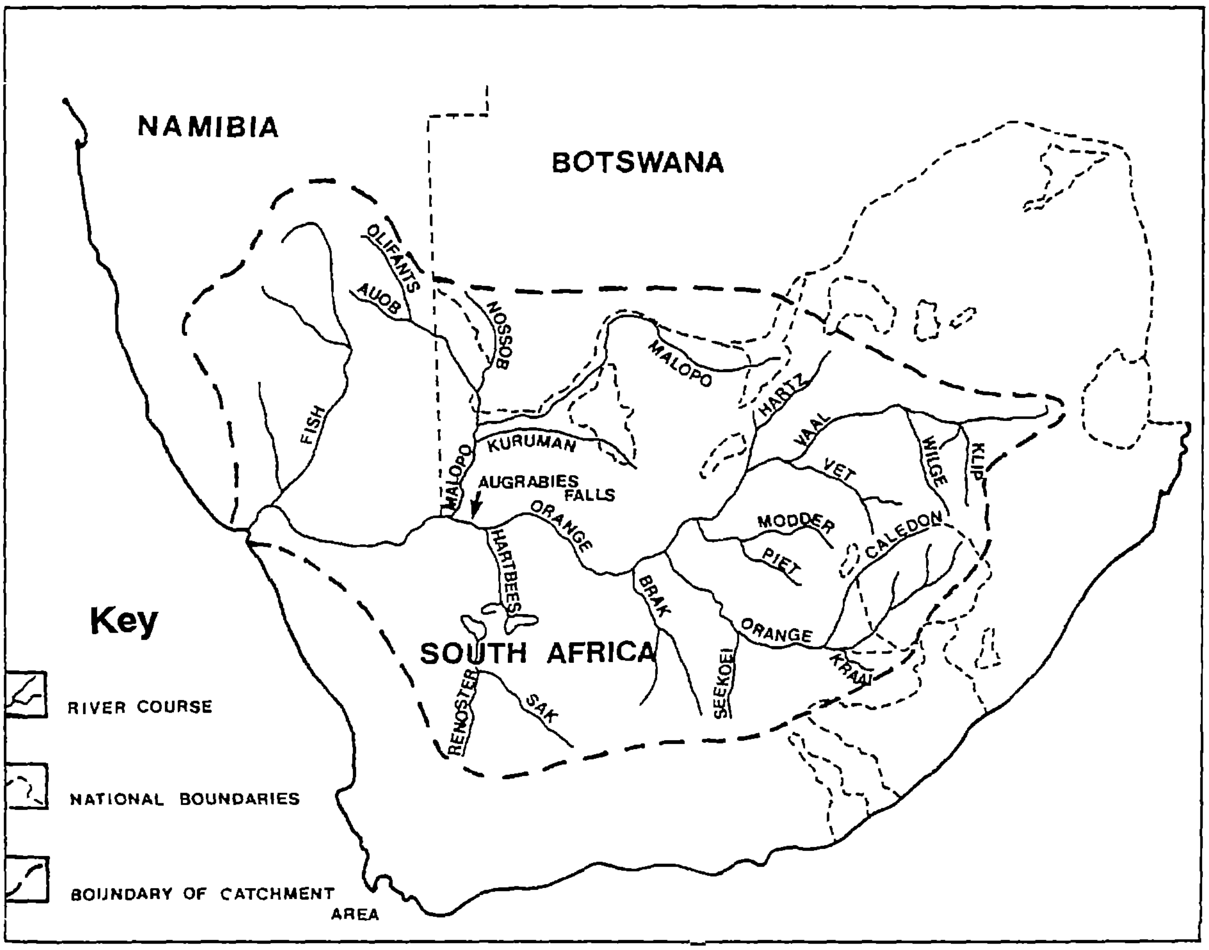
d) Lüderitz Lagoon

There is no freshwater inflow into the lagoon which covers an area of approximately 5km² and supports salt marsh vegetation and a number of species of shore and sea birds. Although the shallow waters are presently being used to cultivate oysters, the wetland may be threatened by pollution from the harbour and future industrial developments.

e) Swakopmund saltworks

This is a large, artificially created wetland that is home to many species of seabirds.

The Orange River and it tributaries



After Benade, 1988

The people who lived along what is today the border between South Africa and Namibia called this river the Gariep, a word that simply means "river". In 1779 a Dutch soldier visited the river and named it the Orange, in honour of Prince William V of Orange, and it has been known as the Orange River ever since.

The mightly Orange River has one of the largest river basins in the world with a catchment area that measures approximately 852 000km^2 (about 47% of the total surface area of South Africa). It is the longest river south of the Zambezi. The Orange has its source in the mountains of Lesotho and flows in a westerly direction across southern Africa into the Atlantic Ocean at Alexander Bay. Not only is it one of Namibia's few perennial rivers, but it is also of political significance since it forms the southern international boundary between South Africa and Namibia. The official border used to be the high water mark on the Namibian side of the river, but this has been ammended and our new official border lies at the centre of the river.

The Fish, Auob, Olifants and Nossob Rivers are all tributaries of the Orange River that have their origins in Namibia. However, as they flow through low rainfall areas they contribute very little water to the total flow of the Orange. The largest of Namibia's tributaries of the Orange, the Fish River, flows from the Nauchas Highlands near Rehoboth, through the deeply eroded Fish River Canyon, for some 805km before joining up with the Orange River. The Auob, Olifants and Nossob Rivers flow from Namibia into Botswana, but seldom reach the Orange River.

The Orange and Fish Rivers have 22 major dams along their lengths. Most of these are in South Africa where they play a crucial role in supplying the highly populated industrial area of Gauteng with water. Namibia's largest dam, Hardap Dam, is located on the Fish River and supplies Mariental and a number of irrigation pojects with freshwater. The building of all these dams has had adverse effects on the flooding patterns of the rivers in this catchment. The flooding cycle of the Orange River has shortened to 2-3 weeks of "flash" floods a year. In 1994, for the first time in recorded history, the Orange did not have sufficient water in it to reach the ocean. Increased demands for water in the uppper catchment and pumping out water for ever increasing numbers of irrigation schemes along the river will determine how much water reaches the Atlantic in the future.

In the early days the weight of diamonds was determined by using the weight of the carob seed. Today the unit for weighing diamonds is the carat which is approximately 0.2 grams.

People of the region have always honoured the Orange River as a source of life in the arid south. The banks of the river are covered in lush vegetation that provides food and homes for a wide variety of wildlife. There is tremendous potential for cultivating the fertile banks of the Orange. There is already a large irrigation scheme that produces fruit and vegetables for commercial purposes at Aussenkehr. The future of such projects depends on good water management practices within both Namibia and South Africa.

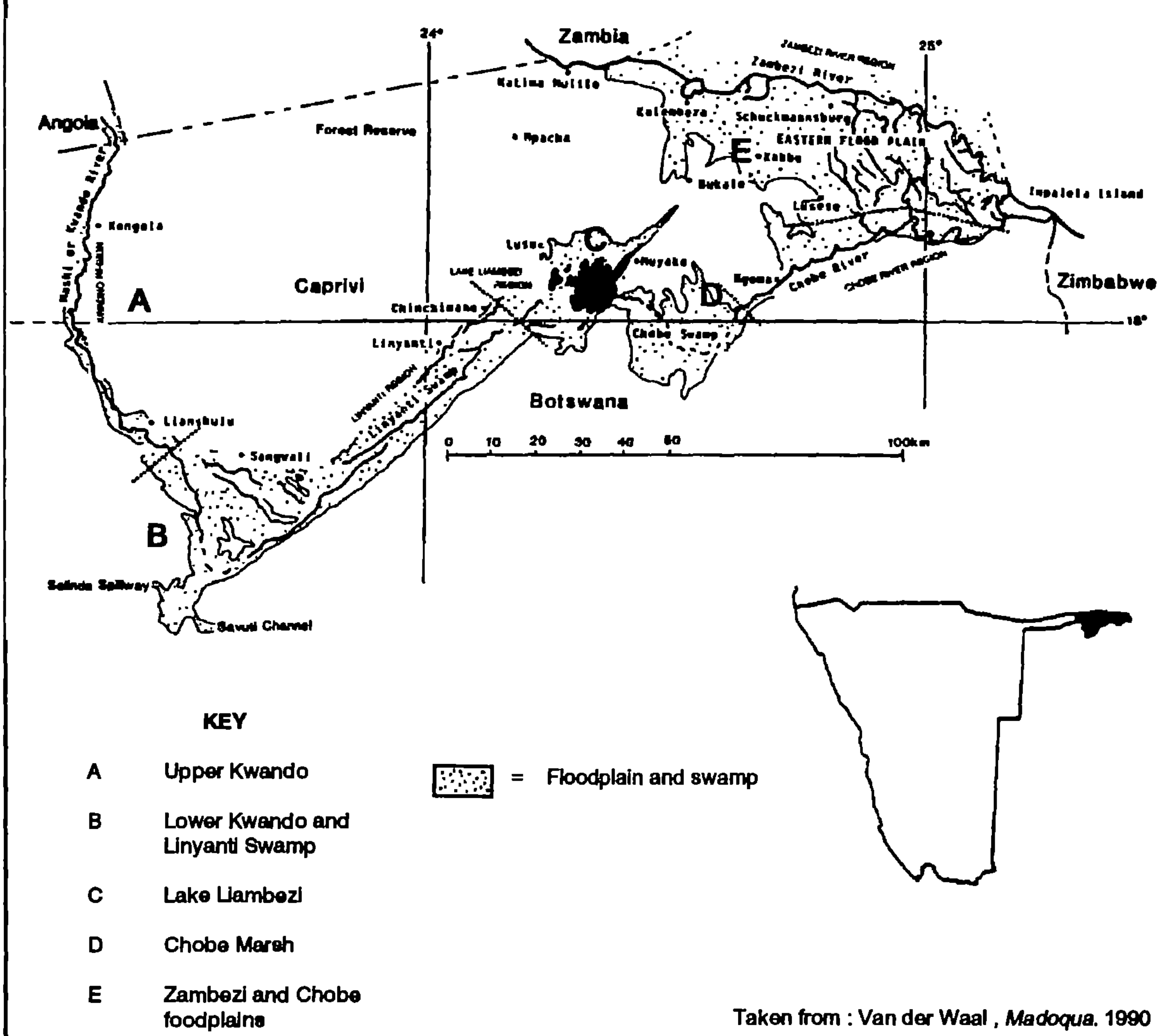
The issue of pollution is a crucial one since the river covers such an extensive area and the potential for it to accumulate toxic substances from such a large area is high. In 1994 there were reports of insecticides being allowed to run into the river. Dumping poisonous substances in the river upstream can have an adverse effect on any schemes downstream because these schemes rely directly on the river, and not on rainfall, for freshwater.

The Orange and Fish Rivers have an important role to play in tourism. The Fish River Canyon attracts thousands of visitors to the south of our country each year. The Orange River is also becoming a popular tourist site, and up to 600 canoeists have been counted per day on this river during peak season. Communities in the area are being encouraged to start projects that will help them receive an income from the natural resources that are associated with the river either through production or tourism. However, the prospects for income generation over the long term are dependant on good management of the region's natural assets.

The refractive index for diamonds is 24°26'. Diamonds are cut in order to trap as much light inside the diamond as possible through internal reflection.

An interesting fact about the Orange River is that it is reponsible for bringing down all the diamonds that are found between Oranjemund and Lüderitz. Geologists believe that the Orange River carried the diamonds down from diamond bearing rocks located inland near Kimberley and, over millions of years, deposited these precious gems along the river and at the coast. These diamonds are now being mined through removing the ancient deposits of sand that cover them. Diamonds provide thousands of people with jobs and the State with one of its most important forms of revenue.

The rivers and wetlands of the Caprivi region



Taken from : Van der Waal , *Madoqua*. 1990

This region receives some of the highest amounts of rainfall in Namibia, resulting in a fairly well-developed system of rivers of which the Zambezi is the largest. In fact, the Zambezi has the fourth largest river basin in Africa and covers a distance of some 3 000km before flowing into the Indian Ocean.

Two important tributaries of the Zambezi flow through Namibia. These are the Kwando and the Chobe Rivers. The Kwando flows from the mountains in Angola down into Namibia where it flows through marshlands of reeds and grasses. It empties into a swamp and emerges as the Linyanti River which then empties into Lake Liambezi. The Chobe River flows from Lake Liambezi and along a flat floodplain into the Zambezi. The Chobe River is a very unusual river in that it can flow in either direction, acting as either a tributary or a backwater of the Zambezi River. When the Zambezi River is in flood water is pushed back into the Chobe, away from the Zambezi, and flows towards Ngoma. As water levels drop and the floodwaters recede, the Chobe reverses its direction of flow and once more flows towards the Zambezi.

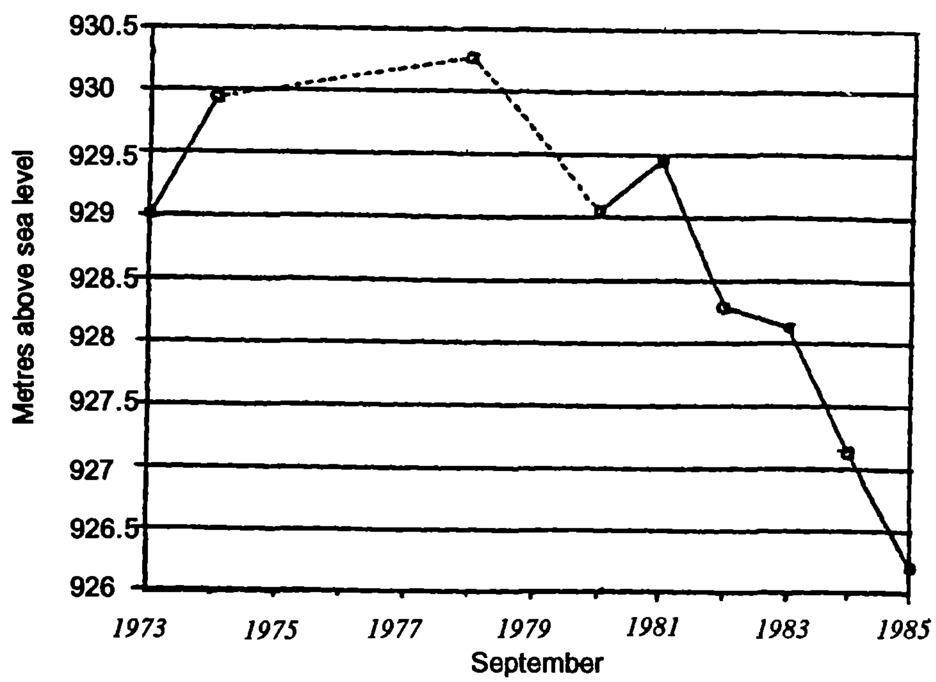
The rivers of this region are associated with a well-developed wetland system that supports a large variety of human activities, wildlife and plants. The ecological water requirement (the minimum quantity of water required to sustain plants, fish and other animals) for these wetlands is in the order of 3 000 million cubic metres of water per year. The wetlands in the east Caprivi region consist of a system of lakes and swamps that form one of the few permanent water features in Namibia. This system can be divided into 5 main regions:

A) upper Kwando
B) lower Kwando and Linyanti Swamp
C) Lake Liambezi (dry since 1985)
D) Chobe Marsh
E) the Zambezi and Chobe floodplains.

The wetlands are very dynamic and change with the seasons. During wet periods there are large numbers of reeds growing in and along the water's edge, but as the water evaporates so the reeds die and grasses begin to grow. Changes in vegetation also mean changes in the types of animals that graze and browse there. The system is highly productive and people take advantage of this by grazing their cattle on the lush vegetation that grows after the wet season.

Lake Liambezi

Lake Liambezi forms part of the wetland system in the east Caprivi region. The level of water in the lake depends to a large extent on the flow of rivers that feed it. This lake has been dry since 1985 due to poor river flow. The graph below shows the water levels in the lake recorded from 1973 up until 1985 when the lake dried up.



From: Madoqua 1990

One of the greatest threats to the Caprivi region is the grazing pressure exerted by cattle. It is estimated that about 60% of the population of the region is concentrated on just 30% of the land - mainly in the eastern floodplain. The carrying capacity of this land is estimated to be between 30 000 and 40 000 head of cattle. The current stocking rate far exceeds this, at about 96 000 head of cattle. The farmers in the region consider 15-20 cattle the minimum number possible for farming. Farmers are not prepared to sell off their cattle until such numbers have been reached. With the large population increase in the area, it is expected that the number of cattle will increase even further. This means there will be even more pressure on the land, and problems linked to overgrazing will become serious issues.

Before Lake Liambezi dried up it used to yield up to 1 tonne of fish a day.

The Caprivi region receives more rainfall than any other part of Namibia. As a consequence of this, the area is more productive than other areas in Namibia and has a great diversity of plant and animal species. Overpopulation, the use of toxic chemicals, military activity and poor land management practices have led to a decline in the natural fauna and flora of the region. Land degradation and clearing land for homesteads and cultivation has resulted in the loss of habitats for a number of species.

Large scale poaching of wild animals has left parts of the region without any large mammals, and consequently with less potential for income-generating tourism and no potential for sustainable harvesting of these wildlife resources for food. Animals most threatened by poaching are elephants, hippo, lechwe and buffalo.

East Caprivi has a very rich bird community. Of Namibia's 620 species, 430 have been recorded in east Caprivi - of which at least 73 species are in danger of becoming extinct. Loss of habitat and the use of pesticides are two major threats to bird life in this area.

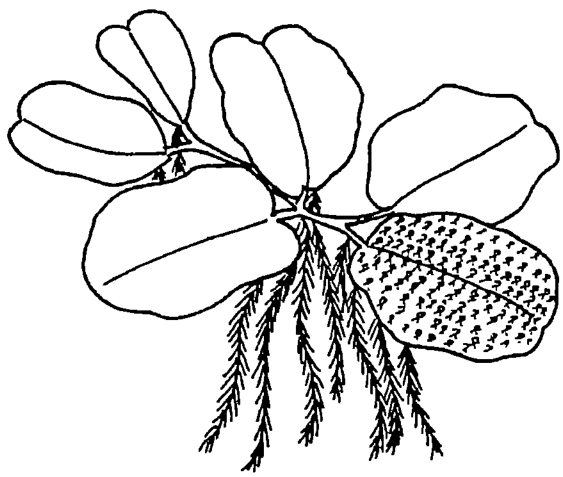
Some 26 species of frogs have been found in the wetlands of east Caprivi. People in the area eat some of these species, providing them with an additional source of protein.

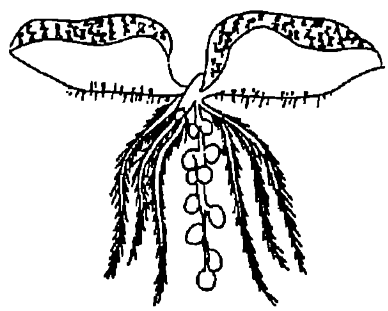
Large areas along the Linyanti and Kwando Rivers are sprayed with the poison Dieldrin in order to control tsetse fly. Because the poison breaks down slowly it enters the food chains of animals and people, and is known to affect the breeding of birds. Other pesticides that degrade more quickly are now being tried, but the amount of damage already done by Dieldrin remains unknown. The management of malaria-carrying mosquitoes is another major challenge in the Caprivi. DDT, a highly toxic pesticide banned from use in many parts of the world, is still sprayed in homes in order to kill mosquitoes.

Another of the region's ecological problems stems from the introduction of alien plant species, especially plants that live in water courses and standing water pools. Kariba weed and water lettuce are both alien water-weeds introduced from South America.

Kariba Weed

The alien aquatic plant, *Salvinia molesta*, commonly known as **Kariba weed**, has threatened to become a major problem in the rivers and wetlands of the east Caprivi region. The plant originated in Brazil and was probably brought to Africa as an ornamental plant. Because it grows extremely fast it can quickly cover the surface of the body of water in which it lives, resulting in a number of problems. In some cases the water channel can be completely blocked.



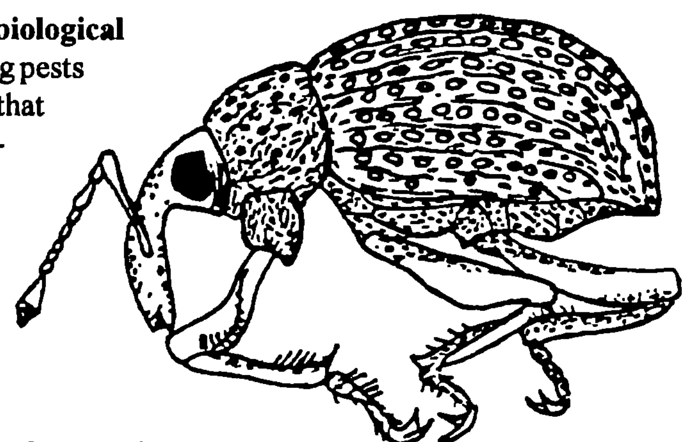


Kariba weed

Biological agent used to control Kariba weed

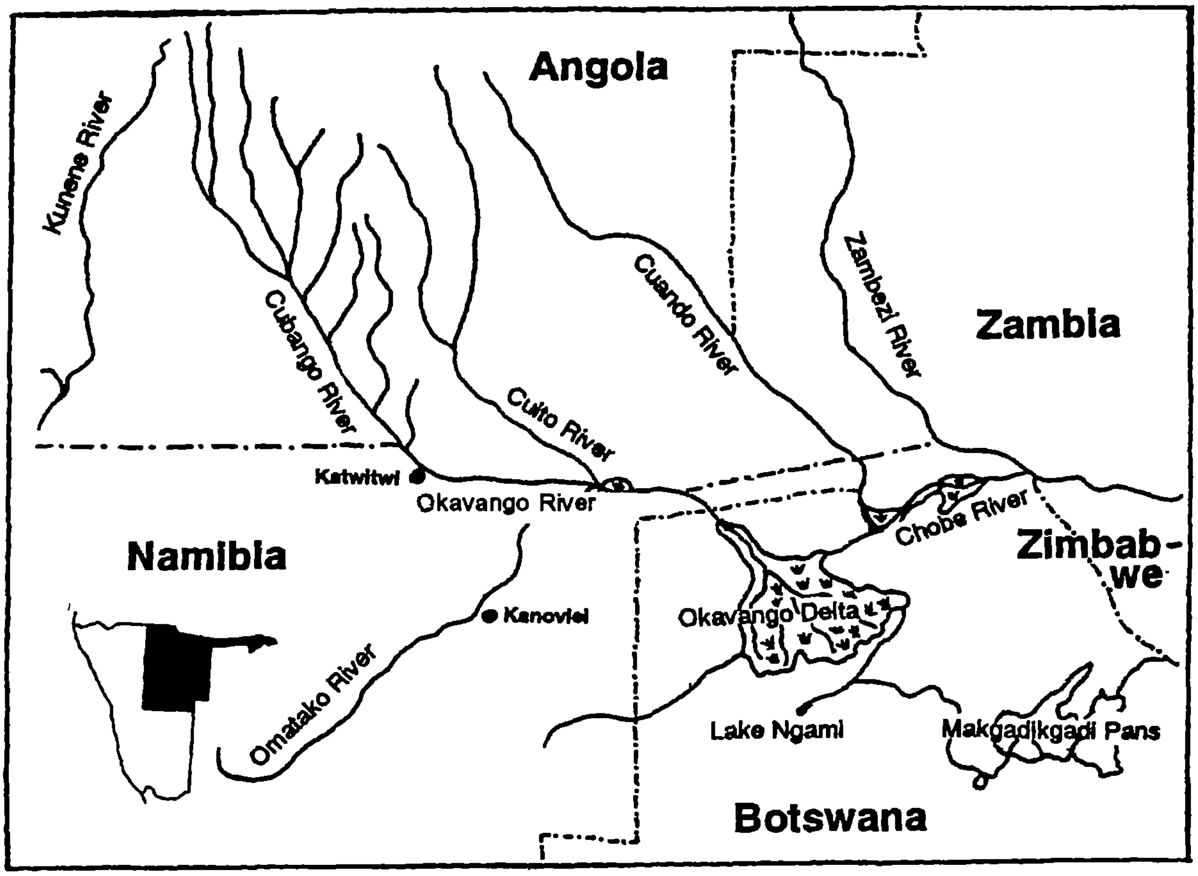
Kariba Weed is being controlled in an interesting way by the Department of Water Affairs. Large numbers of a weevil (a snout beetle), *Cyrtobagous salviniae*, were imported from Australia in 1981 by the Department of Water Affairs. The beetles eat the growing points of the Kariba weed. Eventually the plant dies. When the beetles have no more food to eat, they also die so there is no need to control the beetles. In this way large areas of water have been cleared of Kariba weed. Eventually the Department of Water Affairs established a breeding colony at Katima Mulilo to replace dead beetles. These insects continue to be released, and their progress is monitored.

This form of pest control is known as **biological control** and is a good way of controlling pests because it does not rely on poisons that can damage the environment. However, before any form of biological control is used we must be certain that the organism we are introducing will not create another - and possibly larger - problem.



Cyrtobagous salviniae

The Okavango River and its wetlands



The Okavango River is an important Namibian perennial river. It rises in the Angolan mountains, not far from the source of the Kunene River, but flows east instead of west. After flowing through a region of relatively high rainfall in Angola, it forms the border with Namibia, flows over the Popa Falls and then makes its way into Botswana. It is unlike most rivers because it does not flow into the sea. Instead it ends its journey in an unusual way - spreading out into an enormous system of river channels known as the Okavango Delta.

The section of the river that flows through Namibia and Botswana floods every year and spills over onto nearby land, resulting in large areas of wetland. These wetlands grow and shrink with the flooding pattern of the river. In Namibia the floodplains cover about 434km^2 in the wet season and about 119km^2 in the dry season.

Sections of permanent marsh in Namibia occur where the Okavango and Cuito Rivers meet, and south of the Popa Falls in the Mahangu Game Reserve.

The Okavango - a generous provider

The soils of the Kavango region are generally infertile, but silt brought down by the river greatly enriches floodplain soils and provides a suitable environment for a lush growth of plants. Reeds are some of the most common plants associated with these wetlands. Dense reed fringes, papyrus margins and shallow vegetated floodplains provide favourable fish breeding and bird nesting habitats. Reeds are also a source of building materials for people living near the river.

A number of animal and plant species of the Okavango wetland area are protected by law. This means that it is illegal to kill or remove them. They are protected because their numbers are low and they are in danger of becoming extinct. The list of protected species includes rare plants such as the African protea, an orchid, two types of aloes and a lily. The African protea is very rare because it is sought after for its medicinal value. In the past it was overharvested by local people. Herbalists agree with the protection of these plants because their preservation means that herbalists will have a continued source of medicines.

Forests that grow along the edge of the river provide wood fuel, building materials and fruit for people of the region. Some of the common fruits include the custard apple, the marula and the monkey apple. Above the level of the floodplains are alluvial terraces that also support dense forests. Trees such as baobabs, palms and the the edible mobolo plum grow well in these areas. However, in recent times more and more trees are being removed from these fertile terraces to make way for houses, provide fuelwood, and make space for the growth of crops like sorghum and mahangu. This is done despite the fact that this practice is illegal in Namibia. The Forestry act of 1952 states: "no living indigenous tree, bush or shrub growing within 100 yards of the bank of a stream, river or watercourse may be removed without a permit unless for erosion control" (paragraph 14, chapter 3.14).

Because the Kavango region is home to some of Namibia's most interesting wildlife and is relatively unspoilt by modern developments, it has the potential to become a great tourist attraction that in future will bring money into the region.

Much of the life in this area, human and otherwise, depends on the bounty of the Okavango River. Many cultural and agricultural activities rely directly on the Okavango's natural wetlands.

The Okavango's alluvial terraces are used for growing mahangu and its floodplains for grazing cattle during the dry season. Reeds from the water's edge are used for thatching, fencing and basket making. Fish are harvested in traditional and modern ways and many wild plants and animals are eaten or used as medicines.

The rich diversity of trees means that there is a large variety of fruits and nuts that people can include in their diets. Excessive tree cutting in the region means a loss of these foods which is an important factor when you consider that these trees provide crucial variety and vitamins in the diets of many rural people who could not afford to supplement otherwise poor diets with purchased foodstuffs.

Snails, frogs, crabs, reptiles, fish and birds are common foods eaten by local people.

Baskets and mats are woven from palm fibres and reeds. These items provide households with important equipment that would have to otherwise be bought. Wood from the leadwood tree is used to make handles for hoes and other implements. These items can also be sold as curios or decorations to tourists, supplementing family income. Destroying the environment through overgrazing and deforestation will result in the loss of the plants that enable these activities. Skills associated with these crafts and, ultimately, heritage and traditions, will also be lost.

Plants and animals are not the only resources that the river provides. Sand and clay from the river are used for building, while gravel is used for building roads. Clay from the river is also used to manufacture unique clay pots.

Wetland resources such as wood and reeds provide building materials for the construction of homes.

Threats to the Okavango wetlands

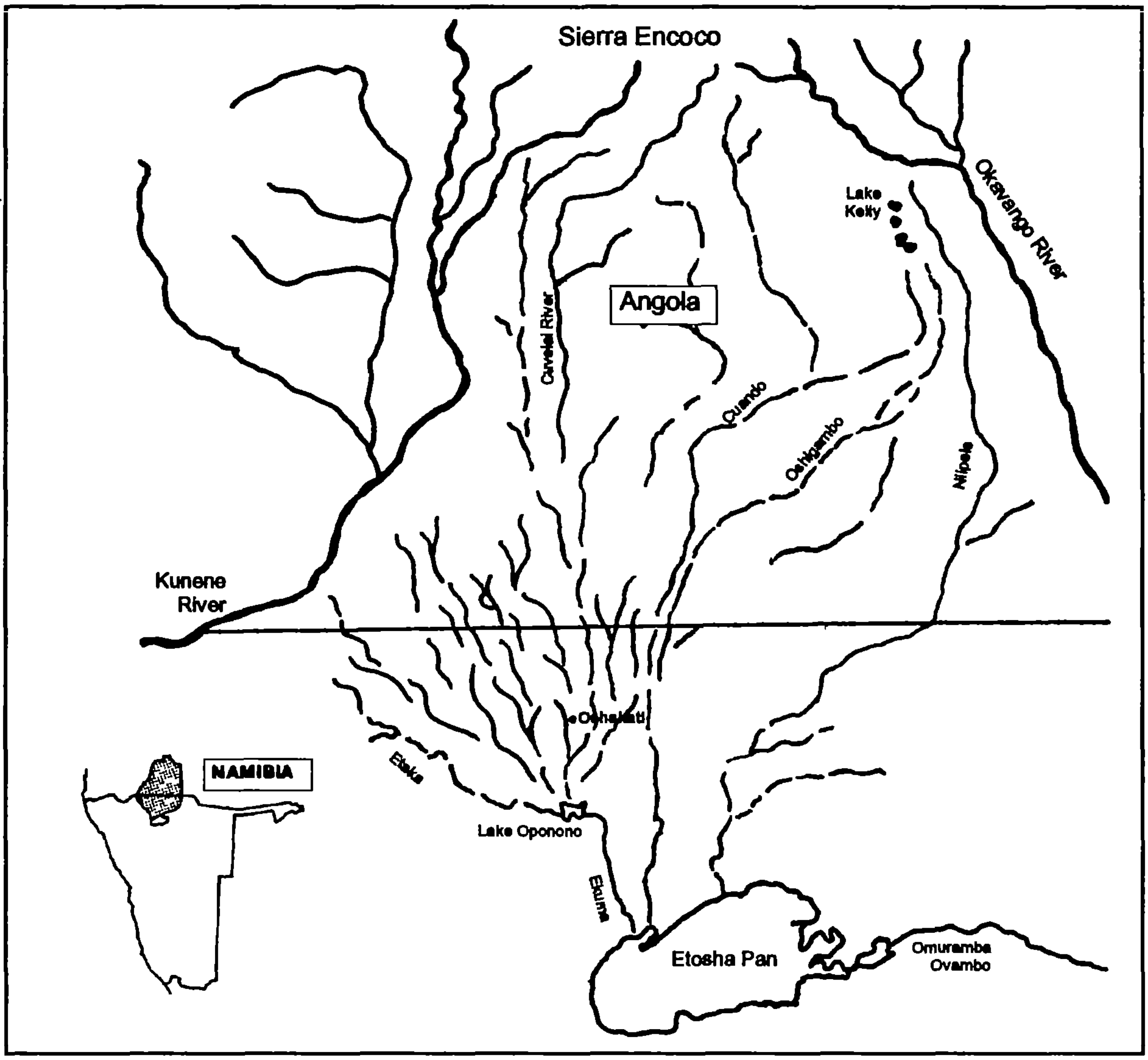
Soil erosion, overgrazing and deforestation are threats to the wetland system. The pressure on the floodplains is increasing as livestock numbers increase and the effects of grazing and trampling of vegetation are particularly noticeable during dry periods. Other activities, such as deep ploughing and the removal of vegetation, all contribute to increased soil erosion.

The increase in human population in the region is expected to result in greater demands for natural resources like water, food, grazing, fish and fuelwood. It is therefore important that these resources are carefully managed and that environmental damage is kept to a minimum. Water pollution from pesticides, fertilisers and waste may threaten people, plants and animals alike.

The Eastern National Water Carrier (ENWC) plans to take water from the Okavango River and, by means of a series of pipelines and canals, transport it to the central region and Windhoek as well as to the west coast of our country. The ENWC will abstract an estimated 60 Mm^3 of water from the river per year. The mean annual runoff for the Okavango is 5 000 Mm^3 per year. Although what will be abstracted is a small fraction of the total, our demand may increase or Angola may reduce the amount of water reaching Namibia by constructing dams or developing irrigation schemes within its borders. Should this be the case, flooding patterns that people, plants and animals in the region rely on may be altered. It is important that the effects of taking water from this river to supply other parts of our country are carefully considered before any final decisions are made.

Five tribes, the Kwangali, the Mbunza, the Shambyu, the Gciriku and the Mbukushu live along the Namibian section of the Okavango River. These tribes practice a mixed economy of subsistence agriculture, cattle farming, fishing, gathering and some hunting.

The oshana system



The whole oshana system consists of an unusual collection of ephemeral rivers, shallow pans and wetlands. It lies between the Kunene and Okavango drainage basins but has no links with either of these two systems. The land within the oshana drainage basin is very flat, and the Cuvelai, Cuando, Etaka and a number of smaller rivers flood over onto the land to form a large number of shallow pans and drainage channels called **oshanas** (in Oshiwambo) or **omiramba** (in Otjiherero). These pans and channels are often well vegetated, with banks lined with trees and bushes.

The oshanas originate in Angola, several hundred kilometres north of the Namibian border, and flow southward through the central north towards the Etosha Pan. While still in Angola, the main water courses spread out to form an inland delta that is about 130km wide at the northern border of Namibia. The drainage lines converge near Lake Oponono and then continue southward to end in the Etosha Pan.

The Cuvelai River which flows through the central oshana zone is the most active of all the oshana water courses. The Cuvelai rises in the Sierra Encoco mountains in Angola and flows southward across the border into Namibia. Only the Angolan section of the Cuvelai has water in it all year round. The oshanas of the westerly and easterly regions flow less frequently.

The ephemeral oshana system depends on rainfall in Angola. Good rains result in a vast sheet of water flooding down into Namibia and filling shallow oshanas and plains in the area. Such floods are called the ***efundja*** by local people and are highly valued as they provide not only freshwater for drinking, but also fish, frogs for eating and water that results in the germination of herbs and grasses that are an important source of food for livestock and people alike. During years of exceptional rainfall the *efundja* may even reach the Etosha Pan. *Efundja* do not occur every year, and in fact the last major flood that filled Etosha Pan occurred in 1954.

Fish harvested from the shallow oshanas provide us with an unusual example of how a resource can be completey exploited without damaging the resource in the future. Since all the fish originate in Angola and they will all eventually die as the oshanas dry up, they can all be removed for use by people without any damage to the system.

A look at the map on the opposite page will show you some of the river channels that can carry water down to Etosha Pan. The Ekuma River, Omiramba Niipele, Omuthiya and Owambo are the most important routes by which water can enter the pan. None of these channels is more than a few metres deep.

Oshanas and the Etosha Pan rarely have water in them for more than a month after flooding. Water is lost to the atmosphere by evaporation, leaving behind only a few shallow pools. Small clay pans, on the other hand, may hold water for up to 3 months after the floods.

The oshana system of northern Namibia represents a large ecological unit that extends across the border into Angola. For this reason, changes made at one part of the system can have effects that are experienced elsewhere in the system. For example, bad land management practices in Angola and within Namibia can have negative impacts on the entire system and the people that depend on it.

The Etosha Pan is the only known large scale breeding ground for flamingoes in southern Africa.

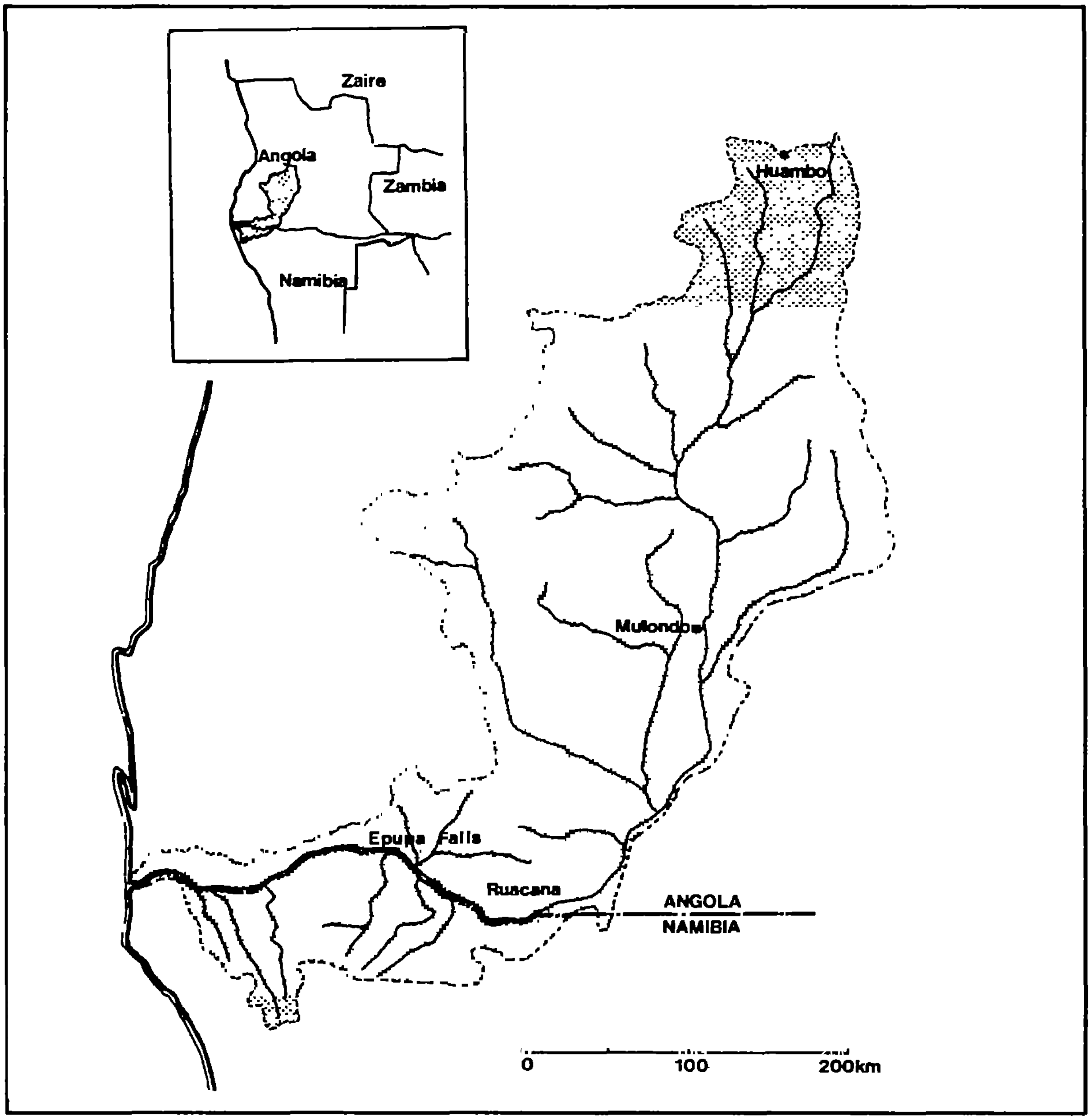
The oshana system supports the four most densely populated political regions in our country. The average population density of the area is 11 people per square kilometre, with most people relying directly on natural resources for survival. When compared to other countries in Africa, this population density figure may seem low but we should remember that Namibia is an arid country and the carrying capacity of our land must be considered before we can draw any conclusions. For example, the oshanas are dry for most months of the year and the system is not particularly productive. Only when rains fall do people have plentiful grazing for their cattle and are they able to grow crops.

Two resources in this area that are relied on heavily are grass (for grazing livestock) and wood (for fuel and building). The unmanaged use of these resources is resulting in serious land degradation and deforestation.

Etosha Pan falls within Namibia's Etosha National Park. The park supports large numbers of African wildlife and is one of southern Africa's most important tourist attractions.

Fish that migrate downstream in the rivers during *efundja* are another important regional resource. These small freshwater fish, which colonise shallow pools, are an important source of food and income for people during the wet season. The over-exploitation of fish resources in the upper reaches of the Cuvelai River may seriously affect the availability of fish in the lower reaches in the future.

The Kunene River and its wetlands



The Kunene, another of Namibia's few perennial rivers, is our country's fourth largest river with an approximate length of 1 050km and a mean annual runoff of 5 500Mm^3/a. It rises in Angola near Huambo and flows in a westerly direction down to the Atlantic Ocean, with part of its course forming the international boundary between Angola and Namibia. The Kunene River flows through rocky mountainous terrain for most of its journey along the Namibian border, and just after Calueque it flows down a number of rapids before plunging over the Ruacana Falls and then the Epupa Falls. After this it continues flowing down the deep river valley until it reaches the Atlantic Ocean.

Because this river flows through mountainous terrain it does not have large floodplains or wetlands. There is, however, a small floodplain between Mutondu and Calueque in Angola and a freshwater lagoon at the river's mouth. At Swartbooisdrift the river is between 80 and 150 metres wide and its banks are associated with dense plantations of makalani palms and other trees. Because the Kunene is perennial, dense reedbeds grow on the banks of the river at a number of places along its length.

The Kunene supports a chain of vegetation that is more tropical than the vegetation associated with the ephemeral westward flowing rivers further to the south.

Along with this chain of dense vegetation comes a great variety of wildlife. Hyaena, jackal, and leopard are large predators found in the area. The clawless otter, an animal that lives near water, is fairly common along the Kunene up to the Epupa Falls. It is not found along the lower part of the river. Records indicate that elephant and rhino were once common along the middle section of the Kunene, but these animals can no longer be found here, mainly due to poaching.

The Kunene River is home to a number of turtles, the Nile crocodile, small species of fish, otters and many species of birds.

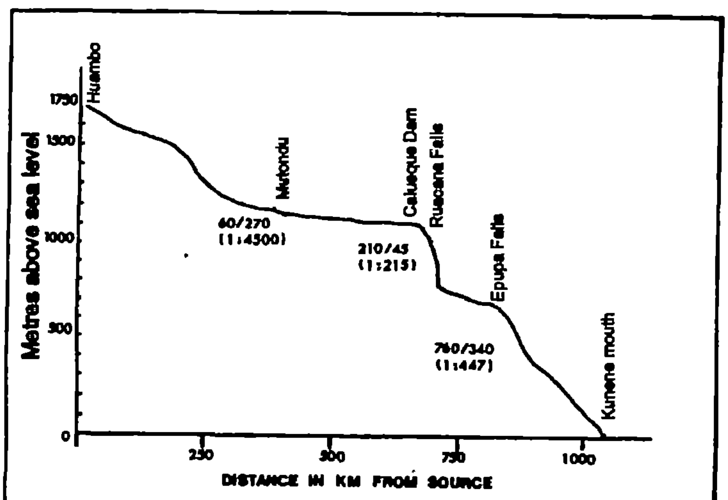
In order to meet ever increasing demands for electricity in Namibia a hydroelectric power scheme is planned for Epupa Falls. A dam that will be 17 times bigger than Namibia's largest dam - Hardap Dam - may be built along the Kunene. Engineers, hydrologists and ecologists are debating the positive and negatives effects of building such a large dam across the river. Although the scheme will provide cheap and pollution-free electricity, the long term effects of the dam need to be considered. Also, the average life span of a Namibian dam is between 40 and 80 years due to the silt that accumulates. It is important for Namibia not to develop a dependency on this power-generating scheme if the lifespan of the dam is limited.

About 3 500 litres of water are abstracted from the the Kunene every second for use in the former Owambo region.

Ruacana Falls

Between Calueque and Ruacana, a distance of 45km, the Kunene River drops about 210m as it flows over a series of rapids and eventually the Ruacana Falls. The Falls have a height of about 120m, and it is this site that was chosen for the construction of a hydroelectric power scheme. The power station and its turbines are located underground near the base of the Falls and water is diverted from the river to the power station by a pipeline. During dry periods, when the water level in the dam is very low, very little water flows over the Falls. Most of it is diverted to the power station so that electricity can be produced. Once the water has flowed through the power station it is returned to the river below the Falls.

Longitudinal section of the Kunene River



After Midgley, 1966

The Himba - traditional people of the Kunene Region

In the far northwestern corner of Namibia is the Kunene region. It is the second largest political region and takes its name from the Kunene River that flows along its northern border, separating Namibia from Angola. The Kunene region is one of the most sparsely populated regions of our country. Its total area is 144 254km^2, yet it has a population of only 58 000 people (according to the 1991 census). This means that the average density of the region is 0.4 people per square kilometre! This is one of the lowest densities of people anywhere in Africa.

Otjiherero speaking people have long dominated the area, and it is from their language that the Kunene River gets its name. It is thought that when Herero speaking people moved south from Angola the river was on their right, so they called the river *okunene,* meaning right arm.

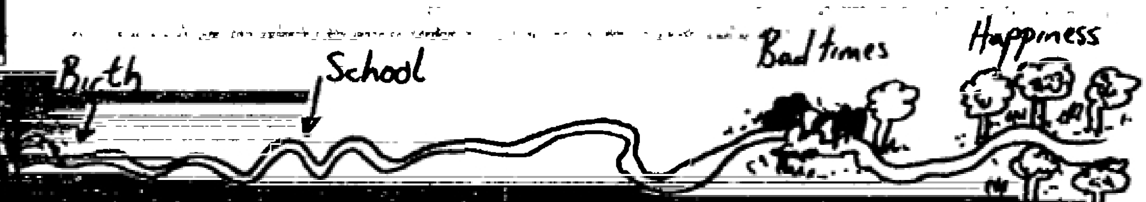
The Herero speaking people who live in this area are known as the Himba. The exact origins of these people are unclear but it is thought that conflict with other groups forced them to move to the semi-arid mountainous areas south of the Kunene. The Himba are now mainly nomadic pastoralists who herd their livestock in search of good grazing. But they did not always follow this way of life. Historical documents indicate that in earlier times these people followed a hunter-gatherer mode of existence, collecting food from the veld and hunting wild animals.

Today the Himba follow a traditional lifestyle, farming with cattle and goats. Their constant shifting in search of good grazing is a system of farming which can be said to equal rotational grazing on a very large scale. Himba herdsmen follow rainfall patterns in the area in order to access the best grazing for their animals. Depending on where and how rains fall, they will eventually return to the land that their cattle have grazed in a previous season.

However, this system of grazing is under threat as people and livestock numbers in the region increase. Heavy grazing in this fragile area results in overgrazing and soil erosion, both of which are common in this region. The end result of this continual pressure is that land becomes less and less capable of recovering from damage, leaving it in worse condition each year.

Chapter 5
Activities

1. Draw up a "River of Life" for yourself. Indicate bends, twists, rapids, waterfalls, smooth patches, etc. and say what event each part of the river represents in your life.



2. Write down as many song titles with references to water, rivers, rain, etc. that you can think of. Devise your own and write the lyrics. Perhaps you can even try performing them.

3. Collect tales and superstitions that involve water from people in your particular region.

4. Flashflood! Write a story about being trapped by a flood.

1. Make a study of the art in your region. What materials are taken from riverbeds, pans and wetlands. Make a collection of these and demonstrate how they are prepared and used. Some examples may include: clay, reeds, wood, pigments, etc.

2. You have been commissioned by the Department of Tourism to design a symbol to represent ... tourist attraction in Namibia that involves water. Choose a river, a wetland or some other ...atery" place and incorporate as many typical features as possible in your design. Examples may include: ... Zambezi River and its wetlands, Etosha Pan, etc.

... Invite a member of your community to give a talk and demonstration at your school about the collection, ...paration, skills and designs used in making reed baskets. Try making your own.

... Learners living in the north-eastern part of Namibia can do a project on the traditional use of clay by the ...imba people for decoration and protection from the sun.

1. What local specialities rely on food from rivers or wetlands. Record the recipes and prepare them in class.

2. Make a seasonal calendar of wetland foods similar to the agricultural calendar in chapter 13. Indicate when each of the foods becomes available and when it goes out of season. You may need to gather information from people in your community to complete this project.

1. Salt gathering trips to the salt pans in the interior of our country feature in the history of many of the peoples of Namibia. Investigate the importance of these salt trips as regards trade and initiation ceremonies.

1. Rice, a wetland species, is one of the most important staple foods in the world. Do you know of any wetland species of plants that occur naturally in Namibia that can be used commercially?

2. What role do wetlands play in the breeding and survival of Namibia's wildlife? You may wish to study how most of the country's plant and animal diversity is associated with wetlands.

3. What is the importance of wetlands as a tourist attraction? What are the most important species of animals as far as tourists are concerned? Interview a few tourists to find out what animals they hope to see during their stay in the country. Which of these animals are rare and why?

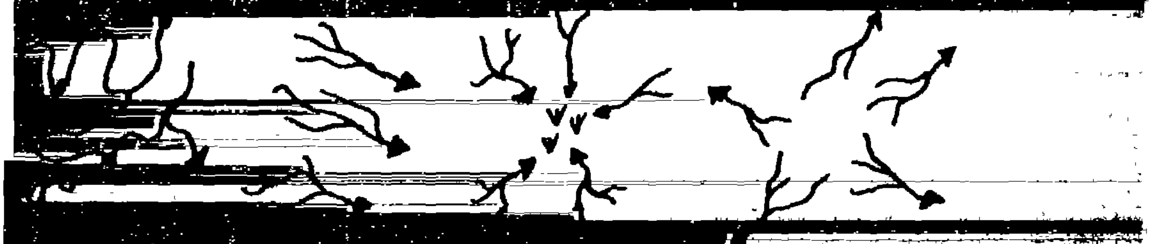
1. Make a catalogue of as many river, wetland and lake references in the Bible as you can find, e.g. Moses in the bulrushes, etc.

1. In a study unit called "setting sail: water and transport" set the learners projects that challenge them to investigate principles associated with floating. Include: surface tension and floating, density and floating, centres of gravity in boats, etc.

1. The waterproofing of homes, materials, roofs, boats, etc. is an important way of making materials last longer and making life more comfortable. Make a study of natural and artificial substances that can be used for waterproofing. Which of them are toxic and which are biodegradable? Learners who live in big towns may wish to investigate what is commercially available at hardware stores.

1. Make a sketch map of your region. Fill in all the water features such as rivers, waterfalls, lakes, pans, etc. Indicate topographical features such as mountains or hills that may be of importance to water flow.

2. Use maps and field knowledge to study the different river patterns near you.



1. Study the history of a river of your choice. What major events have occurred near or on it? What has it been used for in the past? Has it played a significant political role? Has it served as an important means of transport?

1. Pretend that you and a team of learners have been asked to decide on the site for a small-scale hydroelectric power scheme along a river near you. Measure and calculate angles, distances and the gradients of slopes using geometry and trigonometry.

6

Buried treasure

Namibia is a dry country with very little open water on its surface. Our harsh sun and dry winds result in high evaporation rates that leave most pans and rivers empty after only a few months.

However, hidden under the surface of the soil, away from where the sun can cause evaporation, lies stored water that when pumped to the surface brings life to this dry country of ours. It must be remembered though, that our underground sources of water are limited and that if we do not manage these precious reserves correctly we may make our underground water sources as dry as the rivers and pans on the surface.

Groundwater - giver of life in arid countries

When surface water and rain sink into the ground we call this hidden water groundwater. In fact, groundwater is the name given to any body of water that occurs beneath the surface of the earth. One thing that all groundwater has in common is that every drop of it comes from rainfall at some time in the recent or distant past. Rainwater that is not taken up by the roots of plants filters down into the soil until it reaches a layer of clay or rock that it cannot pass through. Here the water remains as groundwater. The upper boundary of this groundwater is called the **water table**.

Records indicate that approximately 130 000 boreholes have been drilled in Namibia, but only 32 000 are in use.

Not all groundwater remains in one place. Water underground, like water on the surface, moves down a slope - the only difference being that it takes much longer to do so. Groundwater flow from one spot to another can take anything from a few years to a few thousand years.

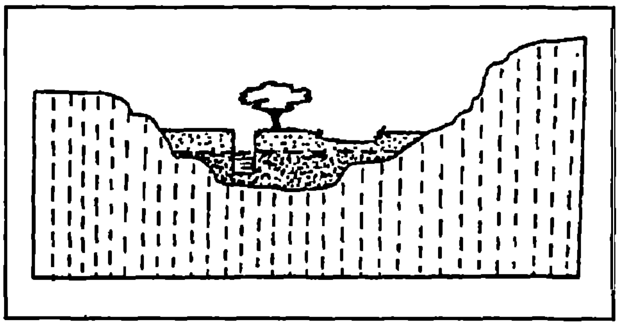
When water occurs underground in large enough quantities for it to be useful to people we call it an **aquifer**. Aquifers are very important in countries with dry climates and where surface water is in limited supply during the dry season. Namibia, Botswana and South Africa are three countries that rely heavily on groundwater supplies. Water pumped from aquifers to the surface provides freshwater for domestic, industrial and agricultural use.

Approximately 57% of the water used by people and animals in Namibia comes from below the surface of the ground

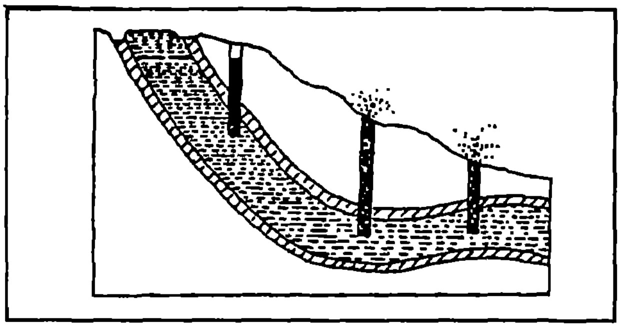
The depth and the quality of water in an aquifer depend on a number of factors. Groundwater in southern Africa can be found from very close to the surface to up to 600m underground. The quality of the water depends on the level of dissolved substances and salts in it. Aquifers whose water has been stored for a very long time tend to have salty water due to salts from the surrounding rocks dissolving in the water.

As mentioned before, Namibia is a dry country and ground water is particularly important in sustaining life throughout our dry periods of little or no rain. People have acess to our aquifers as a source of water by means of hand-dug wells, springs or boreholes. Up to 40% of Namibia's human and animal population relies on groundwater for survival. Groundwater is particuarly important for rural communities that do not have access to municipal water from dams and rivers.

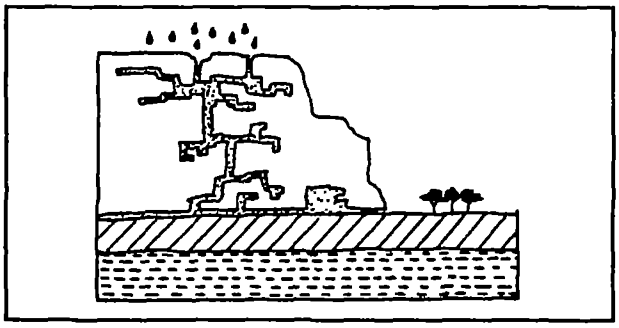
There are five main sources of groundwater in Namibia. These are also known as aquifers



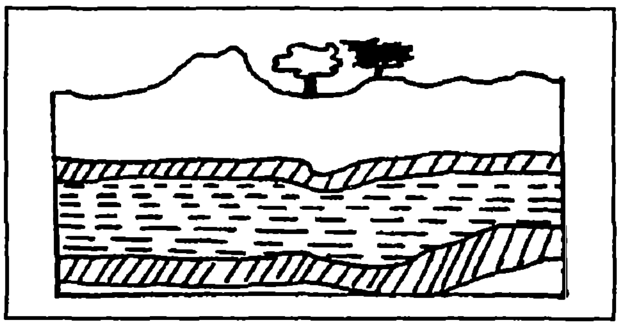
1. Aquifers may lie under riverbeds. This kind of aquifer is known as an **alluvial aquifer**. There may be no water on the surface of the riverbed all year round, but water may occur under the riverbed in large quantities. Boreholes or wells down into the aquifer can provide supplies of groundwater. The aquifers associated with the Kuiseb and Omaruru Rivers are of this type.



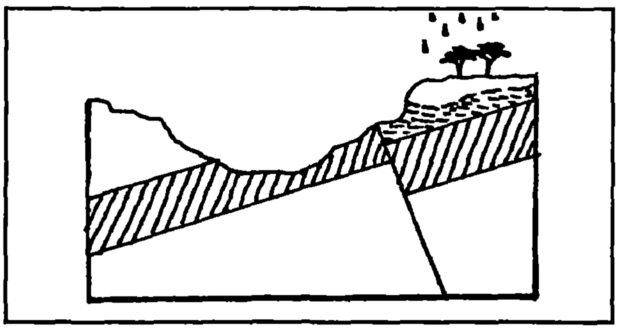
2. If water is trapped in a permeable layer of rock or soil between two impermeable layers we call it a **confined aquifer**. This water is often under pressure and flows to the surface in a steady stream if a borehole is made into the upper impermeable layer of rock. We call such an aquifer that emerges at the surface **artesian**. If the aquifer does not emerge at the surface it is called **sub-artesian**. The Auob-Nossob system and the Stampriet artesian aquifer are Namibia's largest examples of these aquifers.



