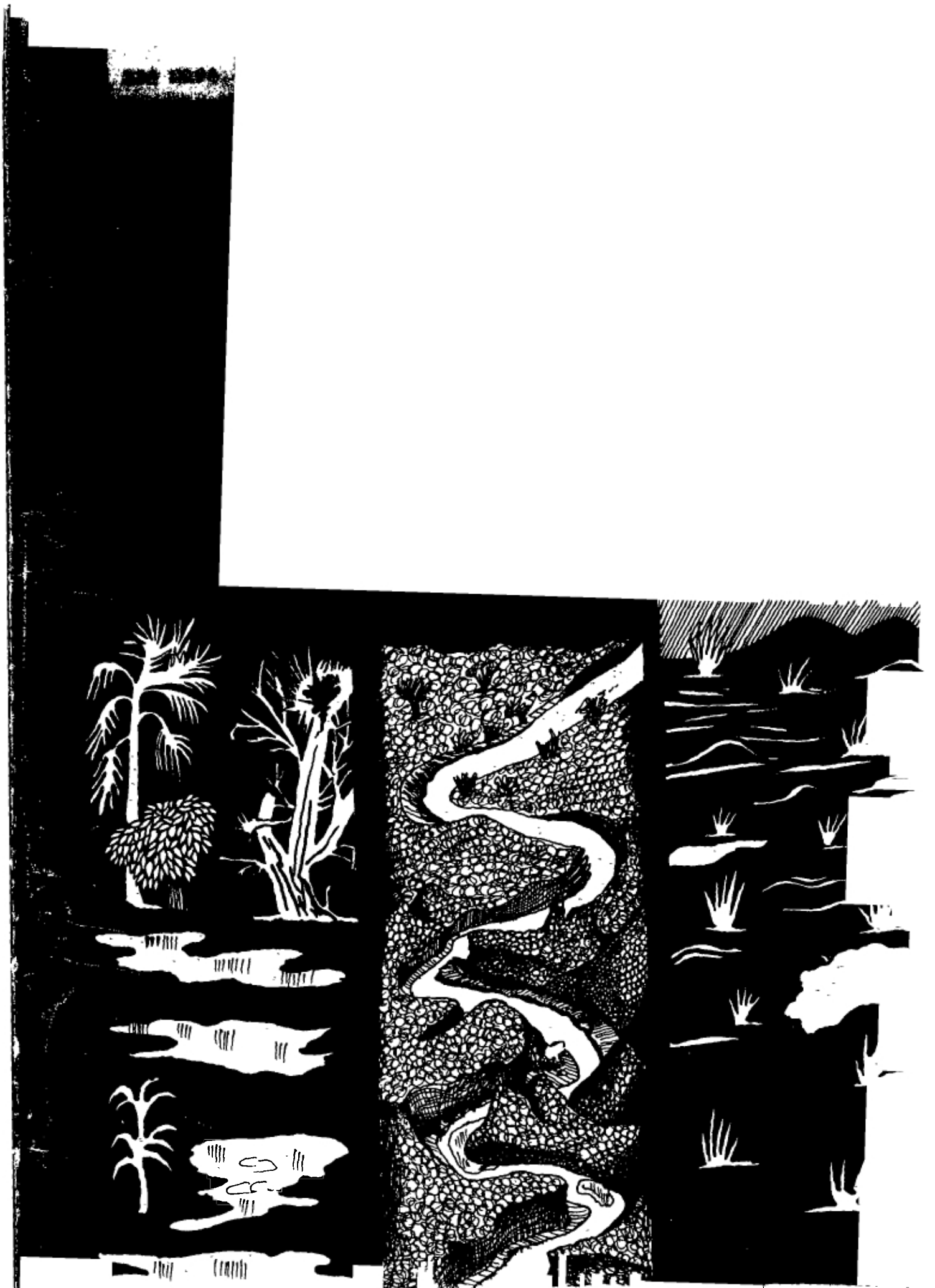

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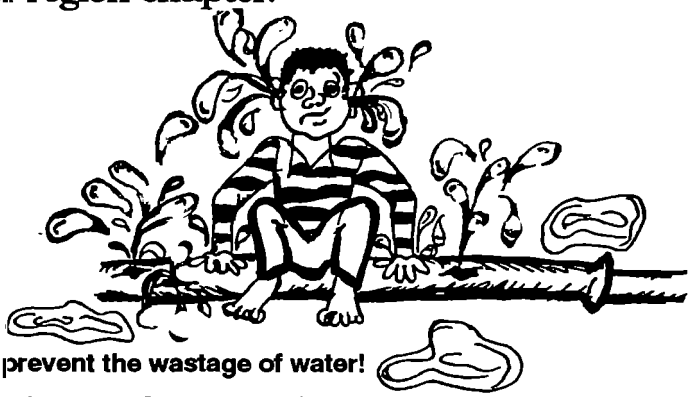
This book is the second in this series and will tell you more about the different **water regions** in Namibia.

- Look at the map of Namibia on the opposite page which has eight numbered water regions on it.
- Find your own water region and turn to the page number given for that region.
- Study your water region and try some of the activities at the end of the chapter.
- Perhaps you would like to study other water regions as well, starting with the regions that join onto your own region.
- Turn the page to find a picture with water-related terms. The words in **bold** print are explained here. Refer to this picture with water-related terms as you read through your water region chapter.



Whoops! let's try to prevent the wastage of water!

Sponsored by: **NORAD** (Norwegian Agency for Development Co-operation)

Produced by: The Desert Research Foundation of Namibia

Written by: Vivienne Ward

Assisted by: Derick du Toit and Teresa Sguazzin of Enviroteach and Mary Seely, all of the Desert Research Foundation of Namibia

Layout by: Asser Karita of Enviroteach

Illustrations by: Asser Karita and Tasha Reid

Maps drawn by: Taloe Wheelock

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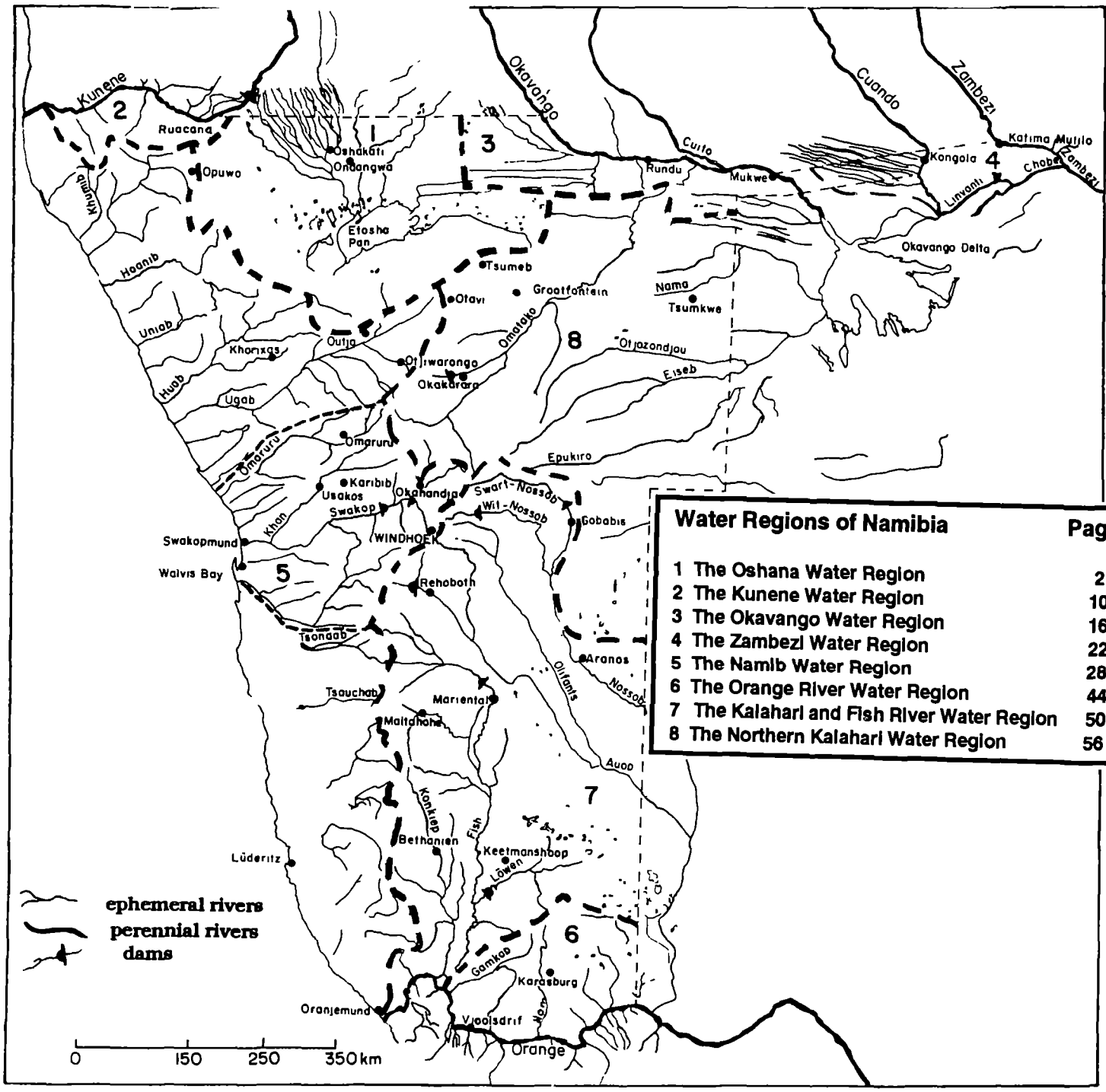
The Wildlife Society of Namibia and the Namibia Nature Foundation endorse this book to encourage an awareness of water and appreciation of its limitations and value in a country as arid as Namibia.