3. Aquifers may occur where water has dissolved certain types of rocks, forming porous rock or large underground caves filled with water. We say the rock has been **karstified** or dissolved by rainwater. The **Karstveld** in the north of Namibia is a large system of karstified rock filled with water.



4. Some aquifers result from water being trapped many years ago in sand between impermeable layers such as clay or rock. This is also a confined aquifer, but it receives no recharge and the water is called **fossil water** because it is very old. It was thought that Koichab Pan, that supplies Lüderitz, contained fossil water but recent studies indicate that the water it contains was deposited fairly recently.



5. Water sometimes collects underground where the meeting of different types of rock creates faults and cracks. Water may seep into the ground and collect up against rock barriers called **dykes**. Boreholes can be drilled along dykes and faults to bring water to the surface. Windhoek has a natural spring of this type.

Recharge - replacing groundwater

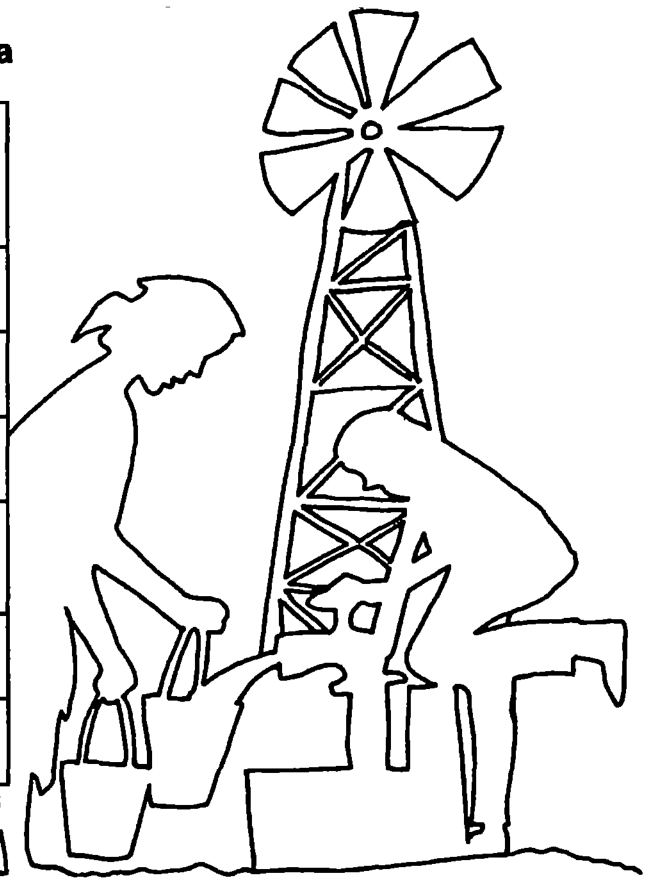
Recharge is the continual process whereby groundwater is replaced by rainwater. In arid countries, such as Namibia, the amount of water that is available for recharge is less than in countries with higher rainfall. In southern Africa only approximately 1% of our rainfall goes to recharge groundwater. The rest is lost through evaporation, transpiration or runoff.

A drop in the level of the water table indicates that an aquifer is not being recharged or that water is being abstracted at a faster rate than it is being replaced.

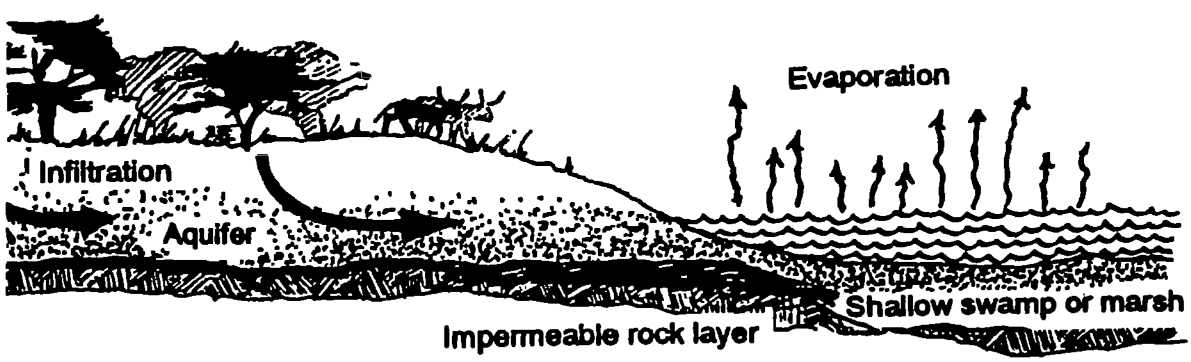
Productive boreholes in Namibia

Authority	Number of boreholes or wells in operation
Department of Water Affairs	180
Districts	140
Regions	70
Local and regional authorities	3,780
Private	27,680
Total	**31,850**

DWA, 1995

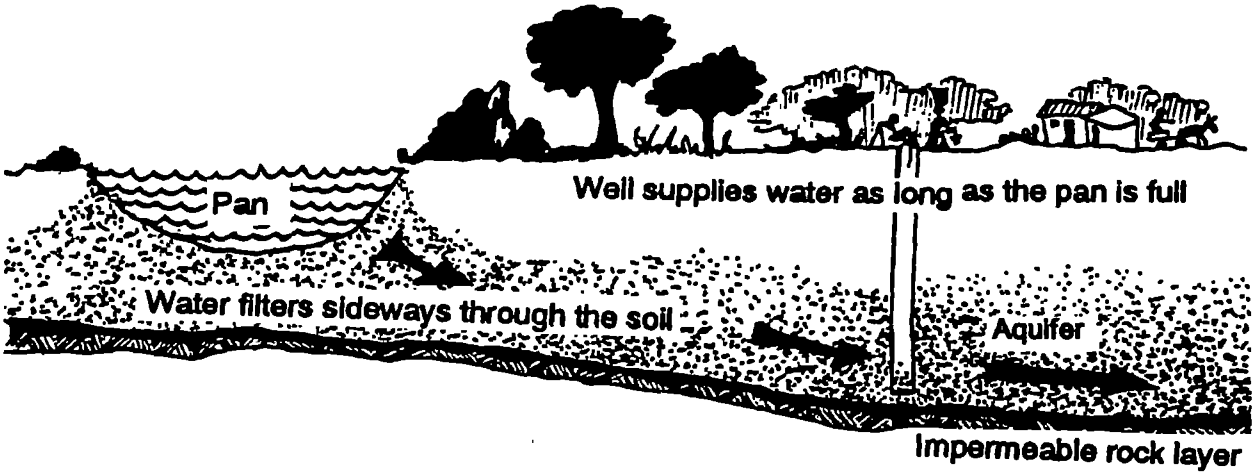


Recharge of shallow aquifers



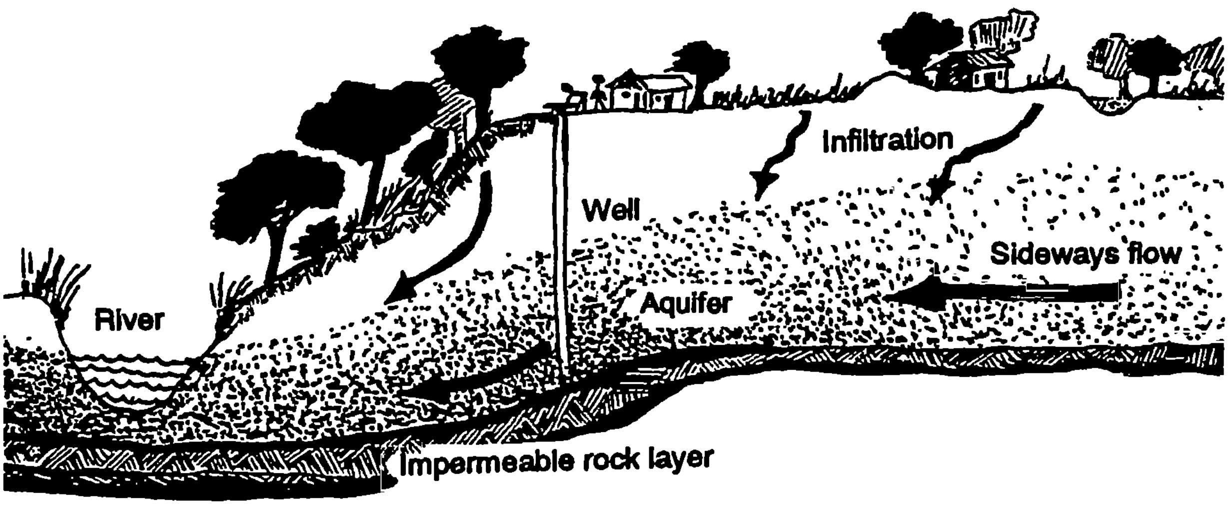
Where the ground is flat and the impermeable layer is shallow, there is the potential for shallow pans and swamps to form.

Rivers and pans help with the recharge of aquifers



Pans and rivers are very important for recharging the groundwater resources in Namibia. Water filters through the soil down to the aquifer from pans, oshanas, dams and rivers. When there is little rain and the pans and rivers are empty, there can be no recharge.

The depth of the water table depends on the depth of the impermeable layer



If the impermeable layer is deep, it is necessary to have deep wells that can reach the water. The aquifer is fed by rain so the level of the water table fluctuates with the amount of rain that is received each year.

Bringing groundwater to the surface

Traditional methods

Different peoples in Namibia have many different traditional ways of accessing groundwater, but most involve some form of well or hand-dug pit down to the level of the water table. Because these are open pits they cannot be too deep, and usually yield only limited amounts of water. Their size and depth are often limited by the type of soil where the well is being dug. In the case of sandy riverbeds some form of support is often necessary to prevent the sides of wells from collapsing.

One does not refuse water to the digger of wells - **Swahili**

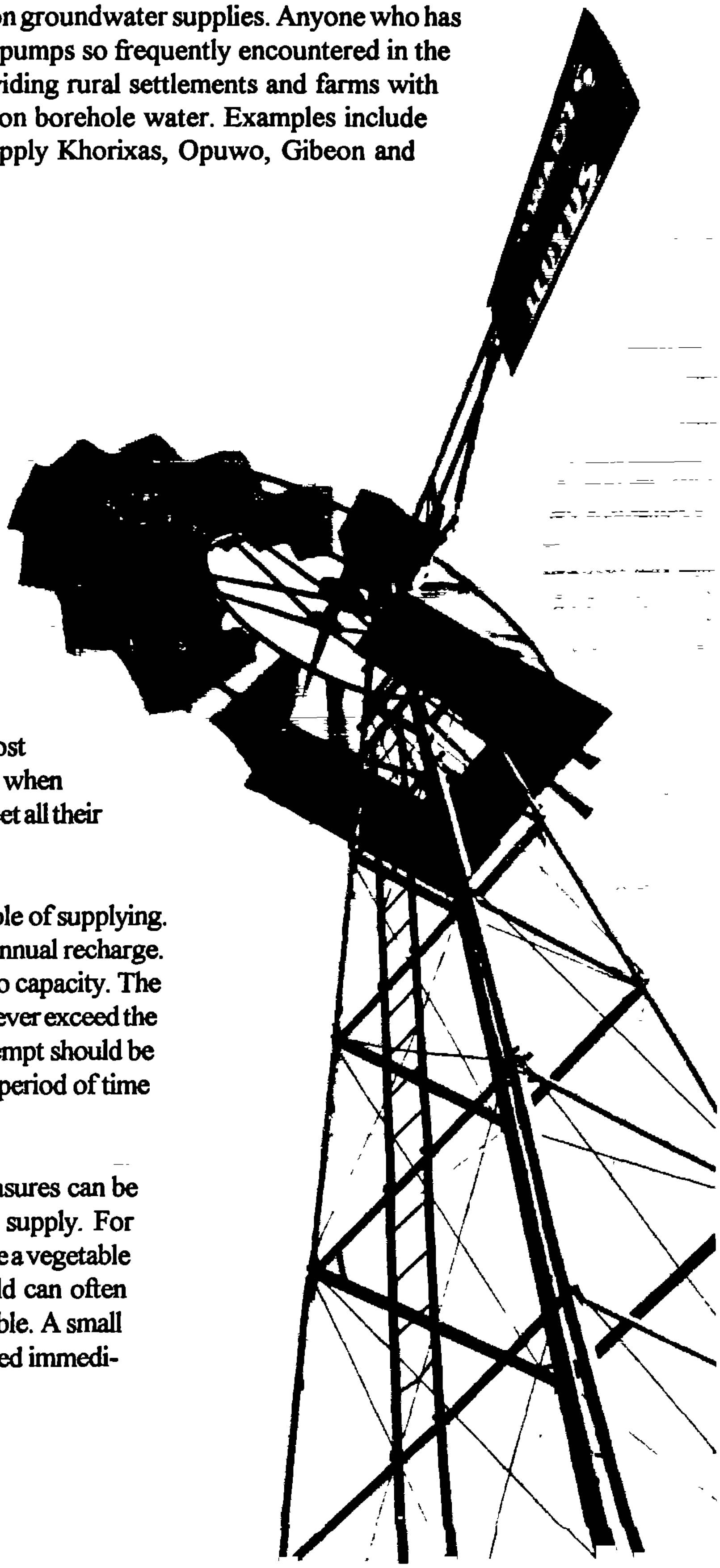
The deeper the hole the more difficult it is to bring the water to the surface, but a number of different devices are used to make the task easier. Some, for example, consist of a pole balanced on a forked stick, with a bucket on one end and a weight on the other to make raising the water-filled bucket easier. Before buckets were freely available, people would transport the water in clay pots, ostrich shells or animal skins.

A simple well into the alluvial aquifer of the Kuiseb River provides water for a Topnaar settlement

Boreholes

Boreholes are the commonest modern way of bringing groundwater from an aquifer to the surface. Holes are drilled into water-bearing rock or soil and water is pumped to the surface by means of wind, solar, diesel or electric pumps.

Most farms and rural areas in Namibia do not have access to perennial or even ephemeral rivers. This means that they rely almost entirely on groundwater supplies. Anyone who has travelled in Namibia must realise that the wind pumps so frequently encountered in the interior of the country are responsible for providing rural settlements and farms with groundwater. In some cases entire towns rely on borehole water. Examples include water pumped from the alluvial aquifers to supply Khorixas, Opuwo, Gibeon and Karasburg.



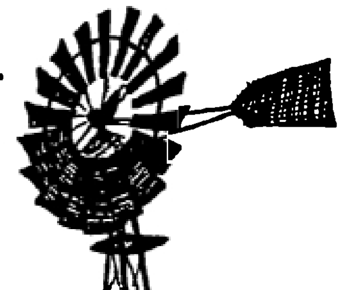
Boreholes for domestic use

It is important to calculate the daily water requirement from a borehole for domestic or agricultural use before drilling it. Most people are not sure of the amount of water that they need every day - all they know is that they want as much water as possible. In most cases the owners of boreholes are disappointed when they realise that their borehole will not be able to meet all their demands.

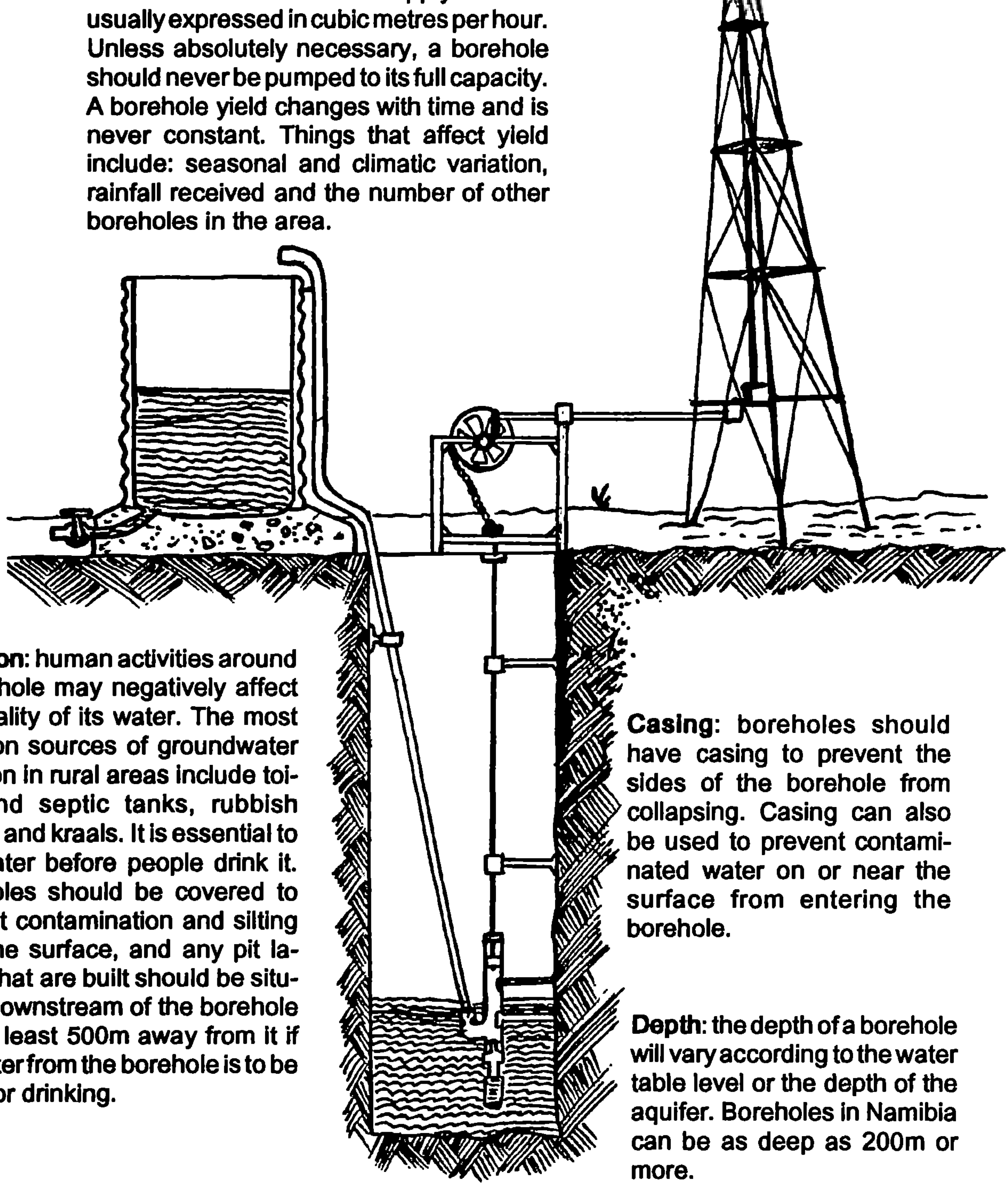
A borehole can only yield what an aquifer is capable of supplying. This depends on the type of aquifer and its mean annual recharge. Of course, it is not advisable to pump a borehole to capacity. The quantity of water pumped from an aquifer should never exceed the estimated safe yield of the borehole and every attempt should be made to verify the safe yield estimate over a long period of time through the systematic keeping of records.

Careful planning, conservation and recycling measures can be used to solve the problem of inadequate water supply. For example, water used for washing dishes can provide a vegetable garden with water and boreholes with a low yield can often provide enough water if a storage facility is available. A small tank or dam can be filled when water is not required immediately.

A borehole



Yield: this refers to the amount of water that a borehole is able to supply. Yield is usually expressed in cubic metres per hour. Unless absolutely necessary, a borehole should never be pumped to its full capacity. A borehole yield changes with time and is never constant. Things that affect yield include: seasonal and climatic variation, rainfall received and the number of other boreholes in the area.



Pollution: human activities around a borehole may negatively affect the quality of its water. The most common sources of groundwater pollution in rural areas include toilets and septic tanks, rubbish heaps, and kraals. It is essential to test water before people drink it. Boreholes should be covered to prevent contamination and silting from the surface, and any pit latrines that are built should be situated downstream of the borehole and at least 500m away from it if the water from the borehole is to be used for drinking.

Casing: boreholes should have casing to prevent the sides of the borehole from collapsing. Casing can also be used to prevent contaminated water on or near the surface from entering the borehole.

Depth: the depth of a borehole will vary according to the water table level or the depth of the aquifer. Boreholes in Namibia can be as deep as 200m or more.

Safe yield: it is essential to establish the "safe yield" of a borehole in order to know how much water can be abstracted without the borehole drying up. Safe yield refers to the rate at which a borehole can be safely pumped. This is usually expressed in cubic metres per hour. Safe yields depend on a number of factors. A good understanding of the aquifer being pumped is required in order to estimate the safe yield.

Borehole water

If you study the table below you will see that borehole water can contain a number of substances - science teachers will surely recognise some of these! Most of them are dissolved in the water while others occur in suspension. The chemical quality of groundwater is determined by amount of rainfall in the region, the chemical nature of the rocks and soil associated with the groundwater and the age of the water.

The table below lists the recommended maximum quantities of some of the chemicals more commonly found in borehole water. Too much of certain substances can be harmful. High levels of salts corrode machines and are lethal to crops and most other plants while certain levels of bacteria and salts can cause diseases in people and livestock.

Groundwater in arid regions tends to be salty. This is especially true if the groundwater was laid down thousands of years ago and has had time to dissolve salts from the surrounding rock or soil.

Borehole water for domestic use		
Property	**Recommended levels**	**Max. allowable limits**
pH	6,0 to 9,0	5,5 to 9,0
Dissolved substances (all values in milligrammes per litre)		
Calcium (Ca)	<150	200
Magnesium (Mg)	<70	100
Sodium (Na)	<100	400
Potassium (K)	<200	400
Chloride (Cl)	<250	600
Sulphate (SO_4)	<200	600
Flouride (F)	<1	1,5
Nitrate (as N)	<6	10
Iron (Fe)	<0,1	1,0
Manganese (Mn)	<0,05	1,0
Bacteria		
Total coliforms/100ml	Nil	5
Faecal coliforms/100ml	Nil	Nil

Adapted from: South African Bureau of Standards 1984

Nearly 80% of all boreholes drilled in Namibia are unsuccessful

Borehole management

If water is pumped from a borehole at a rate that exceeds the rate of recharge, the water table is lowered and the borehole eventually dries up. It may then become necessary to deepen the hole so that the pumps can be lowered - usually an expensive operation.

Once an aquifer is drained the spaces where groundwater was once stored can collapse, resulting in permanent damage to the aquifer. This sort of damage may mean that the aquifer will never again be able to store water.

The Swartbank Aquifer in the Kuiseb River has been monitored over a long period of time. In 1960 the sustainable safe yield was estimated at $13Mm^3/a$. A re-estimation after 30 years of information gathering in 1990 reduced this to $3Mm^3/a$.

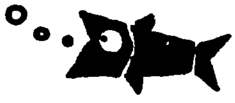
Careful management of boreholes is essential, especially where rainfall is scarce and recharge is variable and unreliable. In an arid and unpredicatable climate like ours it may be necessary to change, from year to year, the quantity of water we pump from our boreholes in order to protect them from permanent damage.

There is no single good borehole management policy for Namibian boreholes - each borehole needs to be understood and monitored separately. The climate, geology, nature of soils and rates of recharge are all factors that need to be investigated if proper borehole management is to take place.

Safe yield

Safe yield is a term that refers to the amount of water that can be pumped without the borehole drying up. Determining safe yields for boreholes is not easy since there so many variable factors associated with aquifer recharge. It is often necessary to make theoretical assumptions and then test them in reality for us to get a "best estimate" of the safe yield for a borehole. The only way we will be able to tell if these estimates are accurate is by using and monitoring the borehole for a number of years. Therefore, determining the safe yield of a borehole is a lengthy and ongoing process that requires concerted effort on behalf of the owner/s.

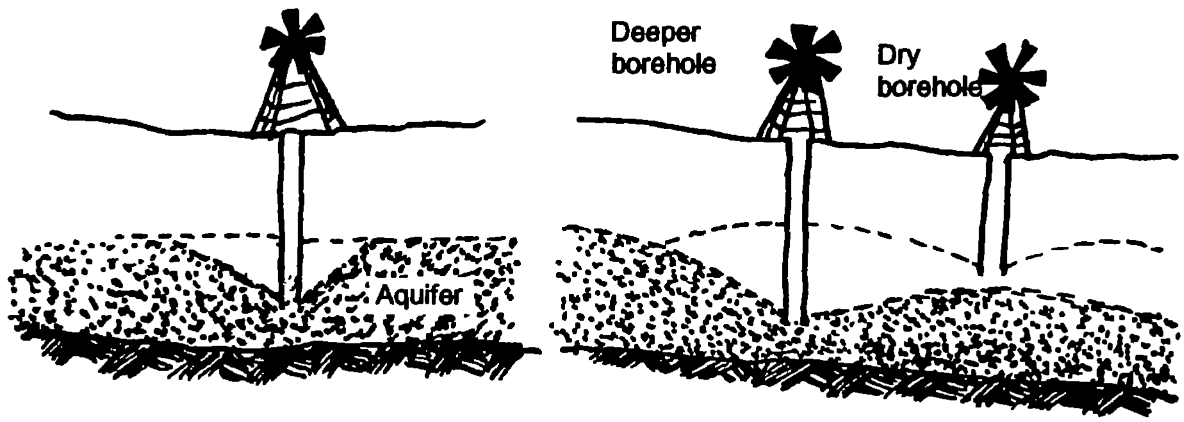
Safe yields for boreholes in Namibia can range between $0,5m^3/h$ and $120m^3/h$.



A detailed explanation of how safe yields are determined is beyond the scope of this book. In general, a hydrogeologist will make an estimate of the aquifer parameters by doing a pumping test on a borehole to measure drawdown of the water table, yield and a number of other factors. The volume of water stored in the aquifer, the potential recharge, and the rainfall conditions of the area will all be taken into consideration.

In the end it is crucial to realise that a borehole cannot supply more water than is replaced by rainfall. All groundwater resources that are recharged are renewable resources, but only if they are not used up faster than rainfall can replace them. Pumping large quantities of water or pumping for many hours in a day may yield more water over the short term, but the aquifer will quickly be depleted and the borehole will run dry.

Good borehole management also needs to consider the number of boreholes that are located on a particular aquifer. It does not help to keep pumping within the limits of the safe yield but to increase the number of boreholes on a particular aquifer. More boreholes simply mean that the aquifer will be depleted sooner.



If a borehole is pumped beyond the safe yield the water table may be lowered around the borehole. Depending on the rate of recharge, it may be necessary to drill a deeper borehole - a sign of poor borehole management!

Additional factors to be considered when determining the safe yield of a borehole:

1. A borehole may be located on a large aquifer that receives plentiful recharge, but if the water-bearing material is unconsolidated (loose sand) the safe yield will be less. If the borehole is pumped too hard, sand may be pulled into the pump or the aquifer near the borehole may clog. The necessity for a pumping rate less than that at which sand or silt is pulled in will have to be considered when estimating the safe yield.

Sand has a porosity of up to 40% while most rocks have a porosity of less than 1%

2. Again, while the aquifer may be large, if the flow rate of water in the water-bearing material is slow less water will be able to be pumped from the borehole. This is because drawdown from the pump will result in the lowering of the water table near the borehole. The safe yield should be determined by the waterflow rate in the aquifer.

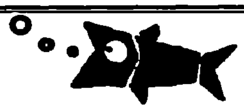
3. One way in which the safe yield can be determined is by using information on the annual recharge of the aquifer. In this case the borehole can be pumped at greater than the sustainable yield for a limited period, but must then be left for a period to recharge before it can be pumped again. The period of rest can be months or even years, depending on the recharge rate of the aquifer.

A history of groundwater use in Namibia

The use of underground water by people in Namibia goes back a long way, to the time before history was recorded. The Bushmen understood the concept of groundwater. They would read signs from nature - such as where certain plants grew - to tell them where underground water could be found. They then dug a small well in the ground with a sharpened stick to reach the life-giving liquid.

Many of our settlements developed around reliable sources of groundwater. Examples of such settlements are found all over Namibia. While the shallow groundwater in the oshanas area provided people with an ideal source of water through the dry season, people living along the Kuiseb River, and other ephemeral rivers of the hyper-arid Namib Desert, have relied heavily on alluvial aquifers to support them in an environment where they would not otherwise have been able to survive. One of the main reasons that Windhoek has grown up where it is, is because of the natural springs that occur in the surrounding hills. The karst waters of Lake Otjikoto are thought to have been an important source of water for people in the area for thousands of years. In fact, the availability of groundwater has probably been one of the most important features that has determined the positions of inland settlements in Namibia.

Boreholes in Namibia in 1994
Number of boreholes: 32 000
Estimated potential: $300Mm^3/a$
Estimated production: $250Mm^3/a$

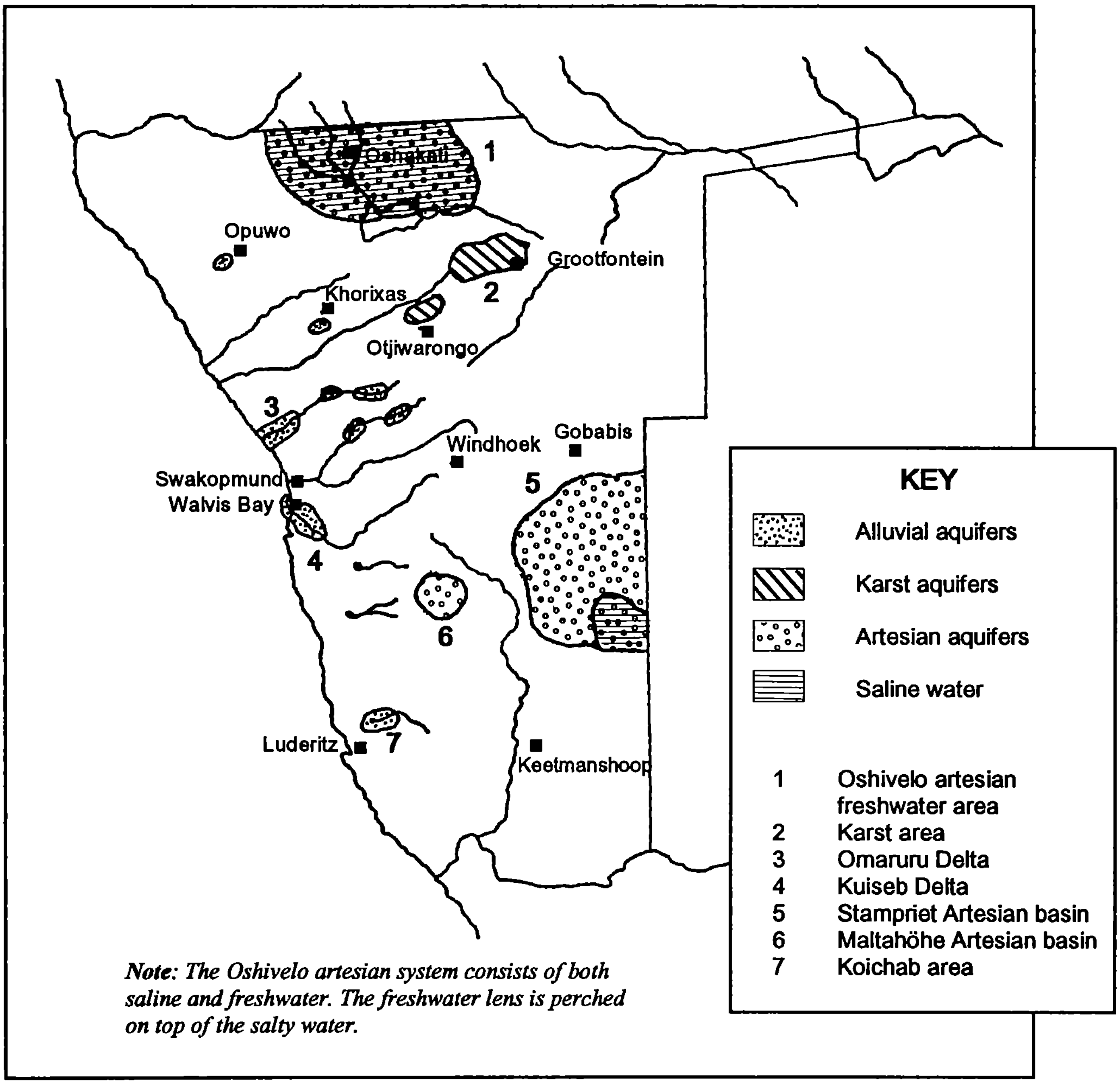


However, the current situation is very different to what it was a few decades ago. Massive urban growth has placed pressure on our present groundwater reserves. Only a few of our underground reserves have enough water to supply large towns, industry and agriculture and these are often at risk of being over-exploited. The advent of technology has enabled people to drill boreholes to ever increasing depths and so further tap our groundwater reserves. However, drilling more boreholes in the same aquifer or pumping over longer hours or at higher rates are no help in avoiding water shortages over the long run. Ultimately groundwater sources cannot yield more water than is replaced by rainfall. We simply have to accept that our groundwater resources are limited and find ways of existing within their limits. The Department of Water Affairs has made it clear that our groundwater is barely sufficient to supply present domestic, stock and industrial demands with freshwater. The Department does not encourage the use of groundwater for recreation and irrigation purposes as this is not sustainable over the long term.

Namibia's groundwater resources

All of Namibia's groundwater comes from rain - either recent rain or pre-historic rain. So to recharge underground water supplies we need rainfall. Unfortunately, rain is scarce and unreliable over most of Namibia which means that groundwater reserves must be managed strictly so that they are given a chance to recharge. One of the simplest yet most important steps that needs to be taken is to ensure that all people who have access to boreholes understand what is meant by sustainable use of groundwater and why it is important not to pump water in excess of the safe yield of a borehole.

Map showing Namibia's main underground water reserves



Note: The Oshivelo artesian system consists of both saline and freshwater. The freshwater lens is perched on top of the salty water.

Aquifers in Namibia

The estimated potential annual yield from groundwater in Namibia is 30 million cubic metres of water

Alluvial aquifers

Although most ofNamibia's rivers are ephemeral, which means that there is no surface water in them for most of the year, there is still a lot of water associated with them. Most of this water lies underground and out of sight. Many of the rivers along the western coast of Namibia have good supplies of water below the surface of their soil. These supplies are called **alluvial aquifers**.

The depth at which the water table occurs in dry riverbeds can vary dramatically from year to year. Things that influence the depth of the water table include the amount of rainfall received in the area, the magnitude of runoff, the duration of river flow in the riverbed and the amount of water removed from the aquifer by pumping.

Some ofNamibia's largest towns, such as Swakopmund and Walvis Bay, as well as Henties Bay, Arandis and Rössing Mine, are totally dependent on alluvial aquifers for their water supply. As these towns grow, so too does their demand for freshwater.

The long chains of vegetation found in the westward flowing ephemeral rivers depend on underground water to live through the periods - often years - between river floods. These rivers and the vegetation they support sustain complex ecosytems. These ecosystems, in turn, form the backbone of ecotourism in this area. Farmers also depend on these alluvial aquifers, sinking boreholes along the banks of these rivers to provide themselves and their stock with water and relying on the vegetation the rivers support for grazing for their animals.

The mean annual recharge of alluvial aquifers determines how much water can be withdrawn from them for people and industries to use. Namibia's low rainfall means that the amount of water available for recharge is small. In spite of this, large quantities of water have been abstracted from Namibia's alluvial aquifers, and it appears that the demand for such water will increase as populations grow and industries are developed.

Artesian waters

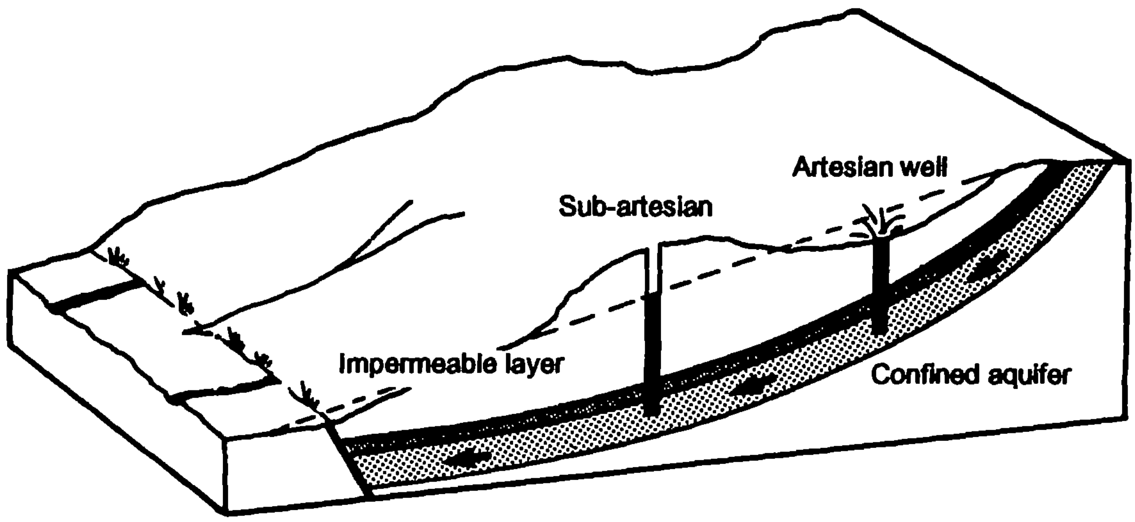
Confined aquifers are another type of groundwater system that plays an important part in supplying us with water for domestic, industrial and agricultural use.

When water from a confined aquifer emerges naturally on the surface of the earth we call it artesian water. However, we need not rely only on natural springs. Boreholes or wells can be sunk into a confined aquifer. Water from such aquifers is often under pressure and flows freely to the surface. An important feature of confined aquifers is the way in which they are recharged, if they are recharged at all. Rainwater must, in some way, be able to enter the porous rock layer (usually sandstone) in which the water is stored. This can take place through a crack or fault in the impermeable rock or clay layers between which the water is trapped; or recharge can take place if the permeable rock is linked to permeable rock that is exposed to rainfall - this may occur some distance away from the main body of the aquifer. If neither of these methods are possible, it may be that recharge does not occur at all.

Namibia's artesian waters are extracted by means of boreholes. These boreholes are strictly controlled by the government and may only be sunk with permission from the Department of Water Affairs.

The towns of Windhoek, Keetmanshoop, Karasburg, Stampriet, Otjiwarongo and Gobabis relied heavily on artesian waters in the past, but the growth of these settlements has meant that this source of water has had to be supplemented by other means. For example, dams have been built to supply additional water to some of these towns.

Diagramme showing artesian wells



Karstwater

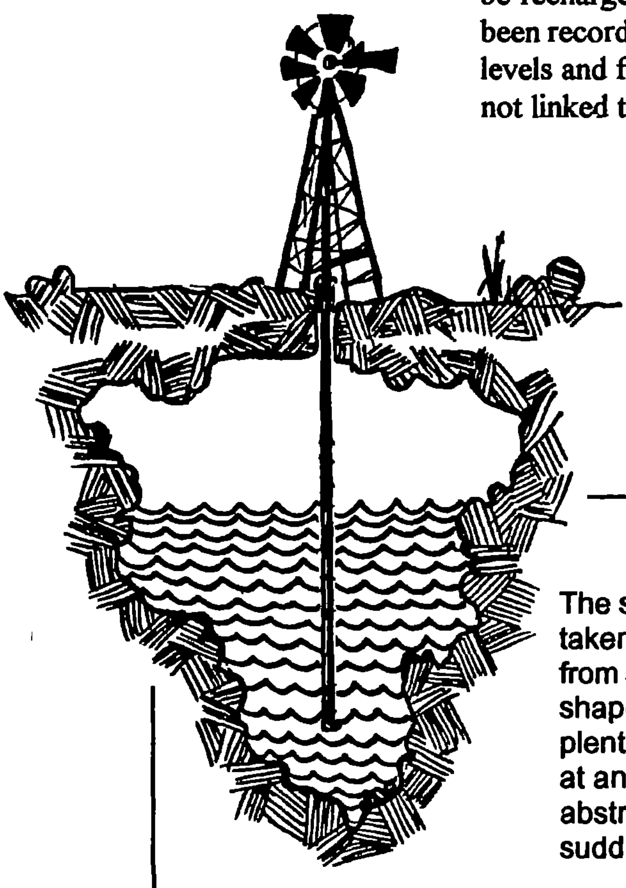
Once rainwater has entered the soil it has the potential to dissolve rocks that are rich in calcium and magnesium carbonate, such as limestone and marble. So wherever large deposits of such rocks occur there is the potential for the rock to be dissolved by rainwater. If rainwater acts on these rocks in this way, they become porous and caves and sinkholes can be formed. When water fills the pores in the rock, or the caves and sinkholes it is known as **karstwater**. In some cases this water may flow to the surface in the form of a spring, such as the spring at Grootfontein. Boreholes are used to abstract large quantities of water from the Karstveld for domestic, industrial and agricultural use.

A constant lowering of 2-3m per year in the water level in the caves of the Harasib/Nosib area has been recorded. This has important implications for the long-term abstraction of water.

Depressions on the surface of the ground in the karstveld region are often signs of underground karstwater. These depressions are called dolines and can lead to sinkholes.

If the layer of rock above a karstwater source collapses, a sinkhole is formed. If the sinkhole becomes filled with water, a karst lake forms. Lake Otjikoto is an example of such a lake. If the sinkhole becomes filled with soil it is called a polje.

It was first thought that all the underground water pockets in the Karstveld were linked, but there is no hard evidence to support this. This has important implications for the conservation of this water resource. It means that if water from one cave is extracted it cannot be recharged by water flowing in from surrounding caves. It has been recorded that, on a regional scale, these waters lie at different levels and fluctuate independently, and that these fluctuations are not linked to rainfall in any simple way.

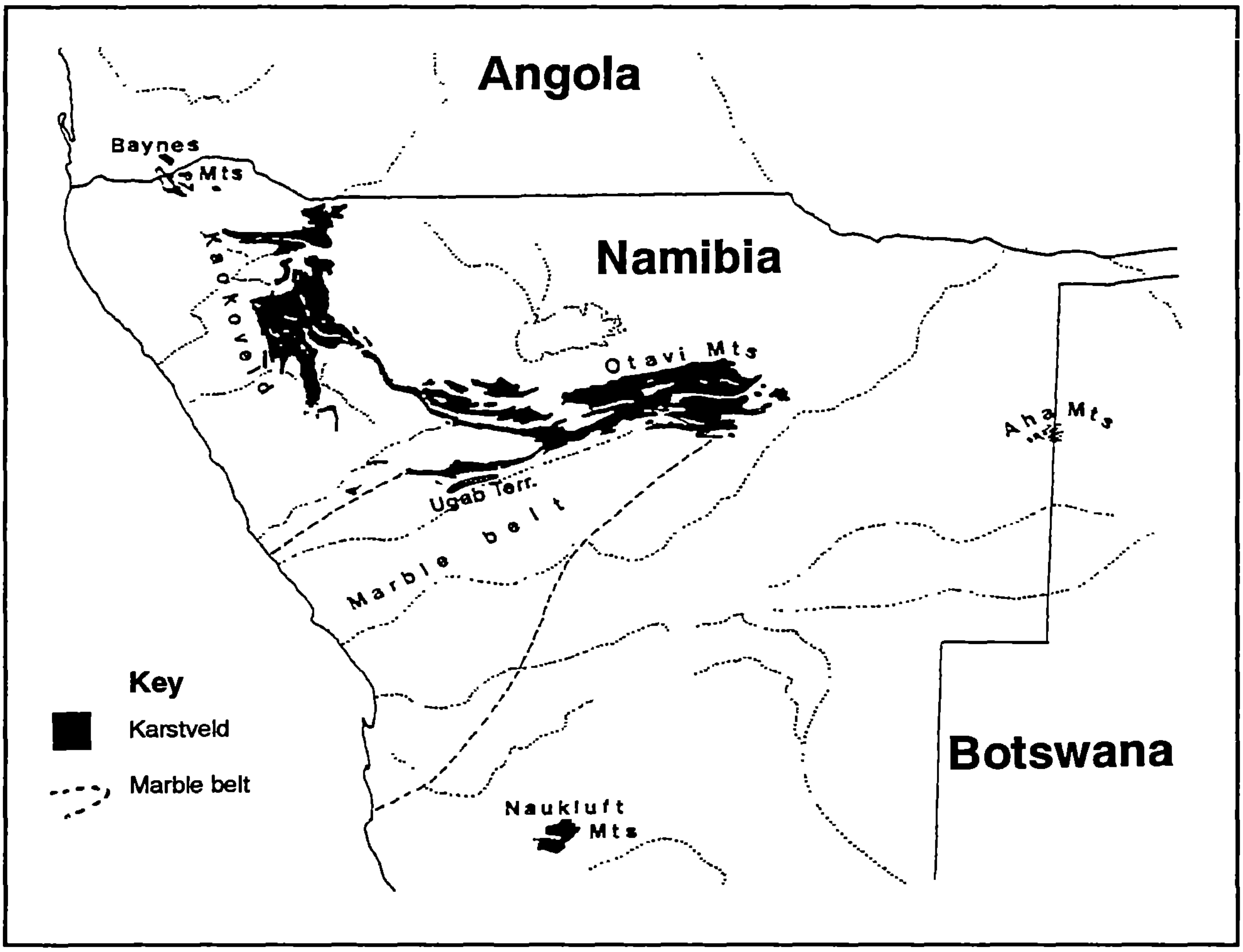


Dragon's Breath Cave is the largest known underground lake in the world.

The abstraction of karstwater

The shape of water-filled underground cavities must be taken into consideration when determining the safe yield from such a source. Water-filled caves are often funnel-shaped which means that water may appear to be plentiful in the beginning, but the level of water may drop at an increasing rate even if the volume of water being abstracted remains the same. This can result in a sudden and surprising end to the source of water!

The Karstveld



Karstveld is the name given to an area in north-central Namibia where **calcium** and **carbonate** rocks (limestone and dolomites) occur frequently. These rocks dissolve easily in water, leaving behind underground caves that can become filled with water. Caves and lakes, where the roofs of the caves have collapsed, are a common feature of such areas.

Another feature of the Karstveld is a landscape that lacks rivers. This is due to the nature of the rock at the earth's surface which allows rainwater to enter the soil easily, leaving little water available for runoff.

The best developed Karstveld occurs in the region of the Otavi Mountains, but places such as Outjo, Grootfontein, Kamanjab and eastern Kaokoland also fall within the karst region. The karstification of rock is higher where rainfall is high.

Lake Otjikoto and Lake Guinas near Tsumeb are two well known places where the roofs of water-filled underground caves have collapsed and lakes have formed. Although these are the largest, a similar lake occurs at Aikab. There are also a number of underground lakes, and the Dragon's Breath Cave is the largest underground lake in the world. These lakes have a unique fauna. There is a certain species of blind catfish that is found only in Algamas Cave and nowhere else in the world, and a unique species of bream, known as the Otjikoto tilapia, which is found in the Dragon's Breath Cave. Both of these fish are endangered species.

Karstwater is also present in the marble formations of the region known as the Marble Belt, an area which extends down from the Otavi Mountains towards Swakopmund. Marble is derived from limestone, and can therefore also contain karstwater, but usually to a lesser extent.

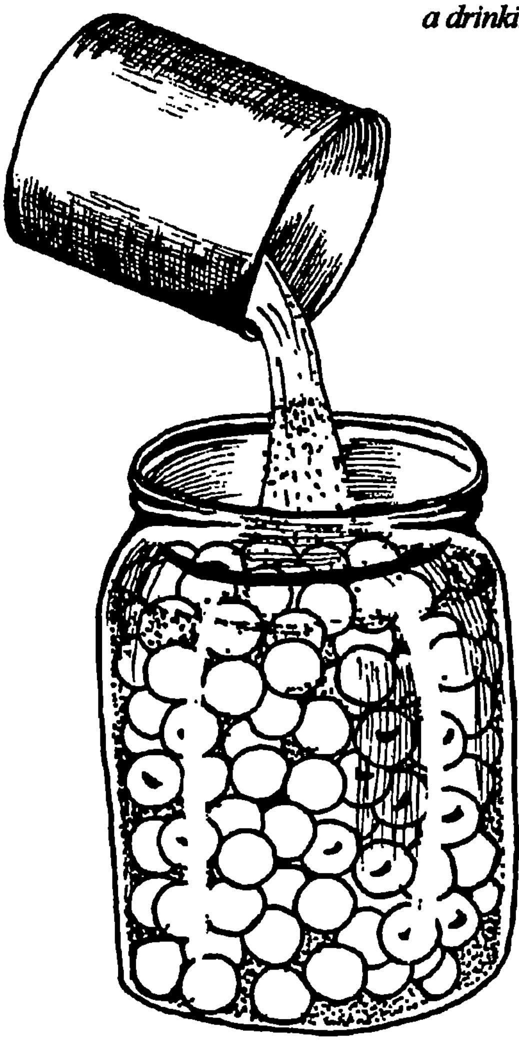
Things to do...

Groundwater demonstration

Learners often have difficulty understanding the concept of groundwater. Many of them have a picture of underground lakes in their minds when we talk about underground water resources, rather than water stored in the airspaces between particles of soil. Here is a simple way of demonstrating to your learners what is meant by groundwater and how we abstract it by pumping it to the surface.

You will need:

1 clear glass jar (for example, a jam jar)
a collection of clean round or oval stones (or marbles)
a container filled with water
ink or food colouring
a drinking straw



Method:

1. *Colour the water with the ink so that it is easier to see.*
2. *Fill the glass jar with the stones.*
3. *Hold up the jar with the stones in it so that all the learners can see it. Now pour the coloured water over the stones.*
4. *Explain to your learners that this is the way that sand or soil can hold water.*
5. *You can measure the amount of water that it took to fill the airspaces between the stones.*
6. *Repeat steps 1 to 4 but this time insert the straw into the glass jar before you add the stones.*
7. *Once you have added the water to the jar, suck on the straw to demonstrate how a borehole can bring water to the surface.*

Chapter 6
Activities

1. There are some Namibian story books available that deal with certain aspects of groundwater. Teachers may wish to use the Build a Book collection published by New Namibian Books. Some titles include: "Water from the Rock" and "Dragon's Breath Cave". Use these to stimulate discussion or as inspiration for the learners' own stories. Why not have them write their own books for children that teach them about the importance of groundwater through the medium of a story?

2. Prepare a simple pamphlet that contains instructions for the careful and safe use of boreholes. Decide which section of your community would benefit most from the information, and make sure the pamphlet is suited to and understandable to them. Test your pamphlet on your intended audience and see if it conveys the message you want it to. Obtain your information from borehole maintenance companies or the Department of Water Affairs.

3. Conduct a series of interviews with elderly people in your community in an attempt to find out where and how they obtained groundwater in the past. Are the sources they used still available today? Write up your findings in the form of a newspaper article.

4. Find out more about water divining and tell the learners about it. Let them create a story about a person who is able to find underground water supplies for people in his/her community.

1. The settlement and distribution of people in the past was largely influenced by the presence of water. In the central parts of Namibia settlements relied on natural springs and wells for water. Study the literature to find out where people who lived in the times of Jan Jonker, Samuel Maherero or Hendrik Witbooi obtained water from.

1. Consider how some of the animals that live in caves have adapted to living there. Some have lost the use of sight while others can find their way around by using electric fields.

2. Draw and paint a mythical cave creature. Imagine what it must be like to live in dark, damp, cold caves. What would the creature look like?

1. In a study unit called "Searching for Aquifers", categorise the most common aquifers and find examples on a map of Namibia.

2. Next time you go on a tour of the country or travel long distances keep a record of all the windpumps that you can see from the road. When you return home mark these on a map. Try to survey as many regions of the country as possible over a period of 3 months. Keep a large map on your classroom wall that all the learners can contribute to.

1. When introducing the topic of karstwaters to learners it is useful to prepare a demonstration that shows how calcium carbonate can be dissolved by rainwater. Place a piece of chalk (it consists mostly of calcium carbonate) in a glass of water. Observe what happens. Add a little vinegar to the water and repeat the demonstration. Note how acid affects the process. Ask the learners what effect acid rain will have on the formation of sinkholes and underground caves.

1. If you live in the karstveld region, collect any information that records past disasters associated with sinkholes.

1. Calculate the percentage of air space present in a certain volume of soil. Set up a demonstration with a certain volume of soil in a measuring cylinder. Pour a certain volume of water over the sand and take a reading of the water level. Leave the column of sand and water overnight. Take a new reading of the water level. Calculate what volume of water infilrated the soil. This volume is the same as the volume of air space. Express the amount of air space ... percentage and a ratio.

1. Test the abilities of different soil types to hold water. Have determined volumes of clay, loam and sand available for the learners to experiment with. Their task is to note how much water the different soils can hold. Discuss the implications for growing plants in the various types of soils.

To demonstrate the presence of air spaces between soil particles in a clear and easily ...standable way, have a cup of marbles or small round stones and a cup of water present. Colour the ... with food colouring or ink. Pour the water into the cup containing the marbles. Note how the coloured ... fills the spaces between the marbles. This is how water fills the air spaces between soil particles and ...s what we call groundwater.

...xplain the term *endemic* using examples of karst cave and sinkhole animals. Why would you expect ... unique animals to have evolved here? What threats do they face and what can be done to protect them?

1. Plan a series of lessons on health associated with communal boreholes and fetching water from watering points. Ask community health workers to visit the school and to give talks and demonstrations on how to keep communal waterpumps free from contamination.

7

Marine resources

The sea provides a home for millions of different kinds of organisms, from the smallest forms of animals to the world's largest mammal, the whale. Most animals in the sea depend, in one way or another, on tiny organisms, called phytoplankton. A strong upwelling of cold water off the Namibian coast brings nutrients to the surface, allowing huge numbers of these phytoplankton to thrive. These small organisms are food for thousands of fish and marine mammals, making Namibia's fishing grounds some of the richest in the world. No wonder fishing and other marine activities play such an important role in our economy.

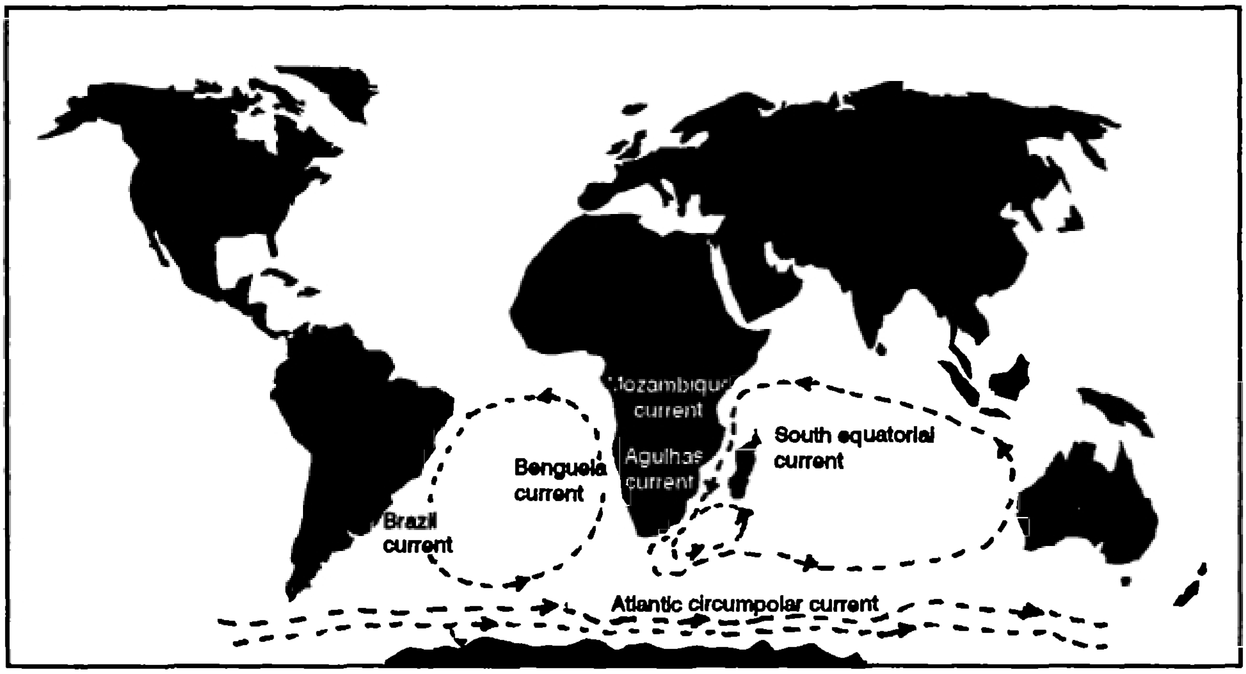
But the waters off our western coast do not provide us only with fish. Namibia is fortunate enough to have a host of other marine resources - including diamonds, guano, salt, gas and seaweeds - which can all play a meaningful role in our economy. And let's not forget that several important tourist destinations lie along our Namibian coast.

Namibia's marine environment

Namibia's shore borders on the waters of the Atlantic Ocean with a coastline of about 1 500km. These waters, some of the most fertile in the world, are the breeding grounds for many different species of fish and other marine organisms. Each year millions of dollars worth of fish are caught off our coast and sold on the local and international market. Fishing is one of the largest sources of income for Namibia and provides thousands of people with employment.

Namibia's marine resources provide much more than just fish. Oil, seaweeds, salt, guano and diamonds are some other important commodities that are obtained from the sea. There is also potential for harvesting phosphate and diatoms from our rich ocean.

Major ocean currents of the southern hemisphere



After: *The Living Shores of Southern Africa* by Branch and Branch (1981)

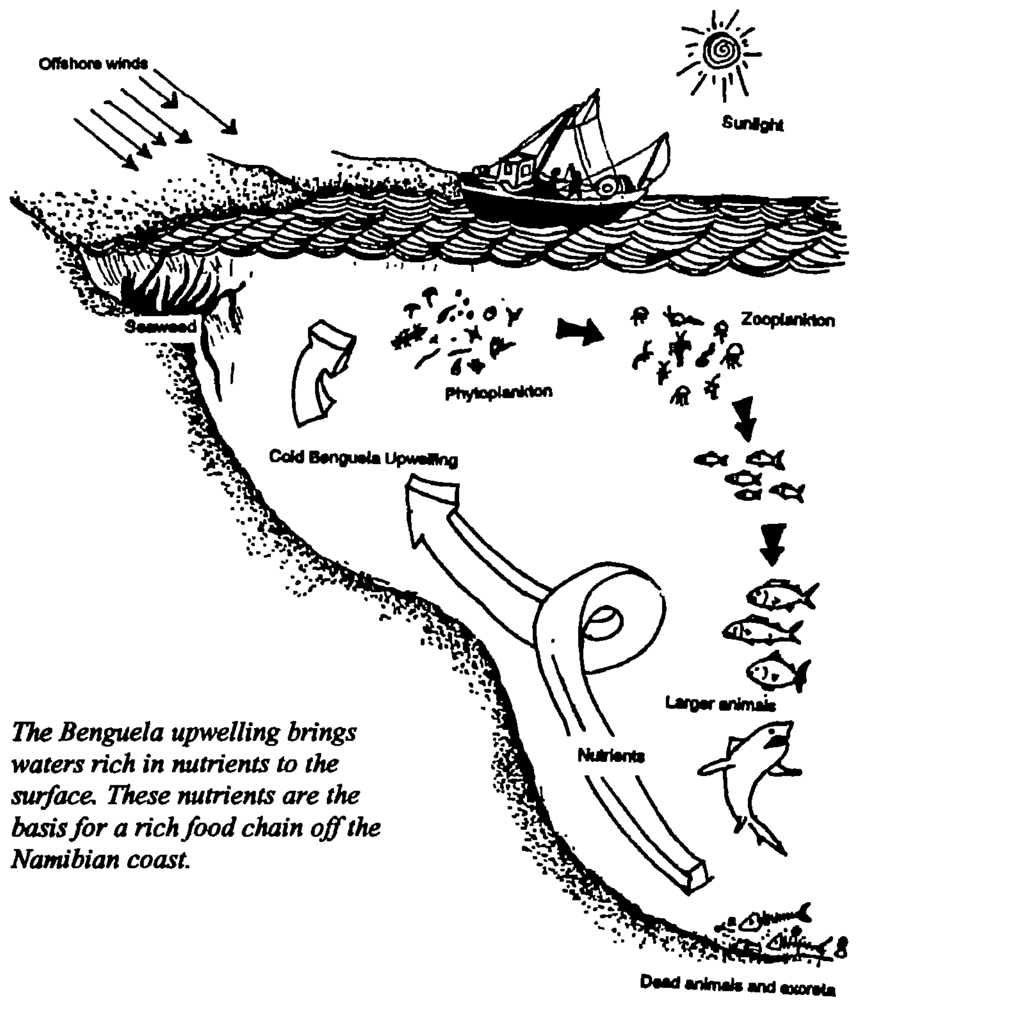
Exclusive Economic Zones (EEZ)

All countries with a coastline have exclusive use of marine resources found along their coastline up to 200 nautical miles out to sea, and Namibia is no exception. Beyond this limit, marine resources are common property and can be used by anyone, so long as this is not in contravention of any global laws. Countries with an EEZ are under obligation to "prevent, reduce and control pollution of the marine environment from dumping", and to make sure that activities in their EEZ do not damage the EEZ of other nations.

The cold Benguela Upwelling

Strong winds blowing up the coast deflect surface water away from the Namibian coast which means that deep cold water must rise to replace it. This rising cold water is an upwelling, which is known as the **Benguela Upwelling**. Although this upwelling occurs along the entire Namibian coast, the strongest upwelling occurs at Cape Frio and Lüderitz.

The rising cold water of the upwelling brings large amounts of nutrients from the ocean bottom to the surface. These nutrients support the growth of millions of small free-floating plant organisms, known as phytoplankton. These phytoplankton need sunlight and are therefore found in the upper layers of the sea. Here small free-floating animals called zooplankton feed on the phytoplankton, and are in turn eaten by fish - such as sardines and anchovies - and other larger marine animals. In this way the upwelling is responsible for supporting a complex food chain that, if managed properly, can continue to support local fisheries and provide a source of income for Namibia in the future.



The Benguela upwelling brings waters rich in nutrients to the surface. These nutrients are the basis for a rich food chain off the Namibian coast.

A history of fishing

Fishing has always been an important source of food for coastal communities, and it has certainly been practised along our Namibian coast for thousands of years. Before boats and ships came into common use, fishing was limited to shallow coastal waters and based on the need to provide food for families. Shellfish such as mussels, and other animals living along the shores were also an important part of people's diets.

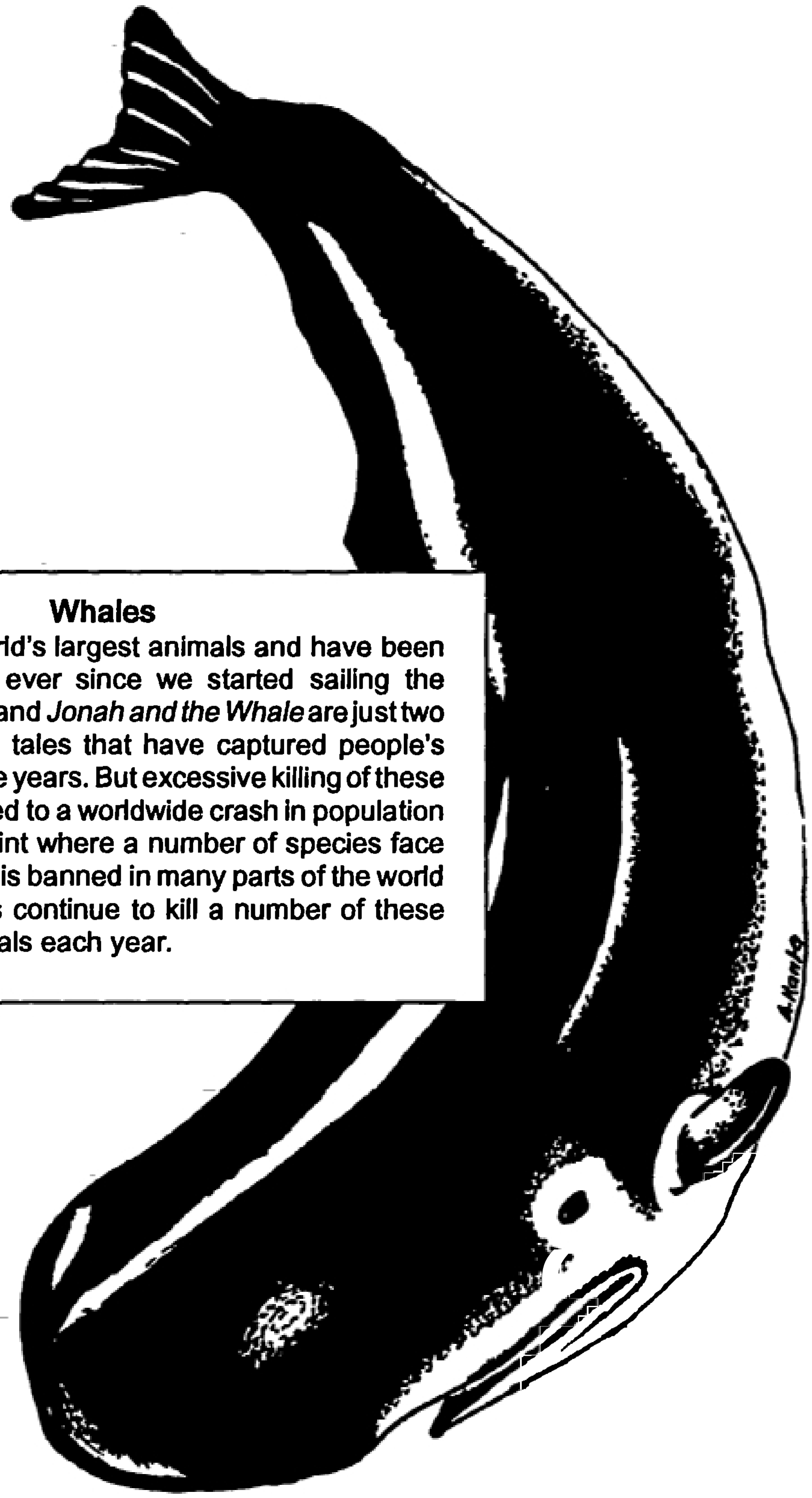
Shell middens in the Kuiseb Delta

There are more than 220 archaeological sites near the mouth of the Kuiseb River. Large heaps of shells from mussels harvested along the coast are found, along with other evidence of early occupation of this area, including, in some cases, pottery. Most of the shells are those of white mussels, which are found in the intertidal zone of sandy beaches. Some of these middens contain more than $10m^3$ of these shells. Namibian marine resources played an important part in the lives of our ancestors.

The exploitation of marine resources on a commercial basis started in the 18th century when European and American vessels visited the African coast in search of whales and seals. This hunting soon led to a drastic decline in the number of these sea mammals. The seal population has since managed to recover and even to increase, but whales are still in danger of becoming extinct. Commercial fishing for smaller fish species such as sardines, pilchards and hake only started in the 1940's when canning factories were established in Walvis Bay.

Walvis Bay

Walvis Bay gets its name from the whaling stations based at this port on the Namibian coast. Walvis Bay was known by a different name before the whale hunters arrived. The original Nama name has been lost, but today Walvis Bay is commonly known by the people who live in the area as !gomen-//gams. In Herero Walvis Bay is known as Ezorongondo, which means the place of the black acacias.

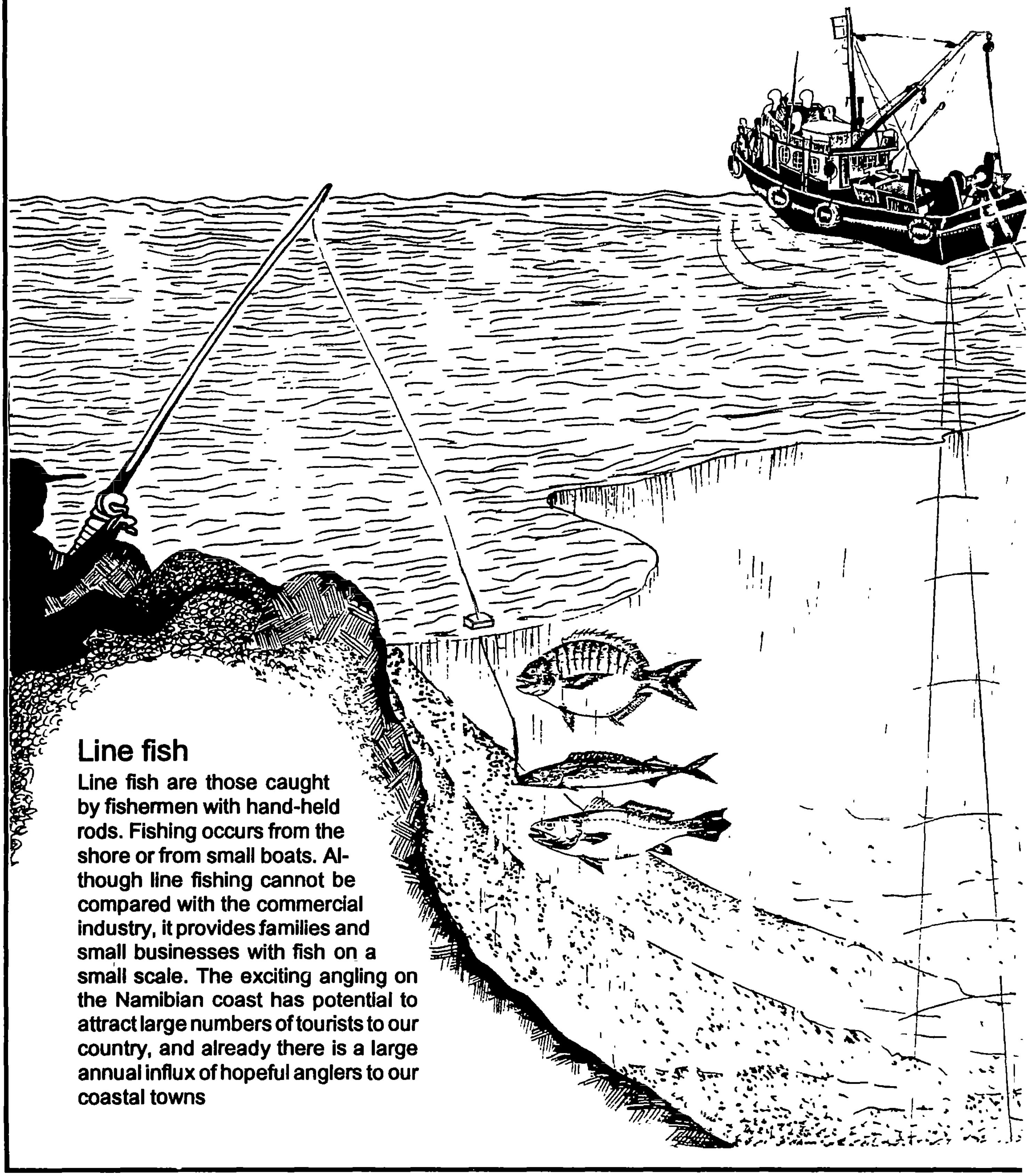


Whales

Whales are the world's largest animals and have been hunted by people ever since we started sailing the oceans. *Moby Dick* and *Jonah and the Whale* are just two of the many whale tales that have captured people's imagination over the years. But excessive killing of these large animals has led to a worldwide crash in population numbers, to the point where a number of species face extinction. Whaling is banned in many parts of the world but some countries continue to kill a number of these magnificent mammals each year.

Namibia's fish resources

Namibia's fish resources can be divided into 3 categories depending on the depth and location at which they are caught. These are pelagic, demersal and line fish.

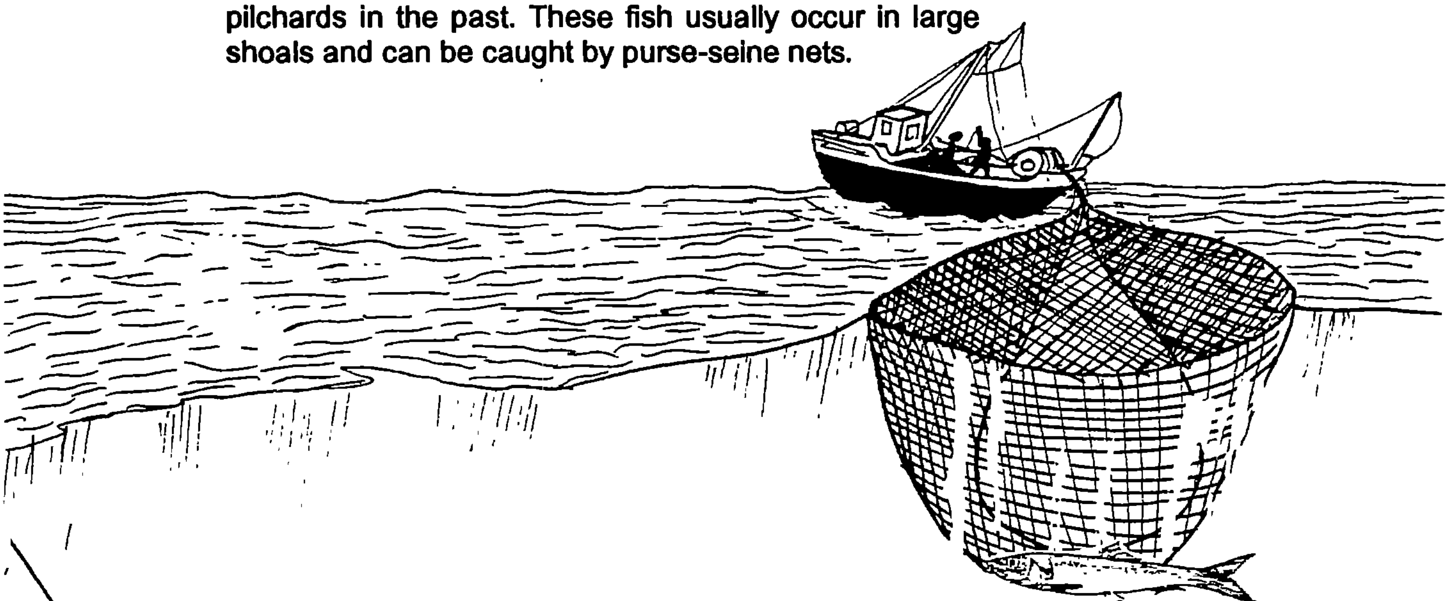


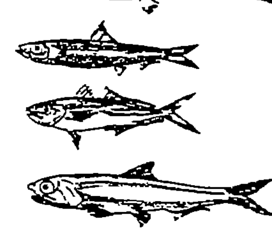
Line fish

Line fish are those caught by fishermen with hand-held rods. Fishing occurs from the shore or from small boats. Although line fishing cannot be compared with the commercial industry, it provides families and small businesses with fish on a small scale. The exciting angling on the Namibian coast has potential to attract large numbers of tourists to our country, and already there is a large annual influx of hopeful anglers to our coastal towns

Shallow water fish - the Pelagic fish

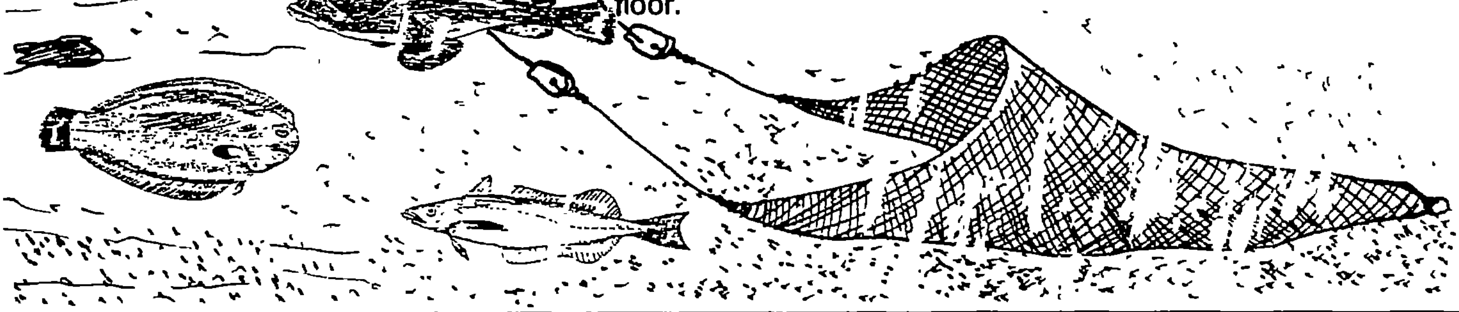
Pelagic fish occur in the upper layers of the open sea. They are the most common fish off the coast of Namibia and probably the most important to the Namibian economy. The pelagic species mainly consist of pilchard, anchovy and horse mackerel. These fish are fast growing and reach maturity early. This means that fish stocks fluctuate from year to year as has been recorded with sardines and pilchards in the past. These fish usually occur in large shoals and can be caught by purse-seine nets.





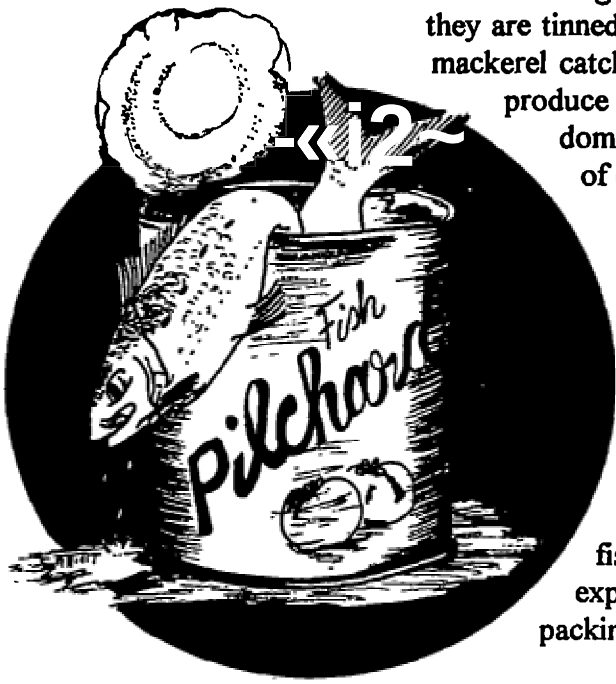
Deep water fish - the Demersal fish

These are fish that occur on or near the bottom of the ocean. They are sometimes called "white" fish and include hake, kingklip, monkfish, sole and snoek. Fish such as hake migrate into the midwaters at night, so it is easier to catch them by day. Demersal fish stocks are different from the smaller pelagic fish because they are longer lived and slower growing. This means that their numbers are more stable from year to year. Demersal fish are usually caught with trawl nets. These nets can cause damage to the sea floor.



Fishing methods and fish processing in Namibia

Pelagic fish are caught by a fleet of boats with **purse-seine** nets. Pilchards caught are taken to three canneries in Walvis Bay where they are tinned for human consumption. The anchovy and horse mackerel catches are taken to factories where they are used to produce fishmeal and oil. Fishmeal is used to make food for domestic animals while the oil is used in the production of cooking oil, soaps and other products.



Trawl nets are used to catch hake off Namibia's shore. Most of the hake are caught by freeze trawlers that process the fish and freeze them while at sea. This means that these boats can stay out at sea for longer periods of time.

Less abundant species such as kingklip, sole and snoek are caught by small inshore trawlers. These fish are filleted, graded, packed on land and then exported to other countries. The largest "white" fish packing factory is located at Lüderitz.

Line fish are caught by hand-held fishing rods from the shore or from small boats. In Namibia line fishing is important as it provides many families with a source of cheap protein, as well as providing fish for small businesses such as restaurants and hotels.

98% of Namibia's fish catch is exported to foreign countries. The Namibian Ministry of Fisheries and Marine Resources is currently running a campaign to promote fish as a source of food for Namibians.

Fishing is also a form of recreation along the Namibian coast and it attracts large numbers of tourists every year.

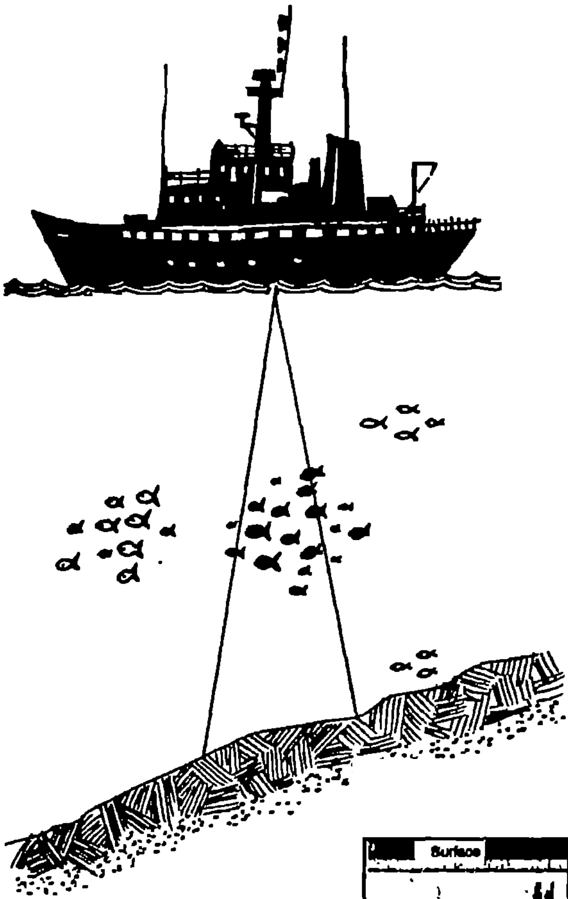
Water and the fishing industry

Not only does the fishing industry depend on water to catch its fish from, but large quantities of water are required by the industry in order to process its catch. Often vast quantities of freshwater are used for washing fish when seawater would do just as well. The common excuse for this is that the processing factories are set up to deal with freshwater, and the use of saltwater would require some structural changes. In a water-short country like Namibia, where the fishing industry is one of our major hopes for the future, shouldn't steps be taken now to ensure that its development proceeds in a water-conscious way?

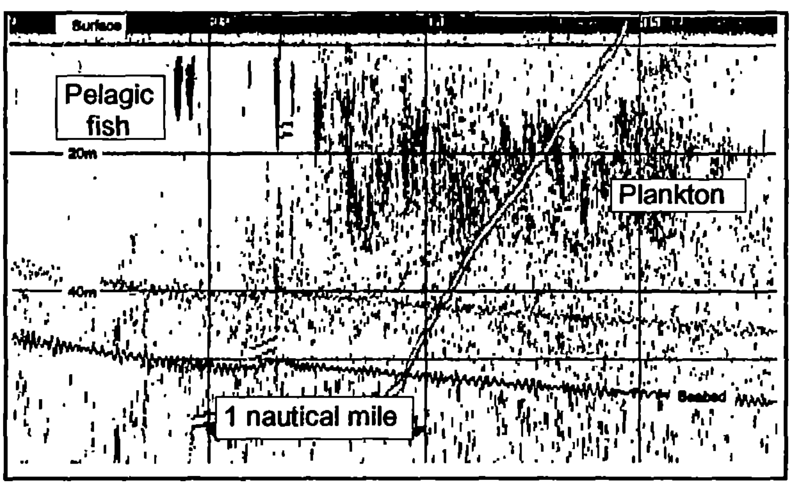
Another negative impact that the fishing industry may have on our marine environment stems from careless handling of factory wastes. Often effluent comprising of fish gut and blood is pumped back into the sea. Not only should our fishing industry be water-efficient, but it should also do its best to ensure that our waters do not become polluted.

Using sound to catch fish

Sophisticated methods such as the use of echo-sound equipment have allowed fishing boats to locate large shoals of fish beneath the surface of the water, making it easier to catch large numbers of fish. A sound pulse is sent from a transmitter, located at the bottom of the boat, straight down to the sea bottom. The sound pulse is reflected off the sea bottom or anything else that occurs in the water between those two points. If fish are present the signal is reflected off them back up to the vessel. A microphone in the water receives the returning signal and a picture is created on a TV screen. In this way fishermen are able to "see" where shoals of fish are in the water.



A sound pulse is sent from the bottom of the ship (left). The sound is reflected off anything in the water (fish) and the seabed. The reflected signal returns to the boat and creates an image on a screen and a trace on a piece of paper (below). In this way the captain of the ship can tell what is in the water below his ship. If fish are found, the nets will be cast.



Overfishing...
unsustainable use of a renewable resource

The horse mackerel has been identified as Namibia's most nutritious fish species

Fish are a renewable resource, but only if used correctly. The natural breeding of fish allows stocks to recover after some have been removed by fishing. The problem is to know when too many fish have been removed from the sea and there are not enough individuals left to breed and allow the population to return to natural levels.

With an increase in the demand for fish and the advances in technology, more fish are being removed from the sea than ever before.

Some of the advantages that enable us to catch more fish	
Bigger boats	so boats can load bigger catches
Navigation aids	so boats can go further
Sonar radar	so fish can be located more easily
Synthetic fibre nets	can hold the weight of larger catches
Nets with smaller openings	catch small and large fish
Factory ships	allow fish processing at sea
Refrigeration	means boats can stay out longer

Adapted from: *The Global Environment*
S. Sterling and S. Lyle (1991)

Overfishing along the Namibian coast

Due to a lack of control before independence, overfishing was a great problem along Namibia's coast. Foreign fishing vessels often removed far too many fish from the ocean with the result that pelagic fish, hake, sole and crayfish populations were reduced to the point of collapse. In an attempt to correct this, a quota system was imposed in 1971 limiting the amount of pelagic fish that could be caught. But enforcement of the quota system was almost impossible because Namibia did not have enough vessels to patrol her coast and monitor what was being caught by foreign vessels. The result was that fish canning was temporarily banned during 1981.

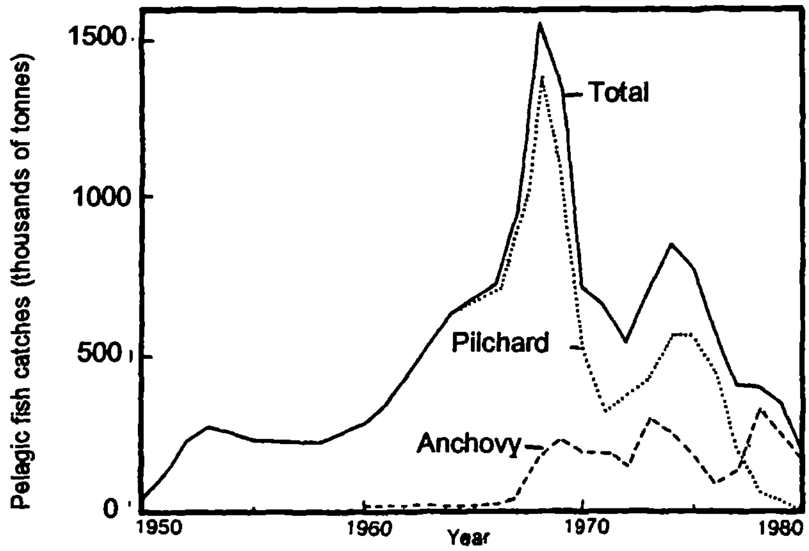
After independence a 200 nautical mile (360km) zone was declared along the Namibian coast to ensure the conservation of Namibian fishing resources. The result was that a large number of foreign fishing vessels were forced to leave the zone.

Managing marine resources

Since marine resources are among Namibia's most valuable commodities, it is important that they are properly managed. Before independence very poor control measures resulted in the over-exploitation and eventual collapse of some of our marine resources. Over-harvesting lobsters and pilchards resulted in the collapse of these populations and they have still not recovered to this day.

Large hake feed almost exclusively on small hake. This is one case where reduction in the numbers of large hake by fishing may aid the survival of the young fish

Pelagic fish catches along Namibia's coast between 1950 and 1980



Source: Ministry of Sea Fisheries and Marine Resources

Other fish species are also threatened by overfishing. Namibia is faced with the problem of foreign vessels fishing illegally in her waters, and only recently has firm action been taken against such vessels.

New policies have been made that aim to replenish Namibia's damaged fish and lobster stocks. Some of these policies include:

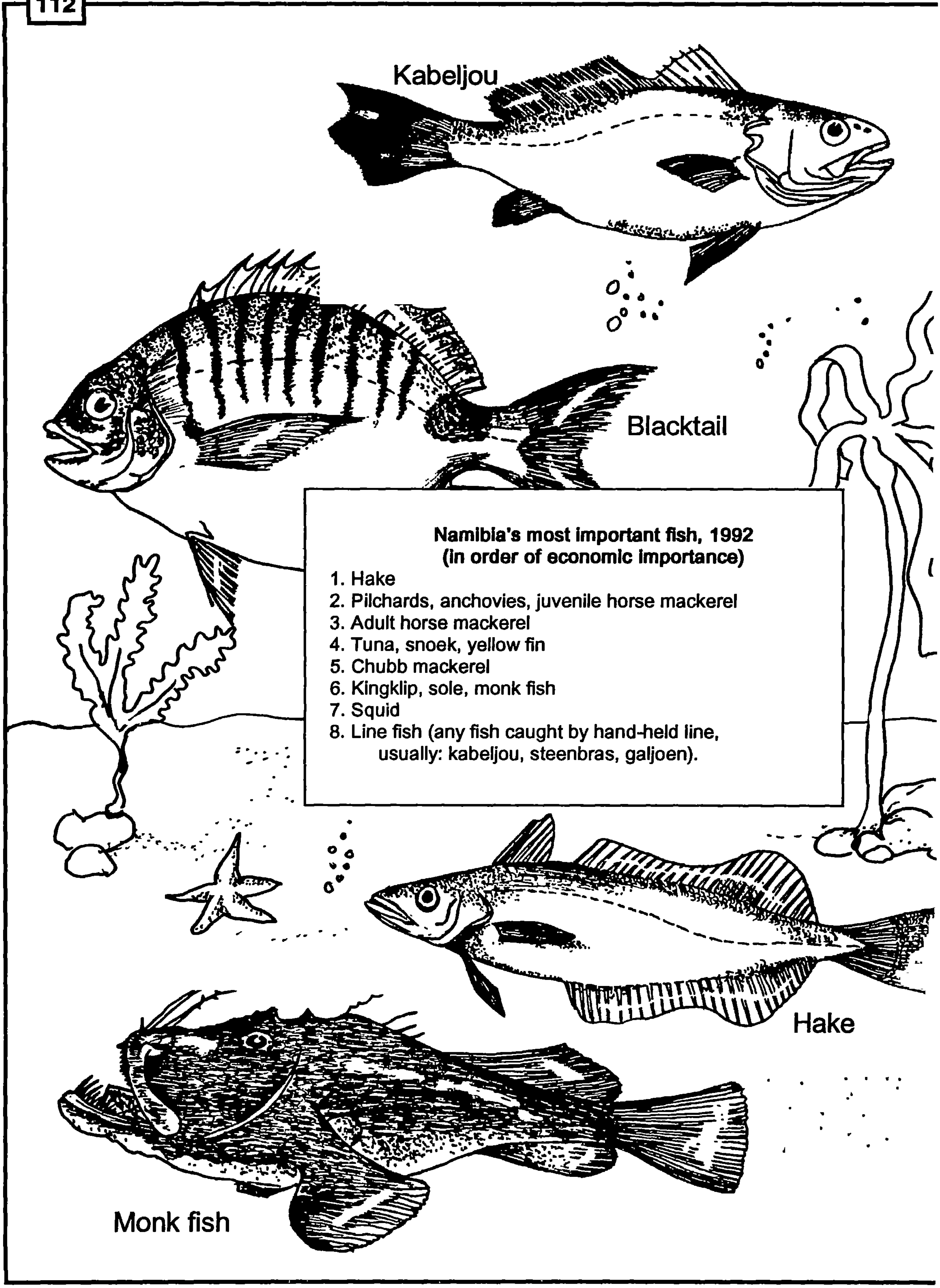
- allowing only a certain amount of each species of fish to be caught each season. This is called the Total Allowable Catch (TAC)
- limiting the amount of fish, such as pilchard, available to the canning industry
- limiting fishing for certain species of fish to certain areas and seasons only
- imposing strict control over the size of lobsters caught, and limiting their catching seasons
- making licences for catching animals such as crab and lobster obligatory.

Limited fish stocks + too much fishing = problem

Total allowable catches (TAC's) for some important species for 1992

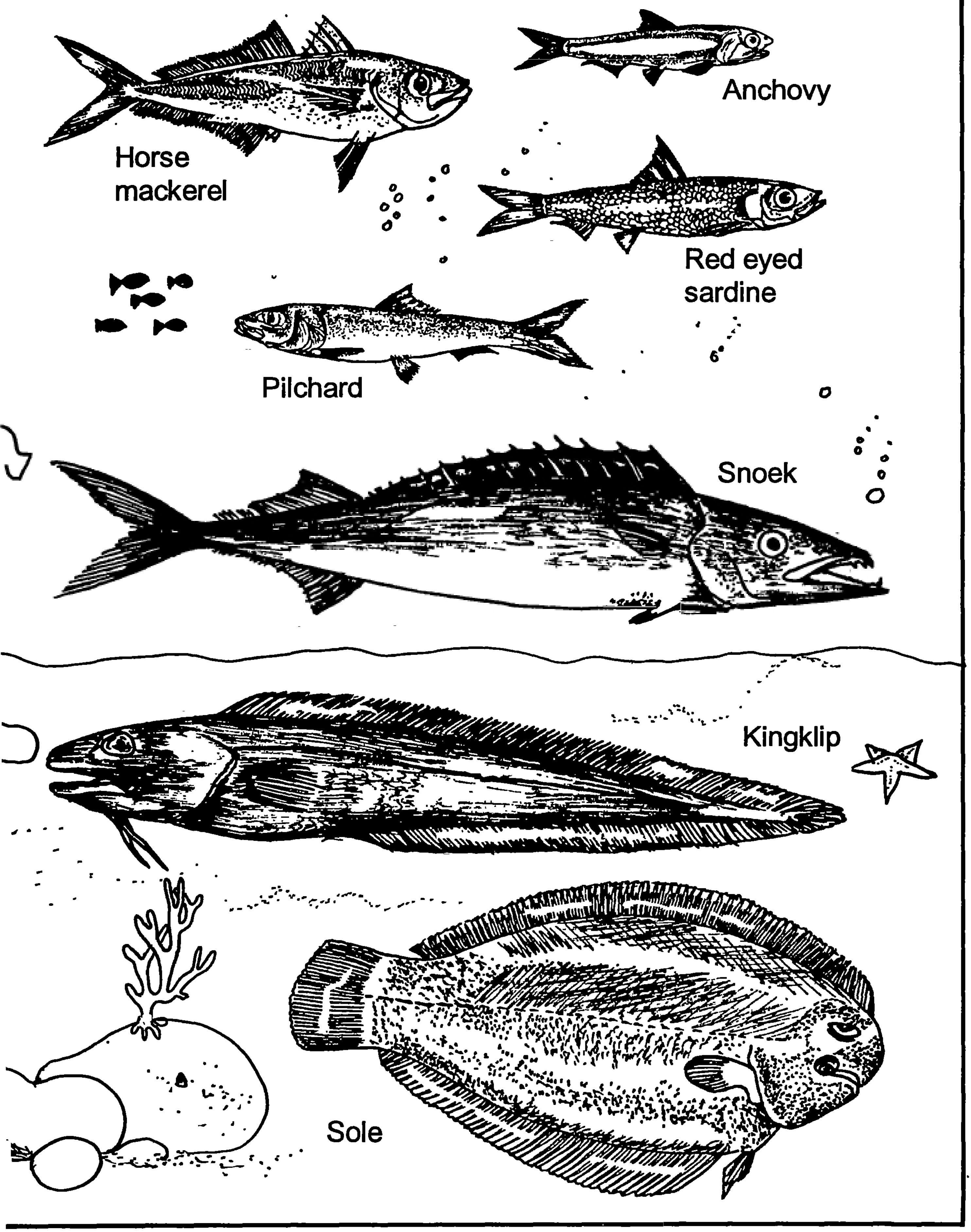
Species	Quota (Tonnes)
Pilchard	400 000
Anchovy	100 000
Hake	300 000
Deep water crab	6 000
Crayfish	1 000

Min. of Sea Fisheries, Namibia. 1992



Namibia's most important fish, 1992 (in order of economic importance)

1. Hake
2. Pilchards, anchovies, juvenile horse mackerel
3. Adult horse mackerel
4. Tuna, snoek, yellow fin
5. Chubb mackerel
6. Kingklip, sole, monk fish
7. Squid
8. Line fish (any fish caught by hand-held line, usually: kabeljou, steenbras, galjoen).


Horse mackerel
Anchovy
Red eyed sardine
Pilchard
Snoek
Kingklip
Sole

The coastal zone

The coastal zone is the part of the sea that lies closest to our shores. This is the zone that is most easily accessible to us, and also the zone in which many of our richest marine resources are found.

Seaweeds

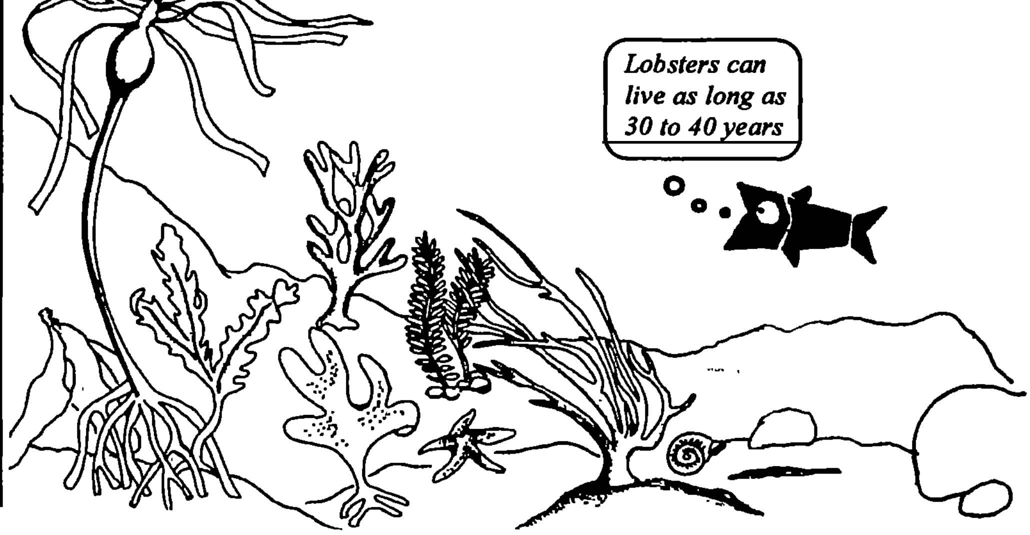
Seaweeds are plants that grow in the sea. They belong to a primitive group of plants called algae, and, unlike most of the land plants we know, do not produce flowers. Seaweeds produce large amounts of food by the process of photosynthesis and require light to do so. This means that they can only live at depths where the light is still able to penetrate the water.

The Namibian coastal zone has an abundance of seaweeds, the most common of which is kelp or sea bamboo. The reason Namibia's marine environment is so rich in seaweeds is that it is almost an ideal habitat for these plants. The Benguela system ensures there is a good supply of nutrients for growth, the temperature of our coastal waters is fairly constant, there is intense sunlight for photosynthesis, and there is very little marine pollution as so few of our towns are located along the coast.

Seaweeds provide food for a large number of marine organisms. They also provide shelter for other plants, and for animals such as lobsters and fish.

Seaweeds can also be commercially exploited. They are mainly used for food, food supplements, gels and fertilisers. Although Namibia has vast seaweed stocks along its shores, very little is used by the population of Namibia. However, seaweed is harvested in and around Lüderitz, dried on the beaches and exported to countries such as Japan, and there is also seaweed farming going on in the same town.

Many Namibians do not like the idea of eating seaweed, but the chances are good that you have eaten it without knowing. Seaweeds are used in products such as jelly, cheese, sausages, cereals, icecream and toothpaste.



Oysters

Oysters are small marine or freshwater shellfish. They usually live in shallow coastal waters and are of great economic importance. They are seen as a delicacy, and can be sold for high prices on the local and international market. They are most usually eaten raw with a squirt of lemon juice and a dash of tabasco sauce.

Namibia has large oyster resources and there is great potential for cultivating these small animals in oyster farms. Oysters have been successfully cultivated in one of the lagoons at Lüderitz and in the shallow salt pans near Walvis Bay and Swakopmund. Most oysters harvested in Namibia are exported to other countries.

Crustaceans

The crustacean group includes lobsters, prawns, shrimps and crabs. Crustaceans are of great economic importance because of the high prices that they fetch on the international market. Lobster and deep-sea red crab are two important species of crustacean that are caught along Namibia's coast.

For many years too many lobsters have been removed from Namibia's coastal zone resulting in a collapse of the population. Because of their high value and because they grow so slowly, lobster stocks are threatened by over-exploitation. Lobsters only grow very slowly and take as long as 9 years to reach maturity. This slow growth means that they are often caught before they have time to breed. Strict regulations now determine the size and numbers of the lobsters that can be legally caught, and, with careful management, hopefully our lobster population will recover.

The intertidal zone

The part of the coast that falls between the low water mark at low tide and the high water mark at high tide is called the **intertidal zone**. This zone is home to a number of living organisms and is probably one of the most stressful habitats for living things to survive in. For approximately six hours of the day, when the tide rises, the plants and animals of this zone are covered by cold water and are exposed to waves. At low tide, they are exposed to heat from the sun (temperatures can reach 40°C) and as much as 70% of their body water can be lost by evaporation. Because of all of these factors, this is a zone where you can find remarkable adaptations to the harsh physical environment.

Seals

Seals are marine mammals that occur in large numbers along Namibia's coast. They depend on the rich fish reserves of the Atlantic Ocean for food. This has given rise to strong conflict between the fishing industry and the seal population because of the large amounts of fish that seals eat. They are also sometimes responsible for removing fish from fishing nets or even damaging the nets.

Research indicates that seal numbers are increasing and the bird populations along our coast and on the islands off the coast are being negatively affected. Seals occupy large areas along the coast and reduce sites where sea birds are able to breed.

Killing seals for commercial purposes is a controversial issue in Namibia. Many people feel that the way in which the seals are killed is cruel and unnecessary. They feel that clubbing seal pups for their skins leads to wasteful and unnecessary slaughter and that the seal population can become threatened in much the same way as the whale population. Although the methods used to kill seals are in many cases not very humane, there is no indication that Namibia's seal population is threatened by extinction. Indeed, the seal population off Namibia's coast is growing, although in 1994 it had a serious setback, when lack of food and disease resulted in the death of huge numbers of seals.

Seal fur is used by the clothing industry, seal fat is used for the production of oil, and meat and bones are processed and used as livestock food. But seals are not only valuable dead. When their numbers are in balance they are a vital part of many coastal ecosystems. They can also boost tourism. One of Namibia's largest seal colonies is at Cape Cross. Thousands and thousands of seals live and breed here - a spectacular sight, and one that earns Namibia a substantial amount of revenue from tourists who come to marvel at it.

Namibia's harbour towns...

our gateway to the world

Much of the most important transport in Namibia takes place not on the land, but off our coast. Namibia's harbours provide us with a gateway to the outside world and allow for the import and export not only of the goods we need or sell but also of the products of some of our neighbouring countries.

Walvis Bay is Namibia's largest harbour and our only deep water port. It handles approximately 98% of all our sea traffic. Its importance as a harbour stretches back to the 18th century, when it served as a base for whaling vessels. It now has large dockside storage capacities, and is a regular port of call for international shipping lines. It also provides marine engineering and ship repair facilities. About a thousand ships a year put in at Walvis Bay, and it handles more than a million tonnes of cargo a year.

Many blame oil tankers for oil pollution, but more than half the oil pollution reaching the oceans comes from onshore activities

Lüderitz is our second most important port, but is comparatively shallow and only capable of handling fairly light cargo. Another drawback is that it is quite isolated from the rest of our country. It handled, in its heyday, up to 100 000 tonnes of cargo a year, but now probably handles less than a quarter of this. Before the northern and southern railway systems were linked in Namibia, Lüderitz enjoyed considerable prosperity, but now that other channels of transport are available to the south of Namibia Lüderitz survives mainly on the fishing and rock lobster industry.

Swakopmund was historically the main German port in Namibia. It is sheltered from the weather and waves and has a shorter and deeper access channel than Walvis bay. However, the drawback to using Swakopmund as a port is that it silts up rapidly when the Swakop River flows into the sea, and requires continuous - and expensive - dredging. Swakopmund is no longer used as a port.

There are currently plans to build a harbour at **Mowë Bay** to provide not only another fishing harbour but also easier access to the northern parts of our country.

Harbours can hurt!

Harbours are economically important, but can be ecologically damaging if not managed carefully. Oil and other waste from ships berthed at harbours can cause considerable damage to marine ecosystems, and the constant passage of ships in and out of a port can disturb and adversely affect sea life.

Walvis Bay is our most important harbour, but is also the site of one of our most important wetlands. If Namibia is to retain the benefits of this ecologically important wetland, the Walvis Bay harbour and any future developments in this area will have to be carefully monitored to lessen any negative impacts they might have.

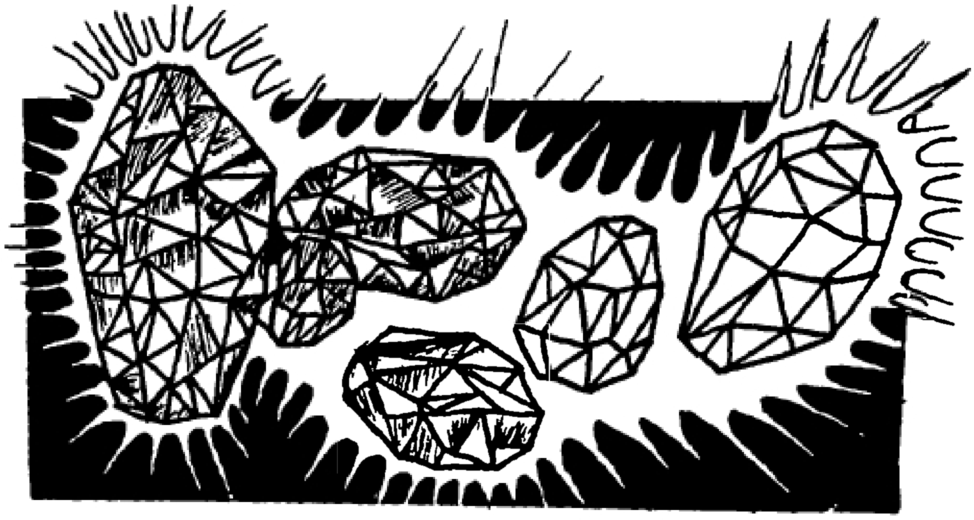
Other Marine Resources

Diamonds

Not only is Namibia's marine environment rich in living resources, but also in precious stones such as diamonds. Namibia's diamond mining industry is closely associated with the Orange River and the sea.

Most of Namibia's diamonds are mined in the coastal region between Oranjemund and Lüderitz. These precious stones, formed from carbon under great pressure, are found in sand deposits that were carried down by the Orange River millions of years ago. Large numbers of gem quality diamonds have been found north of Oranjemund and near Lüderitz.

Namdeb and three small companies are involved in diamond mining in Namibia. Most of the search for diamonds takes place on dry land, but in Lüderitz people dive below the surface of the sea in search of these gems. Diamond divers use a huge pipe to suck up (dredge) sand from the seabed onto a boat and then screen it for diamonds.

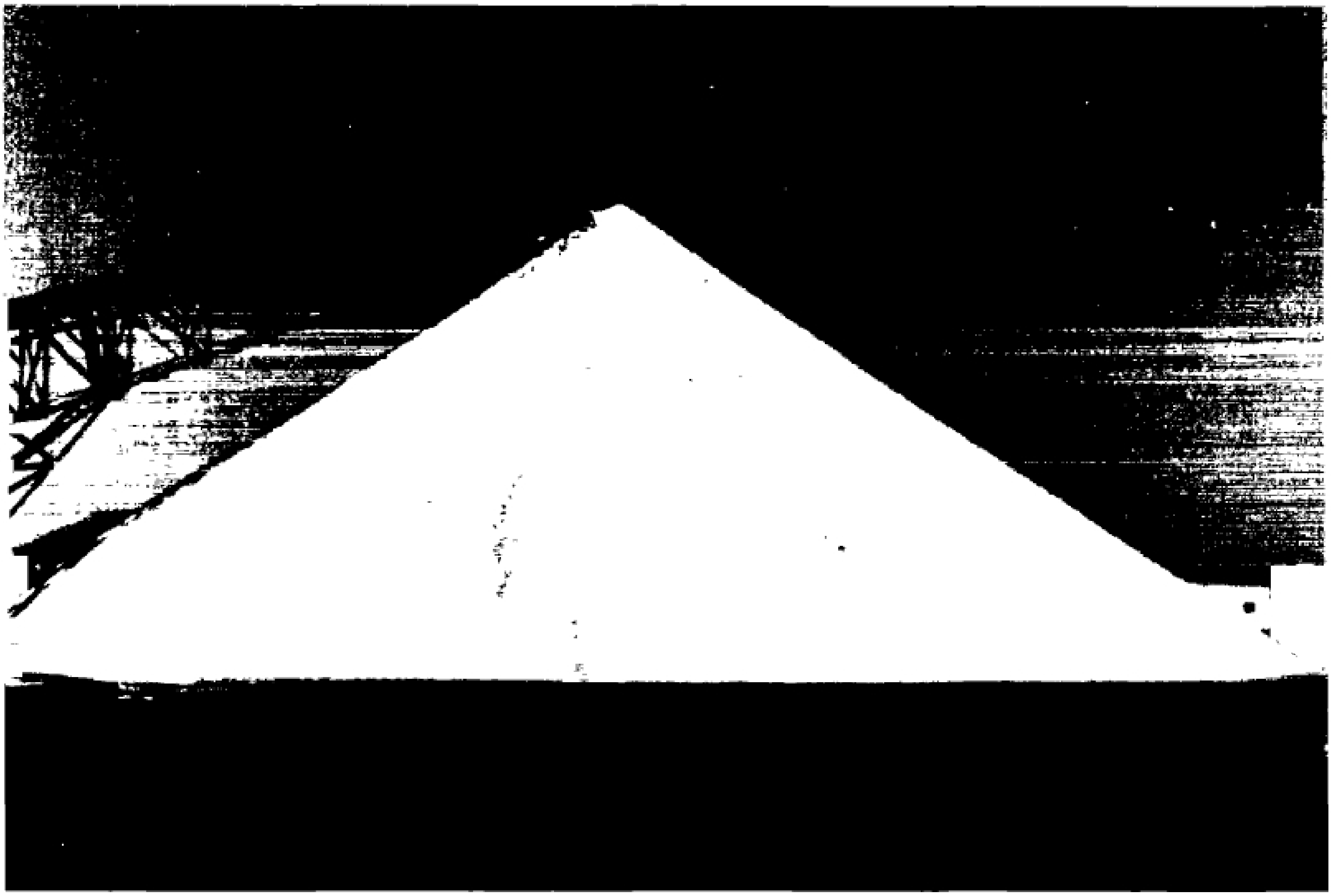


Gas

The sea also provides Namibia with a source of energy. A large field of natural gas is located 120km offshore from the mouth of the Orange River and is known as the Kudu Gas Field. It is suspected that this area may also contain oil reserves. Extracting oil could have a number of both positive and negative effects: Namibia will become more self-sufficient in energy and may make money through exporting oil, and jobs will be created; but coastal communities can be expected to grow which means that there will be a greater demand for resources such as water and electricity; massive pollution along Namibia's beaches is a possible threat; and our rich fish resources may also be damaged by explosions and pollution. Even the techniques used to explore for off-shore oil and gas are potentially damaging to our fisheries.

Salt

Pans along the Namibian coast have large deposits of salt that can be mined and exported. North of Swakopmund and near Walvis Bay, seawater is pumped into artificial pans. The sun evaporates the water and the salt remains behind. The salt is collected by large machines, packed and exported to other African countries.



Salt is harvested from artificial pans on the west coast of Namibia

Things to do...

A delicious fish dish...

Try this quick and simple but tasty recipe for yourself, and next time you eat fish, remember the richness of our marine resources.

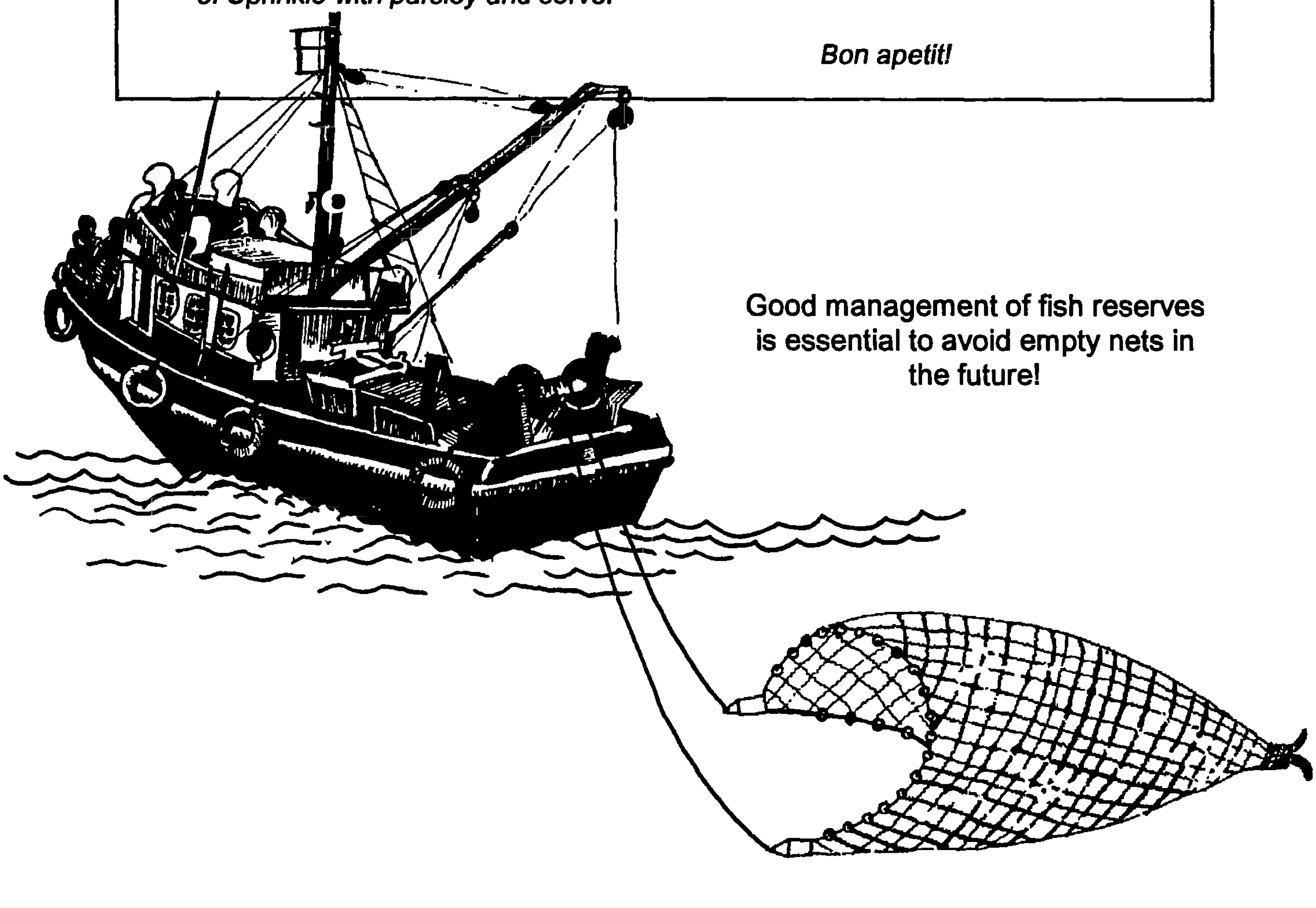
Hake and tomato stew

Ingredients

500g hake, cut into serving portions
Salt and pepper to taste, mixed with a little flour
4 large tomatoes
1 large onion
1 clove of garlic
1 tablespoon vinegar or lemon juice
2 teaspoons sugar
1 finely chopped chilli (optional)
Chopped parsley

1. Roll the hake pieces in the seasoned flour.
2. Peel, chop and fry the onion and garlic in a little oil until the onion is golden.
3. Add the seasoned and floured fish and place the lid on the pot.
4. Cook for 10 minutes, shaking the pan from time to time.
5. Add all the other ingredients except the parsley and cook for another 10 minutes.
6. Sprinkle with parsley and serve.