This map shows the rivers of Namibia within the eight Water Regions.
Most of these are ephemeral rivers.
Only the rivers on the northern and southern borders are perennial rivers.



Water Regions of Namibia	Page
1 The Oshana Water Region	2
2 The Kunene Water Region	10
3 The Okavango Water Region	16
4 The Zambezi Water Region	22
5 The Namib Water Region	28
6 The Orange River Water Region	44
7 The Kalahari and Fish River Water Region	50
8 The Northern Kalahari Water Region	56

Most of the water used by Namibians comes from groundwater sources.
Bulk water is water provided to towns and water schemes by Department of Water Affairs.
40% of Namibia's bulk water is supplied from surface water (mainly dams on ephemeral rivers).
60% of Namibia's bulk water comes from groundwater. However, if rural and bulk water are combined, then 80% of Namibia receives its water from groundwater.

(h) **ephemeral** - refers to rivers that have temporary surface flow only after enough rain has fallen

(i) **floodplain** - area next to river which is flooded periodically resulting in a vegetated plain

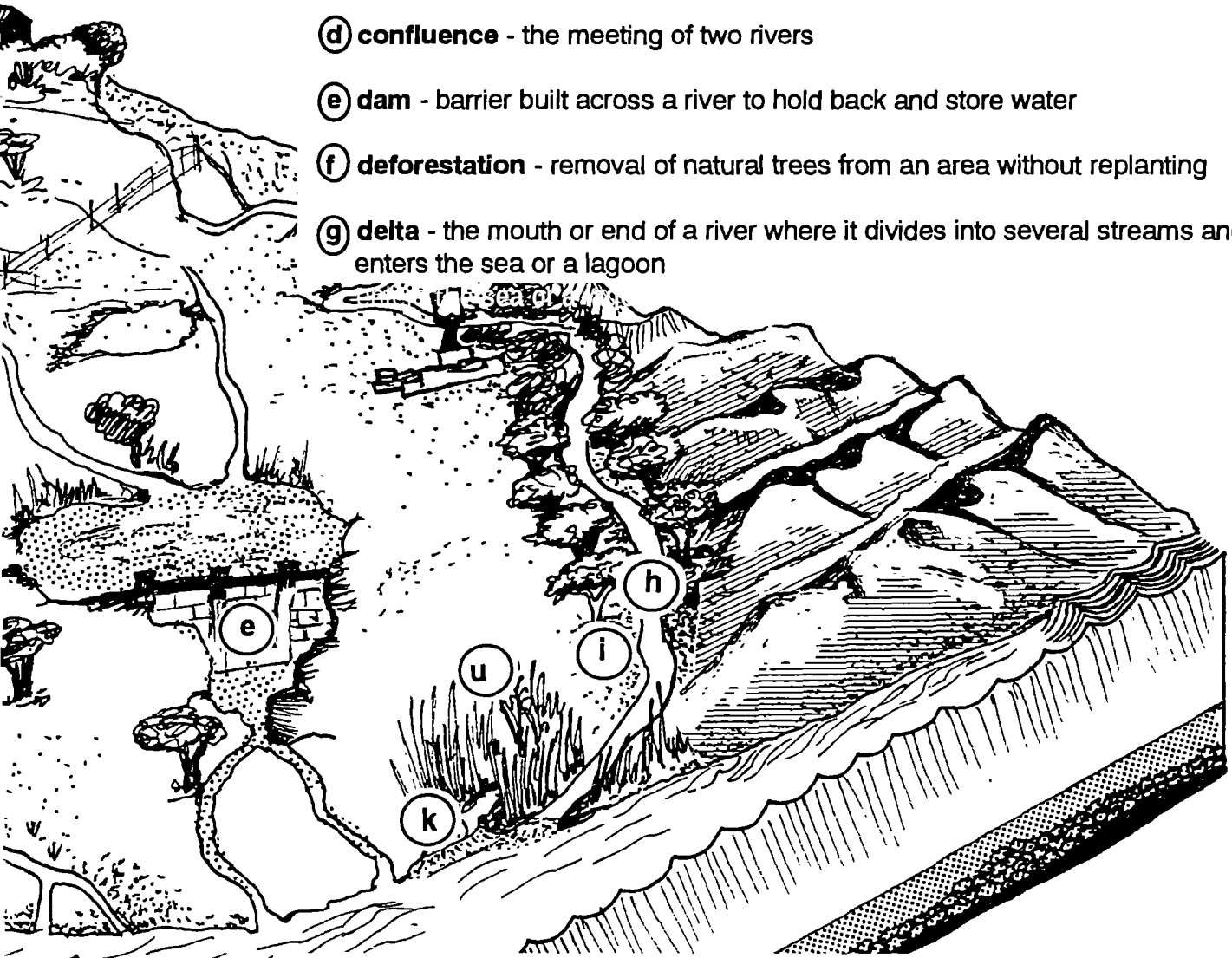
(j) **groundwater** - water occurring naturally beneath the surface of the land

(k) **lagoon** - shallow saltwater lake usually formed when a river is cut off from flowing directly into the sea

(l) **overgrazing** - allowing too many animals to graze in one area, thus damaging the soil and future plant growth and causing soil erosion

(m) **perennial** - refers to rivers that flow above the ground all year round

(n) **reservoir** - storage of fresh water either in a tank or a dam



(a) **aquifer** - underground rock or sand in which groundwater is found
alluvial aquifers occur under rivers and are usually refilled by the rivers
artesian aquifers occur where water rises out of the ground under pressure

(b) **borehole** - hole drilled into the earth in order to pump out water

(c) **catchment area** - area from which rainfall drains into a particular river

(d) **confluence** - the meeting of two rivers

(e) **dam** - barrier built across a river to hold back and store water

(f) **deforestation** - removal of natural trees from an area without replanting

(g) **delta** - the mouth or end of a river where it divides into several streams and enters the sea or a lagoon

(o) **runoff** - water from rain that runs into streams, lakes or rivers

(p) **soil erosion** - loss of fertile topsoil by the action of water or wind

(q) **source** - the beginning point of a river, usually in mountains

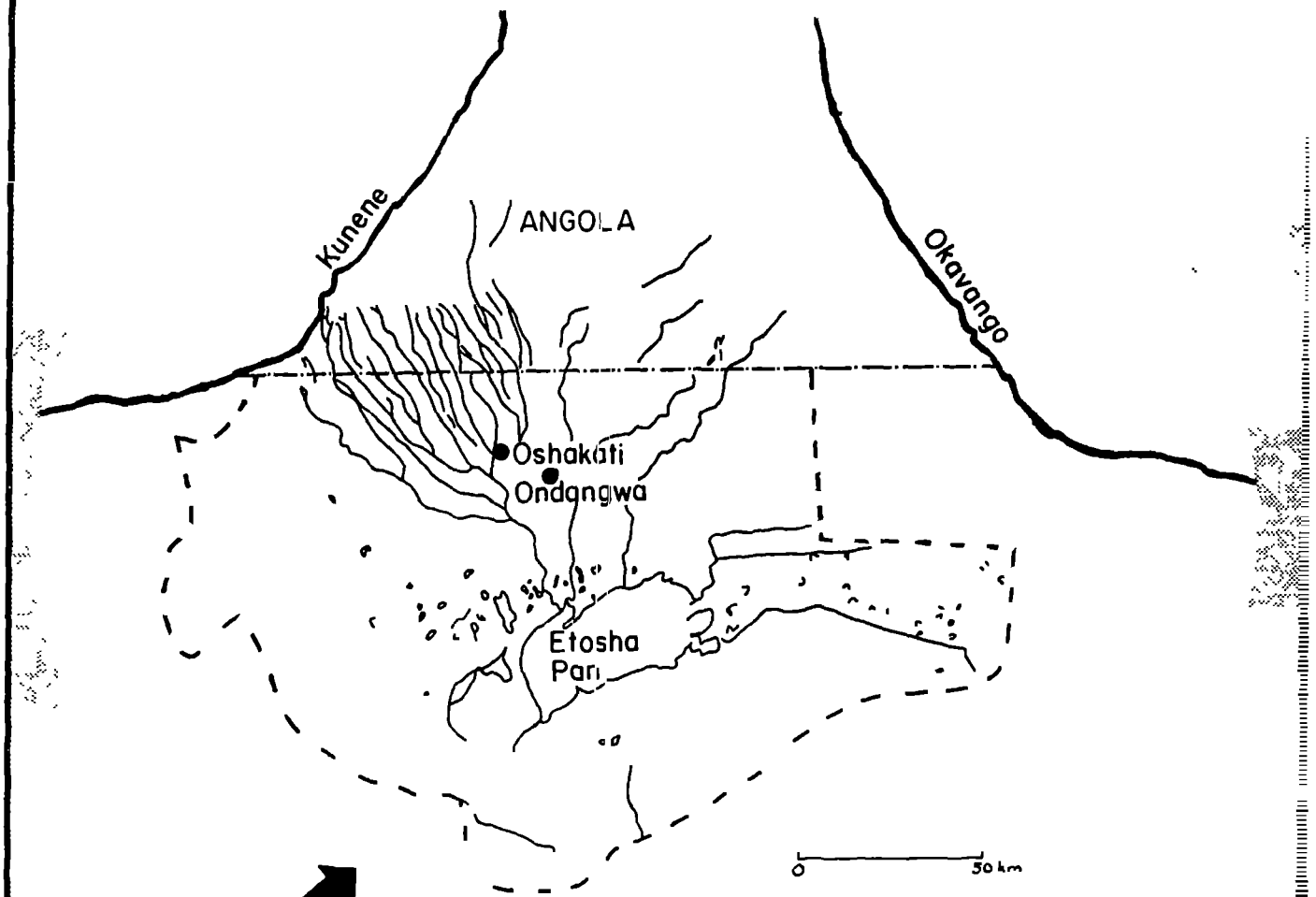
(r) **tributary** - a smaller river which flows into a larger river

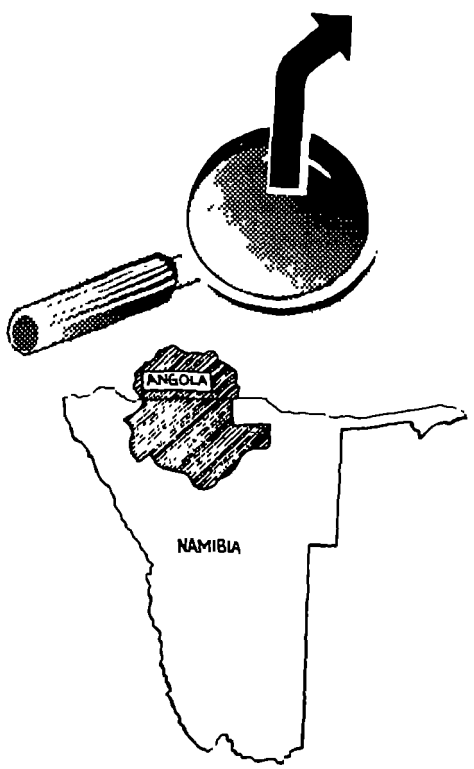
(s) **water table** - the level of groundwater, below which the soil spaces are filled with water

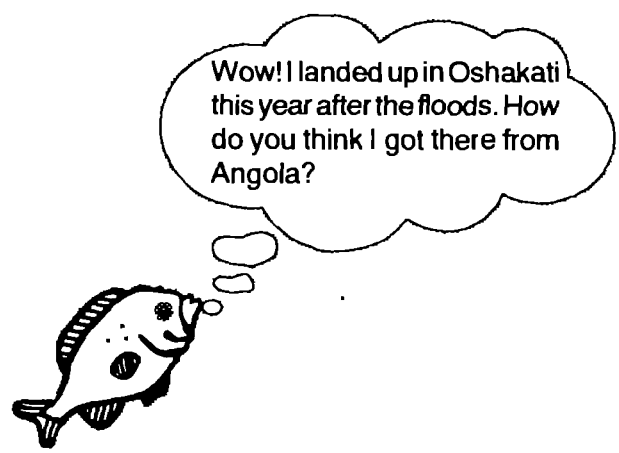
(t) **well** - hole dug into ground in order to get access to water

(u) **wetland** - area that stays flooded most of the year and supports plants and animals which are adapted to watery places

THE OSHANA WATER REGION







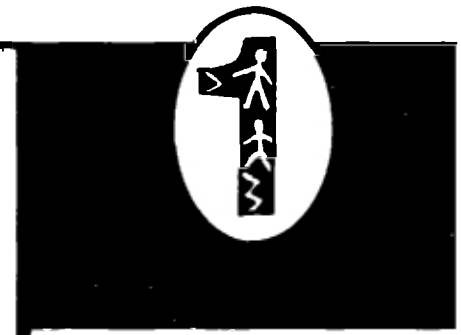
Where does the water come from?

The Cuvelai River (or Oshana Cuvelai) rises in the Serra Encoco mountains of Angola. It is the most active river in a huge system of shallow rivers found on an enormous flat plain, partly in Angola and partly in Namibia. These shallow rivers, called oshanas, spread out in Angola to form a large **ephemeral** river system, then come together in Namibia at Lake Oponono, which in turn drains into Etosha Pan. When there are good rains in the **source** area, the oshanas may flow for many months, sometimes even reaching Etosha Pan. Major floods from Angola or from heavy local rains are called efundja, and change the great dry plain into an endless network of joining waterways. Such efundja do not occur every year, in fact floodwaters only reach Lake Oponono about twice in three years. The last big flood that filled Etosha Pan was in 1954.

The area that gets its water from this region is one of the most densely populated areas in Namibia: more than 25% of all Namibian people live in the Oshana Water Region. Because of all these people and their animals, the ephemeral oshana system often does not supply enough water, especially in dry years. Much of the rain water in this semi-arid area evaporates, and storage of water is difficult in such flat country. There is underground water, but most of it is very brackish, that is, too salty to drink.

It has become necessary to import water from the Kunene River to provide water for all these people [see also section on Kunene Water Region]. Most of the water used in the Oshana Water Region actually comes in canals and pipes from the Calueque Dam on the Kunene River in Angola. Special agreements between the governments of Angola and Namibia led to the building of the Calueque Dam and Ruacana ***hydro-electric scheme,*** which provide water and electricity to Namibia.

Hydro-electric scheme - water is diverted from a river or dam and piped through turbines at great speed. These turbines then generate electricity from the water power

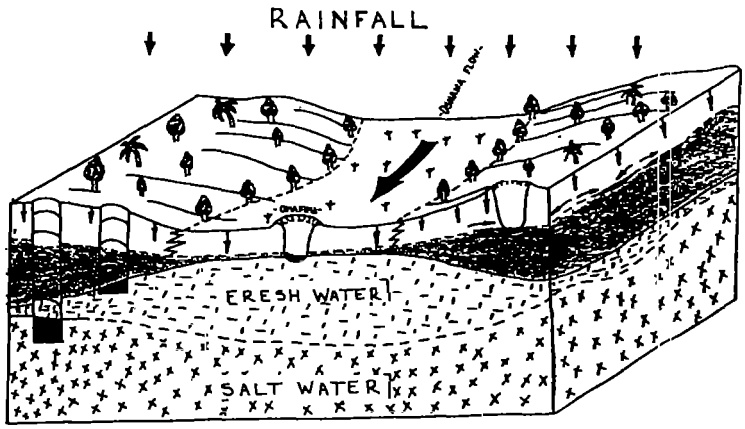


Water supply facts:
30% of the total area of this region served by surface water supplied by canal and pipeline from the Kunene River.
70% of the area gets its water from the groundwater resources.
Yet 70% of the population gets water from the surface water in canals and pipelines.
30% of the population gets its water from the ground.

How do the people in the area get their water?

Groundwater

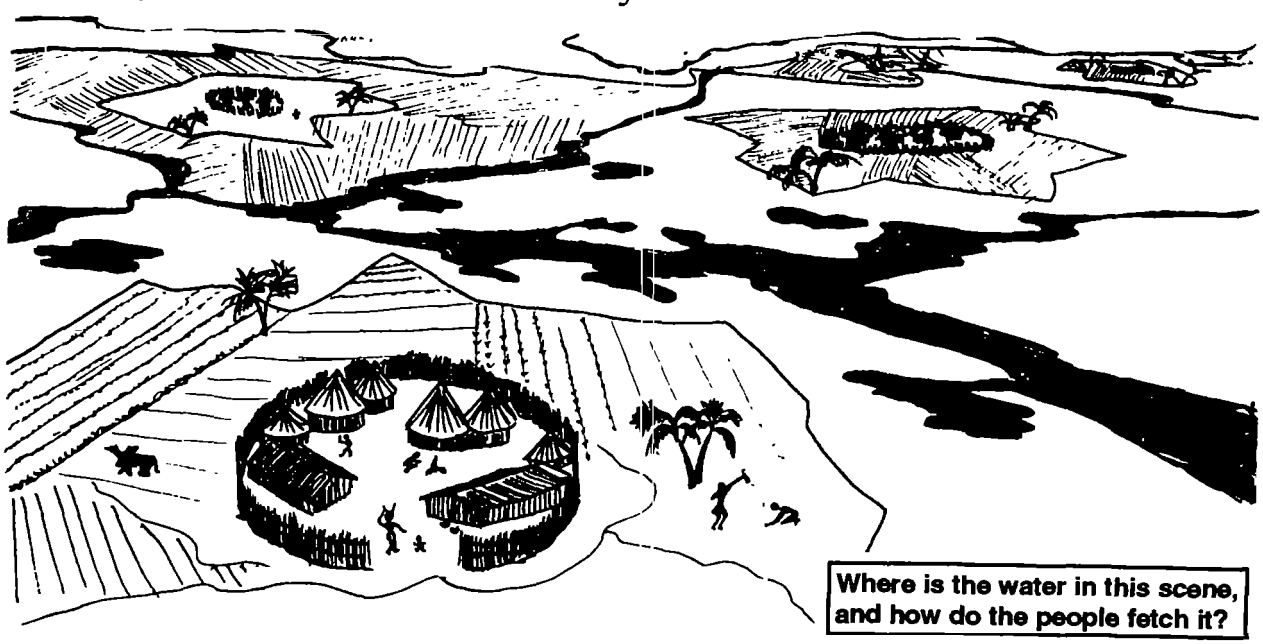
In the Oshana Water Region, groundwater takes two forms. A deep saline (salty) **aquifer** lies under most of the area, and above this are pockets of fresh water (called perched aquifers) which occur where rain water seeps through the sand and is trapped between the heavier saline water and the surface. The people in rural areas dig into the fresh groundwater aquifer by hand, making round wells called omifima. Water is taken out in buckets. There are problems if the sandy sides of the well collapse or if the **water table** gets too low. Then new or deeper wells have to be dug, and the deeper wells may have saline water. If omifima are not fenced off, there may be health problems caused by domestic animals and people polluting the water. Boreholes are also being used in some areas.