Bon apetit!



Good management of fish reserves is essential to avoid empty nets in the future!

Chapter 7
Activities

1. Make a set of "seaword" cards. Give learners a number of cards and ask them to combine words to make marine environmental words. For example, cards can have words on them such as sea, water, horse, fish, jelly, weed. These can be combined to form words such as: seahorse, jellyfish, seawater, seaweed, etc. Teams can score points for each word formed. Use a dictionary to check that words exist.

Choose books and poems with a sea theme to use in your lessons.

Imagine that you are a pirate, ship's captain, deck hand, stow away, etc. on a ship that sailed the seas 100 years ago. Keep a logbook that describes your adventures over a period of 4 weeks.

1. Create a collage of sea creatures or choose one that captures your imagination.

2. Design a postage stamp that reflects some aspect of Namibia's marine environment.

If you can get hold of old colour magazines use them in an art class to make a mosaic picture of the ocean. Tear coloured pages into small pieces and paste them down on another sheet in a way that represents waves and water or any aspect of sea life.

1. If you live near the coast, do a study to determine which marine organisms are being overexploited and why they are likely to face extinction in the future. You may wish to divide the learners into groups and set each the task of investigating a single species. Mussels, clams, crayfish, oysters, and fish all make good study animals. Older learners can be asked to design an experiment or a way of surveying the population numbers of their study animal.

Oil spills are becoming a serious pollution threat to coastal and marine life. Survey world oil spills over the past 10 years. Useful information can be gathered from newspapers and magazines. Trace the routes that oil tankers take and decide which coasts are at risk of ships running aground or of oil spills.

1. Make a study of all the major trade routes of the world. How have countries such as Namibia been affected by being located on a major trade route? Is there any evidence that Namibia is located along a major trade route? Consider all the evidence that you can find, including pollution on Namibia's beaches, foreign ships in Namibia's harbours, etc.

Make a study of countries that make a living from the sea. Note their latitudinal and longitudinal positions from an atlas. Are there any major ocean currents that flow past their shores? If so, are the currents warm or cold?

Make a study of coastal towns in an African country. Find out what the major activities taking place in those towns are. If you have chosen a Namibian town it is useful to use the telephone directory to provide information on what types of companies and activities occur in the town.

1. How has the use of the sea resulted in major changes in the world? Think about trade, colonisation, exchange of ideas, wars, political problems, foreign fishing off the coast, etc.

2. During the 18th and 19th centuries many European sailors surveyed the Namibian coast. Study their records and what effect their presence had on people they came into contact with and on the development of our country.

There are many interesting shipwrecks on the Namibian coast. Find out about these and how the name the "Skeleton Coast" was earned.

1. Make a collection of as many references in the Bible to the sea you can find. What role did fishing play in the lives of people who lived during the time of the Bible? Some of the disciples were fishermen and the sermon on the mount refers to fish. Jesus called his disciples "fishers of men".

Societies that live near the sea or on islands often worship the sea. In South America people old a yearly ceremony that pays homage to the Sea Queen. Respect is paid to her and gifts are offered in belief that she will bless them with good fish catches in the coming year. Do you know of any such s or beliefs.

1. In a study called "Things that float and things that don't", let the learners experiment with the densities of various materials. Have a collection of materials, some denser than water and some less dense than water. Let the learners decide on what materials are ideal for building a boat.

The use of sound waves to detect the presence of fish in water has helped fishermen to greatly ... the amount of fish caught in recent years. Include a study of sonar equipment in the section on sound s in the science syllabus. Sonar detectors provide the ideal opportunity to study reflection, refraction, ...action and the speed of sound in various substances.

...onstruct a mobile from shells or other water ated objects. Hang the mobile in the classroom and use to demonstrate the principles behind levers and vectors.

Other things for study:

orces - test the breaking strain of fishing line
...ction - streamlining of boats
nemical structures - build diamond and graphite molecules with plasticine
...lvents - what effect does salt have on the boiling point/freezing point of water. Conduct simple eriments.

1. Take a trip to the supermarket. Classify all the fish available in tins and in the freezers into the three categories of fish - demersal, pelagic and line fish. Find out more about the biology and habits of each of the fish. How are they caught? How important are they in terms of Namibia's economy?

How does the size of a net influence whether fishing is sustainable or not? Find out about nets. Why are they considered harmful to the marine environment? Make up a game or lesson that will elp others understand how overfishing occurs in our seas. Remember to consider the size of the holes in net, as well as the net size, in your presentation.

Marine resources have always been considered "common property" available to who ever can harvest m. How has this contributed to overfishing? Pretend that you work for the Department of Sea Fisheries. ... laws would you pass in order to protect marine resources. List your laws in order of importance and penalty that you would impose for transgessing each.

...ther things to study:

daptations - adaptations to living in water: streamlining, fins, gills, scales, webbed feet, etc.
... - what intertidal organisms are used as bait? Classify these organisms according to whether they vertebrates, invertebrates, molluscs, etc. Graph your results.

1. Interview a fisherman and write it up in reported speech for a newspaper article. What time does the person go fishing; what equipment does s/he use; what are her/his favourite fish; is the way the fishing is conducted sustainable or not?

8 Water and culture

Water, the indispensable fluid, is linked to all aspects of people's lives. There can be no life without water, and so it is only natural that water plays an important part in many aspects of human culture.

Many religions have beliefs or rituals linked to water, which is hardly surprising as many of the world's major religions arose in dry lands. Namibian tradition and culture also have within them many water linked rituals deriving from our life in an arid land. Rainmaking and the names we call our settlements are only two examples of this.

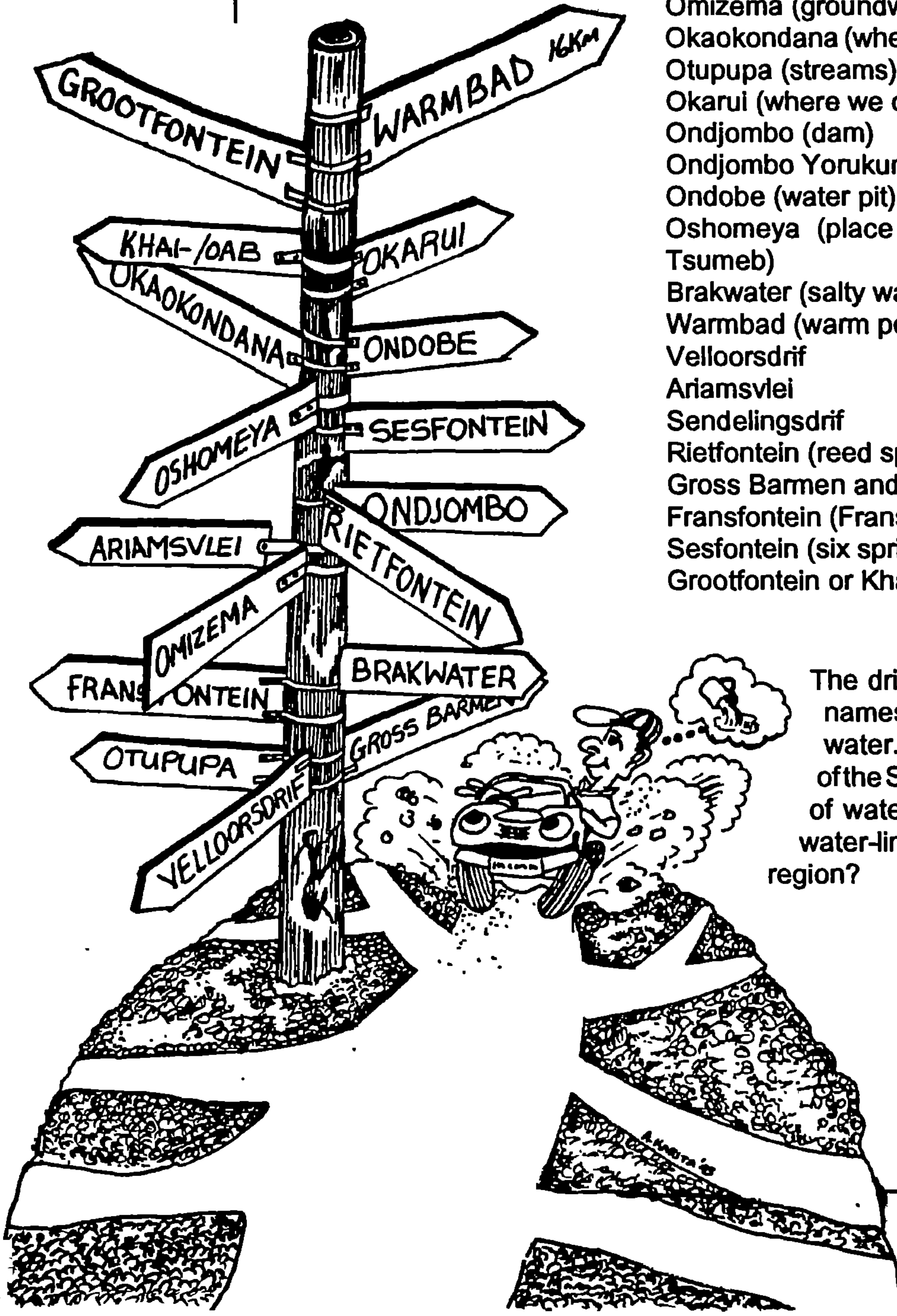
From what we believe to what we eat to how we talk... water is an important part of our culture - and our culture is an important part of us.

Water in Namibian culture

Water is an important aspect of people's lives, particularly when there is a lack of it. It has to be fetched, drawn and transported, and can occupy a substantial portion of their time and thoughts. Water also determines where it will be possible for people to live, and what kind of life they will lead. Namibia is a country where water is in very short supply. Namibians' understandable preoccupation with water is reflected in many aspects of our culture. How is water viewed in the area where you live, and how is it regarded in the cultural and spiritual lives of your people?

Water in place names

Omizema (groundwater well)
Okaokondana (where the calves come and drink)
Otupupa (streams)
Okarui (where we collect water)
Ondjombo (dam)
Ondjombo Yorukune (wooden dam)
Ondobe (water pit)
Oshomeya (place of water - also known as Tsumeb)
Brakwater (salty water)
Warmbad (warm pools)
Velloorsdrif
Ariamsvlei
Sendelingsdrif
Rietfontein (reed spring)
Gross Barmen and Klein Barmen
Fransfontein (Frans's spring)
Sesfontein (six springs)
Grootfontein or Khai-/oab (big spring)



The drier the land, the more place names there are that deal with water. As the driest country south of the Sahara, Namibia has a wealth of water place names. How many water-linked names occur in your region?

Water and the Bushmen

One of the peoples of Namibia, the Bushman, are masters at finding water in the arid regions they inhabit. They are nomadic hunters and gatherers, and depend on their water-finding skills for survival as they roam the dry and inhospitable reaches of the Kalahari desert. They know which plants to pick and which roots to dig up to provide them with water, and also get liquids from the animals they kill. Some of their sources of water are:

- melons, such as the tsamma
- the large, moist roots of certain plants
- seasonal lakes, or pans
- small hollows in the ground after rains
- water holes, which often have to be dug
- hollows in trees, such as the baobab
- antelope stomachs - the water in one of the stomachs of antelopes can be drunk

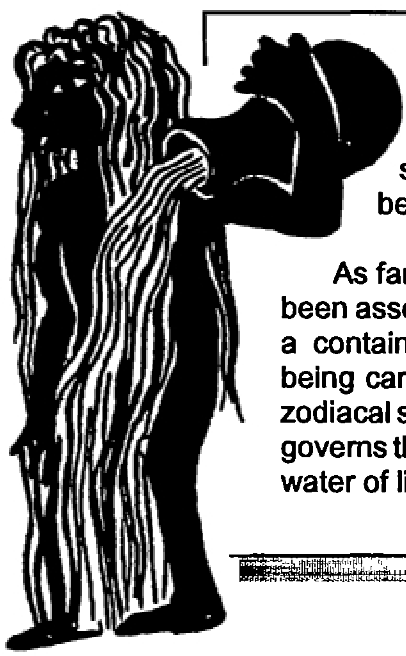
The Bushman's quest for water plays an important part in determining the size of the groups that they travel in as well as the routes that they follow.

Water and beliefs

Water plays an important part in many of the world's religions. It is an essential part of many of the rites associated with our spiritual lives. Christian baptism is the sacrament of entry into a Christian church. When someone is baptised they are washed in water in the name of the Father, the Son and the Holy Ghost, and this symbolises the person's identification with Christ's death and resurrection,in dying in sin and being raised to a new life.

For the Hindu, India's River Ganga (formerly known as the Ganges) not only provides water for the land; but the water itself is the symbol of life without end. Hundreds of thousands of people come to the banks of the Ganga each day to perform a ritual of purification in its water and to drink from its life-giving stream. Every twelve years the Kumbh Mela festival is held at Allahabad, where the River Jumna meets the Ganga, and as many as ten million people share in ritual bathing at this time and place. After death and cremation the ashes of faithful Hindu are, if possible, cast upon the water of the Ganga - and life continues.

The Maori people of New Zealand link water with the birth of the world. Their myth of origin tells of the first parents, Ranginui and Papatuanuku, who were locked in a deep embrace. As their sons were born they were kept between their parents and only allowed glimpses of the light. They struggled for a long time to escape, and eventually one son, Tane, placed his feet against Rangi and extended his arms against Papa. Struggling fiercely, upside down, and helped by his brothers, he forced his parents apart. Rangi became the sky and Papa the earth - Sky Father and Earth Mother. Their grief at being separated is seen in falling rain and rising mists.

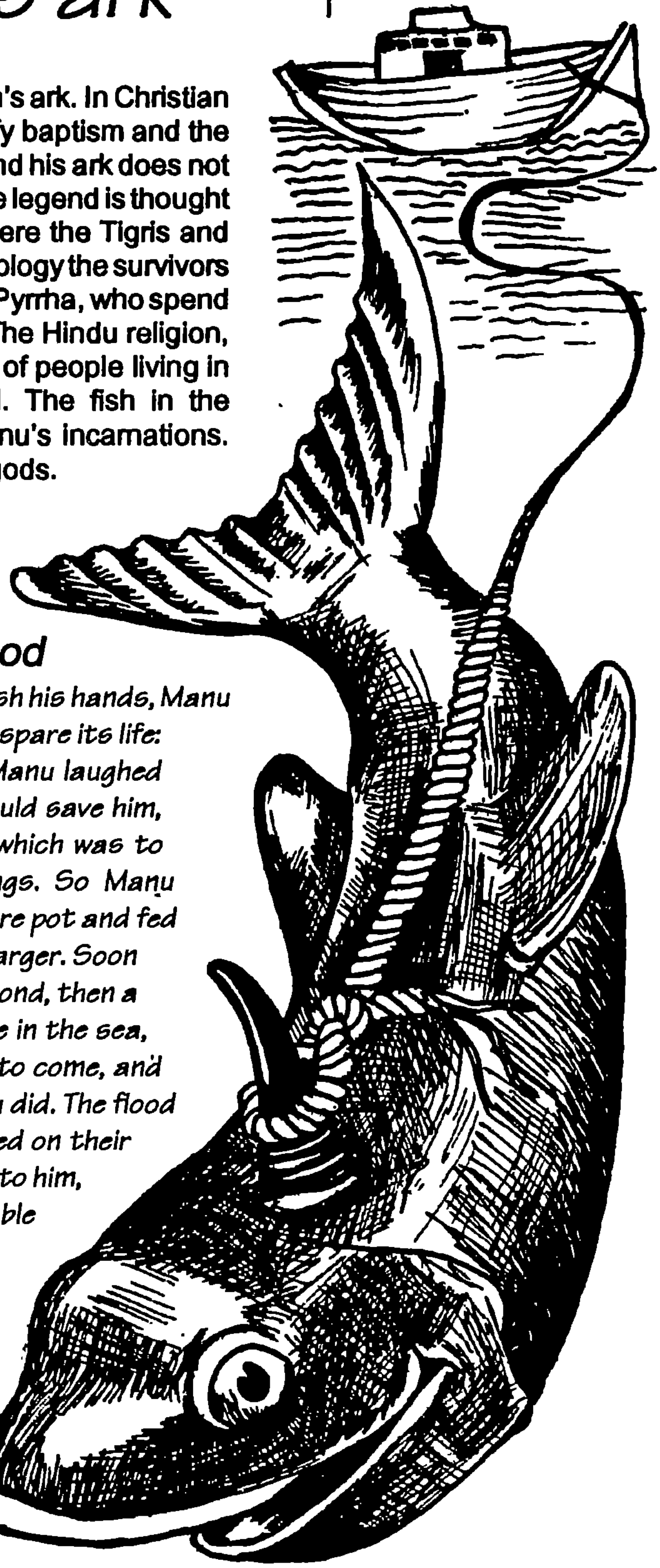


Aquarius - the water-bearer

Many of the signs of the zodiac are linked to water, but the one most firmly tied to it is surely the eleventh sign - Aquarius, the water bearer.

As far back as is traceable, this constellation has been associated with a boy or man pouring water from a container. Many astrologers interpret the water being carried as the water of consciousness. All the zodiacal signs govern a part of the body, and Aquarius governs the circulatory system and thus blood - the red water of life so essential for human existence.

Noah and his ark



We are all familiar with the story of Noah's ark. In Christian symbolism the flood has come to signify baptism and the ark the Church. But the story of Noah and his ark does not belong to one religion alone. Indeed, the legend is thought to have originated in Mesopotamia where the Tigris and Euphrates often flooded. In Greek mythology the survivors of the Flood are Deucalion and his wife Pyrrha, who spend many days afloat in a wooden chest. The Hindu religion, which is followed by the great majority of people living in India, has its own myth of the flood. The fish in the following myth is Matsya, one of Vishnu's incarnations. Vishnu is one of Hinduism's greatest gods.

Manu and the flood

One day, in the water he was using to wash his hands, Manu found a tiny fish. The fish begged him to spare its life: "Save me and I will save you", it said. Manu laughed and asked the fish how it thought it could save him, and the fish told him of a huge flood which was to come that would drown all living things. So Manu rescued the fish, put it in an earthenware pot and fed it. The fish grew larger, and larger, and larger. Soon Manu had to move it to a tank, then a pond, then a lake, and finally into the sea itself. Once in the sea, the fish told Manu when the flood was to come, and advised Manu to build a ship. This Manu did. The flood came and the waters rose. Manu floated on their surface. After some days the fish came to him, and towed the ship by means of a cable fastened to its horn. Their journey was long and difficult, as they crossed the sunken peaks of the Himalayas. Once landed, Manu was lonely, and prayed for children. He was given a wife, and from their offspring all people are descended.

Calling the rain

Rain is essential for both pastoralists and crop growers. Receiving the right amount of rain can make the difference between a good year and a hungry one, and, in some cases, even between life and death. Throughout the world, many different peoples have special ceremonies or rites to bring rain. Namibia is no exception.

For example, the Kwangari people of Kavango make rain offerings at the graves of their rulers. The most favoured offering is a black ox, which symbolises black rain clouds. These beasts are sacrificed at the sides of graves, in the hopes that former rulers will use their powers to send rain to their people.

Below is a translation of a Bushman poem that speaks of a rain maker.

The Rain-Sorcerer

He was of our family, the man we called //Kunn.
He was a rain's man; he used to make rain.
He made the rain's hair, the kind falling softly.
He made the rain's legs, falling only in columns.
He would summon the cloud, this sorcerer of rain.

//Kunn could make rain come out of the west.
When he lived to the north, a mountain Bushman,
the rain from the west would always turn north.
//Kunn could make rain, he could move rain
to the place where he lived in the mountains.

He was one of us, this sorcerer of rain.
But he lived to the north, we to the east.
Both his father, his mother, were unknown to me.
//Kunn was old even then, when I was a child.
He was very old then. He is long since dead.

He no longer dances, catching the rain animal.
His heart no longer falls down, into the water-pit,
fetching the rain-bull, the rain in its wake.
He no longer leads it across the parched flats,
scattering its meat, its blood and milk become rain.

He was the last that I knew, this rain-sorcerer.
He was the very last, the man we called //Kunn -
this maker of rain, and the scent of rain,
this sorcerer of water, of the fragrance of grass,
sorcerer of rain's hair, summoner of clouds.

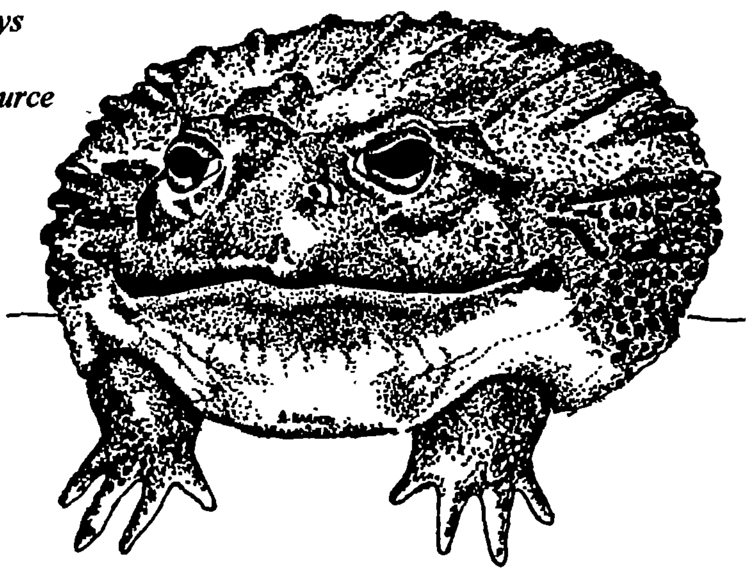
From: *Return of the Moon: Versions from the /Xam*. Stephen Watson.
Carrefour Press, Capetown. 1991.

Wet and watery words

Water and watery phrases can be found throughout the English language. We speak of the ***flow*** *of language, and when people are no fun, we call them* ***wet blankets****. We speak of* ***damming up*** *feelings and of being carried away on a* ***tide*** *of emotion, which may well result in a* ***flood*** *of tears. When we dislike someone, we might call them a* ***drip****, a* ***wash out*** *or* ***wishy washy****. We can describe something as being* ***bathed*** *in light or* ***swimming*** *in grease. The passage above is* ***drowning*** *in water words which have been* ***soaked*** *up by language over the centuries. Or is this just a* ***fishy*** *story that leaves you* ***floundering*** *in a* ***sea*** *of doubt?*

Not only is language **awash** with water words, but watery proverbs and idioms are often a good way of making something understood. Below is a selection of English water proverbs and phrases. What do you think they all mean? How many Namibian water proverbs can you discover, and what exactly do they mean?

- *a big fish in a small pond*
- *a drowning man will clutch at a straw*
- *any port in a storm*
- *there are plenty of fish in the sea*
- *blood is thicker than water*
- *cast no dirt into the well that gives you water*
- *every cloud has a silver lining*
- *fish and company stink in three days*
- *it never rains but it pours*
- *the stream cannot rise above its source*
- *a fish out of water*
- *to drink like a fish*
- *to be packed like sardines*
- *to pour oil on troubled waters*
- *as dull as ditchwater*
- *to be in hot water*
- *that's all water under the bridge*
- *to be all at sea*
- *like water off a duck's back.*



Thunder and lightning!

The following story is from eastern Nigeria, where there is a rich culture of storytelling. It explains the origin of thunder and lightning and tries to give reasons for the way they behave...

A long time ago, both Thunder and Lightning lived on earth, among people. Thunder was an old mother sheep, and Lightning, her son, was a strong, handsome ram.

However, these two were very unpopular with their neighbours. Lightning had a terrible temper, and would often fly into a furious rage and burn down homesteads, cornbins, large trees and crops. Sometimes he even killed people who got in his way. Whenever his mother found out he was behaving in this wicked way, she would stand at her door and shout loudly at her son - and believe me, she could shout very loudly indeed!

Everyone was very upset - firstly by the damage and danger from Lightning, and secondly by the unbearable noise his mother made. The villagers often complained to the king, until eventually he sent Thunder and Lightning off to live on the edge of the village and told them they were forbidden to mix with other people. This didn' t work, as Lightning lost his temper even more frequently and his mother shouted so long and loud that some nights the villagers were able to get very little sleep.

So the king called Thunder and Lightning to him and banished them from the village, sending them off to live in the wild bush. But the villagers' troubles still had not ended. Lightning was so angry at being sent away from the village that he set fire to the whole bush. The flames spread quickly, and soon peoples' farms and homesteads were burning too. They could hear Thunder shouting at her son, but her scolding - even in a voice as loud as hers - could not stop him.

Something had to be done. So the king called a wise old woman to him to discuss the problem. "Why don' t you send Thunder and Lightning right away from the earth?" she said. "Anywhere they live those two will cause trouble, but if you banish them to the sky we should be rid of them forever."

So Thunder and Lightning were sent away from the earth, and built their new home in the sky.

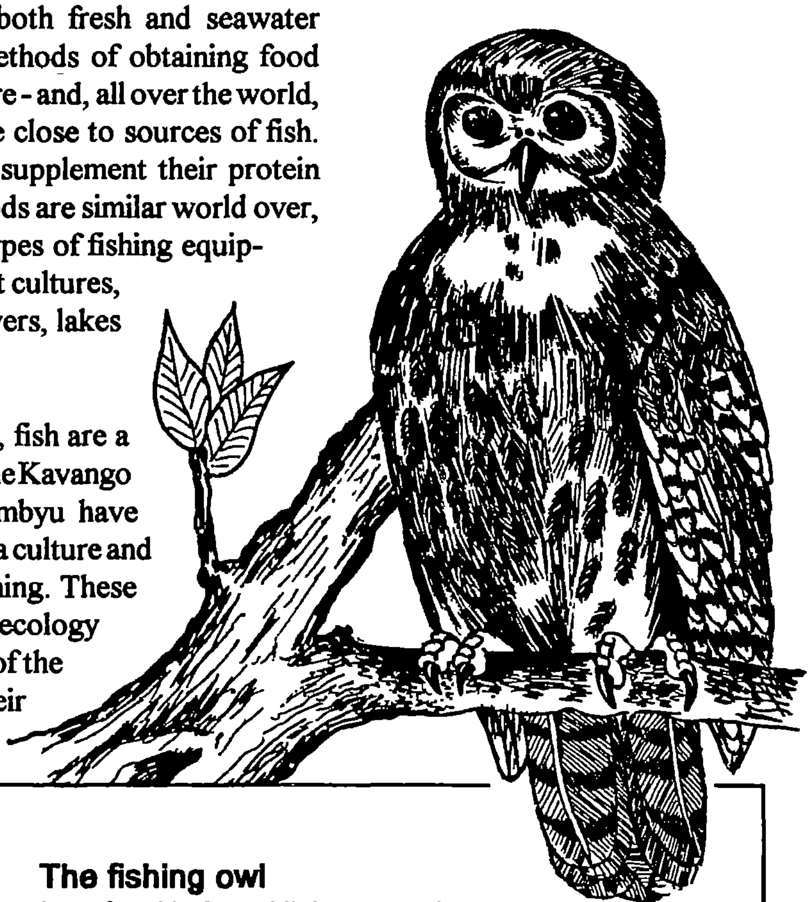
However, this plan was not entirely successful. Whenever Lightning is in a particularly bad mood, he still sends fire down to the earth... and you can then hear his mother scolding him in a loud rumbling voice.

A fishy culture

Methods used to catch fish in the Okavango River	
Method used	Proportion of people using method (%)
fish funnel - sikuku	71
fish corral - sintunga	91
fish fence - masasa/erera	5
scoop basket - tambi	0
fish trap - kanguwa	0
push basket - sididi	30
hook and line - erowo	46
fish spear of bow and arrow - muho or ngumba	15

Source: *Rural development in the Okavango region of Namibia.* G Yaaron, G Janssen, U Maamberua. 1992

Fish are a very important product of both fresh and seawater systems. Fishing is one of the oldest methods of obtaining food known to people - far older than agriculture - and, all over the world, is part of the culture of peoples who live close to sources of fish. Many different peoples fish to meet or supplement their protein requirements, and although fishing methods are similar world over, the materials used and preferences for types of fishing equipment are an integral part of many different cultures, especially those of peoples living near rivers, lakes or seas.



In areas of Namibia near perennial rivers, fish are a very important source of protein. Among the Kavango peoples, the Mbunza, Gciriku and Shambyu have their main protein source in fish, and have a culture and folklore rich in references to fish and fishing. These people have a deep understanding of the ecology of the river they live on and of the habits of the fish from which they obtain much of their food.

As can be seen from the table above, they also have a wide variety of ways to catch fish.

The fishing owl

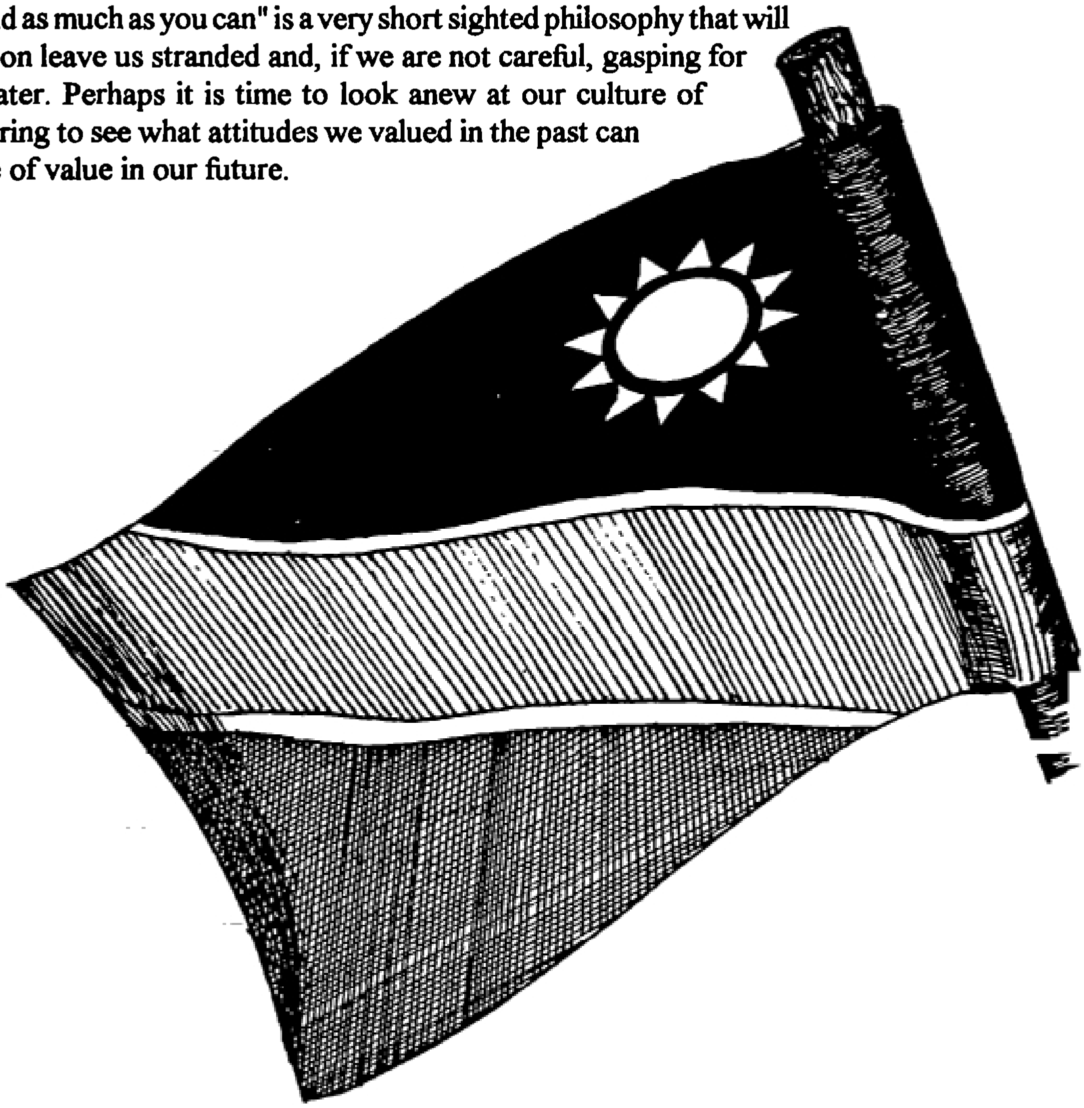
An interesting species of owl is found living near the water bodies in the Caprivi area. Pel's fishing owl, a large nocturnal bird, fishes in gently running water or still pools. It drops from a low perch onto its prey, capturing it with its feet, and then returns to its perch to eat its fishy meal.

A culture of caring

Namibia has for untold centuries been a dry land, and because of this, for untold centuries, our people have been aware of the worth of water. An arid land is a difficult land to live in, so traditionally we are not a wasteful people.

Why now then do we hear so much about Namibia's water crisis? Well, for one thing, our land and our lifestyles have changed. There are at the present moment more people living in Namibia than there have ever been before, and our lifestyles and aspirations differ vastly from those of our ancestors. Never before have such demands been put on our resources, especially water, and never before have we had so little respect for them. We take free, cheap and plentiful water for granted and waste and dirty it. We put greed before the environment we depend on, not only harming the environment but also ourselves and the future of our children. Progress? Perhaps not. There are ways and means of developing that ensure not only a rewarding lifestyle for ourselves but also an environment that will continue to support us in the future.

It is time to re-evaluate our present way of life. "Take what you can, when you can and as much as you can" is a very short sighted philosophy that will soon leave us stranded and, if we are not careful, gasping for water. Perhaps it is time to look anew at our culture of caring to see what attitudes we valued in the past can be of value in our future.



Chapter 8
Activities

1. Watery place names

Because water has played such an important role in Namibia's history, many places have names that make some reference to water. Make a list of these and translate them into English. Maps and telephone directories are useful sources of information.

Write a rain-making song. You can even put it to music.

1. Water plays an important role in a number of beliefs and religions. In astrology there are water signs. Find out what these signs are and what types of people are believed to show watery aspects in their personalities.

2. What spiritual and religious ceremonies are linked to rain in Namibia? You may be able to find out more about rainmaking ceremonies, songs, stories and folktales.

1. The "Best Fisherman" Award.

Divide the class into two groups. Both groups must choose 10 species of fish that are an important source of food in Namibia and find out how they are caught. They must consider ALL possible ways: poisoning, spears, nets, trawling, line, traps, baskets, animals, etc. After 15 minutes or during the next lesson let Group 1 write up their ten fish on the board. It then becomes the task of Group 2 to say how each species is caught. Each correct answer scores ...p 2 a point. After that Group 2 must write up their 10 fish and it is the turn of Group 1 to provide the ...rs. The group with the highest score is the "best fisherman". Remember, a single species may be ...ht in a number of ways. Award points for the most common way that the species is caught.

...ct a class or group project on "Animals that Eat Fish". Let learners choose a single species or as many ...rent species as they can think of and do self-study projects that encourage them to find out more about how these animals are adapted to their diet, where they live, what fish they eat and how they catch their ...als.

1. Shells, river pebbles or other items collected from the shore or the riverbed can be used in your classroom when discussing mathematical concepts and working with numbers. They provide an ideal way for the learners to visualise what is often difficult to understand. Use the collections to explain simple addition, subtraction, etc. or more complicated statistical concepts.

1. Put together a collection of recipes that detail how to prepare food that we get from our rivers, pans, dams, and ocean. Interview elderly people in your community to get some exciting ideas. Prepare some of these recipes in your class.

1. If you live near a perennial river where fish traps are used, study some of the traps used. What are they made of and how do they work?

1. Find out what the various components of the Namibian flag symbolise. Pay special attention to the use of the colour blue.

[redacted]

9

Water supply in Namibia

Drinkable water is one of the basic requirements for any society. Once settlements develop and animals are kept, the requirement for water increases substantially. Water is needed for domestic, livestock and agricultural purposes. In the case of small settlements, the requirements may be met by small springs, but once settlements grow additional water must be supplied by wells and boreholes. Where towns, cities and large settlements of people occur a constant reliable source of water is essential.

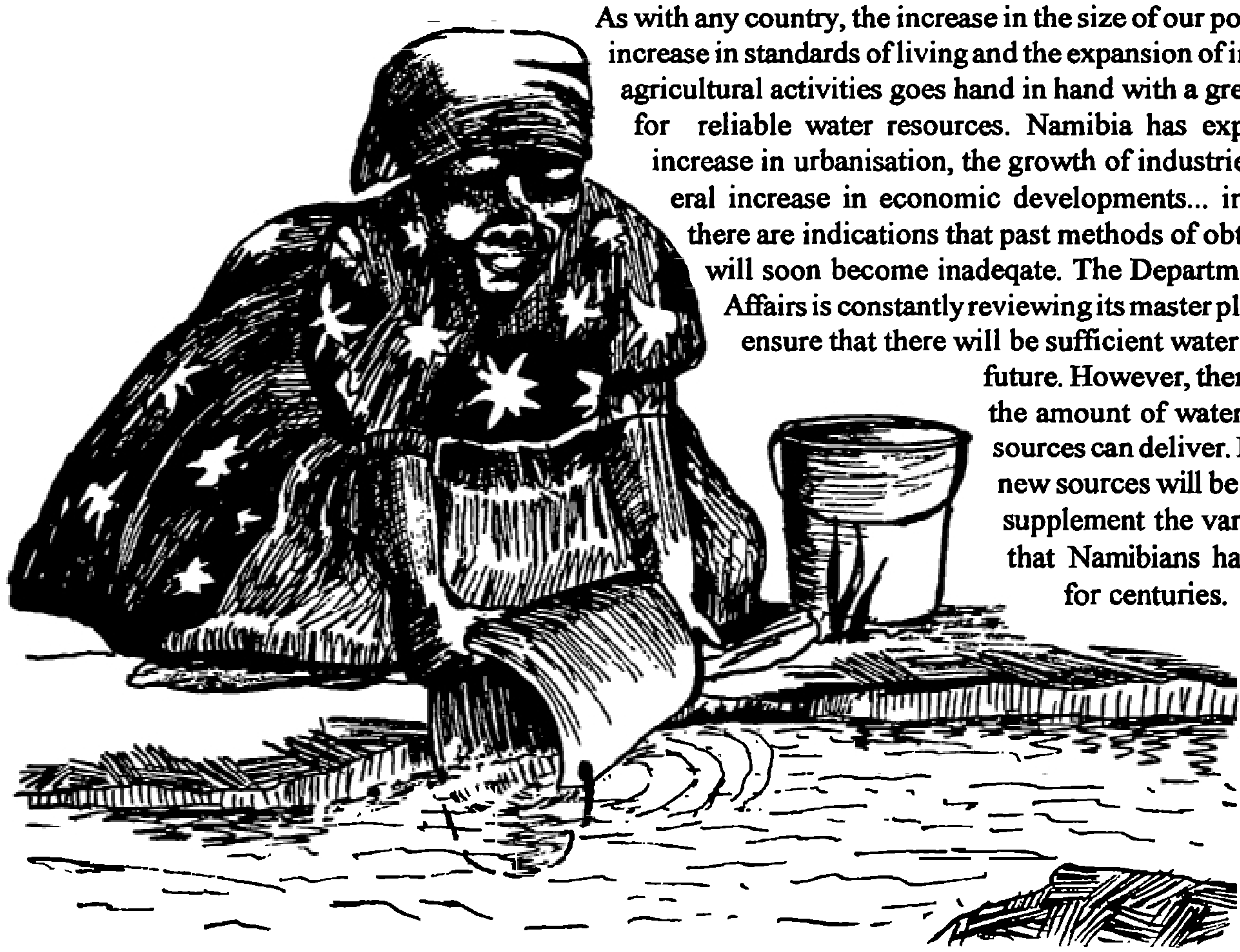
Water supply in the past

In the past, people of Namibia were either nomadic or settled near some natural water source such as a river or a spring. In this way they could be assured of a supply of water all year round.

It is fair to assume that people living inland, where rainfall and river water is scarce, always had difficulty obtaining water. However, these inland people were mostly nomadic - which meant that if water was inadequate at a particular place they would move with their belongings to a place where water was more plentiful. The political situation that came with colonial rule changed this way of life, and a large portion of our population, with their cattle, was forced to settle in designated areas. This meant that reliable, year-round water supply became a necessity. In most cases hand-dug wells became the greatest source of water. Later boreholes and State water supply schemes provided more reliable and plentiful sources of water. You can read about these schemes in this chapter.

The early inhabitants of our country who lived along the perennial rivers like the Kunene, Okavango, Zambezi and Orange, had less of a problem with water supply. They would either rely directly on the rivers or on the annual flooding of the land to provide them with a supply of water. This led to the concentration of villages and homesteads along the banks of these rivers - a situation that still exists today. The central north of Namibia depended for part of the year on groundwater supplies and for the remaining part on oshanas (shallow pans) that would fill with flood or rain water. A system of pipelines and canals now supplies this region with freshwater from the Kunene River, but many rural people living far from water points still rely on hand-dug wells for their water.

As with any country, the increase in the size of our population, the increase in standards of living and the expansion of industrial and agricultural activities goes hand in hand with a greater demand for reliable water resources. Namibia has experienced an increase in urbanisation, the growth of industries and a general increase in economic developments... in most cases there are indications that past methods of obtaining water will soon become inadeqate. The Department of Water Affairs is constantly reviewing its master plan in order to ensure that there will be sufficient water for all in the future. However, there is a limit to the amount of water that current sources can deliver. It is clear that new sources will be necessary to supplement the various sources that Namibians have relied on for centuries.

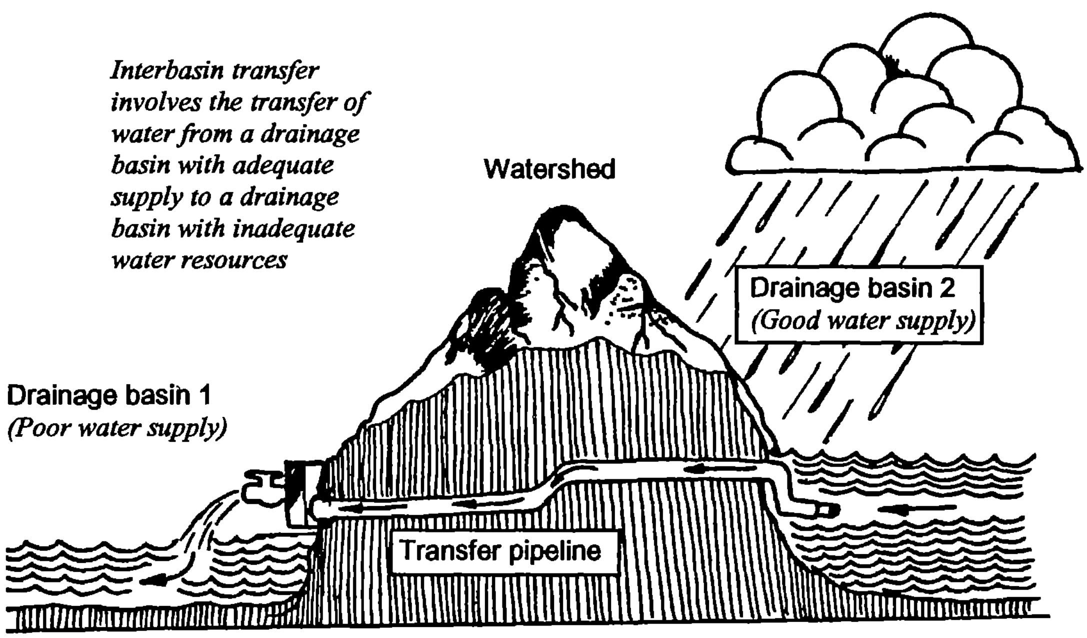


Interbasin transfer

When one river basin has adequate water and another river basin cannot meet the demands for water in the area it supplies, water can be taken from the river basin with adequate water and transported to the other river basin. This can be done by a system of canals, pipelines and pumps. We call this interbasin water transfer. This system has been used to overcome supply shortages in several places in southern Africa. In Namibia we have the Eastern National Water Carrier that will transfer water from the Okavango River to central areas of our country.

Although there are a number of obvious advantages to interbasin transfer, negative effects can and do occur, although they are not always as readily apparent. Decreasing the availablity of water in one basin and increasing it in another is likely to have long term effects on the ecology of both basins. Also, if the transfer of water occurs across international borders there is a need for political agreements between the countries that will be involved in management of the water resources. Conflict over the transfer of water from one basin to another is likely to result, especially where water is in short supply.

Interbasin transfer involves the transfer of water from a drainage basin with adequate supply to a drainage basin with inadequate water resources



The Namibian water supply infrastructure

The Department of Water Affairs
In 1954 the Department of Water Affairs (DWA) was established in order to purify and supply water to towns, cities and mines in Namibia. Today the Department of Water Affairs falls under the Ministry of Agriculture, Water and Rural Development and its responsibility is to investigate, control, supply and manage water resources in Namibia.

Although the government is hoping to privatise most of the water supply schemes in Namibia in the future, it remains the only bulk water supplier. The government's objective in supplying water to the public is to make sure that there is sufficient for all, that the quality is of an acceptable standard, that people can afford it and that the demand for water is reasonable. However, the government does not handle all supply schemes. There are a number of municipalities who manage their own schemes while thousands of farmers and many rural communities are entirely responsible for their own water supply facilities, such as boreholes and wells.

The DWA stores and makes water available to the Namibian population by means of:

- pipelines
- canals
- boreholes
- sand dams
- purification of water
- withdrawal of water from rivers
- storage dams.

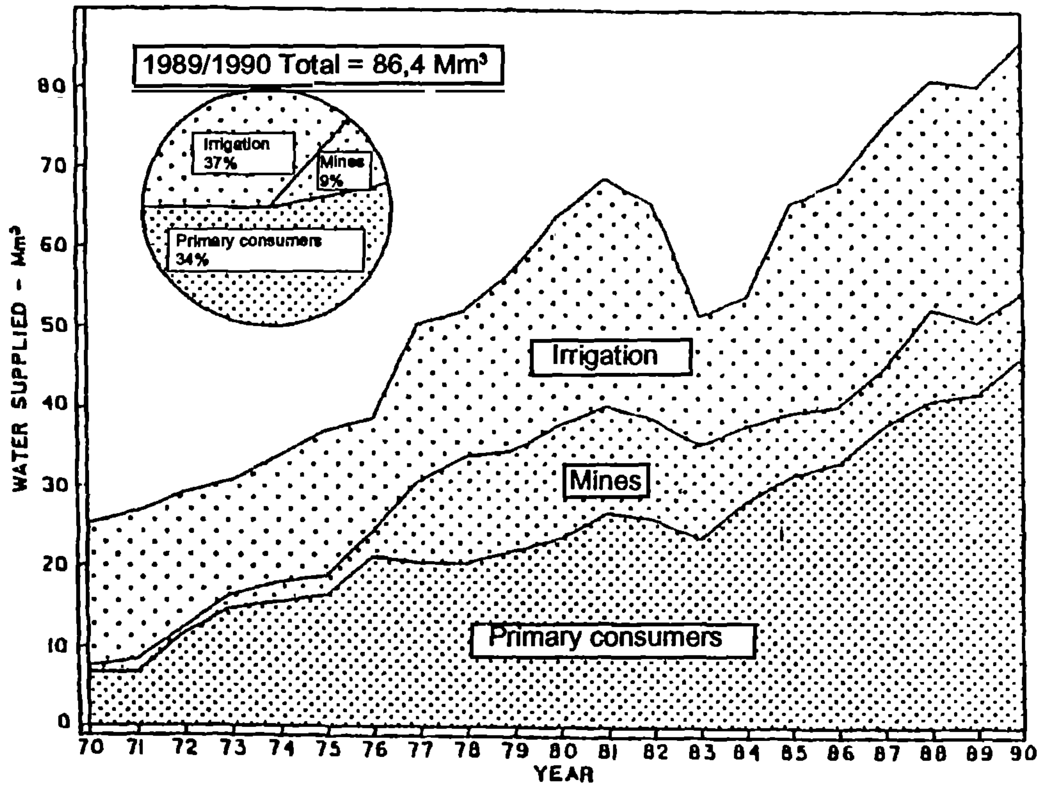
Within every country there needs to be some organisation or part of the government that watches over the use of water on a national level. In Namibia, the DWA plays an important role in fulfilling this function. Legislation that controls the use of water resources, like the Water Act; pollution control; issuing permits; monitoring dams and dam building; water quality and effluent control; and long term research into water related issues are all concerns that fall under the control of the DWA.

State water infrastructure (1995)

Number of water schemes	190
Major dams	13
Pumped storage dams	22
Production boreholes	470
Concrete lined canals	300 km
Pipelines	3 300 km
Purification works	25
Reservoirs	170
Water towers	120
Rural water supply installations	3 600

Pumping water requires a tremendous amount of energy. More than 86 million kilowatts of energy are used annually to pump water in Namibia, not including the huge amount of water pumped by wind

Graph showing water supplied by the Department of Water Affairs according to use



Source: DWA

The graph shows that the total volume of water supplied by the DWA has steadily increased over time.

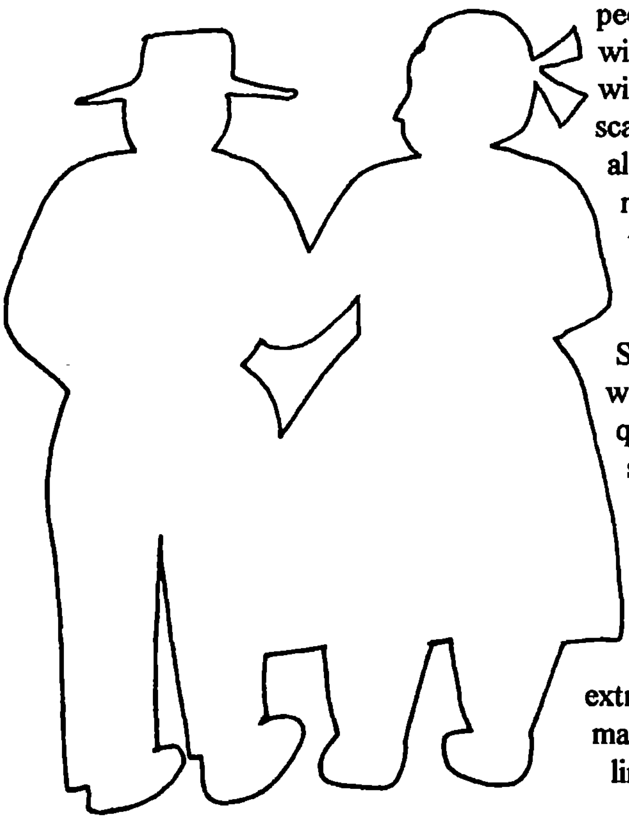
The DWA supplied a total of 78,43Mm³ of water during the 1992/93 finacial year. Of this total, 64% was supplied for domestic consumption, stock watering and industrial purposes, 7% supplied for mining activities, and 29% was used for irrigation. About 50% of the potable water was supplied from groundwater sources. These figures relate only to State water supply schemes. Private boreholes and wells are not included.

Challenges of supplying water in Namibia

Every country has its problems when it comes to supplying drinkable water for its people, but in Namibia the problems are often far more difficult to overcome because of the critical shortage of rainfall. Here are some of the challenges that we all have to face with regard to managing our water resources.

Namibia's climate affects water supply in that high evaporation rates cause the loss of huge amounts of water from dams and open bodies of water. Large, open storage dams lose thousands of litres of water each year because of evaporation. Namiba is faced with the challange of reducing losses through evaporation. Already, experiments with dam design (Omdel Dam) and water transfer schemes are being conducted in order to reduce the effects of evaporation.

Water resources are unevenly distributed in Namibia and so is the demand for water. Unfortunately, most of the demands for industrial and domestic water come from the arid central region of our country. This situation is made worse by the fact that there are no perennial rivers flowing through this central region. Most of the water resources in the region are not adequate for the demands they have to meet. In order to address this the State has embarked on a plan that will transfer water by a system of pipelines and canals from the Okavango River to the central region. This is an extremely costly venture and one that does not necessarily encourage people to adopt water-saving lifestyles as water will be more freely available in the region and there will be little impetus for people to consider what a scarce and precious resource it is. The scheme is also dependent on political stability and agreements between Namibia's neighbours since more than one country relies on the water resources provided by the Okavango.



Schemes have been developed to supply water where it is most urgently needed with the consequence that the most sophisticated water supply schemes are focused on towns and urban settlements. Water supply schemes that serve rural areas are extremely expensive and remain one of Namibia's largest water challenges. The pipelines and canal that supply the northern rural areas of Namibia up to Oshakati were extremely expensive and are a source of tremendous management problems. Illegal breaking of pipelines, overgrazing associated with water points, and unhygienic conditions at watering points are just of the few problems that are experienced in

Poor management of resources, including the land closely associated with the water infrastructure, results in damage that is not easily reversed. People have in many cases developed bad habits and are unaware of the importance of water conservation. Massive education and awareness programmes are now necessary to address the issue. Teachers can play a major role in developing water awareness amongst the Namibian youth.

Some of Namibia's settlements have grown too big for their local water sources. Windhoek, Swakopmund, Walvis Bay and Lüderitz are all likely to suffer from water shortages in the future unless water is transferred from other areas or alternative sources, such as seawater purified by desalination, are used to supplement existing sources.

The supply of cheap or free water in Namibia has created false expectations amongst many of our people. In many cases water is wasted because it is free and there is very little concern for conservation and careful use. The end result is that many of us are not prepared to accept responsibiltiy for the resources that allow us to survive in this arid land. The consequences of this are likely to be serious unless there is a change in attitudes and expectations.

Although there is a National Water Master Plan for Namibia, there has been no conservation policy concerning water use in Namibia, with the result that many supply schemes do not have conservation of water as a high priority.

Rural water supply

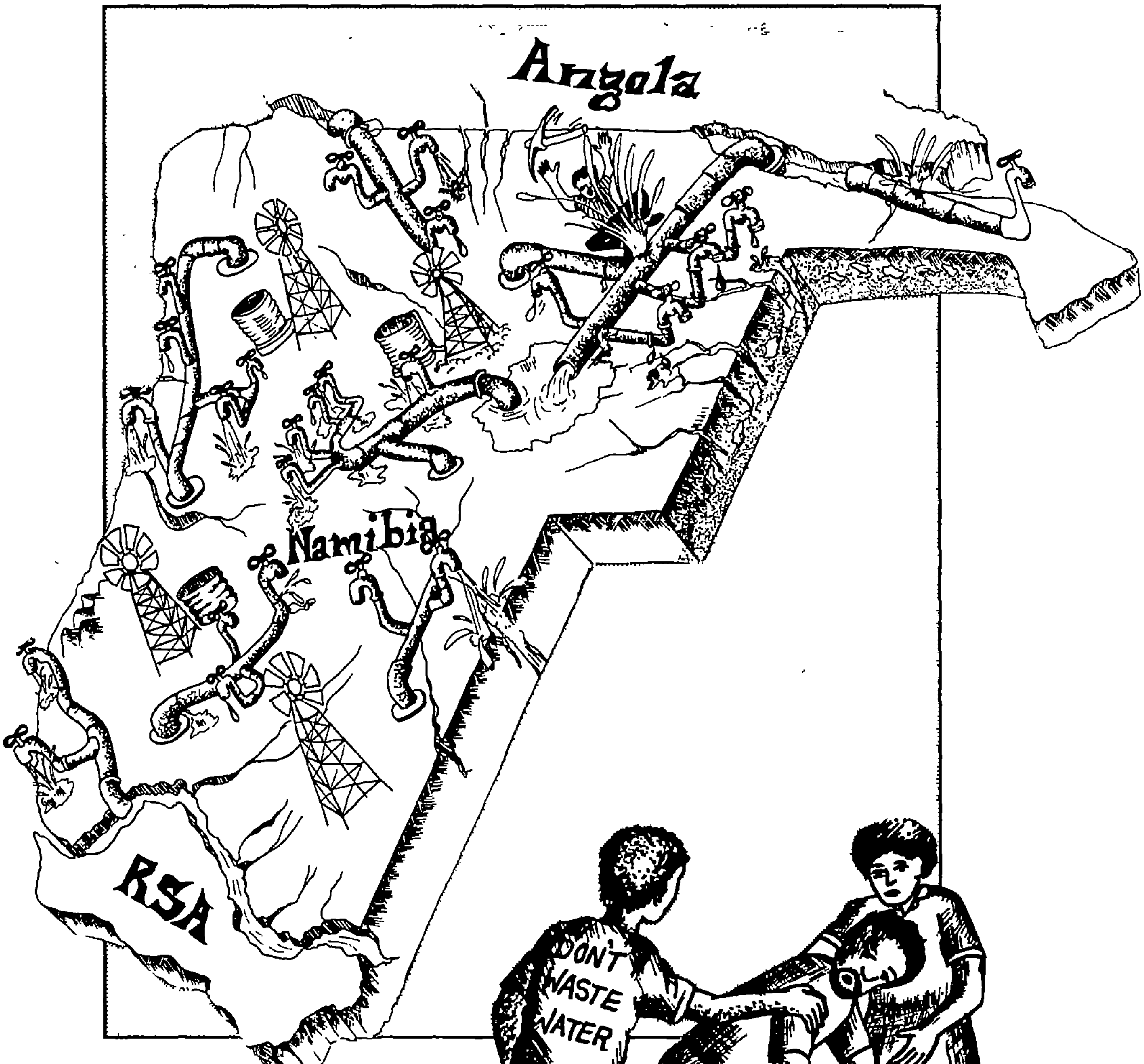
Rural water supply is a crucial issue in Namibia because so much of our population lives in a rural setting. Ignoring rural conditions can set up a chain of events that eventually affect urbansation, public health, land degradation, deforestation, soil erosion and desertification.