Find the wells on this diagram and say whether the water would be saline or fresh, and why.

Surface water

Surface water is available during the summer months when there is enough rainfall to make the oshanas flow and the hand-dug earth dams in the oshanas fill up. The quality of fresh surface water is good to start with. But as the water evaporates, the salts in it get left behind and become concentrated. Salts are also drawn from below the surface and make the fresh water salty. This means that people can only depend on surface water for part of the year and often have to move to other water sources in the dry months.



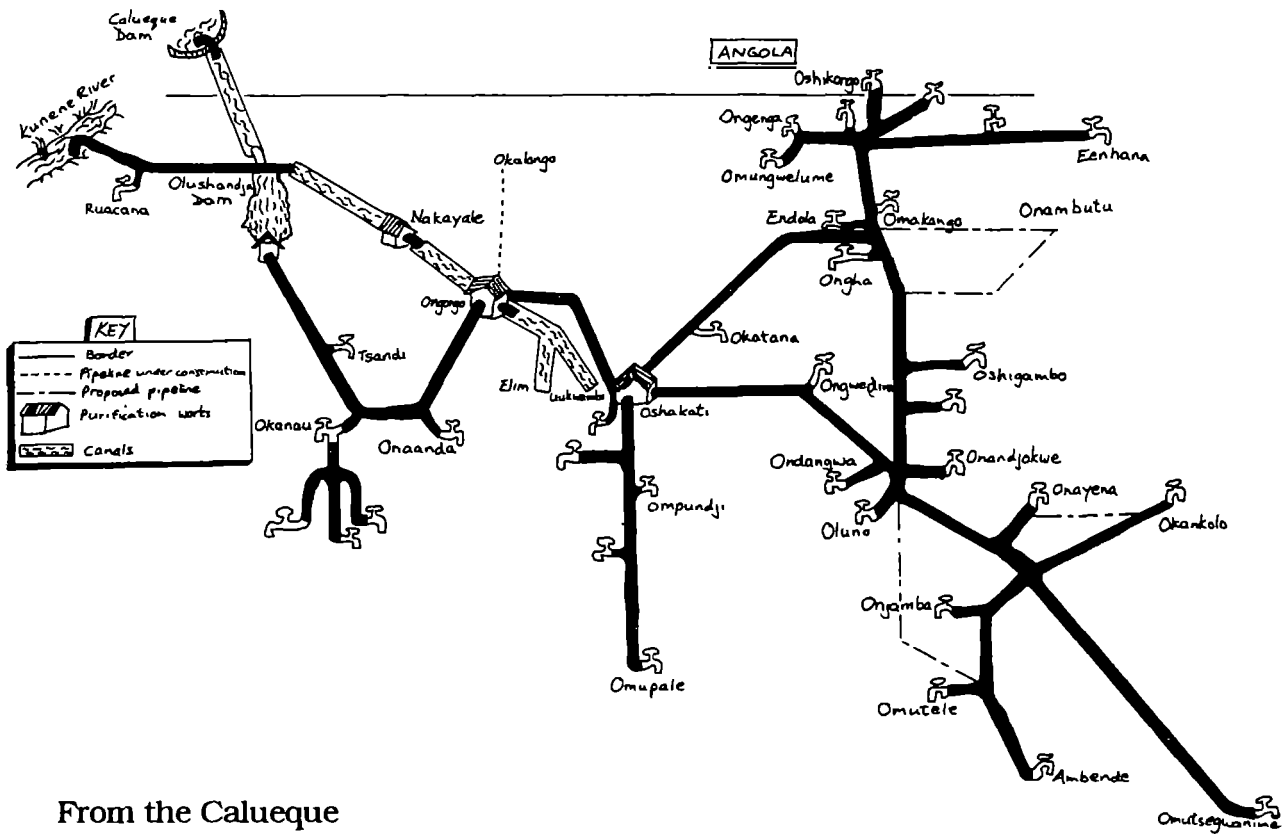
Where is the water in this scene, and how do the people fetch it?

Water supply scheme

Because the population in this area has been increasing so rapidly, a water supply scheme had to be developed to bring more water to the people in this region.

As the Kunene River is the nearest source of **perennial** water, a huge Government scheme has been designed to bring water along canals and pipes from the Calueque Dam to the main towns and irrigation projects in the Oshana Water Region. Outlets from the pipes and canals also supply many rural communities with water.

Using this diagram, explain how people living in Ondangwa , or your home area, get their water.



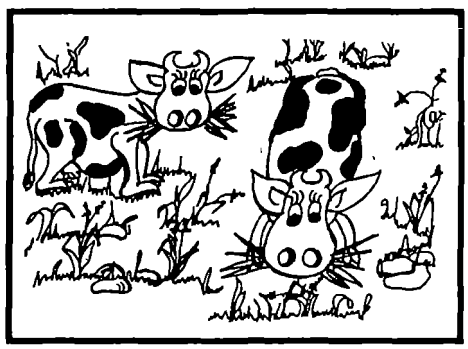
From the Calueque Dam water is pumped into a canal and transferred to the Oshana Etaka and into the Olushandja Dam. This unique dam has a dam wall at each end because the land is so flat. It is 19 kilometres long and 4 metres deep when full. Water is purified (cleaned) then pumped into a pipeline that transports it to the larger urban centres. An open canal has also been built from the Olushandja Dam and ends at Oshakati. The purpose of this canal is to collect and channel flood water in the rainy season towards the main centres of Oshakati and Ondangwa as well as to carry water to these centres that is pumped from the Calueque Dam.

How is water used in the area?

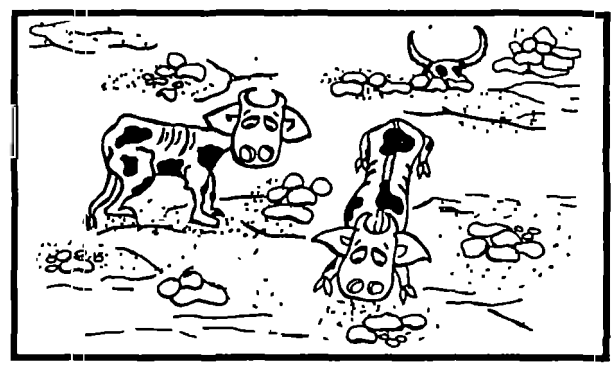
People have lived in the Oshana Water Region for centuries because of the seasonal flow of the oshanas which:

- recharges (refills) groundwater,
- makes grass grow for grazing,
- brings fish down the oshanas,
- provides water for household use, that is, drinking and washing water for the people and their animals.

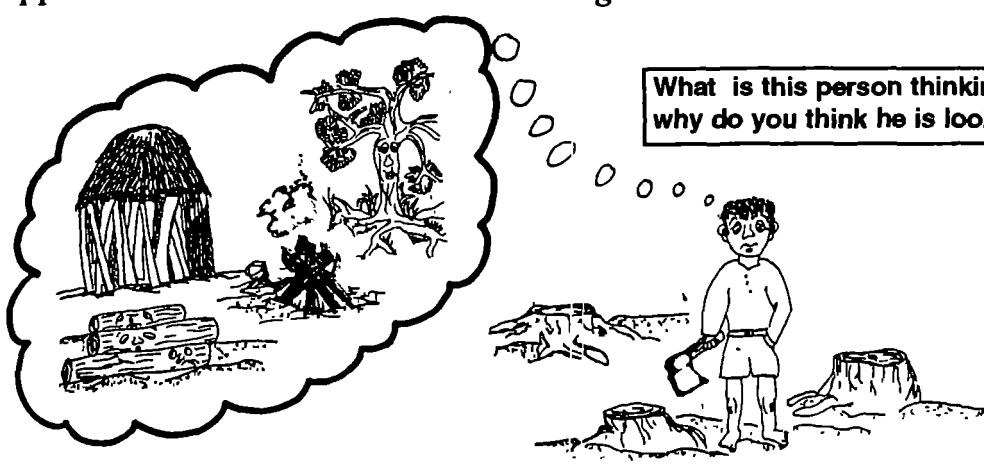
Today the water is used mainly for small farms and household use. Fishing is important when the oshanas are in flood. However, the water supplied from the Kunene River has changed the way water is used in many areas. People in this area used to move from place to place, depending where water was available. Many communities now have permanent water sources from canals or pipelines.



Look at the picture and explain how you think overgrazing happens in Namibia.



An increase in human and domestic animal populations at these water points puts a lot of pressure on the land, resulting in **overgrazing** and **deforestation**: too many animals grazing on grass in one area and too many trees being chopped down for firewood and the building of homes.



What is this person thinking about, and why do you think he is looking so worried?

More and more people are moving to the towns in this area, and in the urban centres the demand for water for households and small industry is growing. Irrigation projects in this region will use more and more water. This water will have to be supplied from the Kunene River.

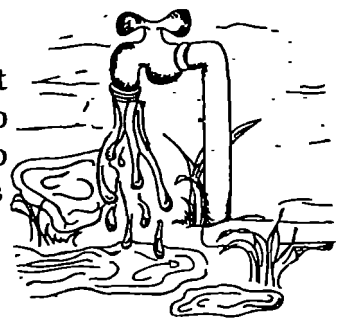
Things to think about!

Groundwater and surface water in the Oshana Water Region keep many thousands of people alive. If people are involved in planning their own use of water resources they soon realise how important it is to save water. Local water resources should be used carefully and imported water (Kunene water) should be used only when absolutely necessary.

The water transport scheme criss-crossing the oshana area has had a marked effect on the people and their environment:

- People are attracted to an area when roads and water are provided because their lives are made easier by these facilities. Thus the population increases rapidly at such points, resulting in overgrazing and deforestation.

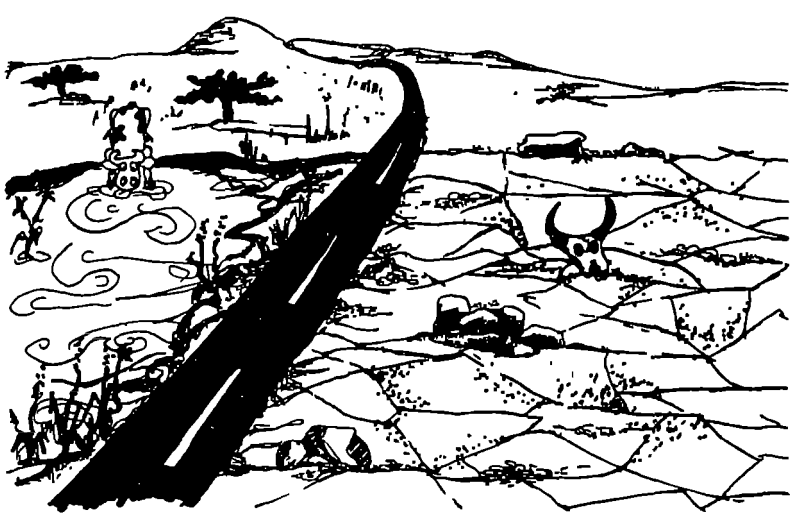
- People using water from canals and pipelines often do not realise that water is scarce in this arid area. They tend to waste more because it runs freely from taps and they do not pay for it. Those who have to draw water from wells realize how little water there really is in the area.



- Many of the water structures set up by the Government are broken or not working properly. A lot of water is wasted through leaks or overflows. Reasons for this may be that the communities do not accept responsibility for the water point or feel that it is not their property and therefore they do not fix it or they even break it. It might also be that the machinery is complicated and people do not know how to use it or repair it properly.

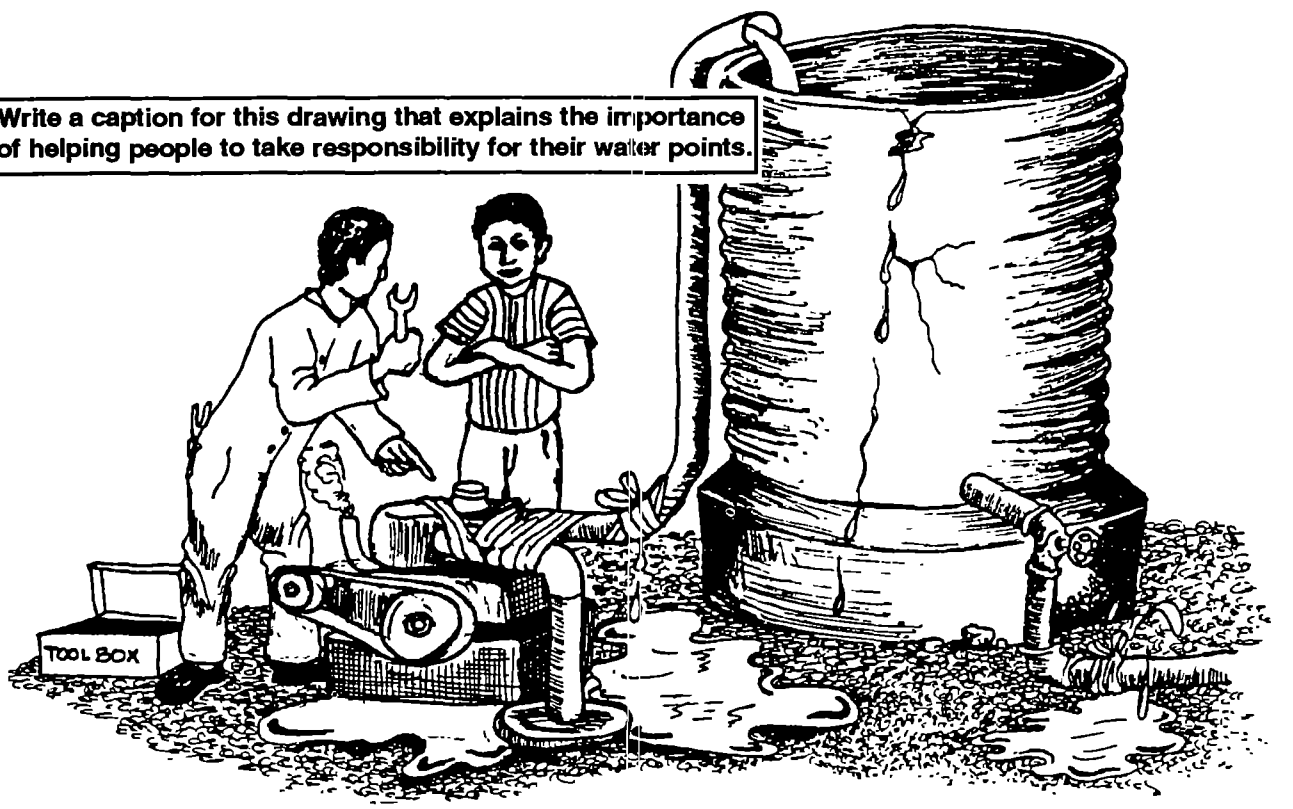
- People, with their livestock, tend to settle in areas where water is supplied. After a while, overgrazing and deforestation become problems as there are too many people and animals using limited resources.

- The oshanas run from north to south, while the pipelines, canals and main roads run from west to east. These canals and roads prevent the oshanas from flowing normally, which means that there is less water further down in the oshanas to recharge groundwater and enable growth of plants. There is less grass for the animals to eat, so the land is likely to be overgrazed. New road developments are now built with culverts which allow water to flow under the roads.



There is a new approach towards water use and conservation in Namibia, with the communities and the Government working together on Water Committees. Each community is encouraged to take part in planning water points and to offer free labour, while the Government provides the training and the heavy equipment. The community is then responsible for the work, for looking after the water scheme and for raising funds for its upkeep. When people feel that they own their water scheme, they become more independent as they become more aware of the value of water in this dry land. This approach has already been successful in the Onaanda / Okahau South area, where the communities helped to build their water schemes and formed Water Committees to handle their water issues.

Write a caption for this drawing that explains the importance of helping people to take responsibility for their water points.



Fish, snails and plants live in the oshana system and are used by the people for food. These animals and plants have adapted to the temporary water that is available to this area.

Activities

- Mix 1 spoon of salt into a cup or tin of fresh water. Taste it and pour it into two shallow dishes. Place one dish in the sun and one indoors. After 2 to 4 hours taste both and compare. What do you notice? How does this explain changes in the water quality in small dams and pans in the Oshana Water Region?

- Experiment with different water densities:
  Add enough salt to 0.5 litres water to make a saturated solution, that is, until no more salt will dissolve in the water.
  Take 1 litre fresh water and colour it with ink or food colouring.
  Pour the salt water into a clear container and allow it to settle. Carefully pour the coloured water over the salt water. What happens?
  Now stir the water lightly. What happens?
  Stir more vigorously. What happens?

  Now repeat the experiment using clear fresh water instead of salt water. What happens when you add coloured fresh water?

  Discuss what you have seen, why does this happen? How is it relevant to omifima (wells) in the Oshana Water Region?