At Lake Kariba, a large dam between Zimbabwe and Zambia, more water is lost through evaporation each year than is used in the whole of Zimbabwe.

Rural water is particularly at risk of being polluted by either animal and human waste or waste disposal. Even though permits may be issued and quality control exercised over pumping groundwater in rural areas, the quality of the water consumed by the end user may be very poor. On the other hand, providing people with clean water does not mean that health and hygiene standards are immediately raised. Many water points and traditional sources are highly contaminated and methods of transport and storage in the home can also contribute to water contamination.

Clearly there is a big need in Namibia for rural people to play a greater role in the management of their water resources. Education programmes need to encourage rural people to adopt hygienic ways of dealing with the water that is available to them. Simple and cheap steps such as fencing off water points, using clean containers for the transport and storage of water and the use of pit latrines can go a long way to providing cleaner water for these people.

Namibians - the water wasters?



A network of thousands of kilometres of pipelines has been set up all over Namibia to meet the demand for water. In some cases Namibia's water pipelines are broken or cut open to obtain free water. This is an extremely wasteful practice and seriously threatens the availability of Namibia's water resources in the future. It is also an extremely expensive practice. It costs more than one million Namibian dollars to install a single kilometre of bulk water supply pipeline. It is in the interest of every Namibian to protect and maintain Namibia's precious water resources.

Women and rural water

In many of Namibia's rural areas, the main means of water supply from whatever sources are being used to homes where water is needed is by hand. Fetching water is a daily and often tiring task, and one that is often left to women.

Depending on how far away the nearest reliable source of water is, and, in some cases, how long the queue for this water is, fetching water can take up a fairly large chunk of time. Water is essential, so these duties cannot be neglected, but this time spent means less time available for other things, and adds to the burden of work.

Carrying heavy buckets, tins or pots of water can lead to health problems. It is not unusual for rural women who have carried water for much of their lives to develop back and neck problems. Health issues do not only relate to carrying the water. If containers are not clean or water is left standing open it can become polluted or contaminated with harmful substances or bacteria. Open containers are the greatest risk. Families using water collected in containers need to be aware of these health risks and need to know how to purify water before they drink or cook with it.

However, fetching water can also be a social event, and when women meet daily at a common water source this can be an important forum for exchanging news and ideas.

The Eastern National Water Carrier (ENWC)

Because of the great increase in the demand for water in the central region of Namibia, a scheme to supply the area with water is necessary if development is to continue. The central region is a focus for commercial and industrial activities and supports a large urban population. Unfortunately the region does not have large water resources - a major factor that limits development.

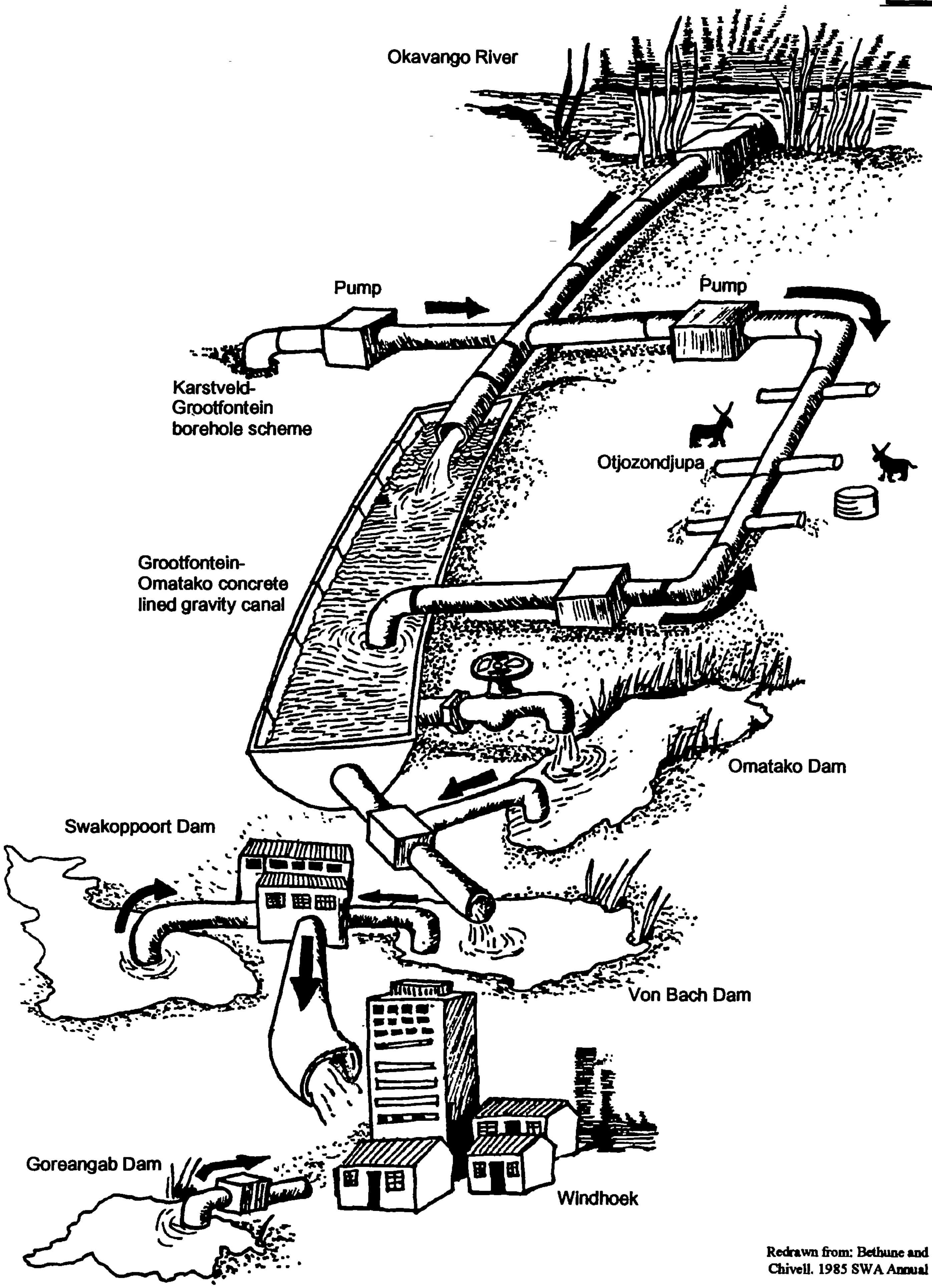
The ENWC aims to transfer water from the Okavango River to the central region of Namibia - a distance of about 750km. Water may also be drawn from Karstwater sources near Grootfontein. Pipelines and open canals will carry water to the Von Bach and Omatako Dams from where water will be supplied to users.

The ENWC is a scheme that will supplement the present water supply system that feeds the demands of the central region. Although the scheme will provide more water for the region, the supply is not limitless and future water demands will have to be carefully managed if the ENWC is to provide enough water in the future.

When the canal was first constructed there were a number of concerns that needed to be investigated. These included:

1. the fear that bilharzia parasites and other diseases might be transferred to the central region
2. the fear that filamentous algae would grow in the canal and cause blockages. However, subsequent research has indicated that the supply of nutrients in the water is too low to support such algal growth
3. the fact that people and livestock would be unable to cross the canal and that wildlife would not be able to follow their annual migration patterns. This problem was partially solved by building bridges across the canal
4. the concern that domestic and wild animals would fall into the canal and drown, thus polluting the water. Possible solutions include the expensive options of fencing the canal on either side or covering the canal completely
5. the concern that use of the open canal for washing and other activities would affect the quality of the water. However, since the canal runs through commercial farm land this, and the settlement of people along the canal, is not a major problem
6. the long term effects of abstraction of water from the Karstveld. Due to slow recharge it is thought that the aquifer will not support large scale pumping of water
7. despite earlier concerns that the open canal would lose large amounts of water due to evaporation it has been shown that evaporation losses are minimal
8. one of the biggest problems with the supply of water from the canal is that it creates false expectations and the assumption that water is freely available. Water supplied by the canal is finite and cannot meet ever increasing demands. The amount of water that the ENWC can eventually provide will be determined by natural limiting factors such as the amount of water available in the Okavango River and the Karstveld.

The ENWC is the largest State water project in Namibia, and, once completed, will import 4 litres of water per second from the Okavango River to supplement water supplies in the central, eastern, and western areas of our country.



Redrawn from: Bethune and Chivell. 1985 SWA Annual

The central Namib water scheme

The central Namib water scheme provides many of Namibia's largest urban centres (such as Swakopmund, Arandis, Walvis Bay and Henties Bay) with water. The supply scheme consists of a number of boreholes that abstract water from the alluvial aquifers associated with the Kuiseb and Omaruru Rivers.

One of the largest consumers of water is the Rössing Uranium Mine, but the demand from this consumer is decreasing as mining activities have been scaled down and water is now recycled at the mine itself. Another consumer of large quantities of water is Namibia's fishing and fish canning industry based at Walvis Bay. The demand for freshwater by this industry has expanded remarkably over recent years. It is fair to assume that future industrial and commercial developments in the region will increase the demand for water substantially unless such developments employ water saving measures or make use of seawater as an alternative.

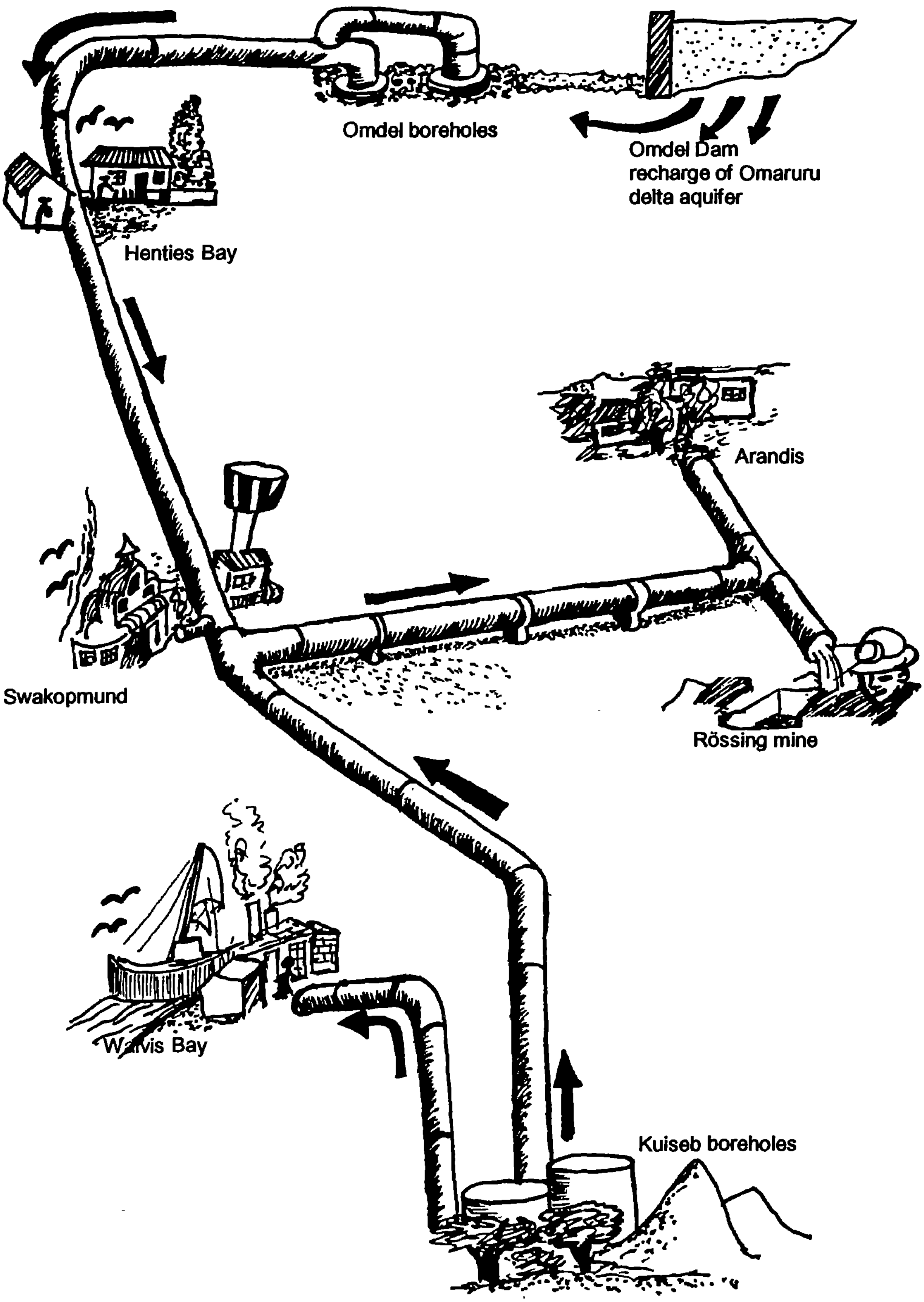
One option that these towns have to supplement their water supply is to desalinate seawater. This is an expensive option, but perhaps the most sensible one since most of the towns in this region are located at the coast. Until such time as an alternative or supplementation system can be found, it is imperative that we use the present water sources in a sustainable way. For this to happen we need to understand more about the nature and recharge of the aquifers that supply this scheme with water. It is possible that they are being emptied faster than they are being recharged by rain water.

Close monitoring of the Swartbank Aquifer in the Kuiseb River over the past 30 years has resulted in hydrologists reducing the estimated safe yield for the aquifer by approximately 75%. Current evidence indicates that there is a marked drop in the water table. This is a result of overexploiting groundwater reserves. On the surface the effects of a lower water table are reflected in the death of large numbers of trees found in the river courses or on their banks. These trees are unable to obtain water once the level of the water table drops below the depth of their roots.

The Omdel Dam on the Omaruru River is a State built structure that aims to assist the natural recharge process of the Omaruru alluvial aquifer. By encouraging runoff to penetrate the sand it is envisaged that the mean annual recharge of this aquifer will be greatly increased. An advantage of this scheme is that it will cut down on water lost through evaporation.

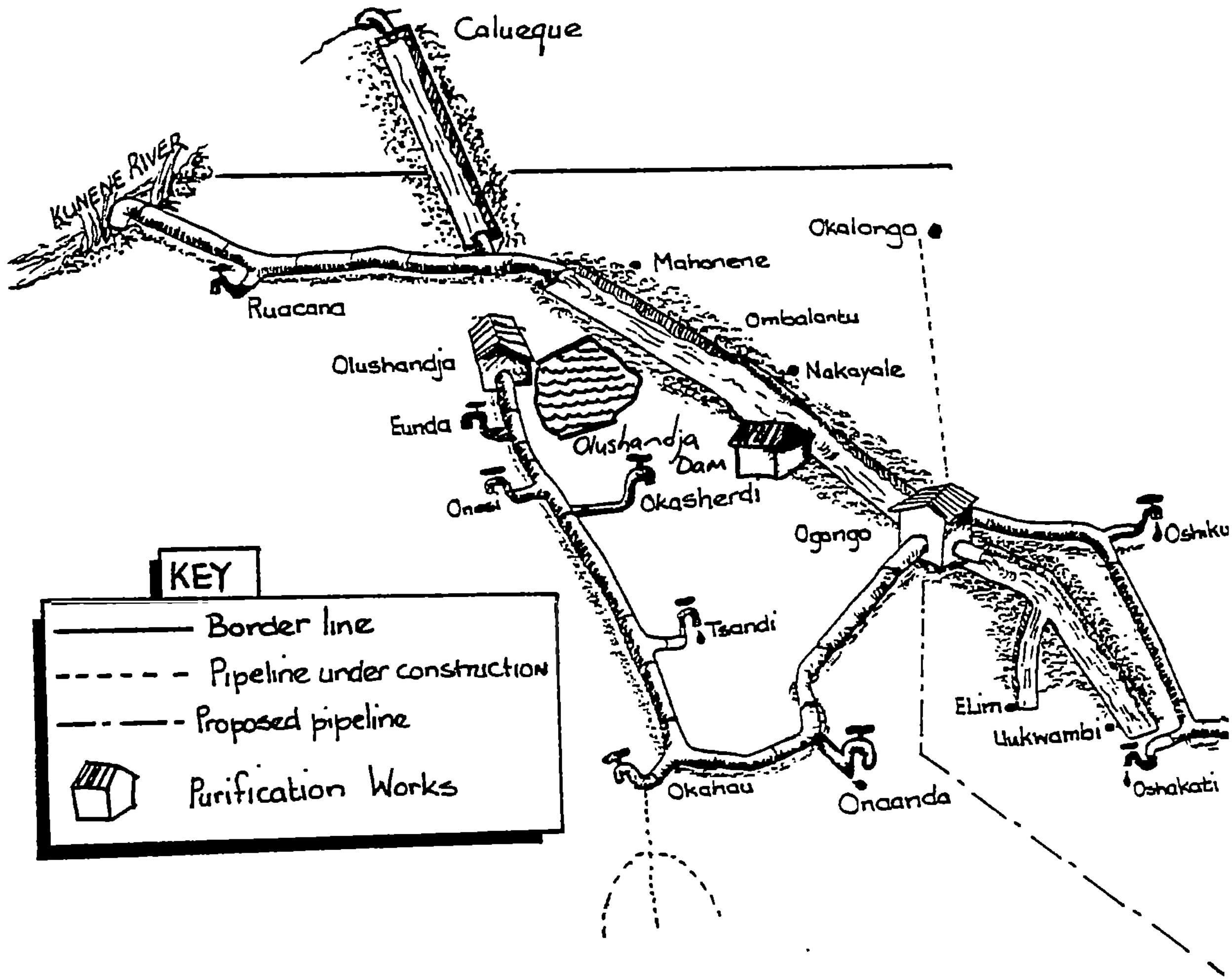
Another potential danger linked to the abstraction of groundwater along Namibia's coast is that of saltwater entering the aquifers as more and more freshwater is pumped to the surface. Seawater intrusion will result in the contamination of fresh groundwater reserves, leaving less usable salty water. Saltwater instead of fresh will kill vegetation that is not accustomed to it and the overall result will be substantial changes to the ecology of the area. Salty soil is not a good medium for growing plants in, and cultivation of any kind will be negatively affected.

It is clear that the aquifers supplying this region with freshwater will not be able to meet the demand for water in the future if development continues at the present rate. Strict conservation measures need to be implemented and alternatives, such as desalination, need to be investigated urgently.


Omdel boreholes
Omdel Dam
recharge of Omaruru
delta aquifer
Henties Bay
Arandis
Swakopmund
Rössing mine
Walvis Bay
Kuiseb boreholes

Water supply schemes in the central north

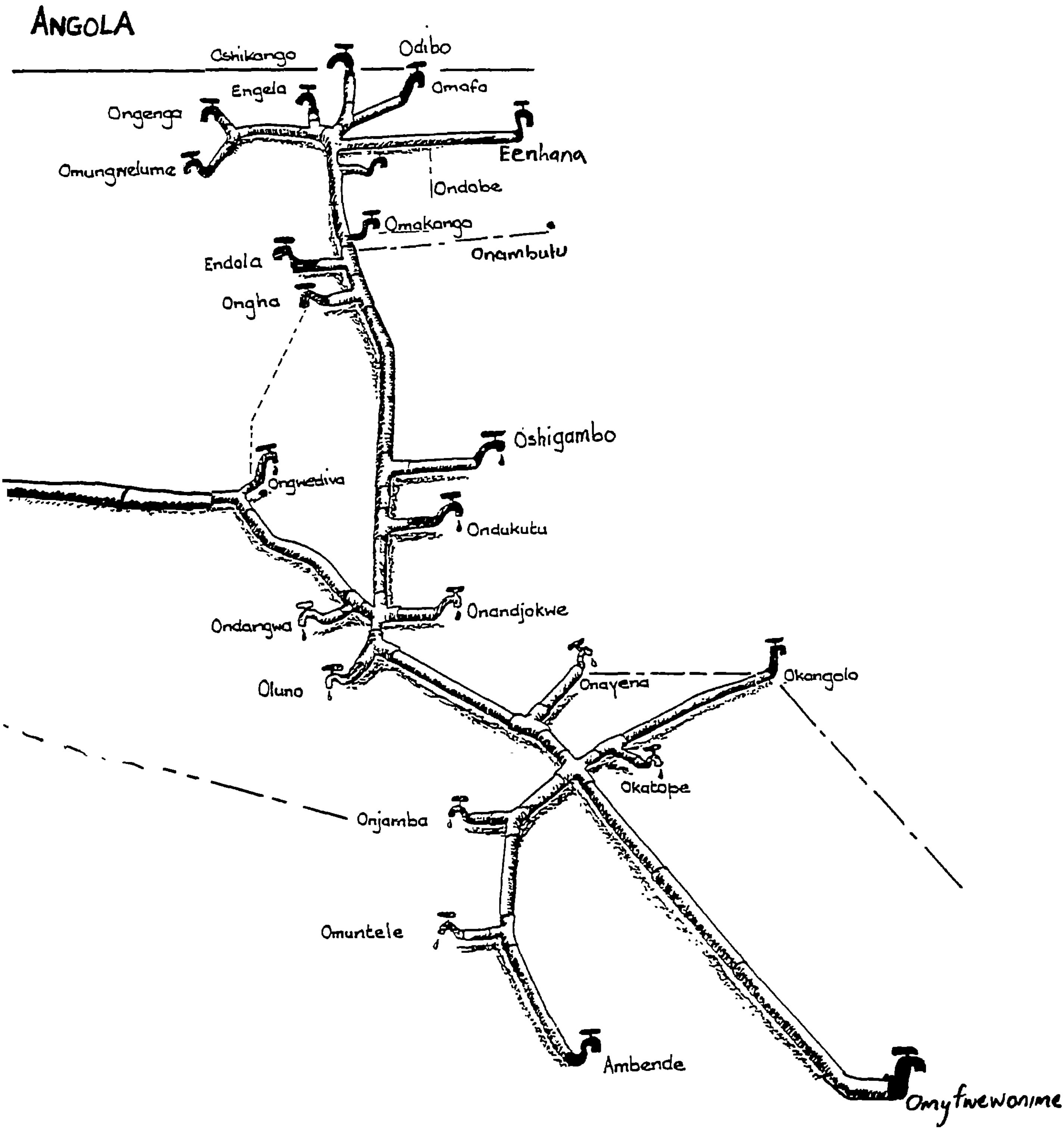
The oshana system supports the highest density of people in Namibia, resulting in a great demand for water. Unfortunately, the area is arid and there is very little natural surface water that can provide rural communities and towns with a good supply of freshwater. Seasonal flooding of the oshanas provides water for only a small part of the year and the region is dependent on groundwater resources and water pumped from the Kunene River.



In the past, people relied on ***omifima*** or wells to bring the groundwater to the surface. Even today, especially in areas away from the canal and pipelines, boreholes, *omifima* and hand-dug wells remain popular. However, the groundwater resources of the region are mostly salty - in fact, they can be described as an underground salt marsh with several salt pans on the surface of the land. Fresh groundwater is found only in the east and far west of the Cuvelai floodplain, and throughout the region in small lenses below the sand which are tapped by *omifima*.

Most of the water supplied in the region comes from the Kunene River by means of canals and pipelines. The raw water is purified at water purification plants. A network of taps and cattle watering points provides rural people with purified water.

An open canal extends from the Olushandja Balancing Dam in the west to Oshakati. The canal was designed with two main purposes in mind: firstly, to carry water that is pumped from the Calueque Dam in Angola into the central northern regions; and secondly, to channel flood water, flowing southward during the rainy season, in the direction of the main developing centres of Oshakati and Ondangwa.



Problems associated with water supply in the Cuvelai region

1. The building of an open canal has had negative effects on the natural oshana system. Because the natural water runoff from the *efundja* is channelled into the canal, less water flows over the surface of the land with the result that less water is available for groundwater recharge and plant growth, thereby lowering the carrying capacity of the land for people and livestock south of the canal.

2. The pipeline that transports purified water from Ogongo to Oshakati was originally designed to to supply bulk water to Oshakati with no tapping points along the line. However, people living along the line broke the pipe in order to get water. To avoid continual damage to the pipeline the Department of Water Affairs later provided taps and cattle watering points. The ultimate result of free water along the length of the pipeline is that people and their livestock have been attracted to the land on either side of the pipeline. Overgrazing and deforestation have now become major problems associated with the pipeline.

3. Because water is supplied freely, people have not been encouraged to conserve water in any way at all. Leaving taps running to make drinking pools for livestock is a common but tremendously wasteful practice. The pools eventually evaporate away in the sun.

4. Watering points can be a health risk. Standing pools of water encourage malaria-carrying mosquitos to breed, and contamination of water by people and animals is a real threat.

5. The daily movements of people and cattle to and from the watering points create many tracks and paths that destroy large areas of grazing land and encourage soil erosion.

Dried up water quenches no thirst - Kikuyu

6. The concentration of people and animals along the canal may lead to severe land degradation, overgrazing and bush encroachment.

7. The use of the canal for washing and other activities may affect the quality of the water.

Water supply and management in this rural area is a tremendous challenge that the people of this region must face. People need to be aware of the need for conservation of water and the eventual consequences of poor resource management. They also need to take responsibility for looking after water installations if all people are to enjoy the benefits of purified water in the future.

Chapter 9
Activities

1. Pretend that you are a water molecule travelling down one of Namibia's major rivers. What do you find along the way and how is it possible for you to enter Namibia's water supply system?

1. In an article prepared for a magazine, document why it is that women are responsible for [collect]ing water everyday. Refer to the Enviroteach lesson card "Rural women" for ideas.

1. Divide the class into 4 groups. Each group must represent one of the following countries: Namibia, Angola, Zambia and Botswana. The groups must familiarise themselves with the water resources that they share and write a brief document that can act as an agreement for all four countries to sign. In the agreement consider things such as water extraction, pollution, fishing, etc.

1. In a brief study consider the importance of shape in building a water canal. Why do you think a trapezoid canal instead of a semi-circlular canal was built in the Owambo region? Think about some of the problems associated with such a canal: the casting of the concrete, animals falling into the canal, etc.

1. Have a collection of taps, pipes, joins, etc. available in the classroom to demonstrate ways [of] joining and mending pipes, changing a tap washer, etc. A person from the local hardware store or from [a] farmer's co-operative can be invited to demonstrate some simple ways of making an efficient water [su]pply available to homes.

1. Cathodic protection is used to protect Namibia's metal pipelines from rusting. In a lesson for chemistry for the higher grades dealing with electrolysis let the learners decide on what elements from the periodic table are suitable for the cathodic protection of iron pipes.

2. Calculate the weight and volumes of various water containers. If you know what the weight [of the] water is can you work out the volume?

[Stud]y how waterwheels can be used to generate electricity or do work. If your school is located near a [can]al, build a small waterwheel that can use the energy of the water flowing in the canal to do work. [Re]member: do not allow learners that cannot swim to attempt any work near the canals.

1. Work out the discharge rate for a tap. Work out how much water is lost if a tap drips for a period of 1 year.

2. Have a collection of pipes, tubes, straws, etc. available in your class so that the learners can calculate surface areas, volumes, radii, etc.

1. Conduct an oral history project that investigates what life was like before pipelines, canals, dams, etc.

1. Look at the water supply for your region. Where does your water come from, how is it purified and how does it reach your home?

1. Use the methods described in *Tools of the trade* to conduct mini EIA's (Environmental Impact Assessments) for your town's water supply. What are the negative and positive aspects of the supply? Are there any ways it could be improved? Write to one of your town councillors with your suggestions

1. Look al the ~of tramphng ando gofveget~ along pipelines, canais and

1. Look at the effects of trampling and overgrazing of vegetation along pipelines, canals and near watering points. Present your materials, methods and findings in a scientific report.

10 The storage of water

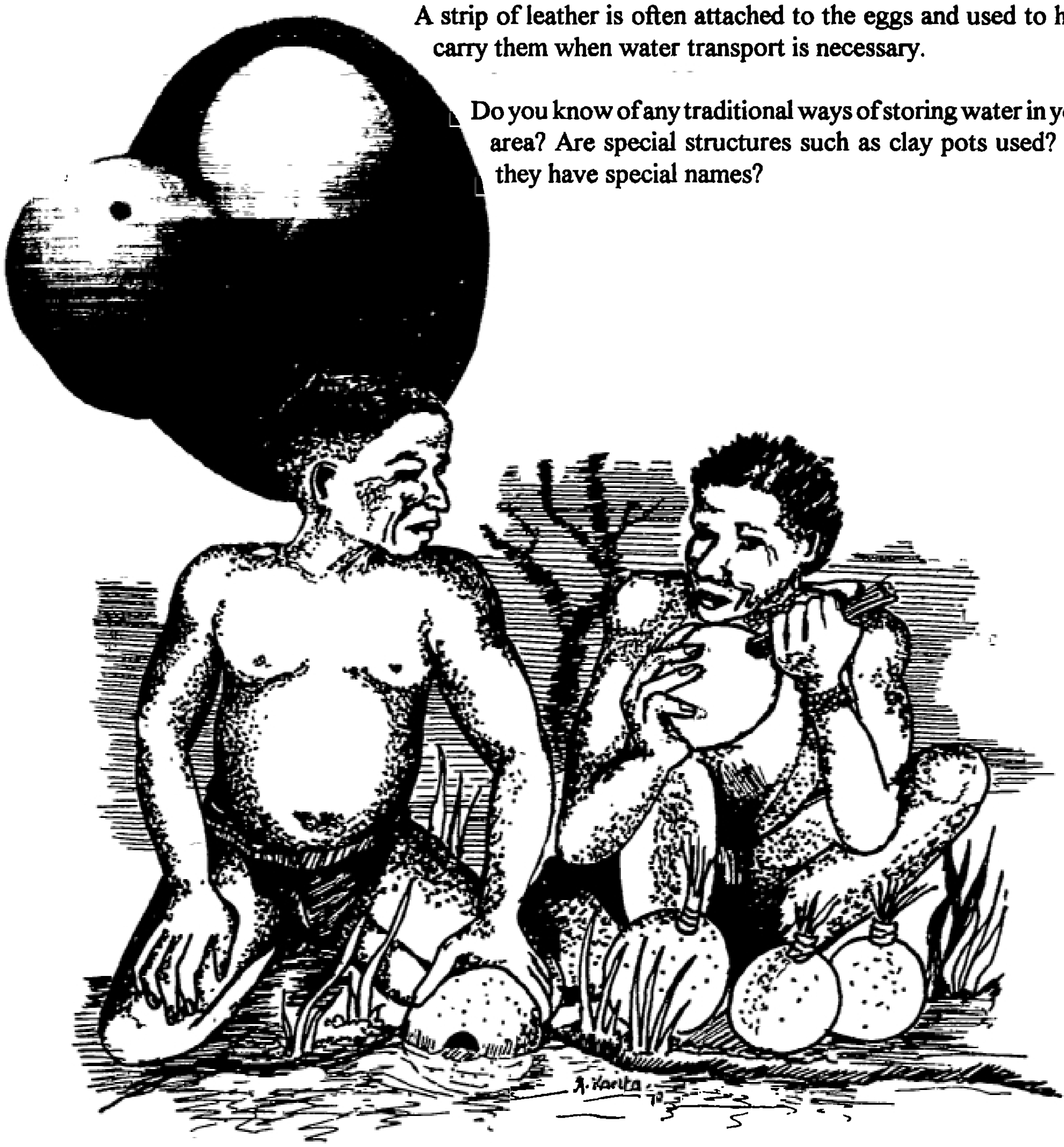
Where water is not naturally available all year round in the form of rivers and lakes, it is necessary to store water so that it will be there during dry periods of the year. In a country such as Namibia, where there is often no reliable natural source of water for most of the year, storage is of vital importance. Water storage can take place in simple containers in the home or in large dams that store water for thousands of people, their crops and animals.

However, water storage is not as simple and straightforward a concept as it seems. Evaporation can rob us of a huge proportion of our stored water, and dams and other forms of storage can bring social and environmental problems as well as benefits.

An age-old method of water storage

The Bushman people live in some of the driest parts of Namibia. Over hundreds of years they have developed many ingenious ways both of finding and storing water. One such method, used both to store and to carry water, makes use of ostrich eggs. Empty ostrich eggs are waterproof, fairly sturdy and capable of holding a considerable amount of water. The eggs are collected, their contents removed through small holes, then they are filled with water, sealed and buried in the soil to keep the water safe and cool. The eggs can be dug up the next time the band of Bushmen pass through the area. A strip of leather is often attached to the eggs and used to help carry them when water transport is necessary.

Do you know of any traditional ways of storing water in your area? Are special structures such as clay pots used? Do they have special names?



Water storage tanks

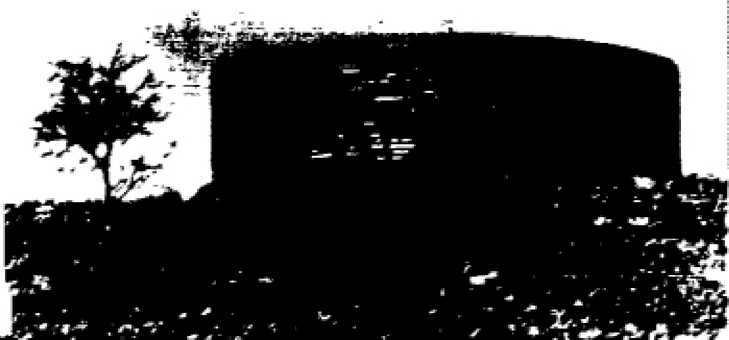
The Bushmen have always understood the importance of storing water so that it would be available in times of need. However, ostrich eggs are not adequate for meeting the needs of families, villages or towns.

Some materials that can be used to make storage tanks:

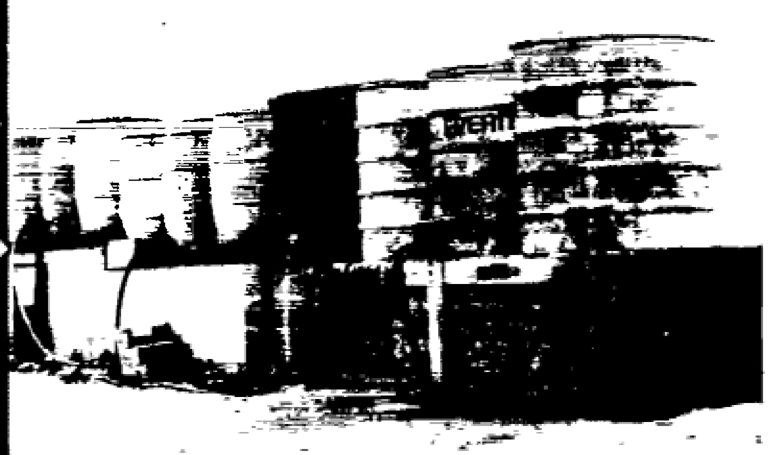
- *corrugated iron*
- *cement containers*
- *concrete, bricks and masonry (natural stone)*
- *pre-cast concrete rings and panels*
- *ferrocement*

Water tanks can be used to store ground, rain or river water depending on the type of water that is available. Storage tanks can be especially important in collecting water from boreholes with a low yield. For example, if a borehole cannot provide adequate water it may be necessary to fill a small tank or dam over a long period of time. This water will then be available at a later date. But storing water is not the only function of a tank. Tanks located on raised ground or poles provide the pressure necessary to drive the water through a system of pipes.

The shape and the size of the tank is important for efficient storage of water. Large, shallow, open tanks are not ideal for Namibia because of the high rate of evaporation. Tanks should be deep, covered and preferably in a shady place to reduce the effects of evaporation.



*Large, shallow, open tanks should **not** be used because they lose large amounts of water through evaporation.*



Smaller, deep, covered tanks are much more suited to our Namibian climate because they lose less or no water through evaporation.

Dams

Since the beginning of recorded history, people have been building dams. The ancient civilisations of Sumeria, Babylonia, Egypt, Ceylon and Cambodia were famous for the large dams that they built. Some of these structures are still standing today and bear witness to the engineering skills of these people. Many of these dams were built to provide water for domestic use and large irrigation schemes.

The capacity of dams in Namibia in 1994 was 650Mm^3/a.

Today, with the progress made in concrete technology and machinery, people have been able to construct even larger and more permanent dams. In fact, the rate of large dam building throughout the world is accelerating at a phenomenal rate, with the worldwide total of dams higher than 150m reaching 113. Of these, 49 were built during the 1980's.

But the height of the dam wall is not the only impressive feature. The area of land that is flooded behind a dam wall is often staggering and cannot be used to live on, or to grow crops after it has been flooded. This, however, is not always the case. Often dams are built in deep, narrow valleys where cultivation is impossible.

Dam terminology

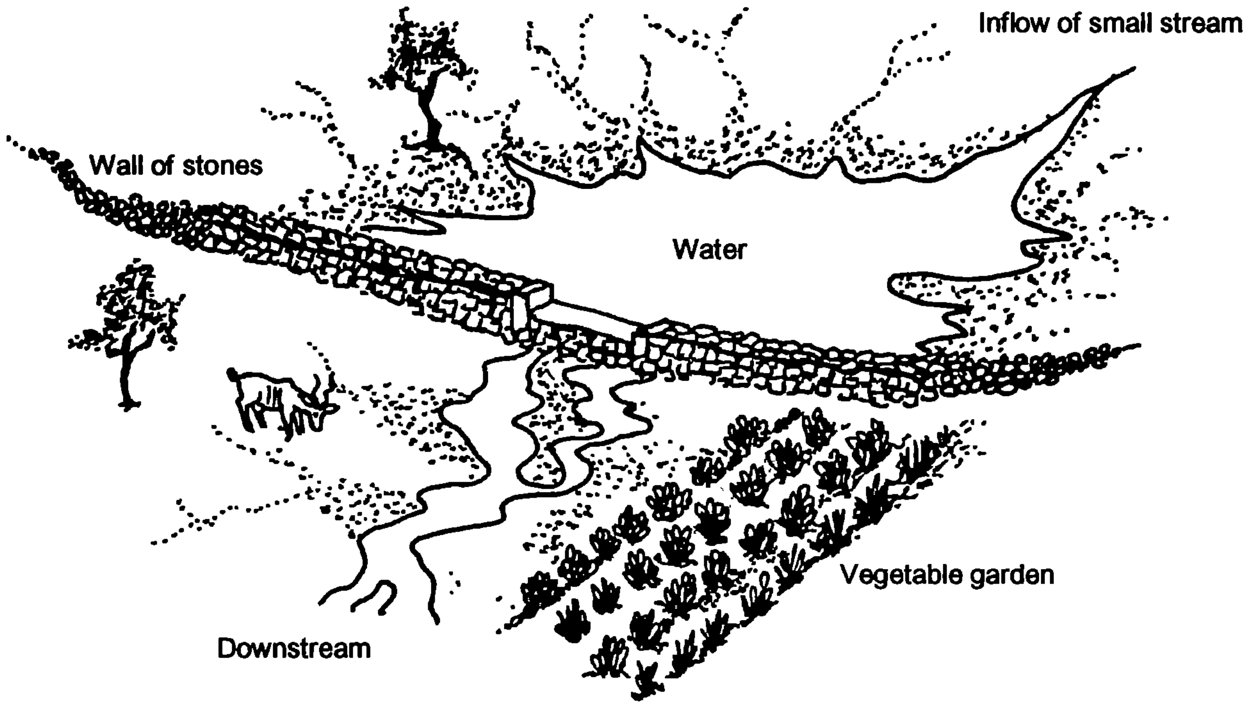
*Although we often refer to bodies of water as dams, the term **dam** refers to the wall itself. The water stored behind this dam is known as an **impoundment**. The flooding that fills the dam is known as **inundation**.*

As early as 1904 Namibia's government of the time provided subsidies to commercial farmers to enable them to build storage dams on their farms. They even established a "dam building squad" that assisted farmers with designing and constructing farm dams. The aim of such a policy was to collect as much water as possible along the ephemeral rivers "which otherwise runs unused to the sea". These dams would then provide water for livestock throughout most of the dry season. What was not considered at the time was the role that flooding plays in maintaining recharge and the ecology associated with the ephemeral rivers.

A view of the Hardap Dam near Mariental

Small-scale dams

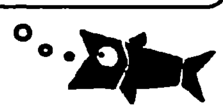
Not all dams have to have a large dam basin that can store millions of litres of water. Small-scale dams can also serve the purpose of providing water for domestic use and farming.



Small dams may provide an ideal source of water for livestock and growing vegetables, even if it is for only part of the year. They are cheaper to build and easier to maintain than large dams.

A small dam is a low structure, built of stones or soil, and designed to trap a body of water not more than two or three metres deep. Well placed and constructed dams may trap enough rainwater and runoff to provide water for vegetable gardens and livestock for part of the year and they may even help to recharge the groundwater supply and reduce soil erosion.

In Namibia, the average annual potential evaportion varies between 2.6 and 3.7m per year. This means that a small dam will empty through evaporation in a single year.



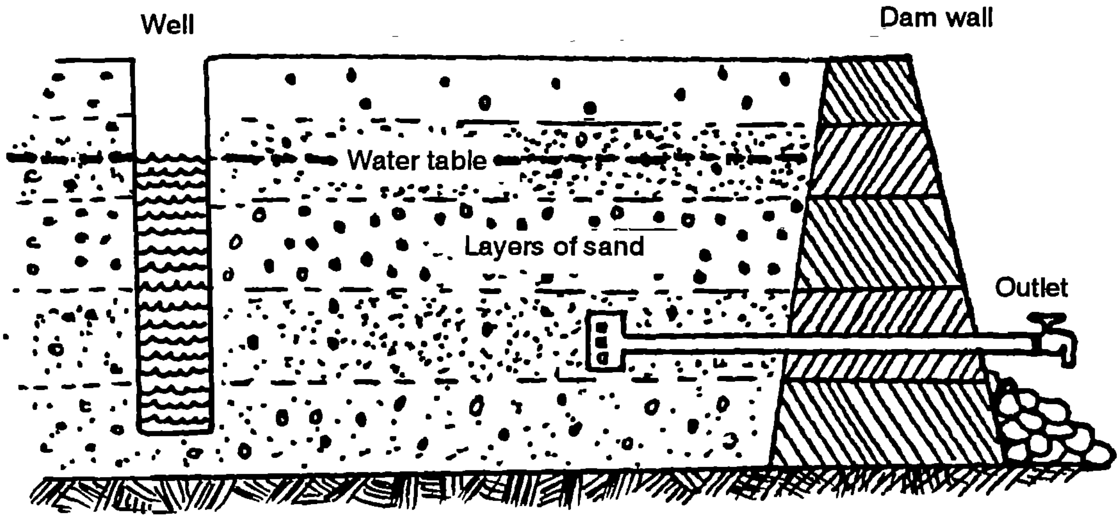
Small dams are very useful in areas where there is a lot of rain. However, in Namibia the use of small dams is limited by low annual rainfall and the high evaporation rate. Most small dams in Namibia will be emptied within a year by evaporation alone.

Small storage dams are common on commercial farms in Namibia. It is estimated that there are more than 1 000 small dams with a storage capacity of at least 30Mm^3 on Namibia's ephemeral rivers. A few small dams on an individual farm do not represent a threat to the system as a whole but when the effects of a hundred or more dams are added together, it represents a major loss of downstream runoff, in most cases depriving lower reaches of the river of nutrient rich waters that are essential for driving the ecosystem and for contributing to recharge of the groundwater.

Sand dams

Sand or groundwater dams are structures that store water within a layer of sand rather than on the land's surface. Instead of water, a mass of sand is stored behind a dam wall. Water is then allowed to saturate the sand. In this way an artificial aquifer is created behind the dam wall. Water can be collected from such dams by either placing a well with a hand pump into the sand or by having a tap with a filter connected near the bottom of the dam wall.

Cross-section of sand dam



There are many reasons for building sand dams but some of the more important points are:

- they reduce the amount of water lost through evaporation
- they help the process of groundwater recharge
- they cause sedimentation so that water is partially purified
- the risk of the stored water being contaminated by people or animals is reduced because the water is protected underground
- insects and parasites (such as mosquitoes and bilharzia) cannot breed in water that is underground
- algae that cause water to taste unpleasant cannot grow in sand dams.

Sand dams can be built on a large or small scale, but it is important to note that they cannot store as much water as open dams because water can only be stored in the spaces between sand particles. Sand is better for storage than clay or silt because the spaces between the particles are larger. Sand dams are only effective in certain parts of Namibia where rivers carry coarse sand or gravel. In rivers carrying large amounts of fine-grained silts or clays, sand dams usually do not work.

If sand dams are built to store water rather than to increase groundwater recharge, they must be built on impermeable rock so that the water does not escape deeper into the ground.

Large dams

Large dams, built by blocking rivers with large dam walls, are relied upon all over the world to provide bulk water for domestic, industrial, commercial and agricultural use. State owned dams are seen as the solution to a number of problems faced by developing countries, especially if the dams provide electricity and water for irrigation. Commonly held views are: "the larger the dam, the better" and certainly "the more dams, the better". This has lead to thousands of dam-building projects all over the world in the last fifty years.

But building large dams can cause social and ecological problems. To name a few, dams can cause massive ecological destruction, social problems of resettlement, cultural degradation, health and disease problems. Often these negative effects are experienced by the people who should be benefitting the most. Negative effects are often ignored in favour of the advantages, and by the time the dam is built it is too late to remedy the situation.

The efficiency of dams in Namibia is between 4% and 13%. Much of the water is lost due to evaporation.

Dams are usually built for the following reasons: the reliable supply of water for drinking, irrigation schemes, industrial and mining use; to generate electricity with hydroelectric power stations; to control floods; to aid groundwater recharge; and to help create more jobs. However, the long term situation must be taken into consideration in order to avoid dam dependency and misguided developments.

Large dams play an important role in the economic development of a country. This is particularly true in the case of developing countries such as Namibia. A major focus is the generation of electricity through hydroelectric schemes. Millions of dollars are made available to Africa in the form of loans to enable countries to construct hydroelectric schemes along their rivers. However, these loans have to be repaid with interest. Foreign debts eventually add up and can have a restrictive effect on long term economic development.

Namibia is one of the few countries in the world that builds State dams on ephemeral rivers

We should also remember that from the first time that water enters a new dam it starts to silt up. This means that after many years of silt being deposited in the dam it can no longer be used to efficiently store water. Estimates indicate that large dams in the tropics have an expected life of no more than 40 years. Two options exist at this stage. One is to replace the dam with a new one. Because we have so few rivers in Namibia and because the construction of such dams is an expensive venture, this option is very limited. The other option is to remove the silt from the dam - again a very expensive and time consuming operation.

Other potential advantages of constructing large State dams include water for irrigation schemes and revenue from tourism and recreation resorts associated with the dam.

Problems facing large dams and associated schemes

- Dams require a tremendous amount of money to construct. Developing countries need to take out loans in order to pay for such construction. The end result is that foreign debts that need to repaid hamper further economic developments.
- Evaporation from any open body of water is unavoidable, but water losses through evaporation are a major problem in arid countries like Namibia. If dams are going to be built, they should be placed where dam basin characteristics are optimal and evaporation is minimal.
- Irrigation schemes, if they are to alleviate food shortages, need to take economic aspects and food ditribution into account. Often very little of the extra food grown by irrigation schemes reaches those who need it most.
- Irrigation schemes need to be adapted to the climate, soils and types of crops that are cultivated. Inappropriate irrigation methods in arid environments (for example, sprinklers and flood irrigation) are responsible for depositing large amounts of salt on fertile land, making it infertile. Strict land management can reduce some of these negative effects over the short to medium term.
- The large industrial developments that are encouraged by the provision of cheap electricity and bulk water are sometimes responsible for the pollution and destruction of the environment.
- Thousands of people are often uprooted from fertile river valleys to make way for large dams that flood huge areas of land upstream from the dam wall. People may lose their traditional lands under water. The proposed Epupa Hydroelectric scheme on the Kunene has highlighted some of these issues in recent years.
- The cultural and traditional heritage of people living in the shadow of the dam can be lost due to the great ecological impact that the dam has on the region. Dietary habits, fishing activities, crafts and social lifestyles can be seriously threatened. The consequences for such people are that they either have to find alternative ways of supporting themselves or to move to towns. The latter adds to the problems associated with urbanisation.
- The health of people is at risk from waterborne diseases that are linked to standing water in dams and irrigation schemes. This is even more serious in regions where malaria and bilharzia are problems.
- Often the people who end up benefiting from large dams are the industrial sector, the urban elite and the politicians who commission the projects - not the people that the dams are designed to help.

Many of these problems are not the dam's fault but rather the fault of poor land management, lack of policy and poor infrastructure associated with the provision of bulk water. However, it is important to aknowledge that once a large State dam is built it is here to stay for a number of decades. Although we may enjoy the benefits that large dams bring, it is also possible that we may have to face the negative side effects as well.

The Aswan Dam is 17 times heavier than the Great Pyramid of Cheops, and the Volta Dam in Ghana is large enough to hold water that covers 5% of the total area of the country.

Dams for surface water storage

This is the main function of most dams and impoundments in Namibia. They are designed to catch and store runoff during the rainy season and to store this water for use by towns and cities throughout the year.

Dams for hydroelectricity

Hydroelectricity is the favoured source of power in developing countries for the simple reason that it is cheaper to produce than electricity from thermal power stations and very much cheaper than electricity from nuclear power stations. It is because of this that most developing countries have initiated schemes to exploit the full energy potential of their rivers, and Namibia is no exception. The hydroelectric power station at Ruacana and the proposed scheme at Epupa will meet all of Namibia's present electricity needs without producing the pollution associated with thermal power stations.

The positive side of hydroelectric developments includes cheaper and more plentiful electric power, but these developments also mean that very few perennial rivers will flow uncontrolled into the sea. This may have long term negative effects on marine and freshwater fish, on vegetation in the area, and on groundwater supplies. There will also be negative effects on the ecology of the area downstream of the dam. This is especially true for rivers with established seasonal flood cycles. The sustainability of hydroelectricity schemes also depends on the rate at which dams silt up. In Namibia the average lifespan of a dam, before silt renders it useless, is between 40 and 80 years.

Multiple use of dams
Dams frequently serve more than one purpose, and multiple use dams are being increasingly encouraged in order to obtain maximum benefits from large impoundments. Other activities that can take place at dams include fishing; aquaculture; tourism; boating, yachting and other water sports; environmental education; and conservation of birds and other wildlife. A good example of a multiple use dam is Hardap Dam. This dam is used to store water for use in nearby settlements; for irrigation; for aquaculture; for tourism; and for conservation.

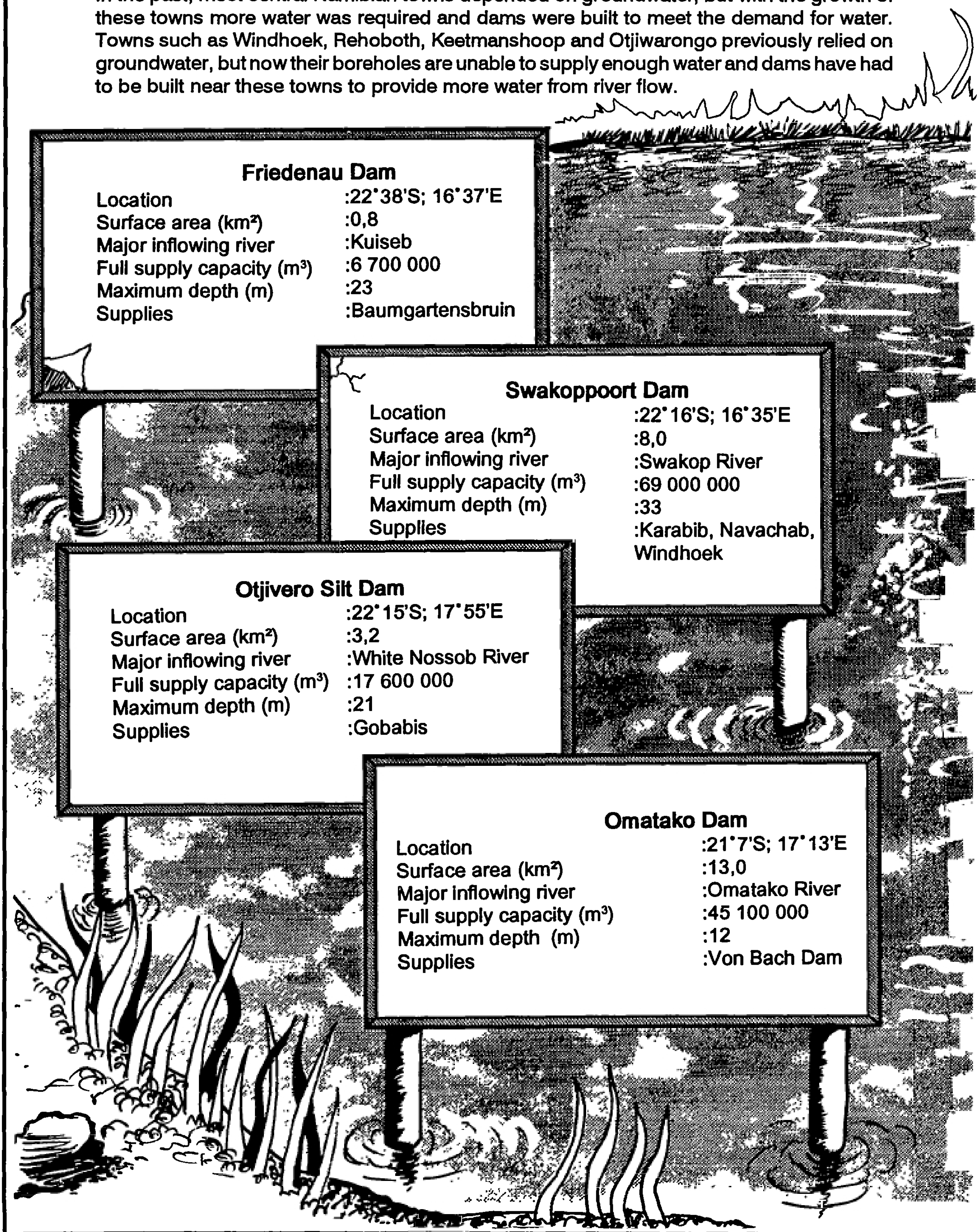
Dams for irrigation

Throughout the world irrigation has been used to increase the agricultural output of land. In some cases yields may increase tenfold when the land is irrigated - an important consideration when you think of the growing demand for food. All over the world there are plans to put more land under irrigation and increase food output. However, irrigation must be approached carefully as it has certain drawbacks and thousands of hectares of fertile land have been lost due to salinisation caused by inappropriate irrigation methods.

In Namibia there is a very real threat from this problem. The use of dams such as Hardap and the proposed Epupa Dam to support irrigation schemes that are supposed to increase food production and allow Namibia to become more self sufficient needs to be carefully investigated. Namibia's arid climate is associated with rapid salinisation of irrigated soils. A number of irrigation schemes, including the one at Hardap and others along the Okavango are experiencing problems with salinisation.

Some of Namibia's large dams

In the past, most central Namibian towns depended on groundwater, but with the growth of these towns more water was required and dams were built to meet the demand for water. Towns such as Windhoek, Rehoboth, Keetmanshoop and Otjiwarongo previously relied on groundwater, but now their boreholes are unable to supply enough water and dams have had to be built near these towns to provide more water from river flow.



Friedenau Dam

Location	:22°38'S; 16°37'E
Surface area (km²)	:0,8
Major inflowing river	:Kuiseb
Full supply capacity (m³)	:6 700 000
Maximum depth (m)	:23
Supplies	:Baumgartensbruin

Swakoppoort Dam

Location	:22°16'S; 16°35'E
Surface area (km²)	:8,0
Major inflowing river	:Swakop River
Full supply capacity (m³)	:69 000 000
Maximum depth (m)	:33
Supplies	:Karabib, Navachab, Windhoek

Otjivero Silt Dam

Location	:22°15'S; 17°55'E
Surface area (km²)	:3,2
Major inflowing river	:White Nossob River
Full supply capacity (m³)	:17 600 000
Maximum depth (m)	:21
Supplies	:Gobabis

Omatako Dam

Location	:21°7'S; 17°13'E
Surface area (km²)	:13,0
Major inflowing river	:Omatako River
Full supply capacity (m³)	:45 100 000
Maximum depth (m)	:12
Supplies	:Von Bach Dam

Naute Dam

Location	:26°58'S;17°55'E
Surface area (km²)	:11,5
Major inflowing river	:Loewen
Full supply capacity (m³)	:83 600 000
Maximum depth (m)	:37
Supplies	:Keetmanshoop, irrigation scheme

Daan Viljoen Dam

Location	:22°26'S; 18°58'E
Surface area (km²)	:0,2
Major inflowing river	:Black Nossob
Full supply capacity (m³)	:400 000
Maximum depth (m)	:17
Supplies	:Gobabis

Hardap Dam

Location	:24°23'S; 17°53'E
Surface area (km²)	:28,9
Major inflowing river	:Fish
Full supply capacity (m³)	:300 200 000
Maximum depth (m)	:30
Supplies	:Mariental, Hardap irrigation scheme

Oanob Dam

Location	:23°13'S; 17°4'E
Surface area (km²)	:3,6
Major inflowing river/s	:Oanob
Full supply capacity (m³)	:35 000 000
Maximum depth (m)	:55
Supplies	:Rehoboth

Goreangab Dam

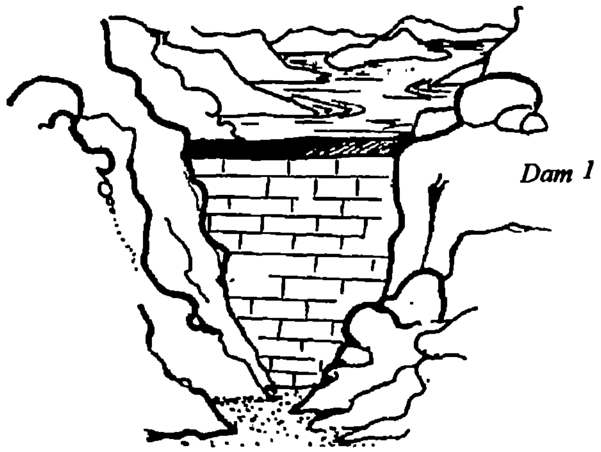
Location	:22°30'S; 17°00'E
Surface area (km²)	:1,0
Major inflowing river	:Gammams
Full supply capacity (m³)	:4 000 000
Maximum depth (m)	:72
Supplies	:Windhoek

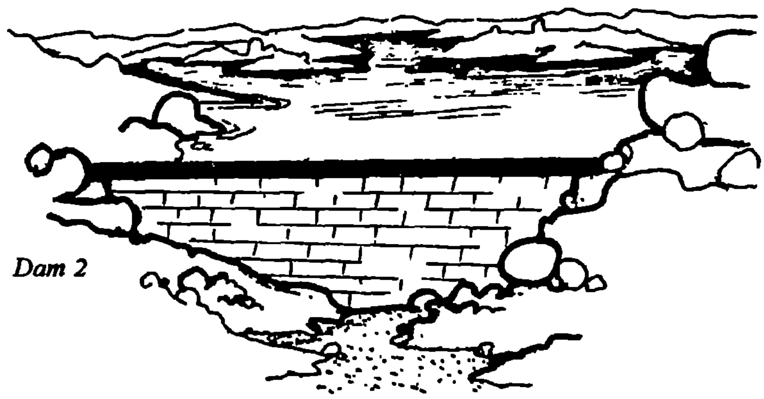
Von Bach Dam

Location	:22°3'S; 16°46'E
Surface area (km²)	:4,9
Major inflowing river	:Swakop River
Full supply capacity (m³)	:50 000 000
Maximum depth (m)	:35
Supplies	:Okahandja, Windhoek

Things to do...