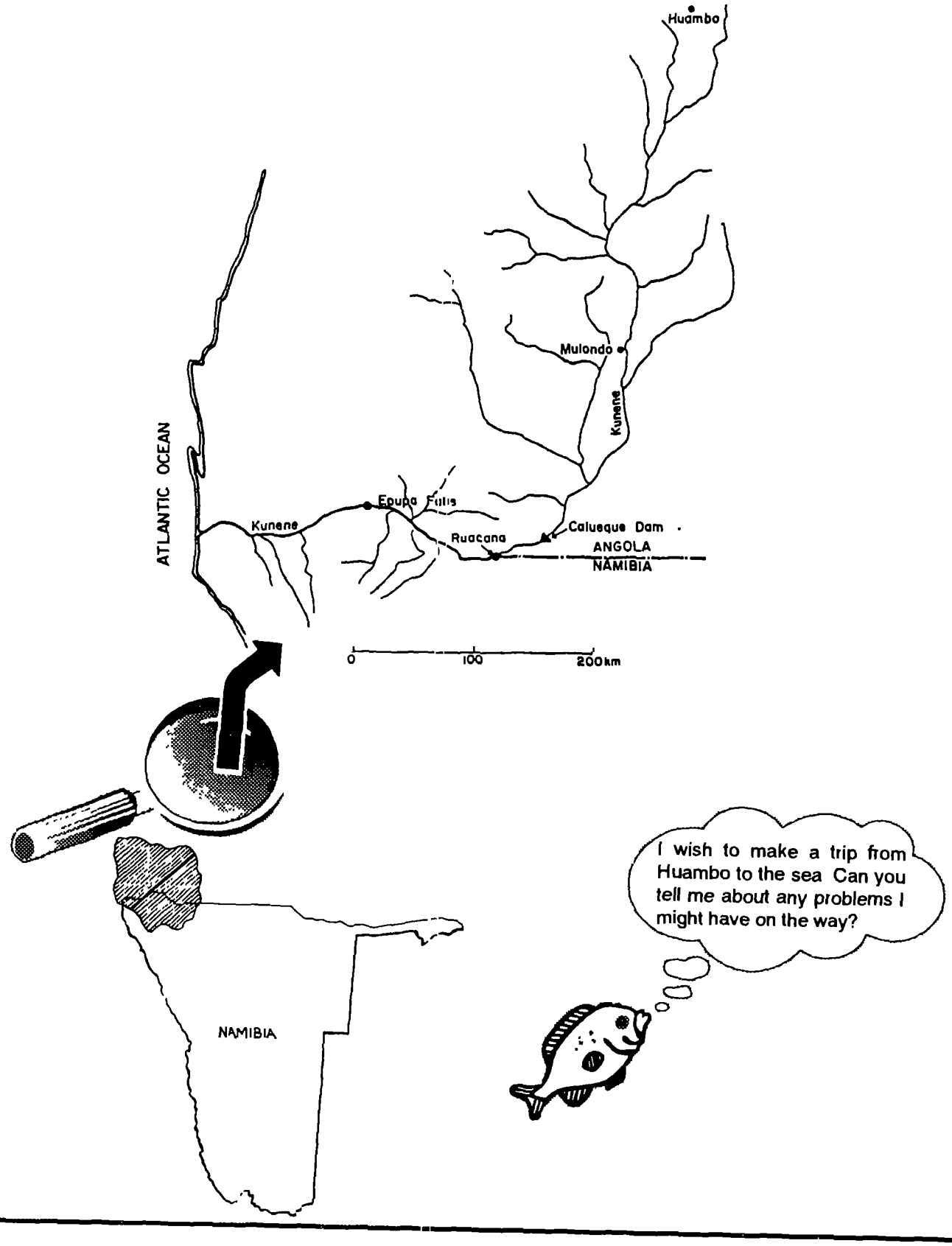
- In a class discussion, talk about the problems of **overgrazing** and **deforestation.** What do these terms mean? What are the signs of overgazing and deforestation? Why do you think the land becomes overgrazed and deforested? What would the effect be on the land in the Oshana Water Region? What could be done about it?

- Compare the oshanas in the wet and dry seasons. Draw pictures to show the differences. Show which types of food are available in each season. Why is seasonal flow so important and could the roads and canals interfere with this system? What could be done to protect the oshana system?

- Divide your class into two groups: one group of water experts, one group of rural people with various water problems. The rural people explain all the different problems they have in their area. The water experts then work together with the people to help find solutions that are practical. In the final meeting of the two groups, show how they can work together to solve problems and suggest a few of the ideas that may solve these water problems.

- Pretend that your class is a village and your well is very saline, polluted and almost dry. The handpump is broken, the sides of the well are badly eroded and the water is making the children very sick. There is a pipeline nearby, from the Kunene River, but someone broke it open for his cattle and wasted a huge amount of scarce water, so the pipeline has been blocked by the water authorities and no longer carries water through that area. Form a water committee to discuss these problems and decide how you can solve them yourselves.

THE KUNENE WATER REGION



Where does the water come from?

The Kunene River is the third largest river in Namibia and rises in Angola near Huambo. It flows south for 500 kilometres, first down steep mountains, then it flattens out towards the Calueque Dam. After rushing down the Ruacana Falls, the river flows westwards for 340 kilometres, through rugged mountains most of the way, over its highest waterfall, Epupa Falls, and on to the Atlantic Ocean. A freshwater **lagoon**, at the mouth of the river where it meets the sea, provides a valuable **wetland** for many birds living in or visiting the area.

The rainfall at the **source** of the Kunene is very high (1300mm per annum) and because of this the river flows strongly in late summer. The amount of rainfall drops to 100mm or less per year where the river passes through Namibia, so very little water in the river comes from the lower **tributaries**. Most of the river water comes from far inland.

Two major dams have been built on the Kunene in Angola in order to provide more water to densely populated areas in Angola and Namibia. The Gove Dam in the upper catchment collects much of the annual **runoff** water and this reduces the river flow downstream. The Calueque Dam was built further south near the border between Namibia and Angola. This dam was damaged during the war; it fills then overflows through damaged sluice gates (sliding gates in dam wall controlling water flow). However, it does hold enough water to supply water, for household use, to the Oshana Water Region. The Ruacana ***diversion weir*** was built upstream of Ruacana Falls in order to control the flow of water and divert water through a ***hydro-electric scheme*** which generates electricity for use in Namibia.

Water supply facts:
Most of this area and its population gets its water from groundwater, with the exception of the people actually living close to the Kunene River. The town of Ruacana ge' water piped in from the Kunene River.

Diversion weir - a barrier which forces water to move in a certain direction, usually for a hydro-electric scheme

Hydro-electric scheme water is diverted from a river or dam and piped through turbines at great speed These turbines then generate electricity from the water power

How do the people in the area get their water?

As discussed in the section on the Oshana Water Region, water is pumped from the Calueque Dam to supply the many people living in Northern Namibia. Not many people live where the Kunene River passes through Namibia, because this area is dry, remote and mountainous. Groundwater is scarce here due to the low rainfall and rocky terrain, so although there is a large river in the region, many people do not have easy access to fresh water. The Himba people living along the Kunene River draw their water directly from the river. Those living farther away use natural springs or dig for water in the larger dry river beds. Many **ephemeral** rivers drain these Kaokoveld mountains, but because of low rainfall they do not flow regularly. Underground water and natural fountains support some vegetation and provide water for the rural Himba people and their animals, as well as for the wild animals in the area.

Tell a story to your class called "A day in the life of a Himba woman", stressing the time she spends collecting water from the distant river.

How is water used in the area?

The Himba people live along the lower reaches of the Kunene River where it passes through Namibia. They grow crops, sometimes using a form of furrow irrigation, and keep animals where the river supports enough plants to feed them.

Many different kinds of wild animals, including elephants, crocodiles, turtles and fish, depend on the river. Since independence, more and more tourists have been interested in visiting this area. There are some safari camps along the lower Kunene. A Kaokoland wildlife reserve was proposed but turned down by the government in 1992.

A possible use for the river in Namibia is being investigated at present: a dam at Epupa Falls could supply more hydro-electric power for Namibia, possibly making it self-sufficient in electricity in future. The dam would be 17 times bigger than Namibia's largest dam, Hardap Dam. However, before plans can go ahead, careful studies must be done to understand the possible effects of such a structure on the environment. Problems include:

- disrupting the flow of the river downstream of the dam, affecting plant life and animal life in the river;
- destruction of the environment caused by building the dam wall and a new town for the many people needed to build the dam;
- increasing tourism, thereby increasing pressure on the sensitive arid environment.
- introduction of new health problems such as increased malaria and bilharzia in the shallow areas of the dam.
- flooding 75 kilometres of river including many Himba traditional grazing lands, settlements and graves. The floodplain vegetation that now supports the Himba herds will not regenerate higher up around the dam edges.

The main advantage would be to provide energy to Namibia, which could contribute to future economic development. We must carefully study the advantages and disadvantages of this dam to Namibia and to the entire region before we go ahead with this expensive development.

The Kunene River is a ***linear oasis*** passing through an otherwise arid region.
What do you think a linear oasis is, and how do you think the people living along this oasis would use the benefits of this oasis?

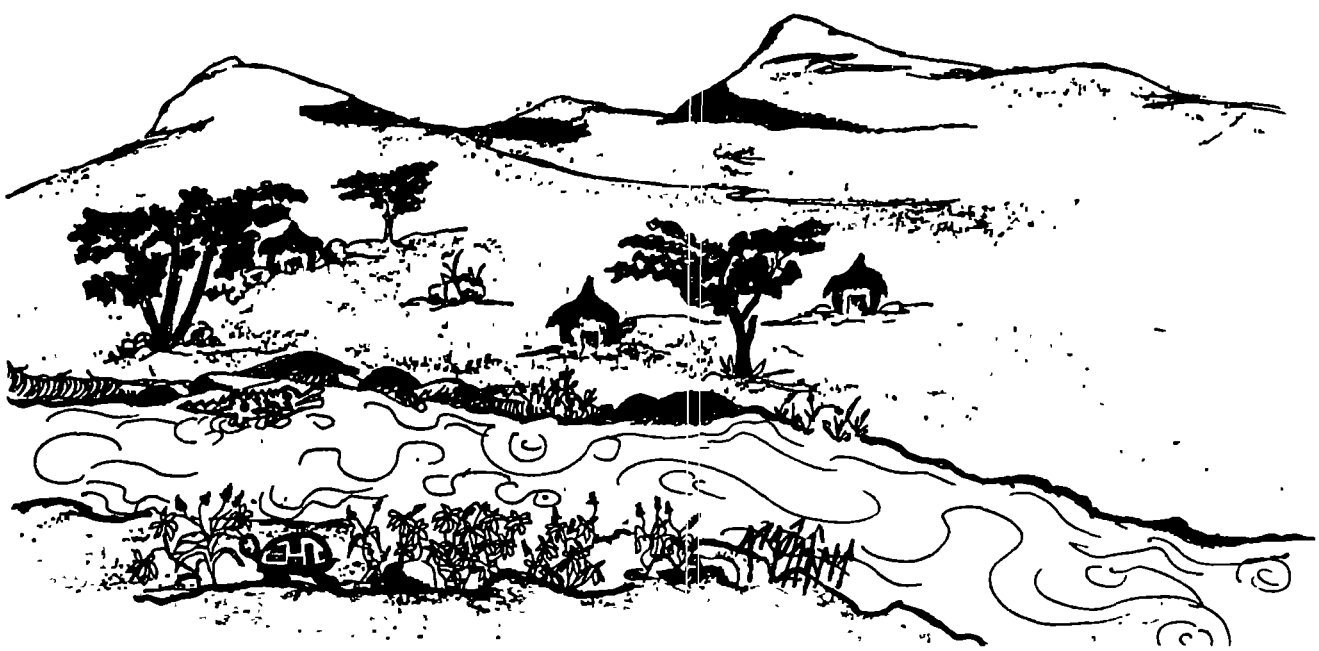
Explain how the vegetation along the river would be used by the people, domestic and wild animals.
What other food resources would the people find in the river?

Things to think about!

Even though the Kunene River is a perennial water source, the water is limited and use of the water should be planned so as not to disrupt the sensitive river system. For example, the highest flooding period of the river is after the inland summer rains, in March/April, while the lowest period is in October/November when the lower river can even stop flowing. But it is in October that the most water is taken from the Calueque Dam. At this time there may be no water flowing over the Ruacana Falls because it is all diverted through the turbines to generate electricity. There is a great variety of fish species, which have adapted to the flood cycle of the river, but when river flow is artificially low, fish breeding sites dry out, and a decrease in fish numbers has already been noticed in the river. The breeding of crocodiles, turtles and otters is also affected by water level changes.

A dam at Epupa Falls may provide an important source of electricity for Namibia, but it would have serious consequences for the river. For example, more sea water could enter the river mouth, and sand dunes may move over the river mouth and block the lower course of the river. The wetland at the mouth, which is important for many species of birds as well as breeding crocodiles and two species of turtle, could actually be destroyed. If the dam is built, it should have more benefits than disadvantages to local people and all Namibians. This could be possible if the various experts on this project work together to get a better understanding of the ecological water requirements of the river. The question is, with careful management can this river serve the immediate and long-term needs of the people living nearby and those in the rest of Namibia?

What plans should be made for the very dry years when there is not enough water in the Kunene River to generate electricity at Epupa and to supply water to the Oshana Water Region?

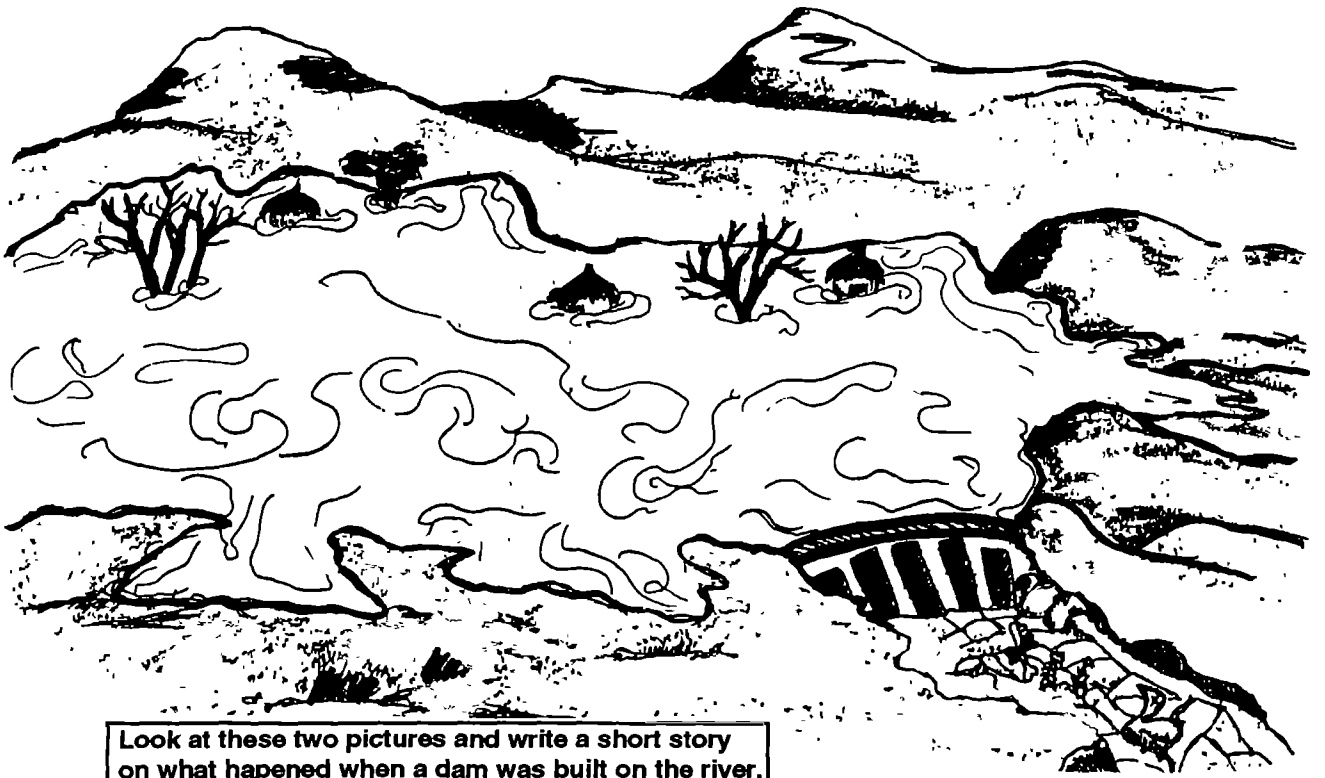


Activities

- Hydro-electric power: write a paragraph explaining how we get electricity from water. Draw a sketch of a river and choose a place to build a hydro-electric scheme. Draw in your scheme. Write another paragraph explaining why you chose this place and how your hydro-electric scheme will work. Name two influences that this scheme could have on the river.

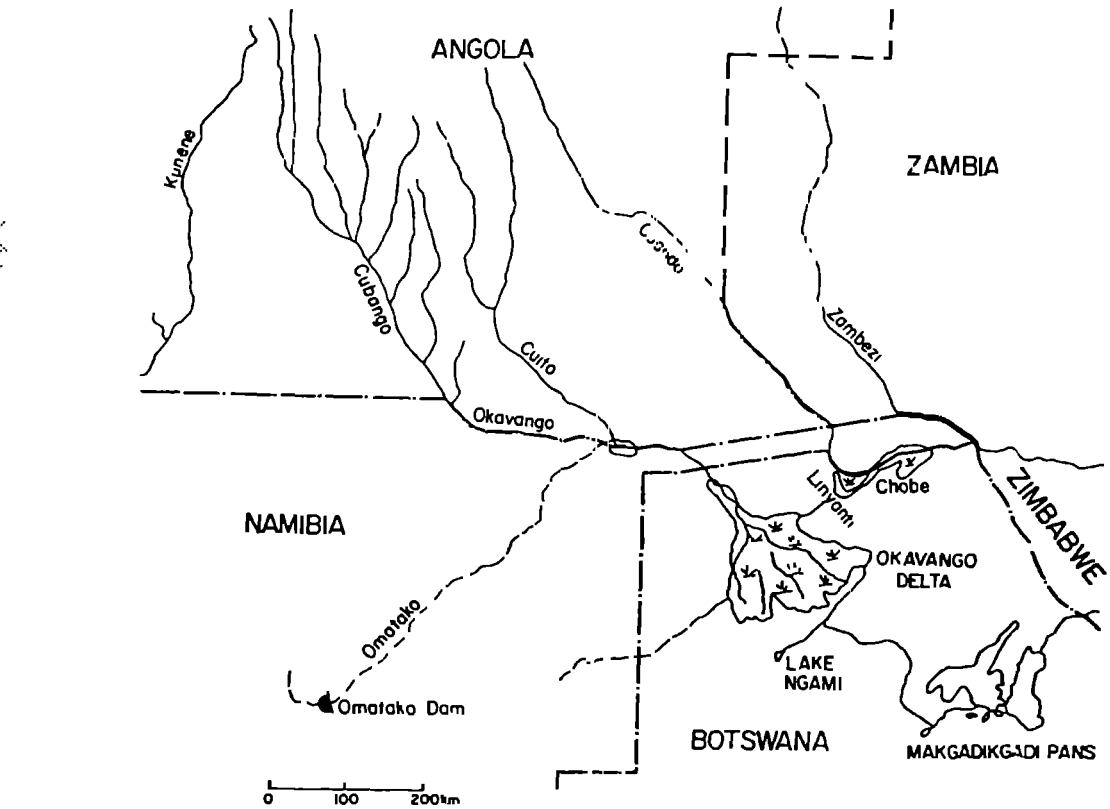
- Find some pictures of dams in books or magazines. Study them carefully and try to work out the influences these dams have had on their river systems.
  Would the same plants and animals be able to live in the river area if the river patterns change? For example, seasonal floods would no longer occur, less water would flow in the river, water would be released from the dam at odd intervals.
  Would the barrier of the dam wall affect animal life?
  What effect does the large body of dam water have on the area, for plants, animals and people?