It is better to build a dam in a deep valley than it is in a shallow dip. In deep valley dams the surface area of the stored water is smaller and therefore evaporation is less. The volume of water stored in the two dams below is the same, but the evaporation is only 1/3 as much in dam 1.





Set up an experiment ouside your classroom that demonstrates why it is better to build a dam the shape of Dam 1.

You will need: *a shallow container or bowl*
a deep container or jar
a container that can be used to measure liquid volumes accurately
a watch
1 litre of water

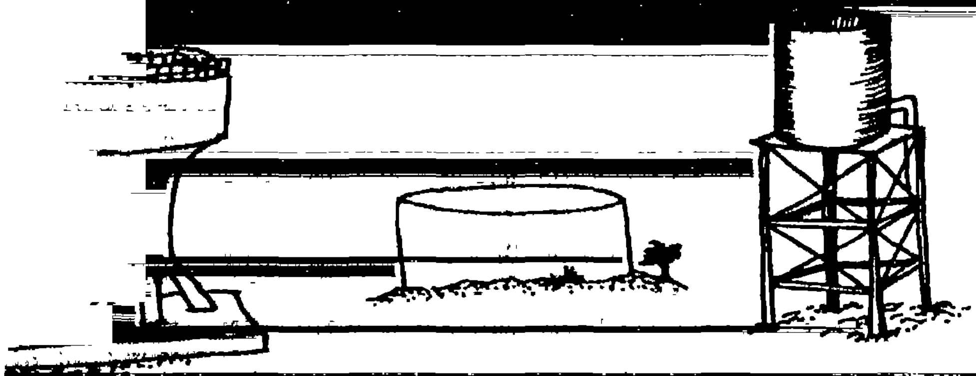
1. Pour exactly 500ml of water into the shallow container.
2. Pour the remaining 500ml of water into the deep container.
3. Stand both containers in the sun for 3 hours.
4. Return to the containers and accurately measure the amount of water in each of the two containers. Which container has lost the most water? Why?

Chapter 10

Activities

1. Use the information in chapter 10 in the following exercise: In a map reading exercise get the learners to locate Namibian dams using the lines of longitude and latitude.

2. Make a study of reservoirs and storage tanks from as many Namibian towns as possible. Write to other schools and exchange sketches or photographs of water storage facilities. Pin the sketches or photo's to a large map of Namibia.



1. Keep a long term record of the level of water in a nearby dam or of the amount of rainfall in your area. Paint a graph on a wall near your classroom. Fill in the information each month.

2. Find out the approximate evaporation rate for your area. An atlas will provide you with this information or you can calculate it yourself. Use the information to calculate the loss of water from storage dams or open containers. Hint: You will need to know or calculate the surface area first.

Use the information on page 156 and 157 to plot histograms of some of Namibia's dams according to depth or volume. Let half the class do one page and the other half the other - compare histograms later.

1. Are shallow or deep dams better for water storage in Namibia? Allow the learners to calculate the rate of evaporation for a number of containers, some shallow, some deep. They will need a container that enables them to measure how much water is lost from a particular container in a specific time interval. Remember to record the weather conditions at the time of taking readings.

In a scientific enquiry into pressure in liquids let the learners conduct experiments that explain why dam walls are thicker at the bottom than they are at the top. Ask them to write their experiments up in their laboratory notebooks in scientific format.

1. Divide the class into groups and let each group write down as many names of things that are used to hold water as they can think of. The group with the highest number is the winner. Use this as a vocabulary-expanding exercise. Some examples: tank, vessel, dam, pot, glass, etc.

1. In a class debate between two groups: "The dam builders" and "The dam busters" decide on the pros and cons of large dams from an agricultural point of view. How would these differ for dams on ephemeral and perennial rivers?

1. Include a section on home water storage in areas where piped water is not available. Demonstrate the importance of hygiene by covering containers and cleaning them regularly.

1. Set the learners the task of choosing materials appropriate for building a storage tank. They must consider durability, rustproofing, hygiene, cost, availability, etc.

11 The uses of water

None of our daily existence would be possible without water which is one of the world's most indispensable fluids. Crops would wither and livestock die without it; the wheels of our industries would cease to turn; we would be unable to extract and process our mineral wealth; and many of our day-to-day activities would come to a halt. Water is an essential substance in the functioning of many of the processes upon which we all depend.

We all use water for many different things, but while using it we should always remember that water use today should not jeopardise the quantity or quality of water available in the future.

Borrowed water

Today's water was yesterday's water and will be tomorrow's water.

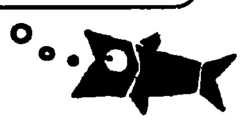
When we use water we neither create nor destroy it. It simply passes through whatever system we require it for and will be recycled by a natural process called the water cycle. This important principle must be at the bottom of our understanding when we talk about water use.

The amount of freshwater that is available for use in any particular country is limited. Yet countries all over the world are experiencing water shortages - not because the amount of water is becoming less but because the demands for water are increasing, either due to an increase in population or an increase economic developments or both.

People depend on water for

- **Survival**. The human body (and all living things) needs a continous supply of water to maintain its functions. Water is lost daily through urine, sweating and breathing.
- **Hygiene**. Water is needed to maintain our bodies in a state in which harmful bacteria and other disease-causing agents are kept to a minimum. This includes washing, cleaning our homes and the removing human waste via sewage systems.
- **Food production**. Plants, which form the basis of all food chains, require water to grow. In the past rain provided enough water for the survival of our crops but current food producing systems rely heavily on irrigation.
- **Industry**. Many industrial and production processes depend heavily on water.

One flush of an urban flush toilet uses the same amount of clean water that a rural person needs for an entire day's household requirements



In Namibia the limit of the amount of water available is imposed by the fact that very little water enters our system as rainfall each year because of our arid climate. Unfortunately, the climate is beyond our control. If we wish to have enough water in the future we must develop ways of using water within the limits of what is available.

Central to the issue of water use is the question of distribution. Since there are limited supplies of water available in a country, the main concern is one of distributing the water that is available amongst all those who need it. If water is not distributed fairly and at an affordable cost, conflict is likely to arise.

Water use in Namibia

How much water do we use?

Below are four examples of the water consumption in Namibian urban centres. Consumption is given in litres per person (capita) per day (*l*/c/d). It is interesting to note that although Swakopmund has very limited reserves of water, it is one of the highest consumers amongst Namibian towns according to the table below.

Otjiwarongo water use		
	Consumption (l/c/d)	
Year	Owetoweni	Rest of town
1970	68	571
1981	85	727
1985	82	655
1988	102	629

Windhoek water use		
Area of the city	Plot size (in sq m)	Consumption (l/c/d)
Katutura	300 to 400	95
	400 to 700	123
	>700	170
Khomasdal	450 to 600	145
	>600	182
Rest of city	900 to 1 300	433
	1 300 to 1 500	533
	>1 500	733

Swakopmund water use	
Area of town	Domestic consumption (l/c/d)
Mondesa	726
Tamariskia	1617
Rest of town	1766

Usakos water use	
Area of town	Domestic consumption (l/c/d)
Hakhaseb	65
Erongosig	85
Usakos*	500
**includes industries, public institutions, etc.*	

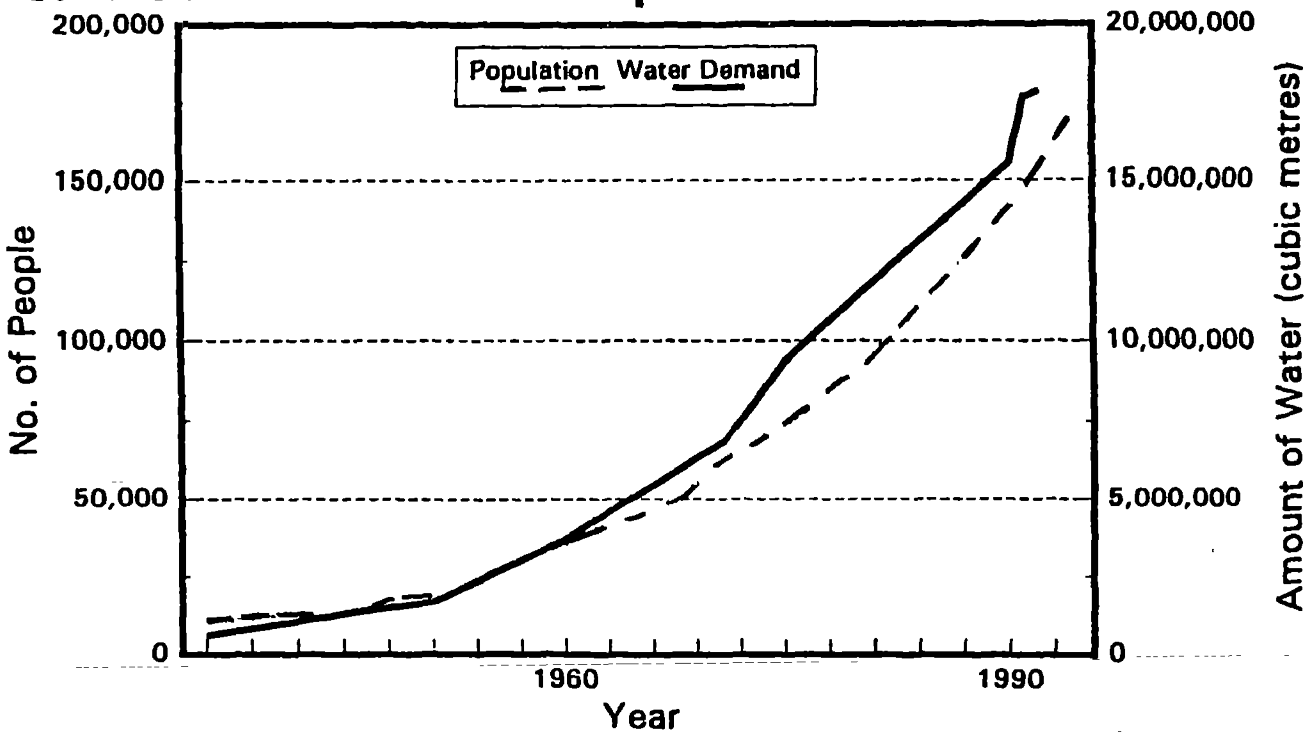
Source: *UNDP assessment of water resources sector in Namibia*, 1989

Distribution of demand for 1990 and projected for year 2000

Consumer	Consumption (Mm^3/year)	
	1990	2000
Domestic	70	115
Stock	60	75
Mining	10	30
Tourism	1	5
Irrigation	109	175
TOTAL	**250**	**400**

Department of Water Affairs, 1993

Growth of Windhoek's Population and Water Demand



Department of Water Affairs

There is a direct relationship between the increase in population and the increase in demand for water. Water restrictions can be used to reduce demand but ultimately people will have to use less as the limits to supply are approached.

Domestic use

Water is used domestically for washing, toilets, cooking, watering gardens, cleaning, filling swimming pools, etc. If we look at the figures for water consumption, domestic use seems to require a fairly small proportion of the national water budget. This is until we consider the reasons behind agriculture, mining and industry. Everyone must be supplied with basic necessities such as food, clothing and certain implements. Certain sectors of the population also require cars, electrical power and household appliances. We are all indirectly responsible for water consumption in all sectors. For example, on average, 33m³ of water are required to keep one adult on a daily diet of 2 500 calories. But water consumption - and waste - also depends on availability. Rural water consumption in Namibia avarages out at 85*l* per person per day, but urban water consumption in our country is an average of 300*l* per person per day!

Recreation

Many of our recreation activities are water-oriented. Swimming, fishing, boating, water skiing and surfing are just some of the activities that we like to indulge in during our time off that depend on water. Many holiday-makers choose to spend their holidays at the seaside or by bodies of freshwater, such as rivers or lakes. Swakopmund is a seaside resort that attracts thousands of visitors, and Etosha National Park, situated in a wetland, is one of southern Africa's best known tourist attractions. Von Bach, Hardap, Naute, Daan Viljoen and Oanob Dams all offer recreation facilities. Tourism and water sports are largely non-consumptive users of water.

Transport

For centuries upon centuries, people have used water as a means of transport. Many of the goods Namibia imports reach our country via the sea. There is a large harbour at Walvis Bay that serves as our major sea port and a smaller one at Lüderitz. Water is also important as a means of transport along Namibia's perennial rivers. Here, people often travel from place to place along the river or from one side of the river to the other by means of makoros or other small crafts.

The largest consumer of water in most parts of the world is agriculture. Some 80% of the water used worldwide is used in one way or another for agriculture. Stock watering swallows many millions of litres of water (for example, a cow drinks 40 to 50 litres of water a day), but by far the heaviest consumer of water in world agriculture is irrigation.

It is estimated that 13% of the world's arable land is irrigated, and these lands require some 1 400 billion cubic metres of water a year. Only about $70km^2$ of land is irrigated in Namibia, but it consumes $100Mm^3$ of water a year. The most common crops grown under irrigation are cotton, maize, wheat, vegetables, fruit and lucerne.

Industry has a great thirst for water. It is an essential element in almost all industrial operations. For example, it takes up to 250 000*l* of water to produce one ton of steel, and up to 30 000*l* of water to produce a ton of wood pulp for paper making. 40*l* of water is needed to produce just one litre of beer. When power is generated in thermal or nuclear power stations, huge quantities of water are needed to condense the steam that has passed through the turbines. Water is used by industries mostly as a solvent, a cooling system, a dust settler, or for cleaning. Since little of this water is actually used up, there is the additional problem of disposing of the resulting waste water, or treating it or recycling it for further use. Water consumptive industries should not be encouraged in this arid land of ours.

In mining, water is used to help separate minerals from crushed ore. It is also sometimes used to carry unwanted residue to waste dumps and slime dams. Not only are vast quantities of water used, but much of it is contaminated during these processes. There are ways in which mining can be made more water-efficient, but because mines are seen as a necessity when it comes to development they have priority over water and there is very little incentive for them to save water.

Management of water use

We open the tap and water gushes out, flowing freely and available for our use. We acknowledge that water is vital for the health and functioning of our country but we often take it for granted, not stopping to think of better ways of using it so that there will be a sure supply of water in the future.

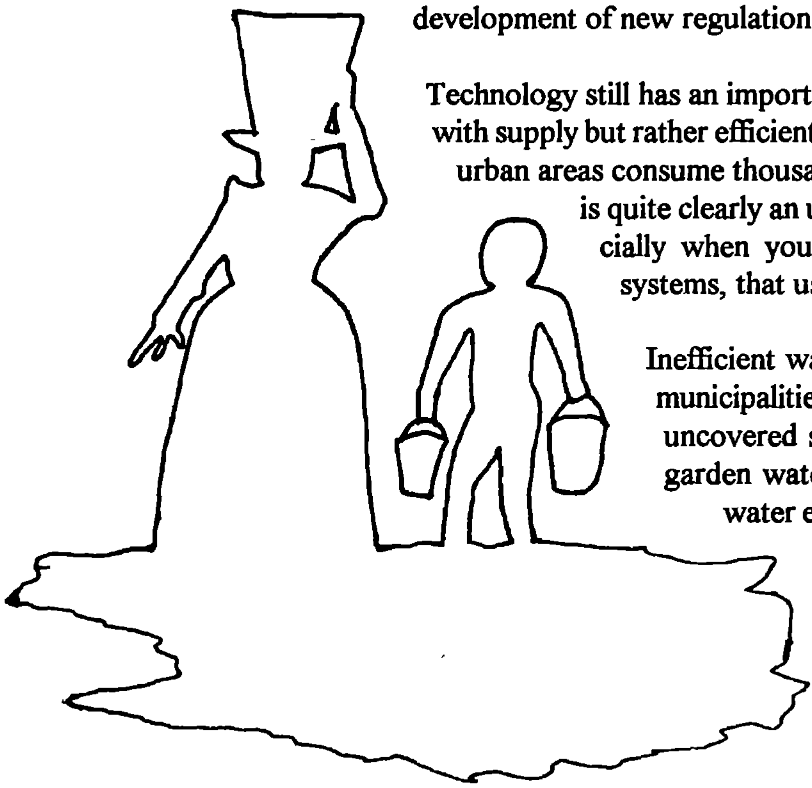
One of the biggest problems confronting the supply of water, especially in Namibia, is that it is often found in the wrong place, at the wrong time of year and of an unusable quality. Technology has played a major role in solving some of these dilemmas by providing pipelines, canals, water storage facilities and purification systems. But physical and financial constraints mean that there is a limit to how much technology can achieve. There are indications that we are fast approaching these limits in Namibia. Perhaps it is time for us to look at the ways in which we use water and start to manage our demand for what is essentially, in our country, a scarce resource.

So that we can manage water resources appropriately we need to consider what resources are available and how we can best use them to satisfy our needs. It is essential that we involve people - their needs, habits and patterns of water use - in the management programme. Furthermore, a big focus of the programme has to be the management of demand for water rather than the supply.

The new approach to water use must include more efficient use of water, reuse and recycling, conservation, reviewing of needs and demands, reviewing of existing supply infrastructure and the development of new regulations and policy.

Technology still has an important role to play, but this time not with supply but rather efficient use. For example, flush toilets in urban areas consume thousands of litres of water a day. This is quite clearly an unnecessary waste of water especially when you consider that alternative toilet systems, that use far less water, are available.

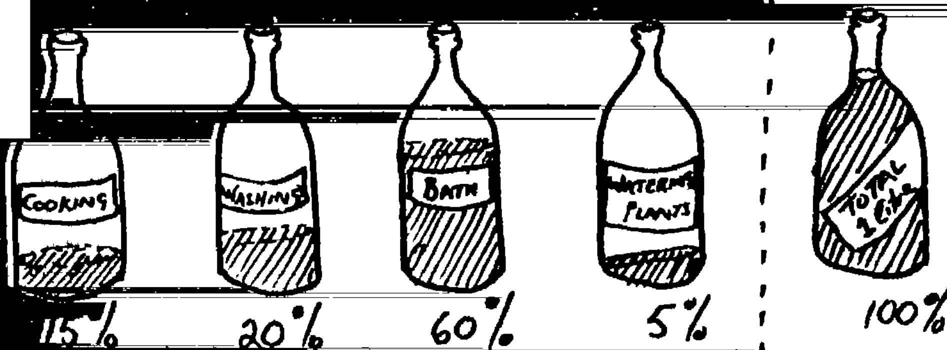
Inefficient water use by industry, wastage by municipalities, taps left running at water points, uncovered swimming pools and methods of garden watering that waste tonnes of clean water each year are further symptoms of a water provision system that has supplied too much water, at too low a price, to too many wrong recipients.



Chapter 11
Activities

MATHS

1. Make "active histograms" of water use in the classroom. You will need a number of the same kind of empty bottle. Ask the learners to divide their water use at home into different categories. They must estimate what percentage of water is used in each category. They must allocate one empty bottle per category. They can then divide one litre of water into the correct proportions and pour the correct amount into each bottle.



Teachers are encouraged to use examples relevant to the learners' situation. In the case of rural schools examples related to cows and goats. For example, use the information from chapter 10 on how much cows and goats require each day. Then consider the safe yield of a borehole. Get the learners to calculate the number of cows or goats they can keep for a specified safe yield. Give them a list of safe yields ask them to calculate the number of livestock that could be supported by each borehole.

HISTORY

1. **"Sailing through time"**
Do a self study on the development of water transport through the ages. Consider how various forms of transport have played an important role in political and historical developments with time.

1. Study "water-conscious" adaptations in animals. Make a catalogue of behavioral and structural adaptations that help animals conserve water. E.g., camels have humps, nocturnal animals avoid the heat of the day, etc.

2. Choose a specific water related recreation activity and study how it affects wildlife and the environment. Pool all the individual studies and list the activities from the most environmentally damaging activity to the least damaging. Which activity is most common in your area?

Water birds are an important part of Namibian wildlife. They are also a major tourist attraction. Make a study of waterbird adaptations in your area. Are any of the birds endangered? If so, why?

How many recreation activities require water? Visit a sports shop and divide the merchandise according to whether it fits into water sport categories or others. While you are there see how many ideas have been borrowed from nature, e.g.:

flippers = webbed feet

wet suits = layer of fat insulation in seals and dolphins.

Look at how different kinds of agricultural activities relate to water availability.

1. Design logos for watersports or recreation activities associated with water. Remember that logos must be simple yet convey a wealth of information without using writing.

1. Binoculars are a common accessory associated with watersport, water recreation activities and birdwatching. Study the principles behind bending and magnifying light in the sections of the syllabus covering reflection and lenses.

12

Water Problems

"Water is more critical than energy. We have alternative sources of energy. But with water, there is no other choice..."
-Eugene Odum

Despite its importance, water is the most poorly managed resource on earth. We waste it and pollute it. We also charge too little for it, encouraging even greater waste and pollution of this vital renewable resource. There are also problems that water causes on badly managed land, for example, salinisation and erosion. In these cases it is the bad management that should be rectified, and not the water that is at fault.

Water problems for one are water problems for all, and it is important for ourselves, for our people and for our nation to deal with them as effectively and efficiently as possible.

Namibia's great water shortage

The shortage of water is one of Namibia's most serious environmental problems. Drought with occasional flooding is the norm. Rainfall is not only generally low, but also variable and unreliable.

Another climatic factor that affects water resources is temperature. Because of our hot, dry climate, water evaporation rates in Namibia are very high. This has a serious effect on water that has been stored in dams and on irrigation schemes. Large volumes of water are lost every year from Namibia's open dams. When water evaporates from soil as it does in irrigation schemes, it can leave behind salt deposits that destroy the agricultural potential of the land.

Do we thank the river for its water? Yet it too may dry up - Zulu

Water availability and accessibility are a major limitation to development. Namibia depends heavily on groundwater which means that rainfall is required for recharge, and rainfall is rare in this arid country of ours. A clear understanding of Namibia's climatic constraints is therefore essential for the success of all development projects. Our climate, and more specifically rainfall, plays a major role in determining the well-being of Namibia's wildlife, agriculture and ecological resources, and through these resources our economic well-being.

Water, agriculture and livestock

The shortage of water is the most limiting factor controlling farming and agricultural development in Namibia. But it is not only the shortage of water that is a problem, it is also a question of distribution and supply. Namibia's water resources are not evenly distributed throughout our country. Some areas are blessed with more natural water than others and some regions have a better water supply infrastructure than others. These differences have resulted in uneven use of land, grazing and other resources. For example, large areas of land are unutilised or underutilised because of lack of water for livestock, while areas near boreholes, pipelines and canals are overcrowded, overgrazed, overstocked and deforested.

Our country's low and variable rainfall makes most of our land unsuitable for growing crops. This means that most of our people use their land for stock farming. In the arid south, rainfall supports vegetation which is only sufficient and suitable for small stock such as goats and sheep. In the centre of the country, pastures improve to the extent that both small stock and cattle can be farmed. In the northern regions rainfall is sufficient to support cattle farming. Often farmers overstock their land in the hope that good rains will fall in the wet season. In some areas boreholes provide water for animals even though there is very little grazing available. In both cases the result can be serious overgrazing.

Large irrigation schemes for food production are restricted to small areas and the long term sustainablitity of these schemes is uncertain. Irrigation schemes have been established along the lower Orange River, Okavango River, Zambezi River, at Stampriet and near the Naute and Hardap Dams. The nature of Namibia's soils and our high evaporation rates make irrigation in our country difficult. The fairly young Hardap Irrigation Scheme is already experiencing problems due to increasing salinity of the soil despite strict management.

With an increase in population and more and more land being exposed to land degradation, it is time for Namibia to evaluate its current agricultural status. Water, as the major limiting resource, needs to be at the centre of this debate. Whether Namibia is in a position to produce all of its food requirements, or should even try to produce all its food requirements is a question that needs to be carefully examined. It may be that we should focus our energies on other economic areas to earn money to buy in the food that we need.

The effects of decades of inappropriate land management practices along with extended dry periods are now starting to show in some areas in the form of severe land degradation. As is the case with all arid environments, natural resources required for agriculture are limited. Namibia is now facing the situation where more and more people need to be supported by fewer and fewer resources.

Namibia will have to meet a number of serious challenges if we are to feed our people adequately. Part of the solution to the challenge is to have a holistic approach to resource management. When natural resources are being considered it is important to pay attention to all resources and not consider them in isolation. This applies particularly to water.

Pollution

Water is often seen as the source of all life, but polluted water kills approximately 25 million people a year in developing countries. Nearly half of the world's major diseases are linked to water, many of them to water which is unclean. Unhygienic practices and poor sanitation in rural areas often result in water being contaminated, while in the cities industrial activities and waste disposal result in rivers and dams being polluted.

Major forms of water pollution

1. **Disease-causing agents** - bacteria, viruses, protozoa and parasitic worms that enter water from domestic sewage and animal wastes. In Namibia these are a major cause of disease and even death. Water related illnesses are the biggest cause of death amongst Namibian children under the age of five.
2. **Oxygen-demanding wastes** - when organic wastes enter a water supply they are decomposed by bacteria that require large amounts of oxygen. Large populations of bacteria supported by organic pollution can result in the reduction of the amount of oxygen in water. Without enough oxygen, fish and other forms of aquatic life die. A Namibian example of this type of pollution is our canneries dumping fish wastes at sea.
3. **Inorganic chemicals** - these include acids, salts and toxic metals such as lead and mercury. These substances often become dissolved in water and make it unfit to drink. They can also kill fish, damage crops and cause equipment that comes in contact with them to corrode. These types of chemicals are often found in water contaminated by mining processes.
4. **Inorganic nutrients** - water usually contains a certain proportion of nutrients, but if there are too many nutrients in water this can be considered a form of pollution. Nutrients like nitrates and phosphates (often used as fertilisers) can cause excessive algal growth in water. As a result oxygen levels decrease and other forms of life such as plants and fish can be harmed.
5. **Organic chemicals** - these include oil, petrol, plastics, pesticides, detergents and many other chemicals used domestically and industrially. These substances are a threat to the health of animals, plants and people. Namibian rivers are often polluted by diesel from water pumps in them.
6. **Suspended particles and materials** - substances like sand, clay and organic particles that do not dissolve in water fall into this category. Suspended material clouds water, reduces photosynthesis by aquatic plants and algae, disrupts aquatic food chains and carries bacteria and other harmful substances downstream. This material is responsible for clogging lakes, dams, reservoirs, hydroelectric schemes and harbours. This kind of pollution is the result of soil erosion on river banks, overgrazing, deforestation and other forms of land degradation.
7. **Radioactive substances** - the discharge of radioactive substances into water can be a major threat to the health of living organisms.
8. **Heat** - water is often used to cool electric power stations and other industrial equipment. If this heated water is discharged into rivers, lakes or the sea the level of oxygen in the water is reduced and this, in turn, affects the whole food chain as well as making organisms more vulnerable to disease, parasites and toxic chemicals.

Water pollution in Namibia

River pollution

In Namibia, river pollution on a large scale is potentially a problem in the perennial rivers, although ephemeral rivers can also be polluted. Fertilisers and pesticides such as DDT may enter the river and pose a threat to plants, animals and people using the water. In ephemeral rivers these chemicals may be deposited in the dry river bed and subsequently washed into dams where they can cause problems. In many cases entire river basins can be affected by pollution and poor management practices. The lower reaches of a river basin are usually more seriously affected, but certain problems, such as disease, may spread upriver. Poor health awareness and unhygienic practices aid the spread of diseases such as bilharzia and cholera through rivers.

Ocean pollution

All water that is polluted on land eventually ends up in the sea. We know less about how the oceans work than we do about the moon, and cannot know how much harm we are doing by dirtying our seas.

The oceans absorb agricultural and urban runoff, rubbish and untreated sewage from ships, accidental oil spills from tankers and offshore drilling platforms, wastes and sewage from coastal towns, industrial wastes and, last but not least, litter from coastal fishermen.

With exploration for oil taking place along Namibia's coast and the importance of Namibia's fish, bird and seal resources to our country's economy, the pollution of Namibia's ocean is something that must be carefully monitored and guarded against.

Ground-water pollution

Groundwater is a very important source of water for urban and rural use in Namibia as well as in many other countries, but laws protecting groundwater resources are weak or poorly implemented.

Contamination of groundwater can be considered permanent damage, with little or no hope of purification by artificial methods. When groundwater becomes contaminated it does not cleanse itself like surface water in a river does because water flow is slow and non-turbulent. Contaminants are not effectively diluted or dispersed.

Contamination need not only be from toxic chemicals. Salts, fertilizers and seawater can render a borehole useless.

The most serious forms of groundwater pollutants

1.**Pesticides** - Many pesticides take a long time to break down and can filter down to the water table before they do so.

2.**Fertilisers** - Fertilisers dissolve in water and filter down through the earth to the groundwater supply. Irrigation can speed this process up and groundwater supplies can be seriously contaminated.

3.**Waste water ponds** - Dams or ponds of waste water from industrial or mining activities often contain toxic chemicals that can filter down into the groundwater supply.

4.**Leaking petrol storage tanks** - Fuels are often stored in underground tanks. A slow leak in such a tank can contaminate the water of thousands of people.

5.**Sewage and septic tanks** - Septic tanks that are located near shallow water tables can easily contaminate the water.

6.**Contaminated industrial waste** - This can consist of tannery and mining waste, including seepage from tailings dams.

Water and soil erosion

Soil erosion is a natural process caused mainly by water and wind. It is when erosion is excessive or goes unmanaged that it can cause severe land degradation. It becomes a threat when there is a marked and irreversible loss of soil - especially the fertile topsoil in which we grow our crops.

There is often confusion between soil erosion and water runoff. Soil erosion means that there is damage to the land and topsoil is lost. Water runoff occurs when water runs over the surface of the land and it may or may not cause soil erosion. There is a point when runoff starts to carry large amounts of soil away with it. In this case runoff contributes greatly to soil erosion.

Runoff does not always result in the loss of soil, but what is always lost through runoff is water that might be better used to grow plants or crops. When there is good vegetation cover, or when land has not been denuded of its natural vegetation, plant roots help prevent erosion and slow runoff through holding the soil in place and encouraging infiltration.

Not only people, but also our domestic animals are linked to soil erosion. Bad farming practices lead to trampling, overgrazing and other forms of land degradation which speed up the loss of our soil.

The loss of topsoil is a serious economic problem all over the world, but people are often not aware of the problem until it is too late. The effects of soil erosion include: the loss of agricultural land; the deterioration of water resources; loss of soil fertility; flooding of valleys and the silting up of dams and lakes.

At a time when the world's population is expanding at a rapid rate and more land is needed to produce food and fuelwood, valuable land is being destroyed by soil erosion. The loss of soil seriously affects future agricultural potential.

People and erosion

Soil erosion is the natural process that has shaped the surface of the earth over millions of years. The agents of wind and water have sculpted rocks and soils into a variety of shapes and nowhere in Namibia are the effects clearer than in the western part of the country. Geologists believe that the Namibian climate was much wetter in the past and that runoff was much greater. During this period the natural processes of erosion proceeded at a much faster rate than they do today.

People and their activities can increase or decrease the rate of erosion. Because an increase in soil erosion decreases the potential of land to produce food it is seen as an unfavourable process. Despite this realisation human activities around the world have accelerated erosion processes through poor farming and land management practices.

People are linked to the most serious cases of erosion in the following ways:

- too many trees being cut down
- bad farming practices
- thoughtless development
- excessive bush fires
- abandoning traditional pastoral customs
- overgrazing
- strip mining
- human greed - the desire for immediate gain without considering the future.

The results of uncontrolled runoff and erosion

1. Runoff water is lost and cannot be used for crops or livestock. In some cases, as much as 80% of water received as rain can be lost due to runoff, taking with it sand, clay and mineral salts and leaving the soil in a worse condition each year. In Namibia, about 80% of rainwater evaporates immediately back into the atmosphere leaving a smaller percentage (about 14%) for runoff.
2. Excess runoff removes large amounts of mineral salts, clay and organic matter which are the most fertile soil elements. The result is that arable land is lost. If fertilizer is applied to the soil it may also be lost - an expensive practice and one that brings with it the risk of pollution.
3. As erosion gets worse on slopes, it causes great problems in valleys. Both fields and homes can be destroyed after heavy rains because water no longer filters into the soil on the slopes but runs down to cause flooding in the valleys.

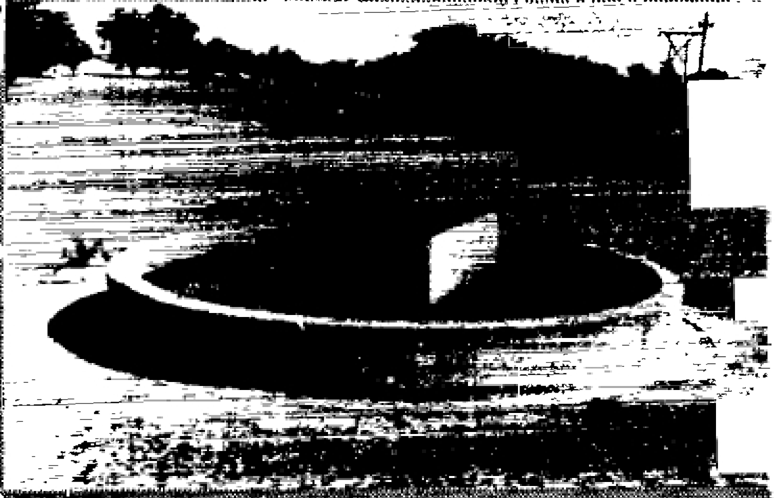
Erosion in Namibia

Rainfall

In Namibia rainfall is scarce and unreliable, but when rain falls it often does so in short, violent storms, rather than in slow and penetrating showers. Because of this, and because of the scarcity of vegetation in Namibia due to aridity, much of our country is at risk of losing its topsoil as the soil eventually makes its way into rivers and then into the sea.

Watering points

Water plays an indirect role in promoting soil erosion in Namibia. Features such as watering points, canals and pipelines lead to the concentration of people and their livestock. Overgrazing and trampling plants results in the loosening of soil near a water supply and thus makes soil in such areas vulnerable to soil erosion. Some of the worst cases of soil erosion in Namibia can be seen near water sources.



Overgrazing

Overgrazing leads to the removal of plants that can protect the soil from heavy rainfall and wind erosion. Overgrazing is a serious problem in years of low rainfall when the vegetation is exposed to heavy grazing pressure by herds of livestock that exceed the carrying capacity of the land.

Deforestation

The loss of trees is one of Namibia's most serious environmental problems. The roots of trees anchor the soil and shade it from the drying effect of the sun. Without trees the soil becomes dry and loose quickly and is exposed to erosion from wind and water.

Controlling erosion

Stopping erosion and controlling water runoff are of vital importance, not only for the land but also for the economy of our country and for the welfare of every Namibian who is in any way linked to the soil - even those who only buy its products to eat. Vegetation, even dry perennial grass tufts, encourages water to infiltrate into the soil, and thus aids groundwater recharge. Increased runoff and erosion means less recharge, and thus less available water as well as poorer soil. Care should be taken before erosion is obvious - by the time it can be seen, it is often too late. There is no single way of controlling runoff and erosion. Every farm and settlement has its own problems and needs its own solution.

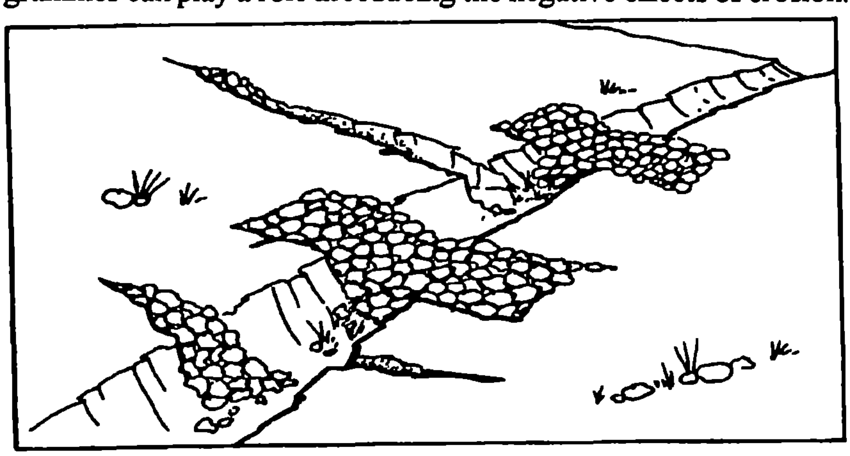
The control of erosion involves one or more of the following principles:

- protect soil against rain damage
- retain rain where it falls
- encourage infiltration
- fight erosion at its source
- channel and control runoff
- force runoff water to deposit its sand or silt load.

After rain storms people in west Africa say that the stones have grown, but in fact fine soil is washed away by water and the large stones are left behind.

There are 2 main direct methods of control:
1.**Mechanical methods** - building physical structures on the land such as stone walls, ditches, barriers, etc.
2.**Biological methods** - these methods rely on planting and encouraging natural vegetation to grow and conserving existing natural vegetation as much as possible.

However, each or a combination is often insufficient for controlling erosion on a large scale. Indirect methods have an important contibution to make here. Ultimately a reduction in people and livestock pressure on the land is necessary to reduce or reverse the effects of erosion. Family planning and stock management then become part of the tools necessary for combatting unwanted erosion. These are however long term objectives. In the meantime, awareness created through the media and school education programmes can play a role in reducing the negative effects of erosion.



Simple gabions built to reduce the effects of soil erosion

Chapter 12

Activities

1. If you have access to contour maps, make a study of high risk erosion areas in your region. Trace the major topographical features onto a piece of paper. Divide the class into groups. Now pretend that you and your group have to decide where to build anti-erosion walls. You have the resources to place ten such walls in the region. Mark on your traced copy the places where you would consider constructing your ten anti-erosion walls. Does everyone in the class greee on the same ten places?

2. If you live in a coastal town make a survey of rubbish collected on the beach. Categorise the rubbish according to place of origin - often rubbish contains some clue as to where it is from in the form of a label, language, etc. Work out what proportion of the pollution is from ships and what country's ships are responsible for polluting our coasts. How much pollution is from anglers on the shore?

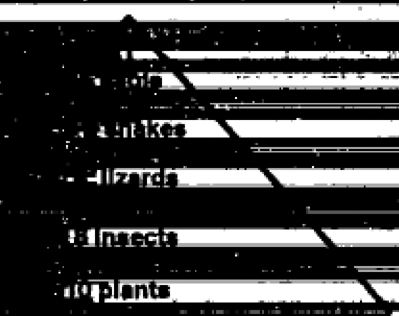
Conduct a series of experiments in or outside the classroom that demonstrate how land management and arming practices can increase or decrease erosion. See the Enviroteach supplementary booklet, *Wholly round*, that deals with soil erosion.

1. Make a scrap book collection of newspaper articles that report on major water pollution events. When you have ten events write a summary of them and hand it and your scrap book in for marking. Examples could include oil spills at sea, factories polluting rivers, dumping of waste at sea, etc.

1. Conduct a survey on the biodegradability of detergents available in shops near you. Do any of them indicate on the packaging that they are biodegradable? Make a list of all detergents and cleaning agents found in your home. What proportion are biodegradable and what proportion are not? Remember that high phosphate concentrations in soaps cause nutrient pollution in rivers and dams. Look out for phosphate-free soaps.

Conduct a self-study into the effects that oil spills at sea have on marine wildlife. Present your findings a poster or display.

Use a role play activity to demonstrate how pesticides are accumulated in the upper levels of food chains. Iraw the following food pyramid on the board and assign individual plant or animal roles to individual arners.



he teacher plays the role of the farmer and "sprays" the plants with pesticide. Do this by handing out a nall stone or piece of coloured paper to the ten learners that represent plants. The insects then "eat" the and the stones are handed over to the insects. This continues up the pyramid with the stones being issed on to the higher level each time until all the stones are handed to the eagle. Draw attention to the fact iat although the "plants" received only one "poison molecule" (stone) the eagle ended up with 10 "poison olecules". This shows how poisons are concentrated in the higher levels of the food chain. Ask the learners draw up their own food chain as a homework exercise. They should include a person at the top of the od pyramid.

1. Create awareness of water pollution by making a collage of things that can be potentially harmful to our water resources. Stick down labels and adverts from magazines to make a poster for display in your community or school.

1. Write adverts for environmentally friendly products.

1. Make a list of chemicals found in agricultural fertilisers, pesticides, etc. Draw up a table that indicates what these substances are used for and what their negative effects on the environment are. Indicate where in Namibia these substances are being used. A trip to the local hardware store or farmers co-operative will provide a wealth of information.

1. Find out from your municipality what happens to sewage effluent and garbage in your area. How do factories and mines treat and dispose of their waste water? What problems are there?

1. **"The oil-spill-clean-up investigation".**
Learners pretend that they are part of an oil-spill clean-up team on Namibia's coast after an oil tanker ran aground and spilled tons of oil onto our beaches. Provide each group of "investigators" with a sample of oil and a number of "mystery agents" labelled A,B,C,D, etc. that can be used to clean up the oil-spill. The learners have to test each of the agents to find out which one is the most effective for the clean-up operation. Use the following:

*cooking oil as the oil sample

*For "Mystery agents": A-dishwashing liquid
B-soap powder
C-vinegar
D-baking soda
E-petrol

End the investigation with a discussion of the dangers that the agents could pose to the environment. Are of these substances biodegradable? This should make the learners aware of the seriousness of oil-spills!

1. Refer to the Enviroteach booklet called *Wholly Ground* for maths problems dealing with soil erosion or make up your own.

13

Plants need water!

There is no life without water, and there can be no agricultural activity at all without this precious substance. Plants are primary producers of food, and depend on water for many processes essential to their growth.

Namibia is a country whose people depend heavily on agriculture, and our agriculture depends on our water. All over Namibia, people grow plants. They do this by many different methods. In the north of our country most crops depend on rain. Near good sources of water, irrigation schemes water plants by artificial means. And almost everywhere in this country of ours people grow vegetables, herbs or ornamental plants in gardens, plots and pots.

We need to ensure that our gardens and crops are grown in the most sensible and waste-free way possible. It is in all of our interests to maximise our benefits from water and cultivation.

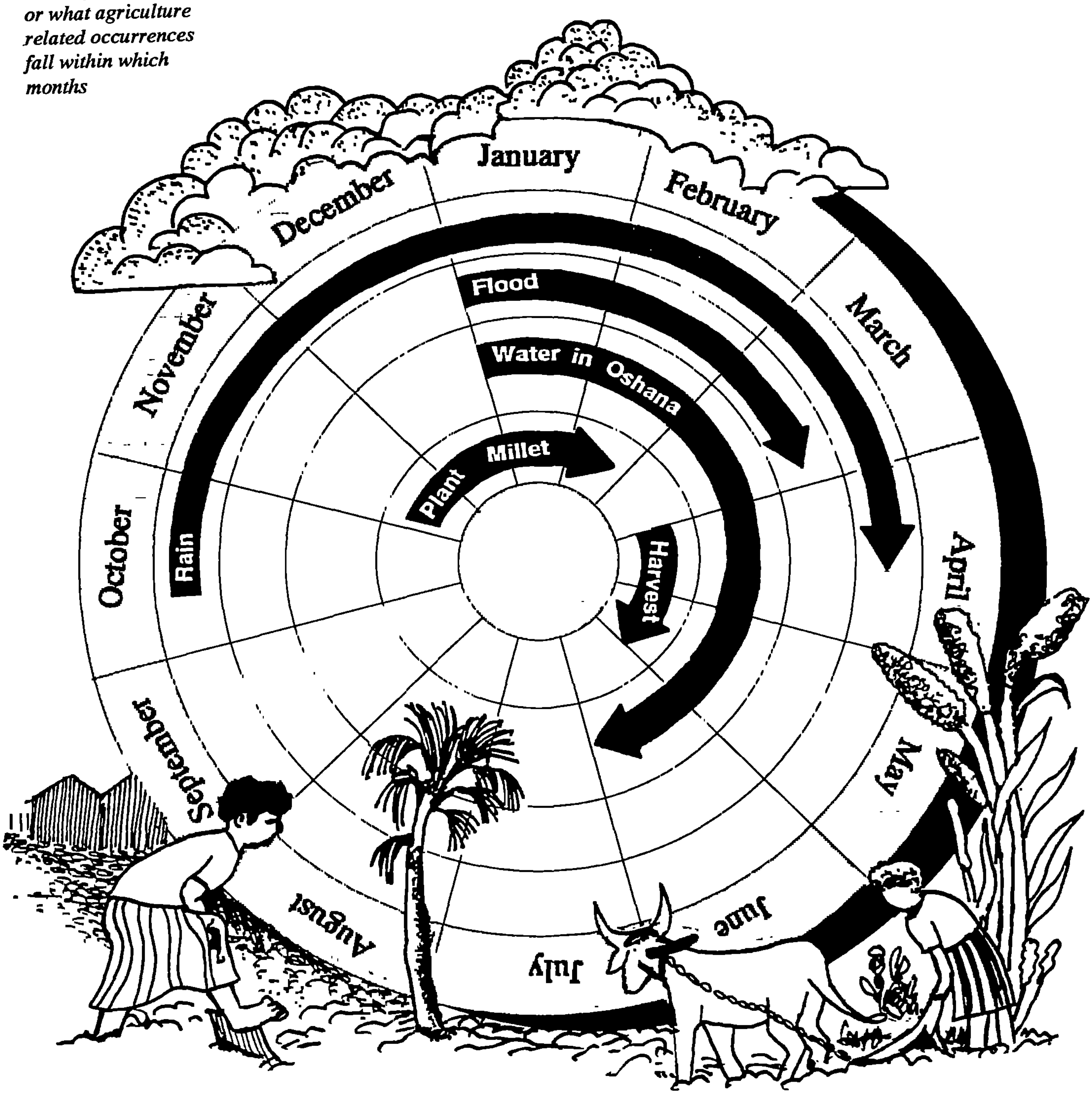
Types of cultivation

Rainfed agriculture

Rainfed agriculture, also known as dryland agriculture, depends entirely on water from the annual rains. Crops can only be grown during the rainy season when there is enough water to sustain them. Rainfed agriculture is practised in much of northern Namibia, where omahangu, sorghum and maize are planted after the first rains of the year in November/December and harvested in late April/May. Rainfed agriculture can only be practised in areas where rainfall is high enough to sustain crops. In areas where there is too little rain, artificial means of watering crops must be employed.

Rainfed agriculture is at the mercy of drought and bad weather - a bad year for rains means a bad year for crops.

This is an agricultural calendar for regions that lie within Namibia's Oshana system. It tells you what agricultural activities or what agriculture related occurrences fall within which months



Irrigated cultivation

"Irrigated cultivation" means that crops are grown by means of artificial watering. Their needs can either be totally supplied through irrigation, or naturally occurring rainfall can be supplemented through irrigation. On a small scale, irrigation is practised almost everywhere people live - in their vegetable gardens, their flower gardens, and even their indoor pot plants. But large scale irrigation depends on having a reserve of water, such as a river, dam or plentiful groundwater, and on the presence of suitable soils. Some irrigation is practised in Namibia, but water is in short supply and most of our country's soils are unsuited for this means of cultivation.

Irrigability of Namibian soils

Classification	Area (ha)	%
Highly suitable	940 000	1,1
Suitable	2 660 000	3,2
Marginal	12 580 000	15,3
Unsuitable	66 250 000	80,4

Source: Department of Water Affairs

Areas under irrigation in Namibia

Region	Area (ha)
Stock farms	2 150
Orange River	1 800
Fish River (at Hardap)	1 500
Okavango River	700
Auob River (Stampriet artesian basin)	610
Grootfontein/Tsumeb/Otavi Valley	100
Caprivi	60
Omaruru River	60
Damaraland	60
Kaokoland	10
Owambo	10
Total	**7060**

Source: Department of Water Affairs

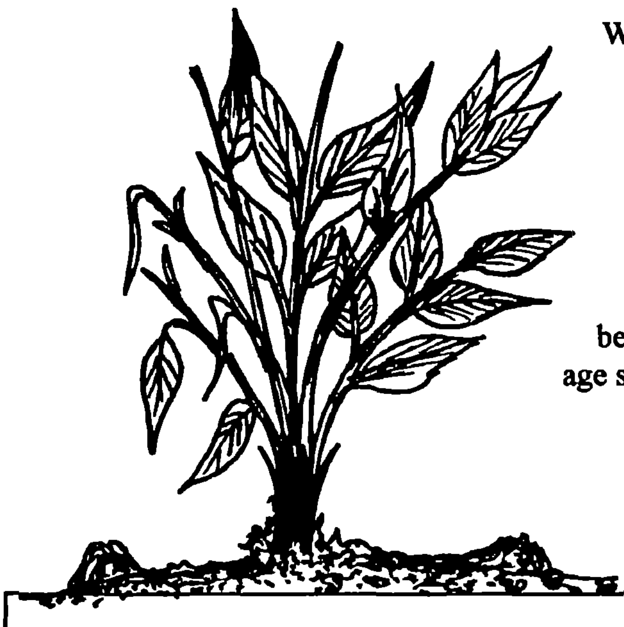
Spilled water cannot be picked up - Swahili

Irrigation - a solution with problems

Irrigated croplands, which cover 18% of the world's arable land and produce 33% of its food, soak up some 73% of water used worldwide. Irrigation is vital if the world's population is to be fed, but there are some disturbing trends emerging as time progresses.

The biggest problems with irrigation are **salinisation, alkalisation** and **waterlogging**.

Salinisation and alkalisation go hand in hand and are a result of substances dissolved in water used for irrigation accumulating in the soil being irrigated. Even the best quality water from rivers or aquifers contains salts. 10 000 cubic metres of water deposit 2 - 5 tonnes of salt per hectare of land if the land is not properly drained. After 10-20 years of this type of irrigation, so many salts accumulate that crop plants are poisoned by them and the soil is, in effect, sterilised. Every year throughout the world about 1.5 million hectares of good agricultural land are made useless in this way. The same amount of new land, much of it less suitable for irrigation, must be brought under irrigation.



Waterlogging occurs when land is over-watered - something that happens more often than you would expect due to the fact that water for irrigation is usually free or heavily subsidised by the government. Water sinks down through the soil and raises the level of the groundwater. When this reaches the level of the plants' roots, growth stops and crops die - drowning in a normally arid area. This problem can be avoided through careful watering and good drainage systems.

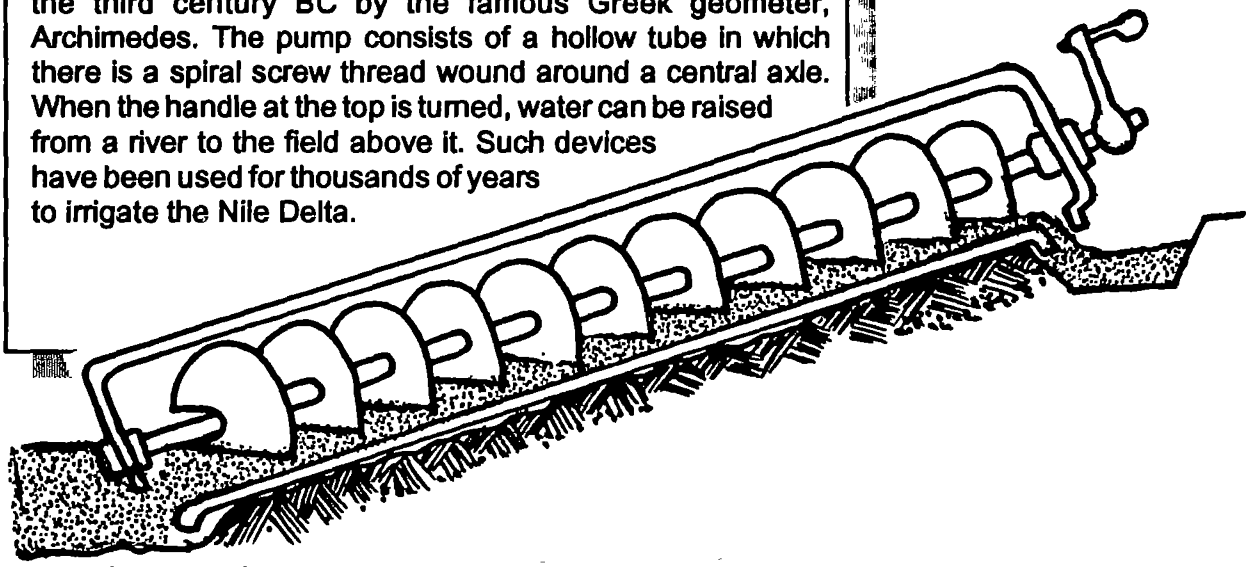
Why plants need water

All plants require water. Some of the exact needs that water in plants fulfils are:

- during germination, to soak the seed and make it swell until the radicle appears
- for mineral uptake: all plants take up the minerals they need to live in a form dissolved in water
- to form living matter
- in the process of photosynthesis in the leaves
- to transport food and other substances to all parts of the plant
- to form the fruit flesh that surrounds the seeds.

Archimedes pump

This pump, invented in ancient times, is still in use in some parts of the world today. It is thought to have been invented in the third century BC by the famous Greek geometer, Archimedes. The pump consists of a hollow tube in which there is a spiral screw thread wound around a central axle. When the handle at the top is turned, water can be raised from a river to the field above it. Such devices have been used for thousands of years to irrigate the Nile Delta.



Other problems linked to irrigation are **wastage** and **unsustainable use** of groundwater. Because farmers often do not realise the true worth of the water they use, some of them tend to over-irrigate or use inefficient irrigation systems. It is not uncommon for over 80% of water withdrawn for irrigation to be lost through evaporation or by seeping into the soil before it reaches the crops it is intended to irrigate. Where groundwater is used, the often enormous demand for water can lead to it being withdrawn faster than the aquifers can be recharged. This depletes supplies and lowers the groundwater table. In some areas of India, the groundwater table has dropped between 25 and 30m in less than 10 years, and many formerly reliable boreholes and wells are no longer of any use, having run dry.

Irrigation schemes sometimes provide breeding grounds for malaria-carrying mosquitoes and other insects that carry disease. It can also provide suitable habitats for the species of water snail that is host to bilharzia parasites.

Rehabilitating ruined land is expensive and sometimes impossible. The solution to these problems lies in **preventing** them from happening. Farmers must be made responsible for their water use, either through rationing or through realistic payment. Education has a large role to play, as does the development of efficient and affordable irrigation methods.

Celestial irrigation?

The Sonjo, a people of northern Tanzania, have practised irrigation for hundreds of years. Their whole way of life, including their social structure, religion and spiritual beliefs, reflects their long link with this kind of farming. Sonjo mythology states that irrigation originated with the establishment of the tribe's six villages by heroes of the Sonjo mythology. Rainfall is believed to be the overflow from a heavenly irrigation scheme.

Watering plants

Without water, no plants would grow. So, when cultivating plants, watering is very important. Water use for cultivation can range from large scale irrigation schemes to family vegetable gardens. Efficient use of water for cultivation means using the smallest amount of water for the largest amount of harvest in ways that do not harm the environment. The two main factors that must be considered when watering plants are:

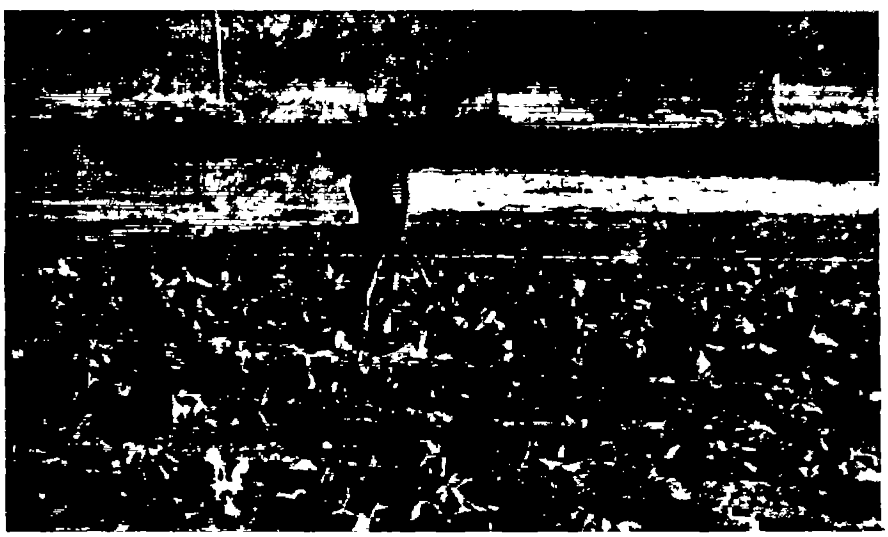
- how much water should be provided?
- when should plants be watered?

How much water is enough?

The amount of water that crops require depends on the type of crop being grown, the type of soil it is grown in, and the temperature of the air. Certain plants require a lot of water, and will wilt if they do not get enough. Clay soils need less water than sandy soils as they retain water for a long time. In higher temperatures plants will require more water. Plants need enough water, but not too much. If the area plants are being grown in does not have good drainage and plants are over-watered, there is a danger of them drowning as their roots cannot take in oxygen, or of their roots rotting due to the constant damp. Too much water can also **leach**, or wash nutrients from the soil.

When is the best time to water?

Plants should be watered before the soil has dried out completely from their last watering. If not watered in time, they will wilt, and this may affect the plant badly. Soil should be moist to a depth of 30-40cm around the plants, as this is the zone from which their roots draw water. A hole dug to this depth will show whether the soil is wet and whether you need to water. The best time of the day to water is in the evening or early morning before the sun gets too hot. This will also help to conserve water as evaporation will be slower at these cooler times, and the water will have a chance to sink into the soil before it heats up and is lost to the atmosphere.



Use it, don't lose it

You can conserve our precious freshwater resources by reducing unnecessary losses through:

1. Runoff - this can be done by improving soil structure and using terraces and vertical mulch.
2. Deep percolation beyond root zone - being careful not to over-water helps in this regard, as does increasing the soil's water-holding ability through increasing organic content by adding compost or manure.
3. Evaporation and excess transpiration - mulching, close spacing of plants, multiple plant levels,shading, wind breaks, watering at the correct times and use of drought-tolerant plants all help slow evaporation and excess transpiration.

You can help to save water before it even reaches the field or garden

1. Improve the quality of the water you use by minimising salts, poisons and organisms that cause disease in plants and people.
2. Minimise the loss of irrigation water from storage in reservoirs, tanks, pots or other containers by covering or shading their surfaces to reduce evaporation and by fixing any leaks these containers might have.
3. Minimise the amount of water lost on the way to the garden or field in irrigation channels, hoses, buckets, etc. by reducing the number of leaks and the amount of time the water is exposed to evaporation or infiltration.

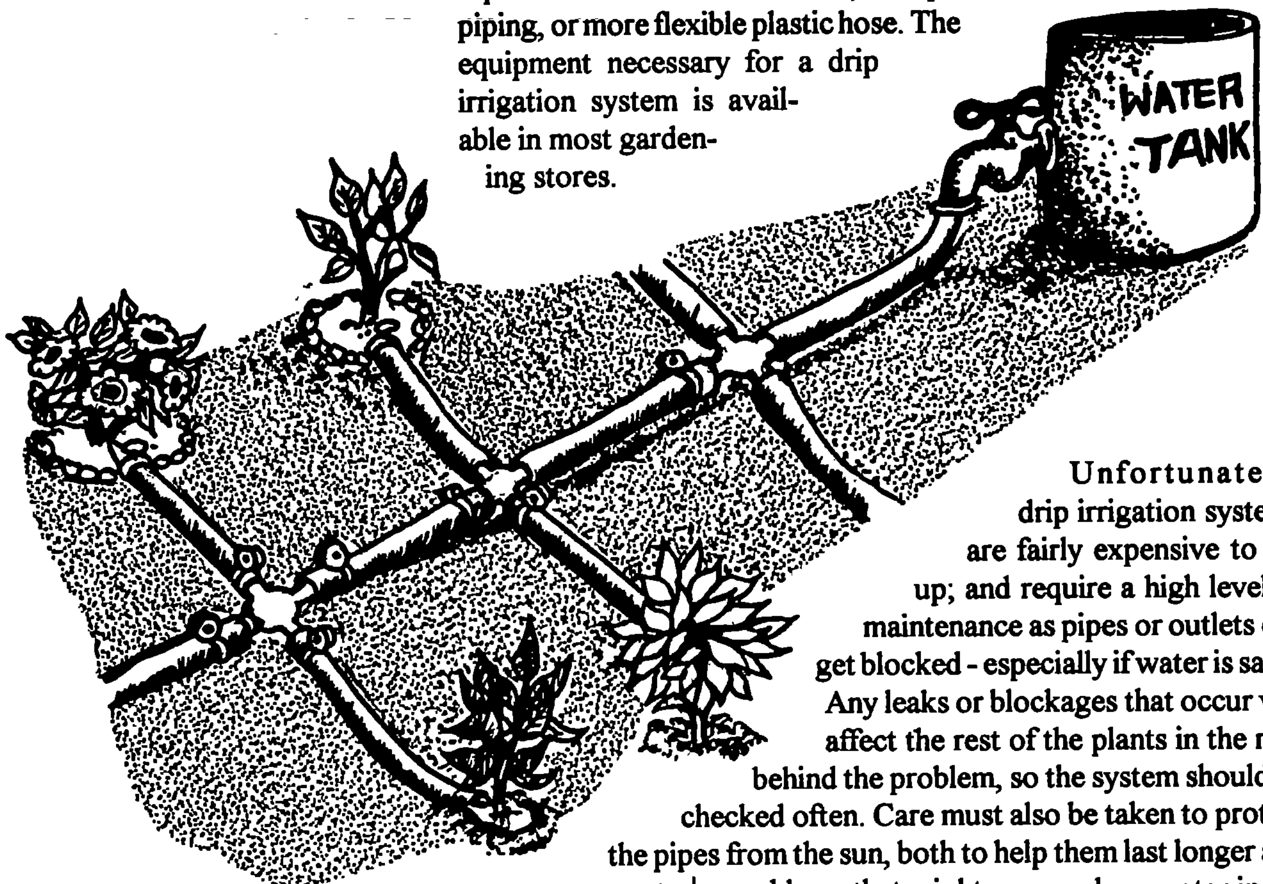
Leaving a garden sprinkler on for one hour uses 910 litres of water.

Two examples of water-efficient ways of irrigation

Trickle or drip irrigation

Trickle or drip irrigation takes water directly to the plants being grown and wets the ground with small amounts of water just where plants can absorb it. In areas where evaporation is high this is a very water-efficient way of cultivation as it cuts down on unnecessary wastage of water.

Pipes used can be either metal, cheaper PVC piping, or more flexible plastic hose. The equipment necessary for a drip irrigation system is available in most gardening stores.



Unfortunately, drip irrigation systems are fairly expensive to set up; and require a high level of maintenance as pipes or outlets can get blocked - especially if water is salty. Any leaks or blockages that occur will affect the rest of the plants in the row behind the problem, so the system should be checked often. Care must also be taken to protect the pipes from the sun, both to help them last longer and to prevent any problems that might occur when water in the system vaporises.

Despite the problems that can occur, drip irrigation is so much more water-efficient than conventional irrigation systems that in arid areas we cannot afford to ignore the idea. Because only small areas of ground are watered, the rate of salinisation of the soil is much slower than it would be with conventional irrigation systems. With drip irrigation becoming more and more popular and water a scarcer and more expensive commodity, in years to come we will no doubt see an improvement in drip irrigation techniques and a drop in prices.

In areas where labour is plentiful, the same benefits of drip irrigation can be obtained by watering by hand, applying small amounts of water near the base of plants in the morning and in the evening.

Watering your plants with pots

Pitcher irrigation is an irrigation method that can be employed on a small scale using buried porous and unglazed clay pots to provide water for plants. This method of irrigation copies what happens in the ground near the water table. Porous clay pots are buried up to their necks in the ground among the plants being grown. They are then filled with water which slowly seeps through the walls of the pots, providing water to the surrounding plant roots and thus allowing the plants to grow.

The method is best used in areas where water is scarce or expensive, water is salty and cannot be used in conventional methods of surface irrigation and there is enough labour to make and bury the pots. Farmers in these sorts of areas could find the method of great benefit and ensure a supply of vegetables for themselves, their families and for sale.

Advantages:

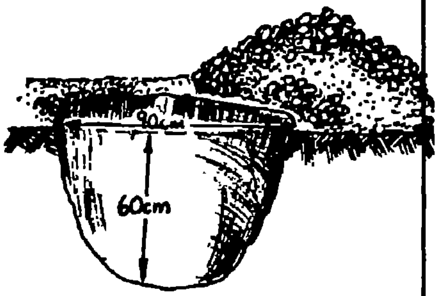
- water use is very efficient
- as pots take a long time to empty, this method is labour-saving
- it promotes economic exchange between farmers and potters and encourages local handicrafts in regions where there is a tradition of pot-making
- small amounts of soluble fertilisers can be dissolved in the water used and thus nourish plants directly
- it reduces danger from salinisation considerably
- it reduces evaporation, especially if the neck of the pot is small or if the pot is kept covered

Disadvantages:

- unglazed clay pots are fragile and easily broken
- only small areas can be cultivated using this method.

Growing potty!

1. Dig a round hole, a little less than a metre wide and a little more than half a metre deep. Mix the soil from this hole with compost or manure.



2. Half fill the hole with the soil mixture, and then place your pot in the centre of the hole. Finish filling in the hole.

3. Plant your vegetables in the newly dug, enriched soil around the pot. Remember to fill the pot with water regularly. A lid on the pot will keep the water clean and stop insects from breeding in it. Large vegetable plants - such as tomatoes, melons or squash - grow best.

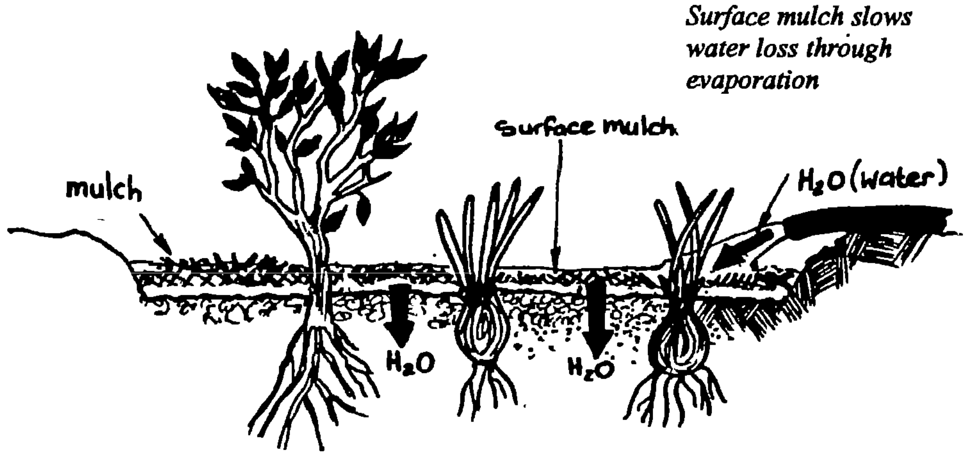
Marvellous mulches!

Mulches can be useful ways to conserve water in gardens as they reduce the amount of water that is lost from the soil through evaporation and improve water movement through the soil. There are two types of mulches:

Surface mulches

Surface mulches cover the soil surface, shading and cooling it and so helping to prevent evaporation. Surface mulch also helps to protect the surface of the soil from the impact of raindrops or other means of watering, thus preventing the soil from compacting and encouraging infiltration rather than runoff. Thick surface mulches also discourage the growth of weeds, which compete with plants for water and nutrients. Many things can be used as mulch - from organic material such as cut grass, compost or manure, to things like plastic bags and stones. Organic material is preferable where possible as it improves the quality of the soil it shelters.

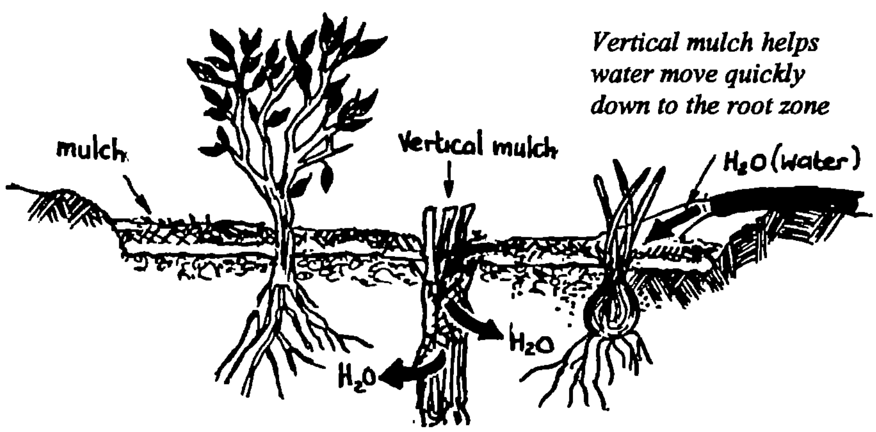
Surface mulch slows water loss through evaporation



Vertical mulches

Vertical mulches provide a pathway for water to the root zone and can reduce the area of soil surface that is wet. They can be constructed by filling narrow trenches in garden beds with crop stalks such as those of maize or sunflowers. The air spaces these stalks create allow water to move quickly down to the root zone where it can do most good and is less likely to evaporate. These sorts of mulches also help to improve the organic content of the soil.

Vertical mulch helps water move quickly down to the root zone



Growing goodness

Near Oshakati, a woman harvests squash from the vine growing along one of the walls of her homestead. She will cook them with the evening meal. In Katutura, a man carefully tends the maize plants he has planted in the small yard behind his house. In Gibeon, an elderly woman fetches water for her mint plants from the communal standpipe. She will use their leaves for tea, and sells these same plants to her neighbours. These people are all gardening.

Gardens can improve nutrition, income and self-sufficiency in rural and urban drylands. Gardens have been part of household production systems for thousands of years - secondary sources of food and income. A small garden, only 10m long by 10m wide, can provide vegetables all year round if tended correctly. Garden foods can provide many nutrients, but are especially important because of their contributions of vitamins and minerals.

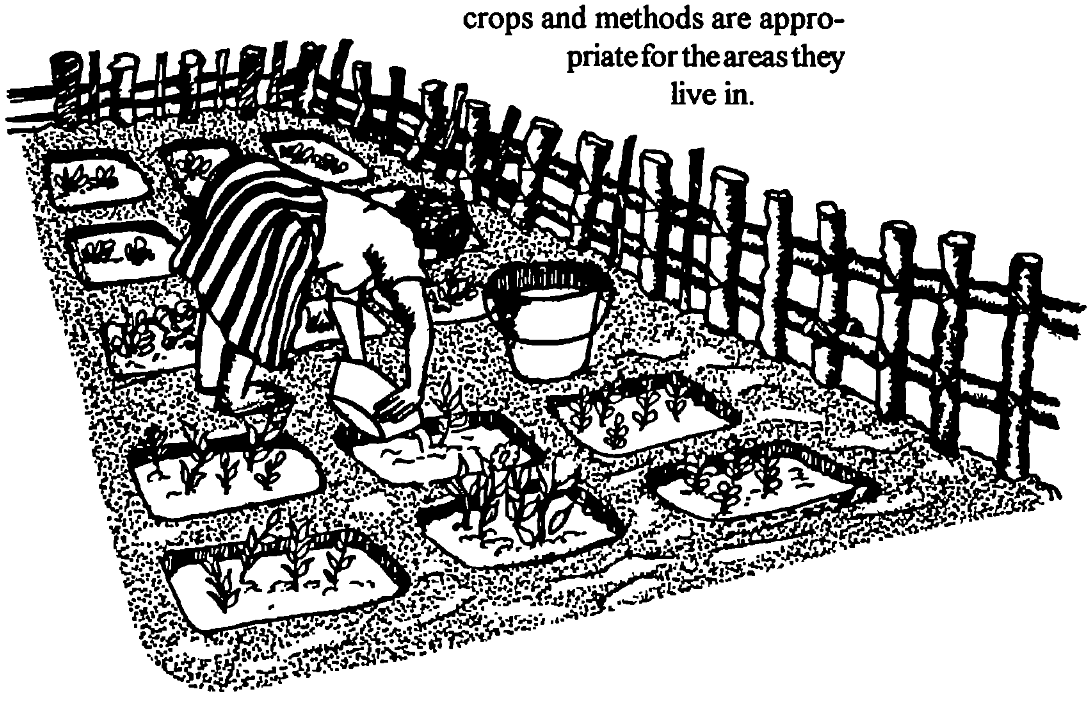
***Environmental sustainability** means the careful management of soil, water and biological resources so that future generations can also use them.*

The reason many people garden is because of the income they can earn by selling garden products or the money they can save by growing their own food. Many households rely on garden produce to provide them with money to pay for medicine, clothing, food and school fees.

Small vegetable gardens can be watered using water recycled from the household - water used for washing or other purposes that do not leave it too dirty. An important requirement to be remembered is that such gardens should be both environmentally and socially sustainable.

***Social sustainability** means promoting improved nutrition and income in ways that are cost-effective, and encourage local reliance and a fair distribution of resources.*

It is important to remember that a good basis for any form of gardening is what local people already know and practise. People who have lived in an area for a long time are likely to know what crops and methods are appropriate for the areas they live in.



Mahangu and women

he hired his field
from the headman
and grew mahangu
from fine white dust
that once was sea bed.
when the rain year ripened,
he cut candle stalks
and passed armful on armful
to a sister's child.
She swept the ground
above the ground,
and stripped the seeds
with a blunt mopani stump,
smoothed by a tribe of fingers.
she shook her basket of seeds
in a drum roll,
winnowing in a light breeze.
then she poured the seeds
into a hollow trunk
and set up elbow rhythm,
with a movement of rural woman,
pounding, pounding
protein meal
to fine white dust

Dorian Haarhof

Chapter 13
Activities

1. Draw up a seasonal agricultural calendar for crops grown near your school or one for the school vegetable garden. Use the example on page178 as a guide.

2. Have a collection in your classroom of the various types of equipment used to irrigate plants for use for demonstration purposes. If they are too expensive to buy, it may be worth asking hardware store if you can borrow some examples for a short period. Put the various pieces a "surprise box" and get individuals to pick out an item from the box, identify it and explain how and it is used for.

onduct a series of experiments that investigate transpiration in plants. Place plastic bags over the leaves a plant and leave it in the sun for a few hours. Observe the water droplets that form in the bag. Discuss role that water plays in the transport of substances in plants.

stand a stick of celery or a flower with its stem in some water coloured with ink. Leave overnight. Cut stem in various places and note where the ink is taken up by the stem.

1. Conduct a series of experiments that investigate the effects of mulching. Test a number of materials and ways of mulching. Apply the techniques in your school vegetable garden. Organise a talk and a demonstration on the advantages of mulching for the members of your community or a group of primary school children. Teachers are encouraged to attend and mark the oral presentations.

1. Design a water pump that is hand or foot driven. The Archimedes pump is one example of this. You may wish to build such a pump if you have the appropriate materials.

1. Make clay pots for use in clay pot irrigation. Do not glaze the pots. Use them in the school vegetable garden. If the project is successful, make more pots and sell them to members of your community. Use the money to improve your vegetable garden.

1. Using an atlas, decide where in Namibia you would plant different agricultural crops. The information from a rainfall map of Namibia will give you an idea of what crops will grow where. You will need to find out which crops are drought resistant and which require a lot of water. Draw your own map of the country with different zones for different crops marked on it.

1. What crops are most frequently referred to in the Bible and other religions. Make a list of references. Which of these crops do you commonly use in your day to day life?

2. Examine the different ceremonies conducted by various cultures to ensure fertility, growth of crops and good rains. Are there any specific times of the year or special events that indicate good times to plant, e.g. new moon.

At a cathedral in Wales there is a garden where all the plants mentioned in the Bible have been planted. he first is an apple tree. Can you name 10 other plants in this garden?

14 Water and health

There are very important links between water, sanitation, hygiene and health. According to the World Health Organisation (WHO), 1.5 billion people do not have a safe supply of drinking water, and more than 5 million people a year die from waterborne diseases that could be prevented by improved drinking water supplies and sanitation. Yet there are simple and cost-effective methods of purifying water and of setting up sanitation systems. With the correct information and a few basic ingredients everyone should be able to make sure that the water they drink is safe. Pit latrines are easy to build and very satisfactory forms of sanitation, and the basic design can be adapted to suit many different circumstances.

Diseases linked to water make up more than 80% of all disease in developing countries, and these same diseases account for more than 90% of the 13 million child deaths each year (UNFPA). These diseases include illnesses like malaria, bilharzia, diarrhoea, typhoid, cholera and dysentery.

Clean, safe water and sanitation

A large proportion of the world's population, most of it in developing countries, has no secure access to clean, safe water. An even larger proportion has no or inadequate sanitation. Without water, people die in a few days from dehydration. Life expectancies are lower and death rates higher in areas with poor water and sanitation. Many people in the world, especially in developing countries, have water but still suffer because of its poor quality or irregular quantity. Many people, most often women and children, spend hours every day fetching and carrying water which is unsafe, simply because it is their only supply and without it they would die. There are ways and means of making water safe, some of which are listed in the following pages.

The Goreangab Dam near Windhoek is seriously polluted because it is linked to the city's storm water runoff system. Water from the dam is not fit for human consumption

Very often, when it comes to the issues of water and sanitation, most of the emphasis has been placed on developing systems that serve the financially better off - providing them with clean, piped water and removing waste by expensive sewerage networks for treatment in sophisticated and costly sewage plants. This form of sanitation is simply not achievable on a larger scale, and increasing attention is being paid to low-cost, appropriate technology solutions to the sanitation problem. More than 1 700 million people worldwide have no form of sanitation, not even a bucket latrine. As sanitation plays such a large role in the transmission of dangerous diseases, this problem is one that urgently requires a solution.

In the rural areas especially, most water is collected by women. Fetching water is a strenuous and time-consuming activity, and in many instances takes time and energy that could better be spent elsewhere in improving living standards. Carrying heavy loads of water over long distances also takes its toll on the health of the women concerned.

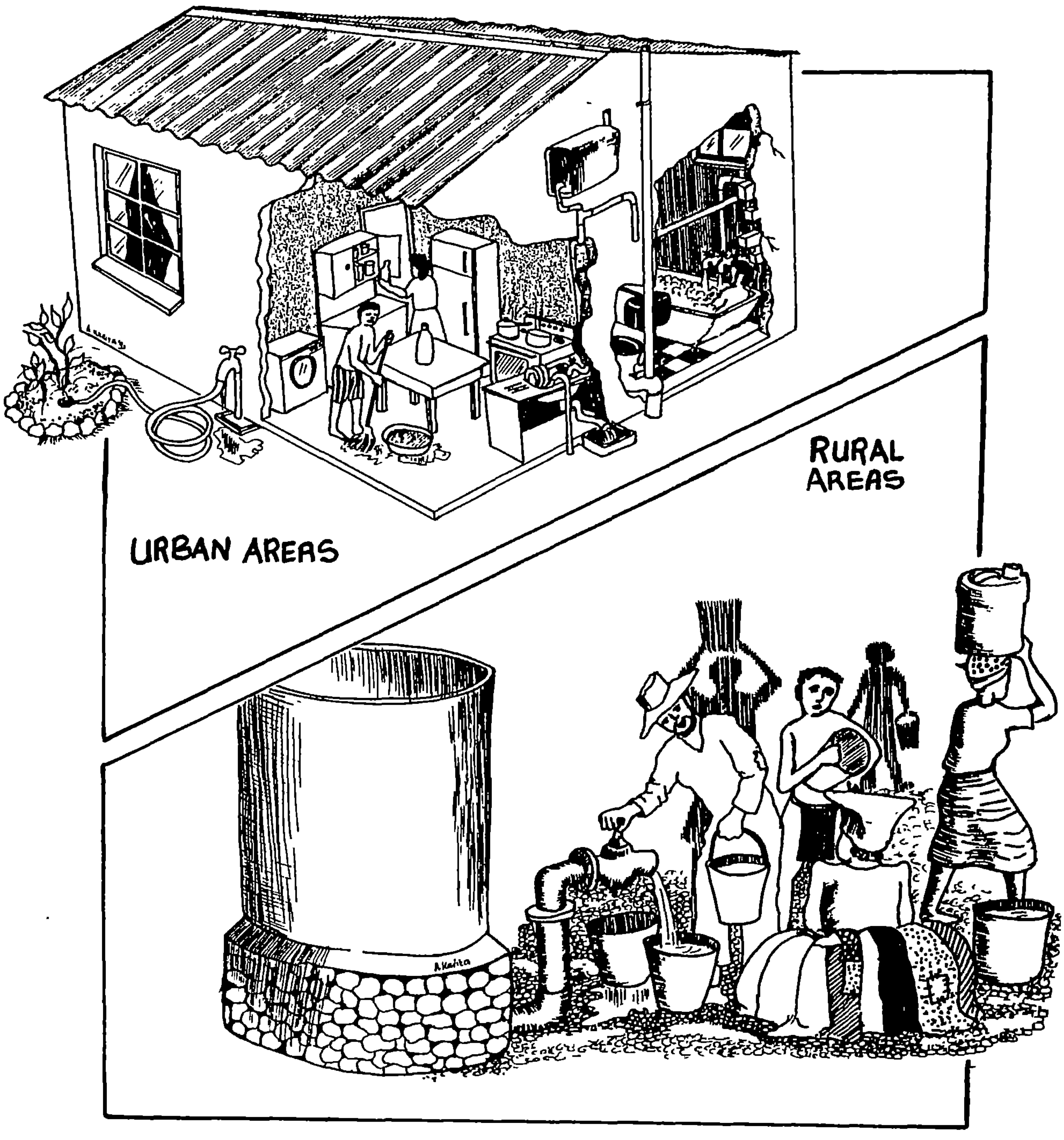
Water and sanitation pose a grave problem in Namibia. Fifty three percent of Namibia's population has no secure access to clean water, and seventy seven percent has inadequate sanitation.

Water and sanitation: urban/rural coverage worldwide		
	Urban	**Rural**
% total population	30/35	65/70
% with adequate water supply	74	39
% with adequate sanitation	52	14

Source: WHO, 1986

As you can see from the table, living in an urban centre does not guarantee you access to safe water or good sanitation. Sophisticated water and sanitation systems established in towns are extremely expensive to maintain and expand, and often do not reach poorer or newer urban inhabitants.

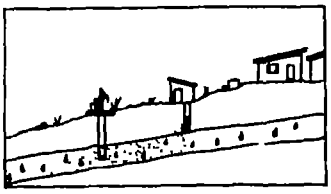
There are no short cuts to improved health. Vaccinations and insecticides are of limited value, but lasting results can only be achieved with the introduction of satisfactory systems for water supply, waste water disposal and sanitation, together with good and relevant health education programmes.

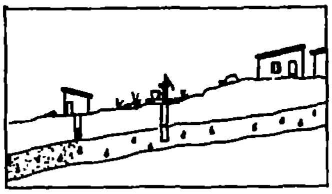


It's all about clean water...

Not only is not having enough water a problem, but having water that is polluted or contaminated or dirty can be a very dangerous thing. More than 1 300 million people worldwide do not have clean water to drink.

- Water from taps is usually safe to drink, having been treated at its source.
- Rainwater is pure and safe to drink, but if collected from roofs or any other surface, it may be contaminated and polluted by bird droppings and dust containing harmful organisms, dust from factories containing dangerous chemicals and dust from fields and roads containing lead, pesticides and other poisonous chemicals.
- Surface waters are often not safe to drink untreated They may be polluted with human and animal waste, or with chemicals from industries, from fertilisers and pesticides used in agriculture.
- Groundwater is usually free from contamination, as the soil acts as a purifying filter. However, it may be contaminated from deep waste pits or latrines situated too close to the aquifer. If wells or springs are uncovered, dust





To keep your water safe, and clean, any latrines built should be situated at least 500m away from water sources, downstream according to aquifer flow

and dirt may enter them and thus contaminate the water.

- Clean water can be contaminated during transport from its source to the home or during storage. The cleanliness of your water is a very important thing, so always ensure that your water is protected. Containers used for storing water should have covers to prevent dirt, insects and small animals from entering the water. Water should either be poured from these containers to ensure that no contamination occurs or taken from the container with a long handled ladle so that the hand holding the ladle never touches the water. This ladle should be kept in a clean place.

Methods of making your water safe

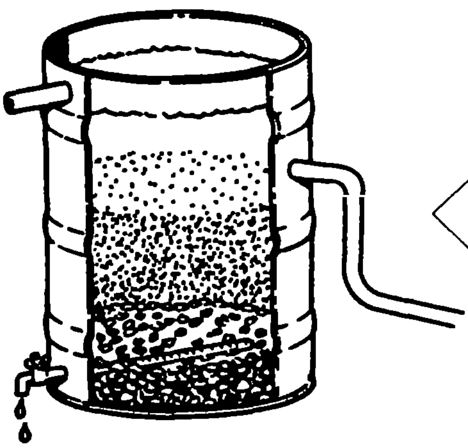
If people don't have access to a safe source of water, there are several ways in which they can ensure that their water is clean and free from harmful germs and bacteria. Most of these are relatively cheap, quick and easy to perform - a small price to pay for safeguarding the health of yourself and your family.

Disinfection by boiling

This is the oldest and one of the most reliable methods of killing harmful organisms in water. Its biggest drawback is that it consumes fuel, and thus, in rural areas, may contribute to deforestation. It is also not practical for large quantities of water. Water disinfected in this way should be boiled for 10 minutes then left to cool and stored in appropriate, clean, covered containers until used.

Disinfection with bleach

One teaspoonful of any kind of unperfumed bleach such as Jik or Javel added to 20 litres of water will kill any germs within it. Stir the water to ensure the bleach is evenly distributed and then leave the water to stand overnight before using it. The bleach contains chlorine which kills bacteria and viruses. Remember to keep the bleach out of reach of children - undiluted bleach is dangerous.



Purification by sand filter

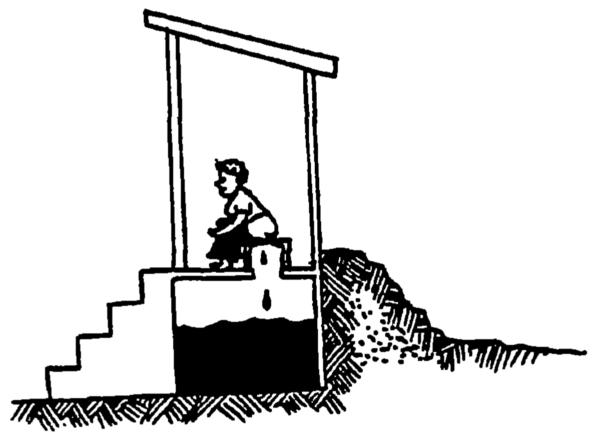
A fairly cheap sand filter can be built to clear water. A simple sand filter can be built with an empty metal drum. Fill it with a 5cm layer of clean gravel and a 60cm layer of fine, clean sand. There must be an outlet for clean water at the bottom of the tank. This water should still be boiled or treated with bleach before it is drunk. With regular cleaning every few months, a filter like this can provide a family with enough water to drink, wash and cook with for many years.

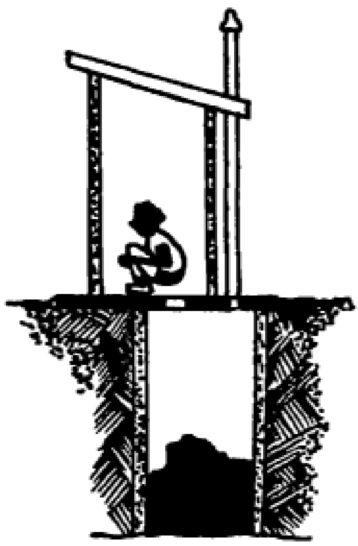
Pit latrines

The most common, low-cost sanitation system is the pit latrine, which, at its most basic, consists of a hole in the ground. Solid matter decomposes in the pit, and liquid percolates into the surrounding soil. If the pit is dug deep enough and the soil is firm, such latrines can last a very long time and can be quite satisfactory.

These latrines should be built at least 20 metres away from houses where people live, and at least 500m from their water source, including groundwater sources.

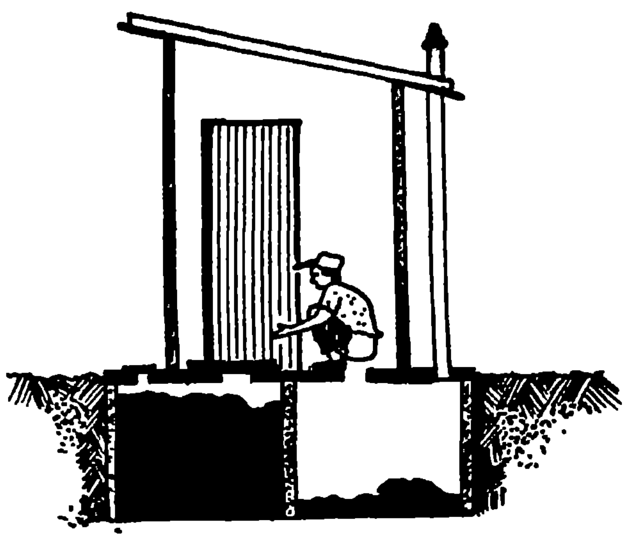
Where the groundwater table is high or where soil is very hard, it may not be possible to dig a deep pit. A mound with a pit in it can then be built to provide the necessary volume, and this is known as a mound or step latrine.





Bad smells, and the breeding of mosquitos and flies are common complaints about pit latrines. The ventilated improved pit latrine (known as the VIP latrine) goes a long way towards solving these problems. A vent pipe, extending about half a metre above the roof of the latrine is used, the top of which is covered with insect-proof netting. In this way, bad odours are prevented as are insects from using the pit as breeding grounds.

Sometimes latrines are built over two pits. When one is full, it is closed off and the other is used. After two years of not being in use, the contents of the pit are safe to handle with no danger of disease, and the full pit can be emptied and used again. The removed solids make very good fertiliser for fields.



Water-associated diseases

Waterborne illnesses and diseases linked to water kill many thousands of people a day throughout the world. These illnesses include diseases caused by parasites, such as malaria and bilharzia, and those caused by bacteria and viruses, such as cholera, typhoid and dysentery. Many of these illnesses are problems in Namibia.

Everyone needs water in sufficient quantity and adequate quality to lead a healthy life. Water is essential for good health, but also plays a major role in transmitting diseases. The most vulnerable group are children under five. Worldwide, around 25 million children under five die every year from water-associated diseases.

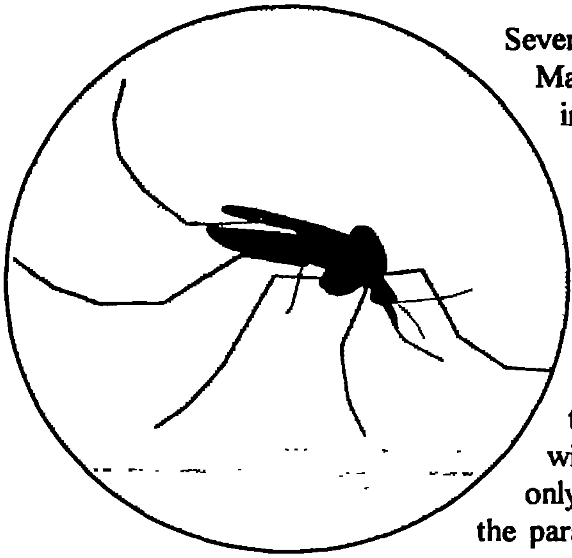
Methods of control of water-associated diseases include improving water quality, increasing water quantity and the provision of facilities for sanitation. Improved surface water management, an improved health service and education in the ways and means of disease transmission and prevention could also make a substantial contribution to combatting these harmful diseases.

Water-associated diseases can be divided into four main groups

Waterborne The pathogen (disease-causing organism) is carried in water and infects people once it has been swallowed along with water. Examples of these types of diseases include cholera and typhoid. The spread of these diseases is affected by water quality and poor sanitation and hygiene.	**Water-washed** Lack of water for domestic and personal hygiene can lead to diseases of the skin, eyes and intestine. Trachoma (a disease which often leaves its victims blind), scabies and typhus are examples of this type of disease. These diseases depend on water availability, and, in the case of intestinal diseases, sanitation. Sometimes the pathogens causing these diseases are carried between people by fleas, ticks or lice.
Insect vector The disease is carried by insects that breed in or bite near water. Malaria is the most widespread and dangerous of these diseases. Diseases in this group depend on surface water management and the use of pesticides.	**Water-based** The pathogen that causes the disease spends part of its life in an aquatic host. The parasite that causes bilharzia which spends part of its life in freshwater snails illustrates this type of disease. These diseases are related to water quality or the presence of the aquatic host (in the case of the example, the presence of the right type of bilharzia snails).

Malaria

Malaria is one of the most widespread and dangerous diseases in the world. The current total number of people infected with malaria worldwide is about 240 million, and every year malaria kills one million people throughout the world.There are four important strains of malaria, the most serious of which, falciparum, is life threatening. This is the most common strain of malaria found in Africa, and most cases of malaria in Namibia are caused by this strain.



Several hundred Namibians die from malaria every year. Malaria is endemic in the north of our country, and has an incidence rate of 473 per 100 000 people in northern Namibia. It is the most common disease, among adults and children in Kavango, and 95% of the region's inhabitants have suffered from it at one time or another.

Malaria is a disease caused by a parasite and not by a bacteria or virus. This parasite has a complex life cycle, reproducing sexually only within *Anopheles* mosquitoes, and needing to spend the asexual phase of its life within a human host. Not all mosquitoes carry malaria, only those *Anopheles* mosquitoes that have been infected by the parasite. When a mosquito carrying this parasite bites a person, several thousand of these parasites are released into this person's blood. These parasites invade red blood cells and reproduce within the cells themselves. Having reproduced they burst the cells and move on to new cells to repeat the process. This destruction of blood cells and the release of the parasite's toxic waste products into the bloodstream are the cause of the fever and other ill effects associated with malaria. If a mosquito should bite a person with the parasite in their blood, it takes in the parasites along with its blood meal and the cycle begins again when the mosquito bites another person.

Common symptoms of malaria are chills alternating with fever and bouts of nausea and headache, followed by profuse sweating and accompanied by backache. The signs of the disease are anaemia and enlargement of the spleen.

Preventive measures include window screens and use of mosquito nets over beds as well as wearing long sleeved shirts and long trousers and staying indoors after sundown where mosquitoes bite at night. Mosquitoes need only a very little water for breeding, so making sure there are no containers holding open water (for example, old tins or discarded car tyres) around your home can stop mosquitoes breeding near where you live and will cut down on the number of mosquitoes present to transmit malaria.

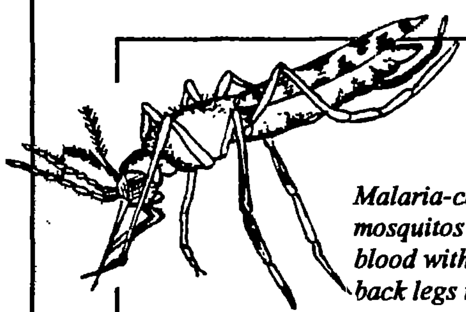
There is no vaccine for malaria. Certain drugs, taken regularly, offer some protection against malaria. These are good for people spending brief periods in malarial areas, but of limited use for people actually living in these areas. Over long periods they are actually harmful and can damage your health. They are also expensive. Another problem with these drugs is that the malaria parasite can become immune to them after a while.

Does the mosquito thank you for your blood? - Swahili

Drugs work against the parasite while pesticides are used to control mosquitoes. These pesticides can cause problems as well as help to solve them. Some pesticides are harmful not just to mosquitoes, but also to other animals and to people. Indiscriminate use of pesticides can have far reaching effects on the ecology of an area and on the health of its inhabitants. Mosquitoes are also capable of developing resistance to pesticides. Pesticides that mosquitoes are resistant to will no longer kill the insects. In 1981 the World Health Organisation reported that 51 species of mosquitoes have developed resistance to one or more insecticides - 34 to DDT, 47 to Dieldrin and 30 to both.

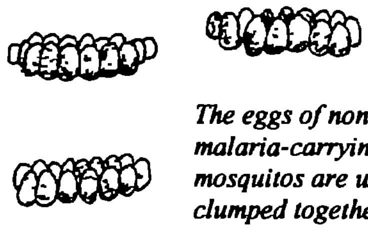
Malaria-carrying mosquitos

The eggs of malaria-carrying mosquitos float separately

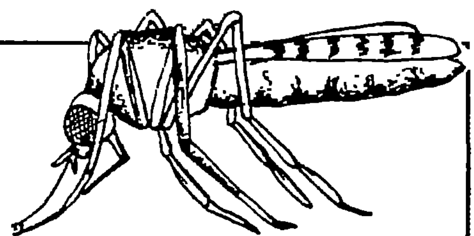


Malaria-carrying mosquitos suck blood with their back legs in the air

Non malaria-carrying mosquitos



The eggs of non-malaria-carrying mosquitos are usually clumped together



Non-malaria carrying mosquitos keep their legs down when feeding

DDT - Helpful friend or dangerous enemy?

DDT is an organochlorine pesticide commonly used in the fight against malaria to eradicate mosquitoes. However, one of DDT's more disturbing properties is that it breaks down extremely slowly and accumulates in organisms that come in contact with it. Because it does this, anything that eats these organisms accumulates the DDT that is in these organisms, and the higher up the food chain you go, the more concentrated the DDT is. DDT accumulates in the body fat of vertebrates, including humans, who are, after all, part of many food chains. For example, even years after exposure to the poison, a lactating woman may have DDT in her breast milk which she will then pass on to her child.

The threat that DDT can pose is illustrated by the example in the box below. However, with careful control and management DDT can be of use in combatting malaria, and any risks from exposure must be carefully weighed up against the risks posed by malaria.

A cautionary tale...

A certain area in Borneo was plagued by mosquitoes and houseflies. To try and get rid of these pests, the area was sprayed with large quantities of DDT. Local geckoes, which depended on these insects for food, continued to eat their poisoned corpses. The dying geckoes were caught and eaten by house cats. The DDT had now been concentrated as it passed from fly, to gecko, to cat, and the cats died. The people of the area were now faced with a new plague - rats. Not only did the rats eat people's food, but they carried the threat of bubonic plague.

Amount of DDT used in Namibia for malaria control and number of houses treated				
Region	*No. of houses treated*		*Amount of DDT used (kg)*	
Year	1986/7	1987/8	1986/7	1987/8
Kaokoland	1 418	2 343	163	285
Owambo	565 773	582 779	41 700	27 525
Kavango	74 794	72 727	7 698	8 148
Caprivi	34 860	30 762	5 055	4 796
The rest	23 406	10 152	1 779	720
Total	**700 257**	**698 763**	**56 395**	**41 472**

Source: Namibia's Green Plan

Natural alternatives

In the past, no modern pesticides were available to combat mosquitoes, yet people still had ways and means of preventing mosquito bites. One way to do this was to use a plant with a smell that kept mosquitoes away. This plant is called *egwanga* in Oshiwambo, *omutungavimbara* in Otjiherero and *engamwe* in Rukwangali. Traditionally it was cut and kept in people's homes to keep mosquitoes at bay.

Other plants, when burnt, have a scented smoke that also discourages mosquitoes. In Oshiwambo these plants are known as *etselyakuku*, *omadimba* or *onghundu*. They are called *donki lhoron* or *lgaubab* in Damara and *siloko* in Lozi. Many of the traditions of our ancestors are of great worth and can help to solve today's problems. Are any other traditional methods of avoiding malaria used in your area?

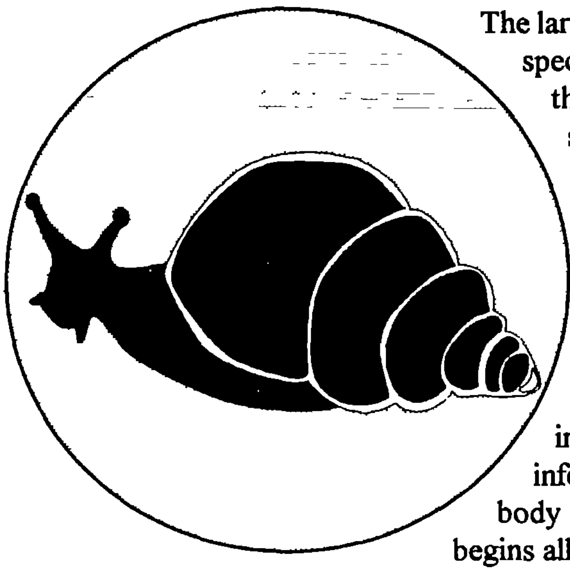
Avoid malaria without DDT

Measures that help to prevent the spread of malaria include many that help people avoid being bitten by mosquitoes. These include:

- mosquito nets
- wearing long sleeves and trousers in the evenings
- keeping clear of damp areas, marshes and reeds
- mosquito gauze on windows
- sprays, lotions and mosquito coils.

Bilharzia

Worldwide, an estimated 200 million people - the equivalent of the population of the United States of America - are affected by bilharzia or schistosomiasis as it is sometimes known. Many Namibians in the far north of our country are affected by this disease.



The disease is caused by parasitic flatworms known as schistosomes. The larvae of these flatworms develop within the body of certain species of freshwater snails. It is the parasite, and not the snails that gives people this disease. When people expose themselves to these parasites by swimming or walking through water in which infected snails live, the parasites bore into people's skin and enter their bloodstream. The parasite then lays its eggs within the human body. The female worm, about a centimetre long, lays several hundred eggs at a time. It is these eggs that do the damage - their number alone is capable of harming the human tissues they are laid in. Often these eggs are laid in either the intestines or the bladder. They are then excreted by the infected person, and if this excretion takes place in or near a body of water containing the right type of snails, the process begins all over again.

The snails that carry bilharzia prefer slow moving water with plenty of water plants in it. Avoid swimming in or walking through this type of water if you live in a bilharzia area. Another effective way of controlling bilharzia is sanitation systems that eliminate urination and defecation in or near rivers, ponds, lakes, dams or other sources of water.

Dams and irrigation canals are often the ideal habitats for bilharzia-carrying snails, and with the establishment of more and more of these kinds of structures this disease is spreading. Good sanitation is one part of controlling the disease, but other measures, listed in the box below, will also help to stop the spread of this debilitating disease.

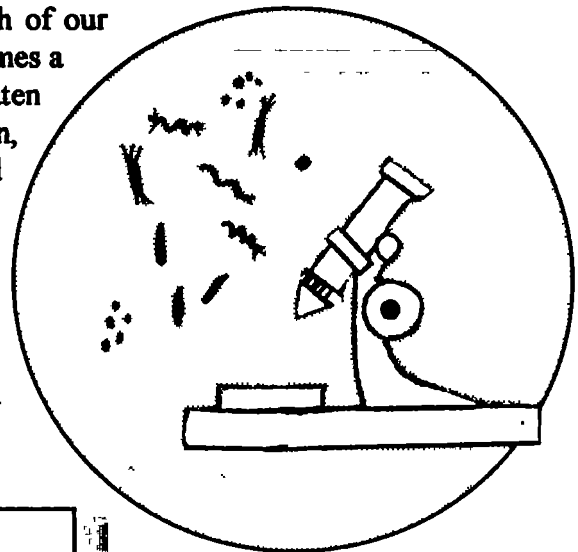
Protect yourself against bilharzia

- Stay away from water which may contain bilharzia parasites and organisms which may cause other sicknesses.
- Make water safe for drinking or washing in by boiling the water or by leaving it to stand in a covered container for one day and one night. Bilharzia parasites only live for about 24 hours, and by the time you use the water they will be dead.
- Clear reeds and weeds away from places where people collect water. This will stop bilharzia snails from living there. Wear protective clothes and boots when you do this.
- Use proper toilets. Prevent other people from using the water or land near the water as a toilet.
- Spread the message about the dangers of bilharzia and how to prevent it.

Diarrhoea

Diarrhoea is one of the leading causes of death among Namibian children under five. This is mostly due to the fact that diarrhoea causes dehydration. Most children who die from diarrhoea actually die from dehydration.

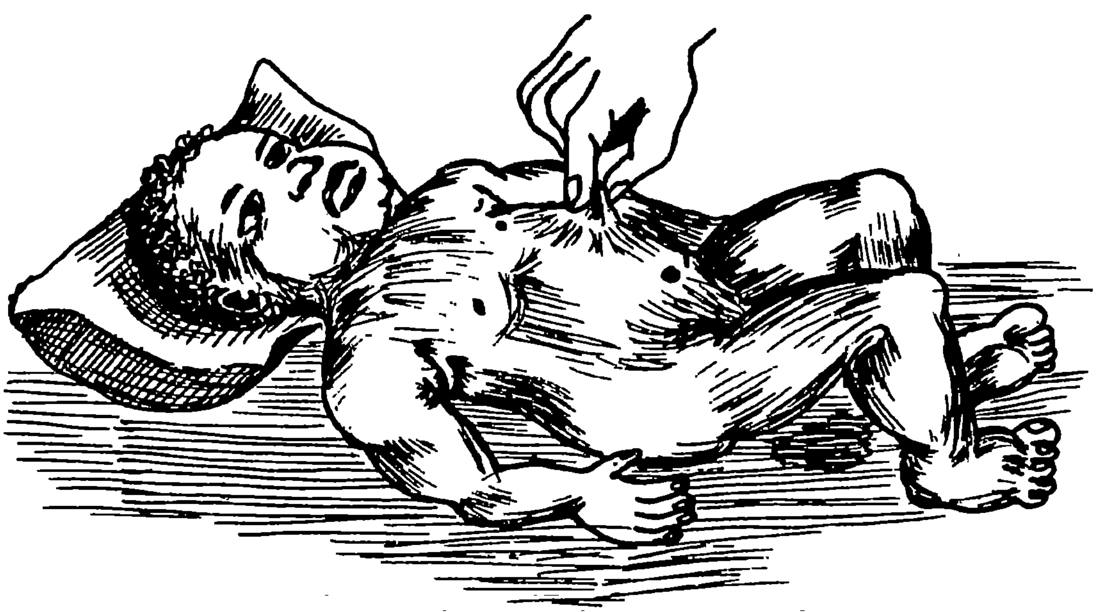
Diarrhoea is associated with lack of adequately protected water supplies and appropriate sanitation facilities. In much of our country children suffer from diarrhoea about 8 or 9 times a year. Repeated attacks of diarrhoea not only threaten children's lives, but can cause or aggravate malnutrition, thus stunting children's growth both physically and mentally.



The biggest danger of diarrhoea is that of **dehydration**. Dehydration occurs when the body loses more liquid than it takes in. People of any age can become dehydrated, but dehydration develops most quickly and is most dangerous in small children.

6 signs of dehydration:

- little or no urine; the urine is dark yellow
- sudden weight loss
- dry mouth
- sunken, tearless eyes
- loss of skin elasticity
- a sunken "soft spot" or fontanelle on a young baby's head



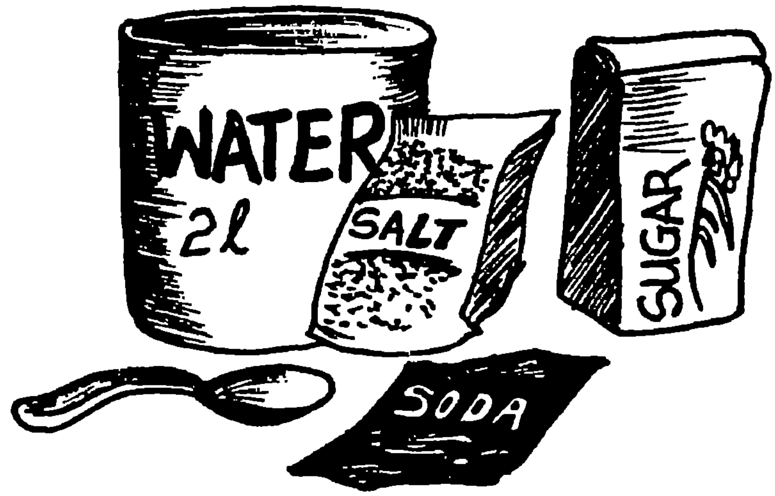
To test small children for dehydration, lift the skin between two fingers like this. If the skin fold does not fall right back to normal, the person is dehydrated

Rehydration treatment for diarrhoea

Prevention is better than cure, but this simple remedy can help save lives!

In 1 litre of boiled, cooled water put:

2 level tablespoons of sugar or honey
¼ of a teaspoon of salt
¼ of a teaspoon of bicarbonate of soda (baking soda). If you do not have soda, use another ¼ of a teaspoon of salt.



Before giving the drink to someone dehydrated, taste it. It should be no more salty than tears. If available, add half a cup of orange juice or a little mashed ripe banana to the drink. This helps to replace the potassium that the sick person has lost.

Give the dehydrated person sips of this drink every five minutes, day and night, until they begin to urinate normally. A large person needs 3 or more litres a day of this liquid when they are sick, and a small child at least 1 litre or one glass for each watery stool. If a baby is being breastfed, continue to feed it often and supplement this with teaspoons of rehydration drink.

Other waterborne diseases

Cholera

The relationship between cholera and inadequate water and sanitation is well known. The disease is caused by a bacteria which is very easily spread through water contaminated by the faeces of an infected person. Good sanitation is required to eliminate this disease.

Many people can carry the disease of cholera but show no symptoms. These people can then infect others who may be more sensitive to it. Cholera is a common infection but a fairly rare disease. However, it is a very dangerous disease, and people who develop the symptoms of cholera often die. It can spread very quickly and whole communities using the infected water source may become sick. In a person who shows the symptoms, cholera causes severe diarrhoea and vomiting, with the affected person losing body fluids at an alarming rate. If these are not replaced very rapidly, the person may die of dehydration. The same rehydration drink used to treat diarrhoea can be used to replace lost fluid. If you live in an area where cholera is a threat, try to stop it by treating your water and always washing hands and food in clean, safe water before eating.

Typhoid

Typhoid is another dangerous disease that can be carried by bacteria in faecally-contaminated water. Like cholera, it can infect whole communities. Typhoid often starts when people have water problems, such as a drought or a flood, or when people have been resettled in a new area without proper homes or toilets. When this happens it is difficult for people to keep clean and they often do not have enough water or a means of ensuring that it is safe. The first two weeks of typhoid are the most dangerous. In the first week the symptoms are usually flu-like, while in the second week fever and often delirium sets in. After this people slowly recover. To prevent typhoid, proper sanitation is necessary. Water should be treated to ensure that it is clean and it also helps to wash hands and vegetables in safe, clean water before eating.

Dysentery

Caused by either amoebas or by bacteria, dysentery can also be spread through impure water. It causes severe stomach upsets and cramps, and is particularly dangerous to infants and young children who may lose their lives through dehydration.

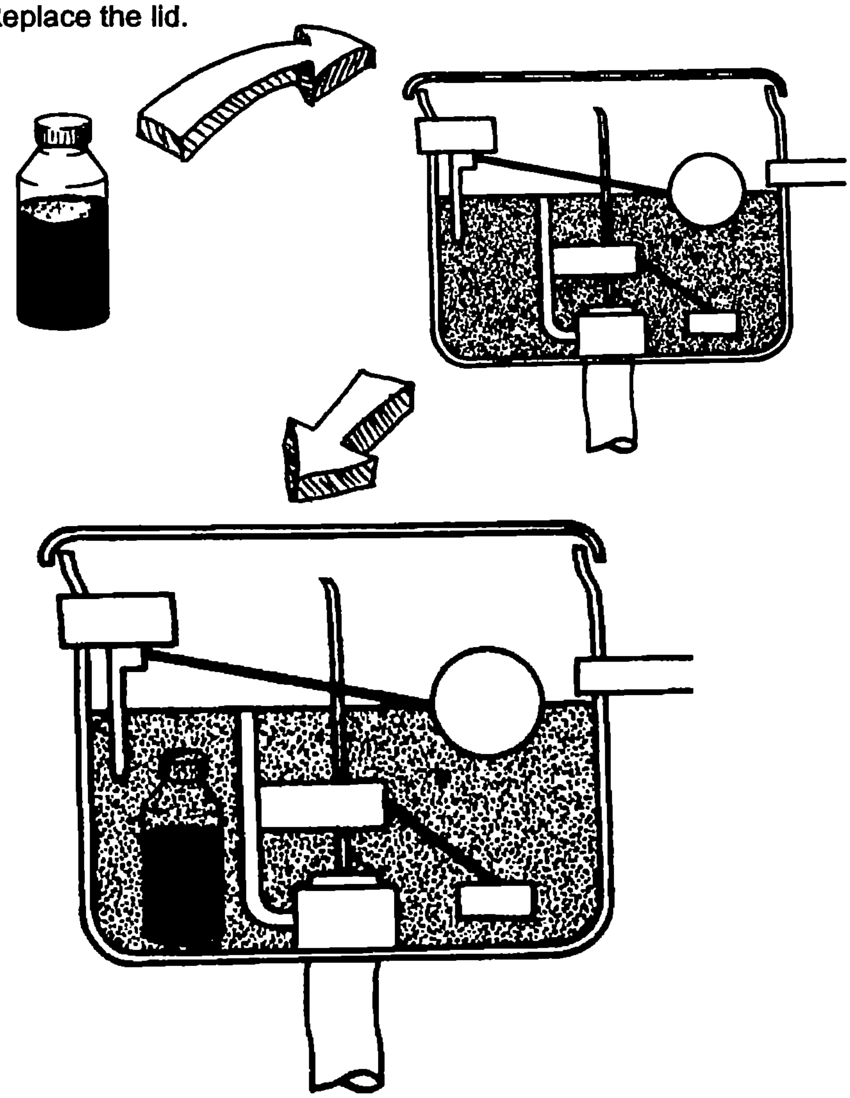
Things to do...

A toilet tip

For those of you who live in areas where there is waterborne sewage and there are flush toilets, here is a simple yet very effective way of conserving water. Instead of flushing up to 13 litres of water down the drain with each flush you can reduce the amount by 2 or more litres by placing a brick or bottle filled with sand in the cistern. If every household did this there would be a remarkable saving in freshwater in a place such as Windhoek.

You will need: *a plastic 2 litre bottle filled with sand and sealed (you can use a brick but some types tend to dissolve after a few weeks)*

1. Fill the plastic bottle with sand and seal it tightly.
2. Lift the lid of the cistern and place the bottle in a part of the cistern where it will not interfere with the moving parts.
3. Replace the lid.



Chapter 14 activities

1. Set the learners the task of choosing a way of purifying water for drinking. They then have to demonstrate it in front of the class as well as write a short set of instructions for people to use. Arrange for the learners to repeat their demonstrations to people in the community who do not have access to purified tap water.

1. What role has the distribution of malaria played in the colonisation of Africa?

1. Design and make a water filter that will remove dirt from water.

1. Study the life cycles of disease-causing parasites such as malaria and bilharzia. What stages of the life cycles are susceptible to drugs and how is knowledge of the different stages important in controlling the disease?

1. Are there any traditional medicines used to treat any of the waterborne diseases mentioned in chapter 14?

2. What plants are used to treat malaria? What traditional methods are used to prevent mosquito bites? Make collections of such plants and try to grow some of them in your school garden. Document where such plants occur near your school.

1. Design posters to hang in the local clinic advising people how to avoid bilharzia or malaria or how to make rehydration drink.

1. Conduct surveys in your area with regard to health and health awareness:
- how many homes have access to clean water and sanitation?
- how many people have had malaria?
- how many people take anti-malarial tablets?
- how many people know how bilharzia is transmitted?
- what are the most common ailments that children under 1 year of age suffer from?
- in how many instances are pit latrines less than 500m from water points or wells?

Devise programmes for creating awareness of health issues as part of the study.

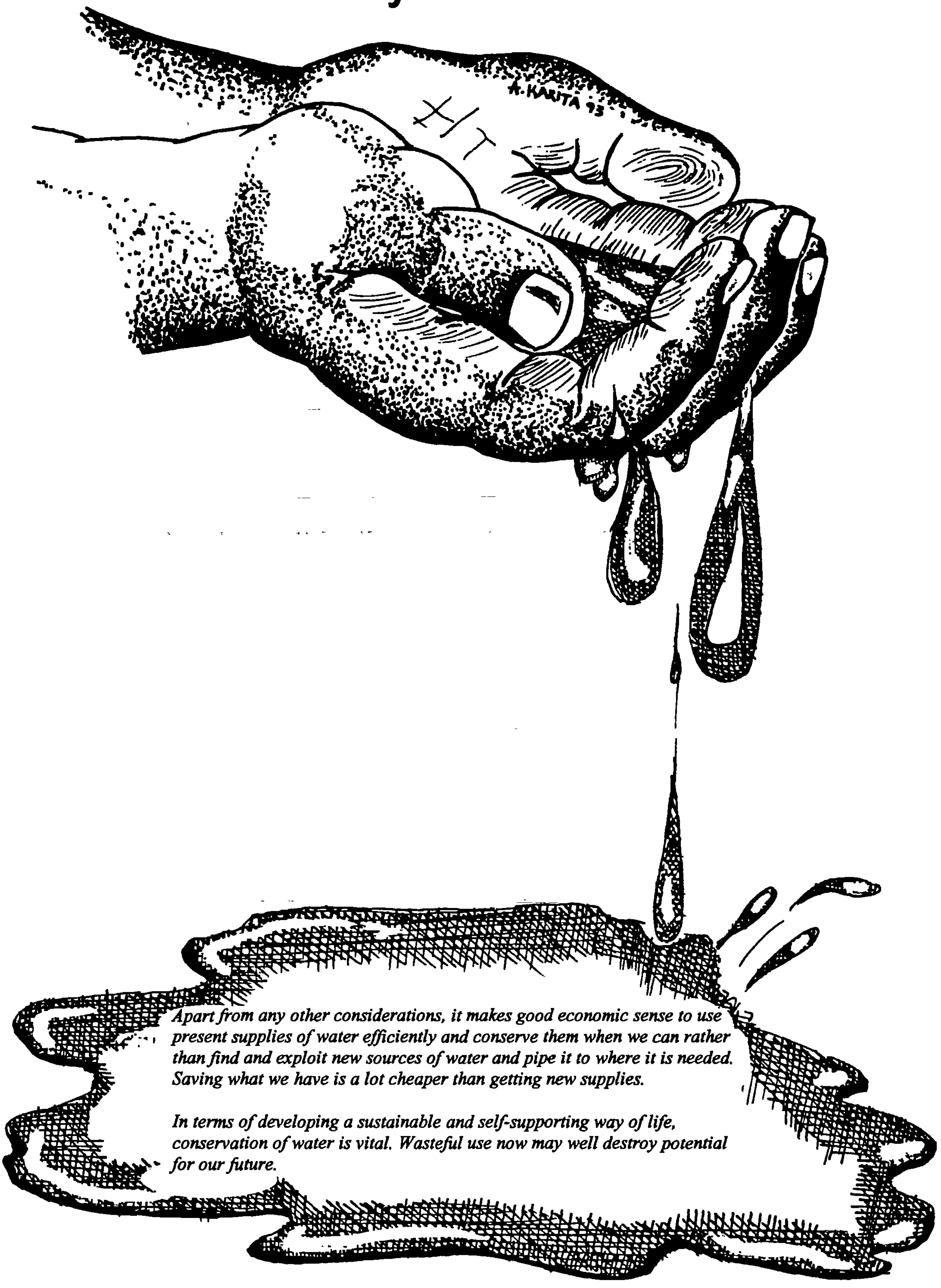
15

Conservation and sustainable use of water

Water is a scarce and precious commodity in many parts of southern Africa, and especially in Namibia. As demand increases it will have to be managed more and more carefully to ensure enough for all, including our environment.

In theory, water is a renewable resource, being constantly circulated and purified by the water cycle. But in many parts of the world, including our country, it is being used in an unsustainable way. Unsuitable agriculture, water pollution and mining of groundwater (abstraction faster than recharge is possible) are causing water problems today and could all add up to a possible future water crisis. And in an arid country such as Namibia, we should be doubly conscious of the threat. The time to start conserving our water is now.

Why conserve?



Apart from any other considerations, it makes good economic sense to use present supplies of water efficiently and conserve them when we can rather than find and exploit new sources of water and pipe it to where it is needed. Saving what we have is a lot cheaper than getting new supplies.

In terms of developing a sustainable and self-supporting way of life, conservation of water is vital. Wasteful use now may well destroy potential for our future.

Conserving water in agriculture

Agriculture consumes the lion's share of water in Namibia, and indeed, in the world as a whole. This is understandable and necessary - without agriculture the world would go hungry. However, the fact that agriculture forms the basis for our way of life does not give farmers license to use water wastefully and this is often the case. Unsuitable crops or livestock; inefficient and inappropriate irrigation schemes; fertilisers and pesticides that pollute our rivers and groundwater; and incorrect land management practices all cut deeply into our precious water reserves. There are ways and means of farming in a water-conscious way, and if these are practised they will result not only in conserving our water, but in taking a step towards a sustainable way of living.

Industrial conservation of water

As we develop economically, we should ensure that the industries that are built up use their water efficiently. Industries that exist already should also be pressurised to reduce wasteful use of water. Industries can either use recycled water or be redesigned to use and waste less water. Industries can make far better use of recycled or partly purified water than households can because many industrial processes can use water that is not of drinking quality. Industries near the coast should look carefully into using seawater for processes that don't require freshwater. Small scale desalination is also a possibility, with each factory being responsible for desalinating the water they require. Industrial pollution of water should be avoided at all costs and the amount of water polluted by an industry taken into account when looking at its overall water efficiency. A good idea would be to make industries responsible for treating and cleaning any water they contaminate.

Conserving water on a domestic scale

It is sad but true that the more water there is the more water people tend to use. Water use depends firstly on availability and secondly on standard of living. The table below illustrates the rise in water consumption that accompanies the increase in availability and the rise in living standards. For this table, a household comprises a family of four.

Domestic use of water according to water source	Litres per person per day	Litres per household per day
Absolute minimum required for health (drinking, cooking, washing hands) - nearest source 15km away, no transport	3	12
Nearest source 1km away - no transport (any washing done at source	5	20
Water in village or water tank near house	10	40
House with tap and shower only	50	200
Full sanitation (bath and toilet), no garden	175	700
Household with appliances such as dishwasher and washing machine (no garden)	-	1150
As above, and with garden and swimming pool	-	1550

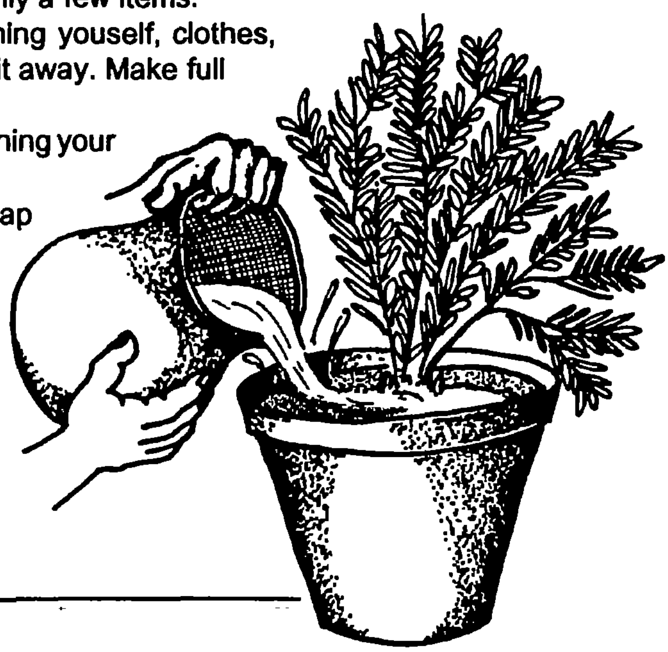
Source: *The biology and conservation of South Africa's vanishing waters.* B R Davis and J A Day

Taken from: *The Namibian* 18 April 1995

Hints for household saving

The following hints will not only save water, but also cut dollars from your monthly water bill. Many of these hints apply to urban households or households with piped water. If you live under different circumstances it is just as important and equally helpful to your country and environment to conserve water whenever possible.

- Find and fix leaks. You can check whether you have leaks in your system or not by switching off all taps in your household and seeing if the water meter is still running. If it is, you have a leak. Rural water supplies often have visible leaks. These should be fixed as soon as they are noticed or huge amounts of water can be wasted.
- Do not leave taps running longer than you need to. In some areas taps are left running all day to provide water for livestock. Huge amounts of water are lost in this way.
- Stop taps dripping. If you cannot switch them off completely then they need a new washer. Washers are cheap and easy to install. A dripping tap can waste up to 60*l* a day, which adds up to 1800*l* in a month.
- If you live in an area where water is supplied by pipeline, do not break or damage the pipeline in any way. Not only does this waste water but it also means that people further down the pipeline do not get any water.
- Shower, rather than bathing. A full bath takes between 150 and 200*l* of water. The average 5 minute shower requires only 40*l*. If you are bathing, the bath should not be filled to a depth greater than 100mm (10cm). More than one person can use the same bath water.
- You can reduce the amount of water used in a flush toilet by placing a brick or one or two water-filled plastic bottles in your cistern.
- If you are using washing machines or dishwashers, only switch them on once you have a full load. The same amount of water is used whether you wash a lot or only a few items.
- If the water you have used for washing youself, clothes, food or dishes is not too dirty, don't throw it away. Make full use of it on plants, etc.
- Don't leave the tap running while brushing your teeth or shaving.
- Do not rinse dishes under a running tap - it is more economical to fill the sink and rinse them in there. Try to save your dishes to wash together rather than washing up five or six times a day.
- Do not use a hosepipe to wash your car. Rather use a bucket and sponge.
- Use water-efficient methods of cultivation in your garden.



How to read a water meter

Below is an example of a water meter in use in Namibia.

1 m^3 is equal to 1000*l* and this will show as one unit on your bill for water.

To find out how much water your household is consuming, take a reading from your water meter. Wait for a few days and take a second reading at the same time of the day as you took your first one. Then subtract the first reading from the second one and divide the number you get by the number of days you have waited. For example, if your first reading was 23659,87 and your second, four days later, was 23667,50, then your calculation would look like this:

23667,50 - 23659,87 = 7,7units used in four days

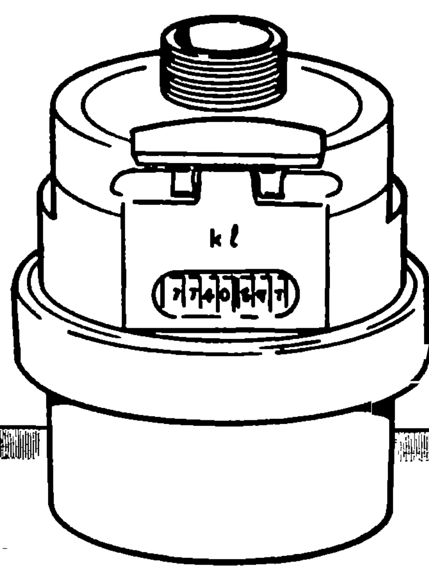
therefore 7,7 ÷ 4 = 1.925 units in one day

but one unit is equal to 1 m^3 and 1 m^3 is equal to 1000*l*

therefore 1.925 units is equal to 1925*l*

Thus, your family uses almost 2000*l* of water a day - and is obviously not very conservation-minded!

Reading your water meter regularly will help you keep track of how much water you are using, and will help you to see the effect of any water-saving measures you might put into practice. Why not keep a special book in which you record your household's water use and the things you do to reduce it?



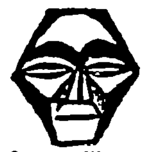
Learning to live within Namibia's limits

The Namibian Department of Water Affair has drawn up a list of 'water demand norms' on which they will base their future water supply schemes.

Namibian proposed water demand norms	
Consumer	**Norms (litres per day)**
Clinic out-patient	30
Clinic as a whole	1 000
Clinic per bed	300
Hospital per bed	500
School per pupil	15
School (or other) grounds per ha	30 000
School hostels per resident	100
Low income houses per house	500
Middle income houses per house	1 000
High income houses per house	2 000
Low income individuals	60
Middle income individuals	150
High income individuals	400
Public stand pipes per person	25
Largestock units per animal	45
Smallstock units per animal	12

Source: Department of Water Affairs

The United Nations estimates that 15 litres of water per person per day is the basic minimum for survival and health. Many of the Namibian norms are way in excess of this figure, especially those for middle and high income households and individuals. While it is true that rising standards of living often go hand in hand with rising water consumption, Namibians should stop to consider whether rising living standards demand wasteful use of water. Many countries in the world, most of them with greater water resources than those possessed by Namibia, have much lower norms of water demand for these categories. Can Namibia afford to support such wasteful lifestyles or could our country's precious water be put to better use?



A frog will never realise the importance of water until drought comes - Rundu

Water in Namibia is very cheap in our cities. 1 000l costs just 80c! Compare this to the price of softdrinks. These are 2 000 times the price of water. Can you run a nation on soft drinks? Are we paying the true worth of water?

Namibia's options for increasing water supply

Recycling water - waste not, want not

Windhoek is world famous for its use of recycled water. The Stander Recycling Plant near Windhoek has a capacity of 2,2Mm³ a year and provides 6% of Windhoek's water. Plans are being made to increase its capacity. In Swakopmund a small recycling station produces water that is used to water plants in public parks. Rössing Mine, near Swakopmund, recycles the water used in treating uranium ore, producing water that is suitable for industrial purposes.

The first Namibian water distillation plant was built in Lüderitz in the 1890's. It supplied this coastal town with fresh-water disilled from seawater.

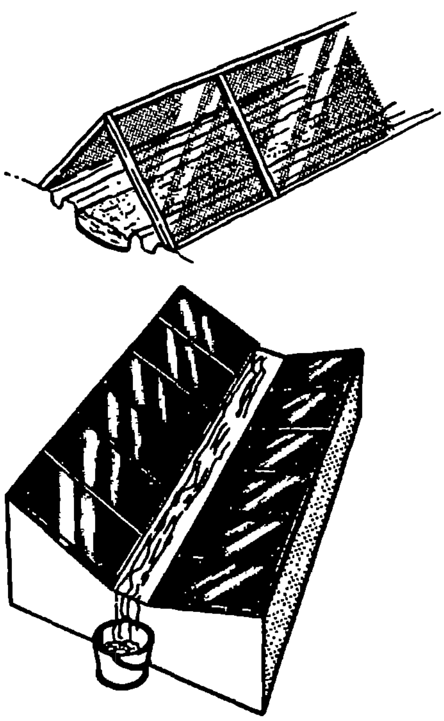
All the water that we use has already been used thousands of times before, rejoining the water cycle and being naturally purified on its progress. Recycling by people can only salvage one quarter to one third of the water being processed depending on the efficiency of the recycling plant. Still, this can make a substantial contribution to our water supplies, and as time passes perhaps more efficient ways of recycling our water will be discovered.

On a smaller scale, we can recycle water in our homes and gardens. Water can sometimes be used twice. For example, rinsing water can be saved and used to water plants.

Desalination

Desalination - removing dissolved salts from seawater or brackish groundwater - is one possibility for increasing available freshwater supplies. The process is still fairly expensive and impractical on a large scale, but as the need for water increases it will become increasingly attractive.

Simple solar stills



There are two main ways of removing the salt from water - **distillation** and **reverse osmosis**.

Solar distillation, which entails water being evaporated by the sun and then condensed, leaving the salts behind, is perhaps the most practical option in our sunny country. Solar distillation is already being used on a small scale in many parts of the country and can provide a reliable source of good drinking water for people living where the groundwater is very brackish.

Reverse osmosis is a very promising process. Natural osmosis occurs when water passes through a semi-permeable membrane from an area where less salts are present to a saltier solution. This process is used by plants to take up water from the soil. In reverse osmosis, pressure is applied to the saltier solution, which forces freshwater back through the membrane, leaving salts trapped behind.

Desalination of seawater might seem like the solution to all our problems, but there are drawbacks. Not only is the process expensive, but it leaves behind it large amounts of brine which must be disposed of in an ecologically sound way. However, salt is an important export commodity in Namibia and desalination may help increase our capacity for salt production. The cost of piping water from the coast inland is also tremendously high. However, for coastal towns short of water, desalination could offer a valuable means of survival.

In the 1990's, desalination only produces 0.1 % of the world's total water use.

Things to do...

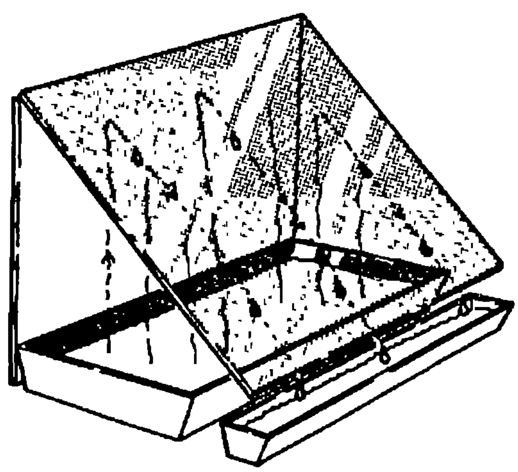
Make a simple solar still

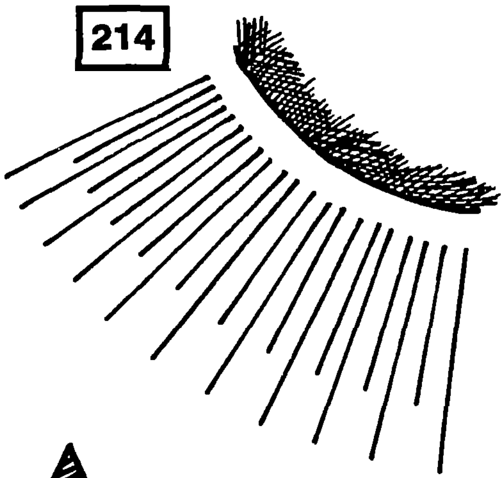
A simple and cheap solar still can be built to demonstrate the principle of desalination of water. There are a number of models that you can construct but the most important features of the model are that: it should have a pan or container to hold the salty water, a collection pan, and a piece of plastic or glass to provide a surface that water vapour can condense on. Remember to paint all surfaces except the glass or clear plastic black to increase the heat absorptivity of the solar still.

For the solar still shown in the picture you will need:

1 evaporation dish/pan
1 collecting dish/pan
a sheet of glass
a piece of cardboard or wood, painted black
Sellotape
water
salt
Food colouring

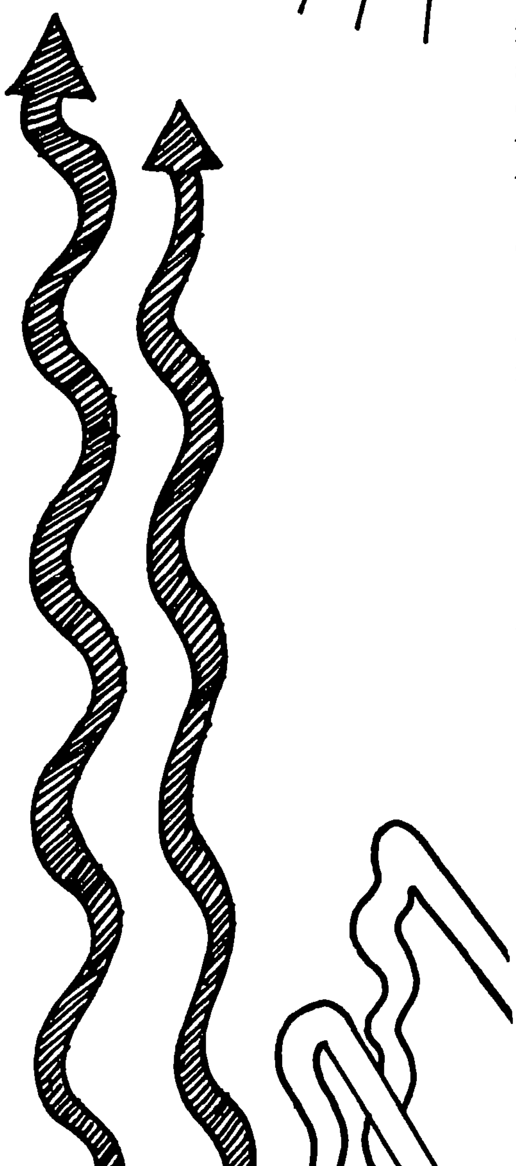
1. Dissolve 4 teaspoons of salt in water and pour into the evaporation dish. Taste the water.
2. Add a few drops of food colouring to the salty water.
3. Set up the apparatus as shown. Manipulate the different pieces so that water will be collected in the collecting pan and not run back into the evaporation dish.
4. Make sure that the still stands in full sunlight. Leave the still in the sun for a few hours.
5. Check the water that has collected in the collecting dish. Taste it. Is it salty? Is there food colouring in it?





Cutting losses through evaporation

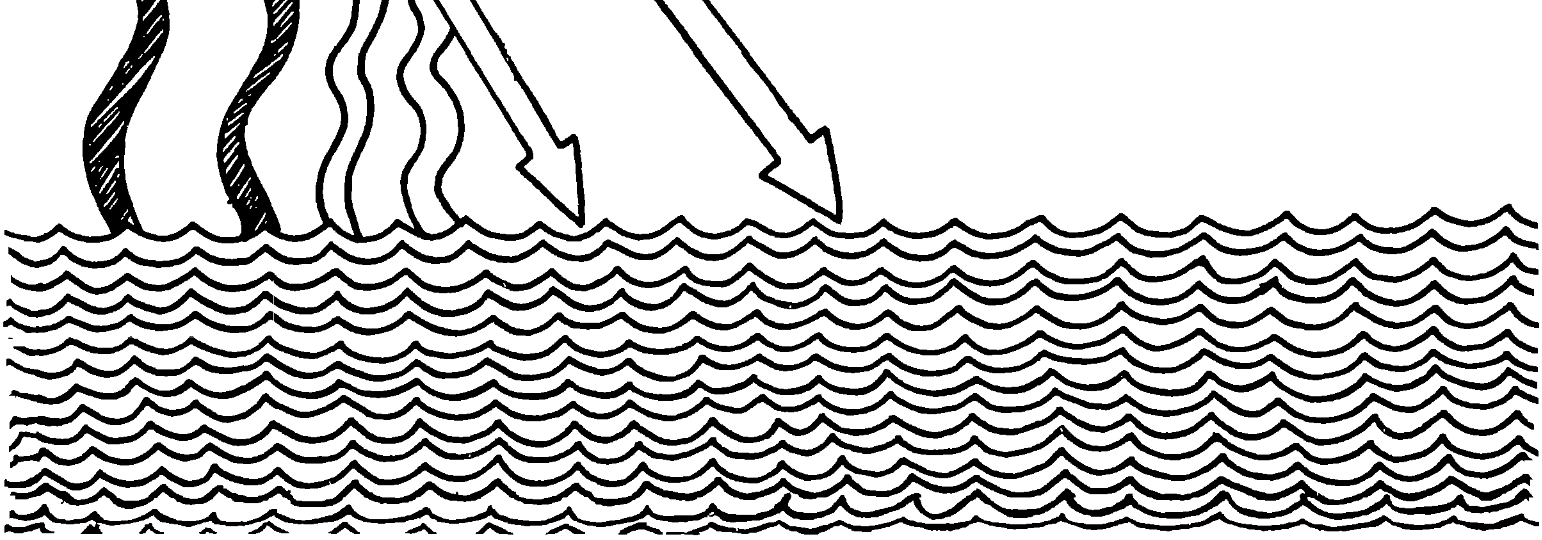
In areas with a high rate of evaporation, huge amounts of water can be lost from the surfaces of dams, reservoirs, pools and ponds. In fact, the losses through evaporation often exceed the amount of water actually used. Reducing evaporation is an important way of increasing the available supply of water. Controlling evaporation also lessens the concentration of salt in the water, as when water evaporates it leaves the salts it contains behind, and water bodies that have lost a lot of water through evaporation are far saltier than the water that originally filled them.



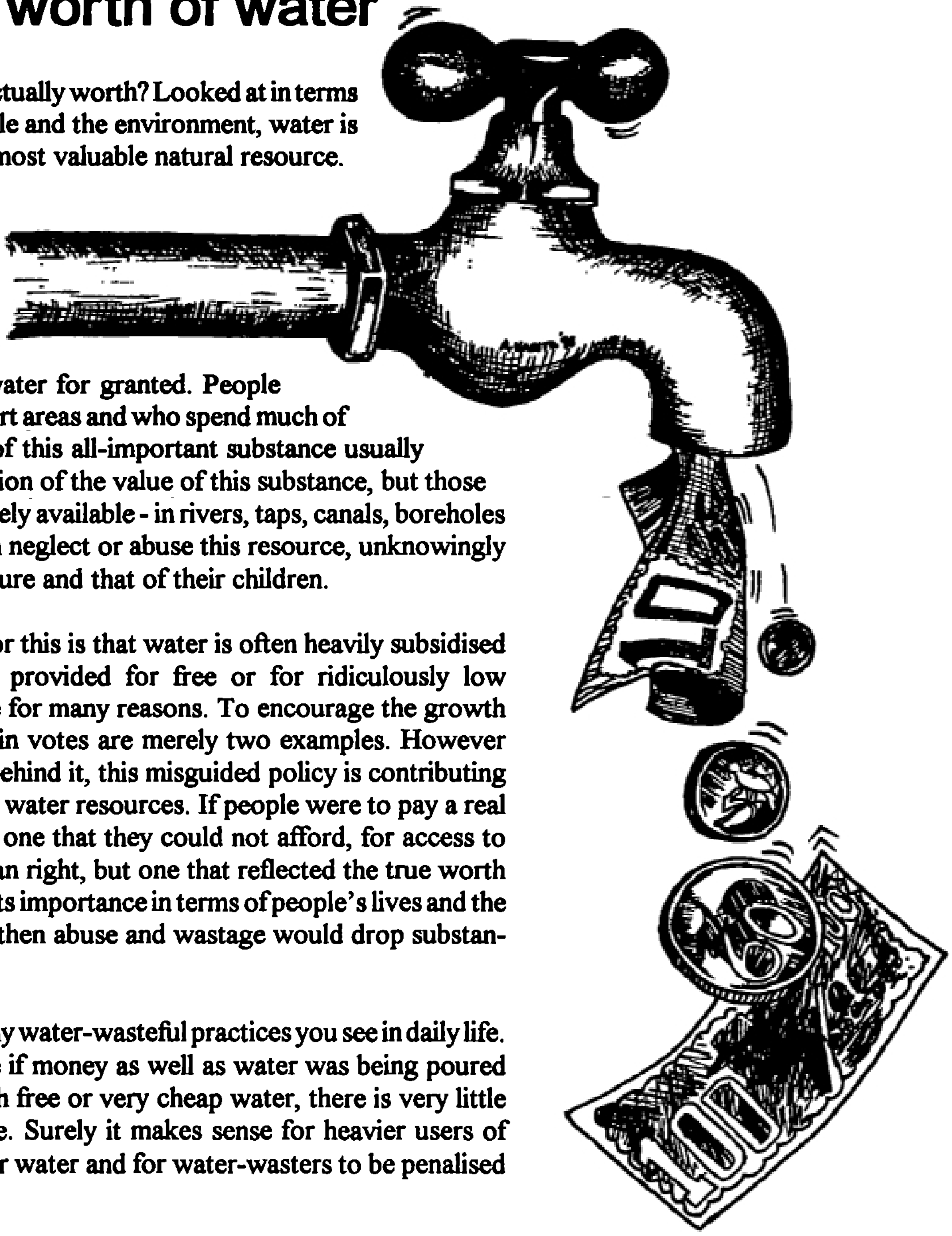
The most effective way of reducing evaporation is to cover the surface of water. This is possible and works well for small reservoirs and can reduce evaporation by 80 to 90%. Unfortunately, it is impossible to cover larger dams and stores.

Sand dams, which are in use in many areas of Namibia, are a very effective means of preventing evaporation for fairly large amounts of water. Many other methods of preventing evaporation are being researched. There are certain chemicals that form a film over water surfaces, thus preventing evaporation, but use of this method is still very impractical. Other ideas being experimented with include floating blocks of wax on water. In hot weather these melt, forming a protective layer over the surface of the water. Floating other substances on water, such as thin concrete slabs, also helps to cut evaporation substantially. On small bodies of water it has been found that a floating layer of ping pong balls cuts evaporation by 80% by keeping the water cool as well as shading it from the sun!

Most of these ideas are still in their beginning stages and not practical to use, but hopefully in the not too distant future ways and means of reducing losses through evaporation will be found. Teachers can get their learners to experiment with different ways and should encourage them to use all their creativity to solve this pressing problem.



The worth of water



How much is water actually worth? Looked at in terms of its impact on people and the environment, water is probably Namibia's most valuable natural resource.

Yet we often take water for granted. People who live in water-short areas and who spend much of their time in search of this all-important substance usually have a true appreciation of the value of this substance, but those for whom water is freely available - in rivers, taps, canals, boreholes or stand pipes - often neglect or abuse this resource, unknowingly endangering their future and that of their children.

One of the reasons for this is that water is often heavily subsidised by the government, provided for free or for ridiculously low charges. This is done for many reasons. To encourage the growth of industry and to win votes are merely two examples. However good the reasoning behind it, this misguided policy is contributing to the wasting of our water resources. If people were to pay a real price for water - not one that they could not afford, for access to water is a basic human right, but one that reflected the true worth of the substance and its importance in terms of people's lives and the good of the nation - then abuse and wastage would drop substantially.

Think about how many water-wasteful practices you see in daily life. Would they continue if money as well as water was being poured down the drain? With free or very cheap water, there is very little incentive to conserve. Surely it makes sense for heavier users of water to pay more for water and for water-wasters to be penalised financially.

An effective start to managing Namibia's water resources would be to recover the costs associated with supplying it. However, an analysis of the situation reveals that this would be unrealistic over the short term. In cases where the full cost of supplying the water cannot be charged, at least the operating cost component needs to be recovered from the consumer. This requires the full cooperation, understanding and willingness of the user to participate in such a scheme. Participation will probably only be achieved through massive awareness and education programmes that help people change their attitudes to water use.

The responsibility for Namibia's water resources lies with all of us who live in this country. Water is vital for the growth of our nation. Can we afford **not** to charge a real price for it?

Water and development

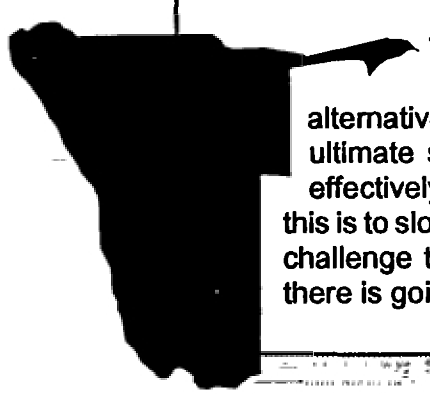
Water plays a vital role in all life's processes and, unfortunately, there is no alternative substance that can replace it. If we run out of water we run out of potential. This understanding needs to form the basis of our attitude towards water and the way in which we use it.

People living in Namibian towns use an average of 300 litres of water a day. Rural Namibians use an average of only 85 litres a day.

Water in the modern world is necessary for more reasons than simply to sustain life. In an attempt to "improve" our standards of living we now require much greater quantities of water than ever before. We now need water to support industry, increase food production and manufacture a wide variety of goods that we have come to see as essential to our modern lifestyles. Even the demands for household water have drastically increased over the years. Flush toilets, washing machines, swimming pools, gardens and the like result in vast increases in the demand for water. The end result is that people living in urban environments use between three and four times as much water as people living in rural areas.

Development in Namibia

There is much need for development in Namibia, but we should be careful to ensure that such development is sustainable and makes good use of our scarce natural resources. The most important issue affecting development in this country is how will we be able to do more with less? Development into the next century will need to provide more food for people, more housing, medical services, more job opportunities and more freshwater supplies. The truth of the matter is that there will be fewer natural resources available for our use in the future than there are now. We must choose our development path wisely as development mistakes can be impossible to reverse, and can leave us with an environment that is less able to support us.



Technological advances may well provide solutions to accessing more or alternative resources over the short term, but the ultimate solution has to lie in using less more effectively. The most obvious step to achieving this is to slow our rapid population growth. This is a challenge that all Namibians will have to meet if there is going to be enough for everyone.

Development, in general, aims to improve the material conditions of the people within a country and provide support for the national economy. Yet neither of these goals can be achieved without wise and careful use of water. It is therefore necessary to adopt an approach to development that is sustainable, which essentially means that development should not damage the future ability of our resources to support people.

When we are dealing with water supply we need to acknowledge the fundamental concept that water is not created or destroyed. Rather, we are taking it from one place and giving it to another. Although one party will benefit from the redistribution, in arid countries it is almost certain that another party will suffer.

One of the biggest problems associated with improving water supply to meet the demands of development is that we are often trying to meet unlimited demand increases by continuously expanding a limited supply. In Namibia we are fast approaching our water limits - in some cases we have even exceeded them.

At current population growth rates, the number of countries in Africa that qualify as water-scarce will double in the next 30 years.

It is clear that, over the past few decades, Namibians have grossly overconsumed their most precious resource - water. Yet the demand for it continues to rise drastically and with a rapid increase in population we can expect continued increases in the demand for water. Namibia has to face the fact that it is an arid country with a very limited supply of freshwater.

Despite this, developments in the field of water have often focused on chasing demand rather than managing it. Meeting demand means finding more water. In Namibia this means building more dams, drilling more boreholes and considering different ways of increasing the supply such as desalination and solar distillation. Water engineers are continuously under pressure to explore new and creative ways of finding a solution to the problem of supply. But these solutions have limits to how much water they can provide and they are often very costly - economically and environmentally. We have no option other than to use less.

Reducing demands for water requires a number of approaches, some of which have been touched on in this book. But the most important cornerstone of such an approach is to create an awareness among water users for the need to conserve water. People are often quick to demand freshwater but slow to accept responsibility for conserving and protecting it. But most people do not waste water on purpose. Unsustainable water use is often due to a lack of understanding of the resource, having no skills to manage it and a lack of affordable alternatives. With the right knowledge and appropriate skills, all users of this precious resource will be in a better position to use it more sustainably.

Conservation and development are two sides of the same coin. With equal care for both of these two aspects a brighter future for Namibia and its inhabitants can be built.

Teachers are in a good position to make a valuable contribution to wise water use in Namibia. With their help we can build a nation that is aware of the difficulties of living in an arid country. With the right attitude and skills we can ensure that we have enough water for everyone and still some left over to share with all the living things that inhabit this land called Namibia.

Chapter 15 Activities

1. Osmosis is an important phenomenon associated with the movement of water in plants. In the study unit include a section on the potential use of reverse osmosis in the desalination of seawater. What are the advantages and disadvantages of the process?

Build a solar still to demonstrate how saltwater can be converted into freshwater. It may aid understanding to add a few drops of ink to the saltwater. The salt and the ink remain behind when the water evaporates.

1. Write a script for a radio show that urges people to cut down on the amount of water that they waste. Make sure that your play addresses issues that are relevant to your area.

1. **"Stop flushing our water resources down the drain!"**
If you live in an urban area you can conduct a campaign that will save thousands of litres of water each year for your town.

Approach a building company or a hardware store for a sponsorship of 100 bricks. Divide the bricks between the members of your class. Conduct a door to door visit ... homes. Deliver one brick to each home. Ask the home owners to place the brick in the cistern of their ...et. In this way less water will be used with each flush.

...culate the displacement volume of a brick and the volume of an average cistern. This will give you some ...a of how much water can be conserved by placing a brick in the cistern. Calculate the amount of water ...at will be saved in one year if you delivered 100 bricks.

...you cannot get bricks use bottles that are filled with water and sealed.

... a report for a local newspaper explaining what your project involved and how you are contributing ... water saving.

1. Record water meter readings for a week and plot the information on a graph. You may monitor a water meter at home or use the school's water meter.

1. If you live in a town, do a survey of water efficient washing machines and other household appliances available in the shops.

2. Compare washing by hand with washing by machine in terms of :

- time taken
- labour
- water used
- soap needed
- water reuse potential
- cleanliness
- electricity consumption
- costs

Glossary

acid - with a pH less than 7; sour
adaptation - a change in structure, behaviour or function that allows an organism to exist
adhesion - ability to stick to or bond with something
agriculture - everything to do with farming
agricultural drought - when rainfall and temperature conditions result in crop failures
alien - a plant or animal introduced from elsewhere, not indigenous
alkaline - with a pH greater than 7
alluvial aquifer - a body of groundwater which lies under a riverbed
alluvial terraces - areas above the level of floodplains which have fertile soil
annual - occurring every year
aquaculture - agriculture in water; growing and harvesting fish, shellfish or seaweed for human use
Aquarius - a sign of the zodiac that runs from 20 January to 18 February
aquatic - anything which has to do with water
aquifer - a trapped source of groundwater
astrology - the study of the movements of stars and planets interpreted as an influence on human affairs
arable land - land that can be cultivated to grow crops
archaeology - the study of the past through digging up such things as fossils, tools and burial grounds
Archimedes pump - an ancient water pumping device developed by the Egyptians in third century B.C. and still used today
arid - dry area with less than 250mm rainfall a year
artesian aquifer - water trapped in a permeable layer of rock between two layers of impermeable rock
artificial - made by people, not naturally grown or developed
atmospheric gases - gases and vapours which surround and protect the Earth
atoms - minute particles which are the basis of all matter
bacteria - unicellular microorganisms, some of which can cause disease
bedrock - a layer of rock underlying a layer of soil or loose stone. Bedrock can also sometimes be exposed at the earth's surface
Benguela Upwelling - cold water rising up from the bottom of the sea to its surface due to strong south westerly winds on Namibia's coast.. It creates rich fishing grounds but also decreased rainfall due to cooler air
bilharzia - disease caused by parasitic flatworms which enter the bloodstream through water in which infected snails, the carriers, live
biological agent - an organic material used to cause changes in the environment
boreholes - a hole drilled into the earth, often to a great depth, for water, oil or exploration
brackish - slightly salty
bubonic plague - disease characterised by swellings and transmitted by fleas which live on rats
bush encroachment - thick scrub growth which takes over areas of land, making them unsuitable for farming or grazing
canals - artificial watercourses cut through land for open transport of water
capillarity - water's ability to move upwards by sticking to itself or another substance
carrying capacity - the number of animals, in particular livestock, that can be supported by a particular area
cash crops - crops grown for sale rather than for food. In some parts of the developing world these are grown to make money to pay the nation's debt, using land that should be used for growing food for local people
catchment area - area from which the water from rainfall drains into a particular river
celestial - of the sky; heavenly or divine
cholera - serious, often fatal disease caused by bacteria which thrive in unhygienic circumstances

climate - general pattern of weather conditions, seasonal variations and extremes in a region over a long period of time
cohesion - ability to stick together
colonise - establish a settlement
commodity - article of trade
condensation - any substance, but especially water, that has evaporated and then reformed, or the act of reforming after evaporation
conservation - the act of protecting the environment and using it wisely so that it provides both for us and for future generations
constellation - a group of stars
contaminate - to make dirty or impure
corrosion - destruction by chemical action, eg. rust
crustacean - animal with a hard shell usually living in water, for example, crabs or lobsters
cubic metre - a cube measuring 1m by 1m by 1m, which holds 1000 litres of water. 1m^3 of water weighs 1 metric ton
cultivation - the growing of crops
dam - barrier built across a river to hold back water
DDT - a poisonous chemical used to kill insect pests but also toxic to other animals, including man
decomposition - the breakdown by micro-organisms of dead plant and animal matter into simple minerals
deforestation - the cutting down and removal of trees from an area without replanting
delta - the mouth of a river where it divides into several streams
dehydration - loss of moisture
demersal fish - long-lived and slow-growing fish which occur near the bottom of the sea
density - mass per unit or volume
depression - sunken area
desalination - removing dissolved salts from seawater or brackish groundwater
desertification - the spread of desert conditions, due to human actions, that results in the loss of productivity and environmental degradation
developing countries - countries which are economically poor with low to moderate industrialisation
diameter - distance straight across the widest part of a circle
diarrhoea - condition with frequent fluid faeces which can lead to dehydration
diatom - single cell simple plants, usually aquatic
diet - selection of foods
disease - specific illness
disinfection - to clean by eliminating harmful bacteria and viruses
dolines - hollows which indicate the presence of underground caves in limestone regions. These caves may contain water
dolomite - a common mineral that forms rocks
domesticate - to tame
drainage basin - an area of land that has a number of rivers and streams flowing through it
drought - a period of less rainfall and/or higher temperatures than usual. Drought is often defined as when a particular region receives less than three quarters of its average rainfall, but this is a normal occurrence in arid and semi-arid areas
dryland gardening - gardening in which water is used in the most efficient way possible
dyke - underground rock barriers where water collects
dysentery - disease causing severe diarrhoea
earth walls or **earth embankments** - walls made of soil and rocks designed to change or stop the flow of water
ecology - the study of the interactions of living organisms with one another and their environment
economy - system of production, distribution and consumption of goods

ecosystem - a fairly self-contained system of plants, animals and other organisms
efundja - a large flood in the oshana system
electricity - a type of energy most commonly associated with electric current for lighting, heating
electron orbit - the path that an electron follows around its nucleus
element - a substance which cannot be separated into other substances; also, the powers of nature
endemic - only found in one particular region; also, regularly occurring in an area
energy - the capacity to do work
environment - living and non-living things surrounding all organisms
environmental refugees - people forced to move from their homes because the environment where they live can no longer support them
environmental sustainability - careful management of the soil, water and biological resources so that future generations can also use them
ephemeral - something that lasts a short time; refers to rivers which flow only when there has been enough rain
erosion - the loss of topsoil which is carried away by wind or water
estuary - the wetland associated with the area where a river flows into the sea
evaporation - to turn from liquid into a vapour
evaporation potential - the amount of water that would be evaporated if unlimited uncovered water were present
evapotranspiration - water given off by plants through their pores (**transpiration**) and returned to the water cycle through evaporation
exploitation - the act of making use of something which is available, eg. resource exploitation is making use of the resources found in an area. The term is often used to mean over-use of a resource to the detriment of the environment
exploration - an act of travelling or searching in order to learn or discover something
extinction - the complete, irreversible disappearance of a species from the earth
extraction - to draw out or take out by force or pressure
faults - cracks underground
fertile - productive
fertiliser - a material which is added to the soil to make it richer and healthier so as to give plants more nutrients
filamentous algae - very fine thread-like water plant
flood basin - area covered by water during the highest known floods
flood plain - large area on either side of a river which is periodically flooded when the river overflows
fluctuation - irregular rises and falls
fog - a thick mist made up of tiny drops of water
food chain - series of organisms, each eating or decomposing the one which comes before it
fossil water - groundwater originating from ancient rainfall which has been trapped in rock. This groundwater can never be recharged
freshwater - water which is not salty, brackish or seawater; or an adjective used to describe something that lives in freshwater
fuelwood - wood burned to provide energy
geological fault system - two or more fault or crack sets in the earth that were formed at the same time
geology - a science which studies the earth and how it and the rocks which compose it were formed
germination - the stage at which seeds begin to develop into plants
gradient - slope; used to describe the slope down which a river flows
gravel - small, rounded pebbles
gravity - the force that causes things to fall towards the earth. Gravity also causes other planets to stay where they are instead of floating away in to space
malnutrition - a dietary condition caused by the lack of some foods or essential elements

groundwater - water occurring naturally beneath the surface of the land
groundwater mining - extracting groundwater faster than recharge is possible or where recharge is not possible
guano - a very rich fertiliser made from bird or bat droppings
habitat - the environment in which a plant or animal lives
harbour - a place of shelter for ships
harvest - the process of gathering in crops; the season's yield or crop
heat capacity - the power of containing, receiving, experiencing or producing heat
herbalist - a person skilled in the uses of herbs for medicinal purposes
hunter-gatherers - people who live off what animals they can hunt and food they can gather from uncultivated land
hydroelectricity - electricity produced by means of falling or flowing water power
hydrogen - a light, colourless gas
hydrological cycle or **water cycle** - the flow of water from the ocean, through the atmosphere, over the land and back to the sea
hydrological drought - when lack of rain causes reduced flow of rivers
hydrology - the study of the properties, distribution and circulation of water on earth
hygiene - cleanliness and freedom from germs
igneous rock - rocks formed when molten rock cools and hardens
impermeable - a texture or substance which does not allow water to move through it
indigenous - something which is native or occurs naturally in an area
industrialisation - the establishment of trade and manufacturing in an area, often with great changes to traditional socio-economic systems
infertile - non-productive
infiltration - introduce by means of a filter, often slowly
infrastructure - the basic structural foundations of a society or enterprise; a country's basic economic foundation (eg, roads, bridges, dams)
inorganic - not arising from natural growth; usually of mineral origin
insecticide - a substance used for killing insects
insect vector - insect which carries and transmits a disease
interbasin transfer - taking water from one river basin to another by means of canals, pipelines or pumps
intertidal zone - area which is covered with sea water at high tide and uncovered at low tide

irrigated cultivation - crops grown by means of artificial watering
irrigation - to provide crops with water artificially
joules - one joule is the energy needed to lift a one kg object one metre off the earth
Karstveld - name given to an area in northern Namibia where there is lots of limestone
karst water - water found in underground caves and sinkholes created when Karstveld limestone has dissolved in water
kinetic energy - energy present in moving objects
lagoon - a shallow saltwater lake, often formed when a river is cut off from flowing directly into the sea
lake - a large body of water surrounded by land
latent heat - the heat required to convert a solid into a liquid or vapour without a change in temperature
lava - molten matter which flows from an erupting volcano and solidifies as rock
leach - water filtering through soil and washing nutrients away
limestone - a sedimentary rock composed mostly of calcium carbonate which is water-soluble
linear oasis - refers to ephemeral rivers which support life in the area that lies along them, resulting in a line of green trees and productive land running through a desert
line fish - those fish caught with hand-held rods
lithop - "stone" plant, well adapted for arid conditions as most of the plant grows beneath the soil surface
malaria - disease transmitted by mosquitos which attacks the blood system and may cause death, frequently occurs near areas of open water where mosquitos breed

needed for health
manual - of or done by hand
marble - a rock composed essentially of limestone
marine - of the sea; of shipping
marsh - low-lying watery ground
mass - the amount of material in an object
metamorphic rock - rock which has undergone changes due to natural forces like heat and pressure
meteorology - the study of atmospheric conditions, especially to forecast the weather
midden - accumulation of waste around a dwelling place, a rubbish heap. In archaeological terms the word is used to describe early people's rubbish heaps, from which we can tell much about their way of life
migration - move or change ones living area with changes in the seasons, availability of food or water. Many migrations, human and animal, follow fixed paths that have been used for centuries
mimic - imitate; behave like something or someone else
mining - digging into the earth for metals, salts, water and removing them for use
mineral - substance found naturally in rocks and the earth
molecule - the smallest part of a chemical compound that can take part in a chemical reaction
mudflat - a muddy, low lying strip of ground by the seashore or on the edge of reservoirs, usually underwater with high tide
mythology - the body or the study of myths, folklore or traditional stories
natural disaster - a great or sudden misfortune or failure caused by the forces of nature (eg, earthquake, tidal wave, prolonged drought)
natural gas - underground deposits of gas
natural spring - a watersource where underground water wells up naturally to the earth's surface
nautical mile - a distance of 1852m; term used to measure distance when sailing through water
navigation - the act of directing or plotting the path of a ship, aeroplane or other means of transport
nomadic - describes a lifestyle or persons who roam the land seeking food, water and pasture for their animals
nuclear power - power generated by a nuclear reactor; energy released by nuclear fission
nuclei (sing. - **nucleus**) - central core of atoms, seeds or cells
nutrient - element or compound needed for survival and growth of a plant or animal
omifima - shallow, hand dug pits used to trap and store water in the oshanas
omuramba (pl. **omiramba**) - Otjiherero name for **oshanas**
ore - solid rock or mineral from which metal is obtained
organic - substances which are or were once a part of a living organism
organism - anything that is living
oshana - Oshiwambo name for the system of interconnected drainage channels that flows through the Owambo region
overcultivate - to plant too many crops, too soon after each other, to the detriment of the soil
overgraze - grazing too much or allowing too many animals to graze on one area, thus damaging the soil and the future growth of plants and grazing
overstock - putting too many animals in an area; exceeding the area's carrying capacity
oxygen - gas in the atmosphere essential for respiration
pan or vlei - dip or depression in the surface of the ground deep enough to hold water for part of the year, sometimes formed when ephemeral rivers are blocked from reaching the sea by sand dunes (eg. Tsondab and Sossus Vlei)
parasite - organism that feeds on another living plant or animal(host). Parasites often harm their hosts
river energy - refers to a river's capacity for work relative to its volume of flow and velocity

pastoralist or **pastoral nomad** - people who roam the land with their animals in search of grazing
pathogen - organism that causes disease
pelagic fish - fast-growing fish which mature early, occur in the upper layers of the open sea and are the most common fish off Namibia's coast
percolation - to filter through small holes
perennial - refers to rivers which flow all year round
permeable - something that liquids may flow or pass through
pest - unwanted organism that directly or indirectly interferes with human activity
pesticide - chemicals designed to kill or inhibit a pest
phosphates - chemical compound found in fertilizers
photosynthesis - process which takes place in green plants where energy from the sun is used to combine carbon dioxide and water to produce food for the plant and oxygen, which is released into the atmosphere
phytoplankton - plant organisms, usually microscopic, which live in water and are an important part of the food chain
pitcher irrigation - burying porous clay pots and filling them with water so that the water seeps slowly through them to water surrounding plants
plankton - microscopic organisms drifting or floating in the sea
poaching - the illegal taking or killing of game, fish or stock animals
poison - toxin; substance that can destroy life or harm health
polje - a sinkhole that has become filled with soil
pollution - damage and destruction of the environment caused by people introducing poisonous waste substances into it
porosity - amount of air space found in a particular body of rock allowing liquid or air to move through and into the area
precipitation - any moisture deposited on the earth (eg. rain, hail, snow, fog, mist, dew or frost)
protein - very complex organic compound; an essential part of food which helps to build one's body
purification - to make pure; cleanse
quota - limited, permitted amount
radar - system of detecting objects by means of high frequency radio waves
radicle - part of a seed which develops into the primary root of a plant
rainfall harvesting - collecting rainwater for future use
rainfall intensity - describes the amount of water falling over a given period of time
rainfed agriculture - depending entirely on rain water for growing crops, common in northern Namibia
recharge - when groundwater is replenished by precipitation or river flow
recycle - use more than once
rehabilitation - restore to a normal life or good condition
renewable - can be made new again or replaced by a natural process over a fairly short period of time
reservoir - body of standing freshwater often collected behind a dam; a means of storing water
residue - what is left over
resources - raw materials obtained from the environment to meet human needs or wants
respiration - breathing; the breaking down of organic compounds in a controlled reaction that releases energy, water and carbon dioxide. This process only occurs in living organisms
reverse osmosis - a process for desalinating water whereby water is forced through a semi-permeable membrane leaving salts behind
river basin - the land from which a river gathers its water
river channel - course that water takes or flows in the river
river discharge - measurement of the amount of water in a river flowing past a certain point in a certain amount of time

river loads - amount and type of material carried by a river's flow
root system - a part of a plant which is normally underground, attaching the plant to the earth and taking nutrients and water from the soil to the plant
runoff - water from rain that runs across the earth's surface to join and form streams, lakes or rivers; water lost to the immediate area if there is not enough plant cover to retain it
safe yield - the rate at which a borehole can be safely pumped. This changes over time depending upon the rate of groundwater recharge
salinity - amount of salts in a body of water or soil
salinisation - accumulation of salts in soil that can eventually prevent plants from growing in it
sand or groundwater dams - structures that store water within a layer of sand
sandstone - rock formed of compressed sand
sanitation - arrangements to protect public health through drainage and disposal of sewage
saturation - to reach saturation is to have absorbed or accepted as much as possible
scabies - contagious skin disease caused by an organism similar to a tick that lives in the skin and causes itching
seaweed - plants which grow in the sea; some are edible and can be commercially exploited
sediment - soil and other materials that are suspended in water and eventually settle to the bottom of the water
sedimentary rocks - rocks made of gradually accumulated and compacted sediment composed of weathered rock, shells and the skeletons of dead animals
semi-arid - areas where mean rainfall is seasonal and between 250 and 600mm per year
sewage - waste water and refuse
sewerage - an arrangement of underground pipes to remove waste water and refuse
shales - slate-like stones
shoal - a large group of fish
shoreline - land along the edge of a lake or the sea
silt - mud deposited by water
sinkhole - a depression or doline where the layer of rock above a karstwater source has collapsed; usually caused by the rock having been dissolved by water
soil - earth or ground
soil erosion - loss of fertile topsoil, either through it being washed away by water or blown away by wind
solar distillation - desalination due to water being evaporated by sun, leaving salt behind, and then condensing in a pure form
solvent - able to dissolve another substance
sonar - device for detecting objects under water by reflection of sound waves
species - all organisms of the same kind
stabilisation - to make secure, steady or fixed
stagnant - motionless; having no current or flow
subsistence - minimum required for survival, often refers to subsistence agriculture, hunting or fishing. These occupations would provide enough food for a person or family but no surplus for sale
sustainable - to use something in such a way that its potential for future use is in no way impaired
swamp - a type of wetland; an area of land that is too moist for cultivation and that may have standing water in it for all or some of the year
symbolism - use of symbols or images to express things
"Third World" - term used to describe economically underdeveloped countries; those countries sometimes referred to as "developing countries"
thunderstorms - rain storms with thunder and lightning, during which large amounts of water can reach the ground in a short period of time
topography - describes the shape of the land including slopes, hills, valleys, rivers

topsoil - top layer of soil; the fertile layer of soil capable of sustaining plant life
toxic - poisonous
trachoma - a contagious disease of the eye and eyelids which may lead to blindness
transpiration - the process by which plants give off water through pores in their leaves and stems
trawl - to drag a net at a deep level behind a boat to catch fish
trickle or drip irrigation - to wet ground with small amounts of water just where plants can absorb it
turbulence - in air, stormy conditions as a result of warm air rising, creating atmospheric disturbances; in water, disturbed and swirling flow of a highly erosive nature
typhoid - serious infectious feverish disease
typhus - infectious feverish disease transmitted by parasites
unsustainable - if something is used in an unsustainable way, it is used in a way that lessens its potential for future use
upwelling - movement of nutrient-rich cold water from the depths up to the surface of the sea
uranium - heavy metal used as a source of fuel for nuclear power
vaccine - a preparation which gives people or animals resistance or immunity to an infection; sometimes known as **immunisation**
vapour - the gas form of a substance; moisture or other substances suspended in the air
variability - the existence and measurement of fluctuations over time
vegetation - plants; plant life
velocity - rate of motion in a given direction; speed
water balance - the relationship in an area between the amount of incoming water from precipitation and water losses due to evaporation and water given off by plants
waterborne - originating in water
water cycle - see **hydrological cycle**
water table - boundary between the layer of soil where the spaces between soil particles are filled with air and the layer of soil where the spaces are filled with water
waterwheel - early means of harnessing the mechanical power of water to help people to do work
waterlogging - saturation of soil by irrigation or precipitation so that the water table rises close to the surface. If the level of water in the ground is higher than the root zone, plants cannot grow
watershed - a raised area of land that provides runoff water to drainage basins
wetland - land that stays flooded all or part of the year with fresh or saltwater
wildlife - the natural fauna and flora of an area
zooplankton - floating animal plankton which feed on plant plankton

Index

Enviroteach
Desert Research Foundation of Namibia
P O Box 1592
Swakopmund
Namibia

ISBN 99916-43-00-1

TYPOPRINT – WINDHOEK