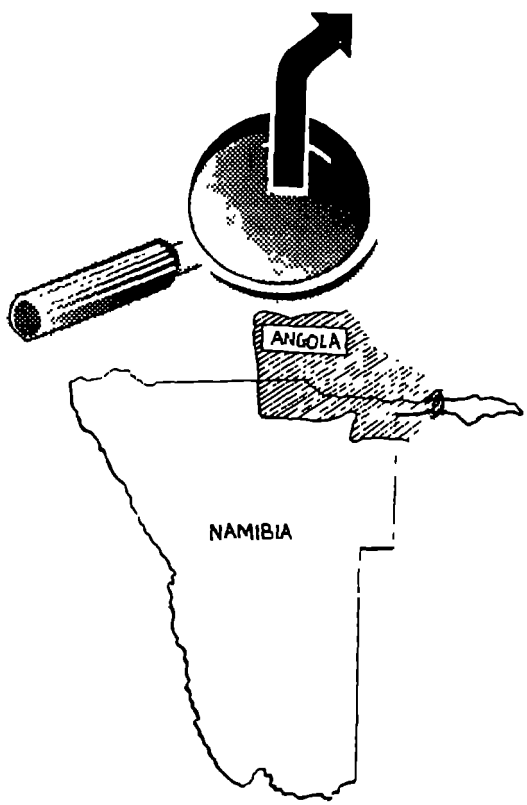
- Form two groups in the class - those in favour of building a dam at Epupa Falls and those against it. Each group makes a list of arguments, and then presents these in a class debate. Each pupil then decides whether he/she is in favour or against a dam at Epupa Falls. Each pupil then discusses these arguments with his/her family and friends at home and reports back to the class on his/her findings. Use the findings of the class to write a report for a newspaper.



Look at these two pictures and write a short story on what hapened when a dam was built on the river.

THE OKAVANGO WATER REGION





Where does the water come from?

The Okavango River originates in the Angolan mountains, not far from the **source** of the Kunene River. In Angola the river is called the Cubango. After twisting eastwards through mountains and gorges for 600 kilometres, it reaches the Kalahari sand zone, and becomes the flat, often strongly-flowing waterway on the north-eastern border of Namibia. It then bends southwards through a narrow valley, over the Popa Falls, and into Botswana where it spreads into a massive **delta**, the Okavango Delta. From this huge area of vegetated islands, channels and water grasses, only two **ephemeral** streams emerge, one used to flow into Lake Ngami which dried up in 1860, and one flows into the Makgadikgadi Pans.

The main **tributary** of the Okavango River is the Cuito River which also rises in the high rainfall mountains of Angola and joins the Okavango River east of Rundu, forming a large **floodplain** where they meet (the **confluence**). Very little **runoff** reaches the river from its tributaries in Namibia, as most of the rain is absorbed by the sandy soils or flow is blocked in the vegetated river beds (called omiramba). The biggest Namibian tributary is the Omuramba Omatako which does not often reach the Okavango River. During high floods the Okavango River waters flow back into the Omuramba Omatako, creating a large **wetland** area.

High summer rainfall (1300mm per annum) in the Angolan mountains causes river flow to increase between January and April. These flood waters reach Rundu in March/April and affect the southern Okavango Delta in Botswana only in June. The annual floods cause the Okavango River waters to rise and spread over the floodplain in the form of large linking lagoons and channels. By November the river water is at its lowest, leaving only isolated ponds and small channels on the floodplain.

Groundwater in the area is found mainly in the large **alluvial aquifer** associated with the river. This aquifer depends on the river for recharge and makes water available to areas within 30 kilometres of the river.

Water supply facts:
About 60% of the population of this area gets its water from the Okavango River and this represents about 10% of the total area of this region. 90% of the area only has groundwater to offer and this groundwater supplies 40% of the population.

How do the people in the area get their water?

The annual floods that spread over the floodplain are an important part of the local people's lives. The many people living near the river draw their water directly from the river and its channels and depend on the floods to irrigate their fields.

Rundu is the largest town in the area and has grown a lot in recent times. Water is pumped from the river and purified, then supplied to the town for household use and small industry.

Water is also pumped from the river for some large irrigation schemes, and for mission stations and schools along the river. Settlements and mission stations away from the river use boreholes with hand pumps or motor-driven pumps. There is groundwater within 30 kilometres of the river. Where the **water table** is shallow, hand-dug wells are used, but these often collapse because of the sandy soils. There is also a health risk where this open water is contaminated (polluted) by people and their animals.

The river is very important to these people. Explain why. How can they care for their river?

How is the water used in the area?

Wato's are an important form of transport for people who live near the river. How do you think the chopping down of trees is affecting this form of transport?

The sandy soils in the area are not fertile except on certain floodplain terraces where the river has deposited silt over the years, making a rich environment where plants and animals can grow, and fish and birds can breed. The floodwaters of the river are used by the large local population for:

- small-scale crop farming
- fishing,
- hunting,
- grazing for animals during the dry period,
- reeds to build housing, fencing, baskets and fish traps.

The larger settlements in the area use the water for domestic and agricultural purposes.

The Okavango River is the main source of water for the Okavango Delta in Botswana. The delta supports a large population of fishermen and farmers, as well as the many tourist facilities in the area.

Because of the increasing demand for water in Central Namibia, the Okavango River may form part of a plan to transport water from the northern water resources to the central area of the country. This Eastern National Water Carrier, when it is completed, will draw water from the river to be pumped through a series of canals and pipelines to dams in the central area of Namibia. This is called the Central Area Water Master Plan.

Two interesting facts about water-use from the Okavango River:

* The mission station at Andara generates its own electricity using water from the river. Some water is diverted by a stone barrier into a side channel upstream of the mission, and the constant through flow drives a small turbine. Prior to 1985 this was done by using a water wheel.

* At Biro Clinic, the water pump is powered by the river flow. A float with a propellor is anchored in the river and generates enough power to pump water from the river to the clinic water tanks.

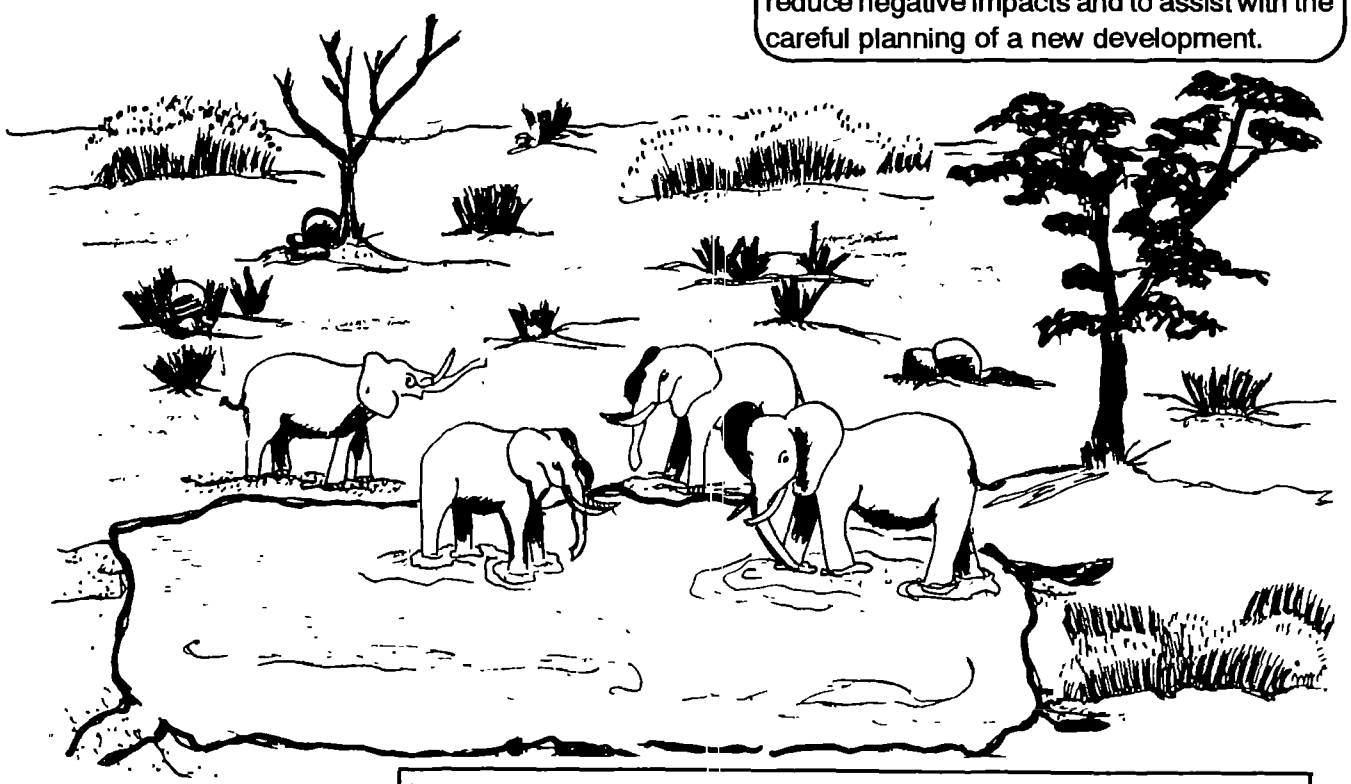
Things to think about!

Water forms part of the total environment and should be cared for together with the environment. Because there are more and more people living along the Okavango River, depending on the water and the soil for their survival, this river environment is beginning to suffer:

As river margins and floodplains are cleared for settlement and agriculture, and reeds are removed to thatch roofs, **soil erosion** becomes a problem and much of the fertile topsoil is lost by being washed into the river.
The surroundings change as trees are chopped down for firewood and animals overgraze the seasonal grasses (**deforestation** and **overgrazing**).
Uncontrolled hunting reduces the bird and animal life.
The use of fertilisers and pesticides (poisons that kill pests) pollutes the water.
Removal of large amounts of water for irrigation or to supply the Central region could interfere with the flow patterns of the river and have a lasting impact on the whole river system.

The environment could be better protected if the clearing of vegetation along the river was stopped, and if farmers improved their methods to prevent overgrazing and water pollution. A study on the positive and negative effects of each development scheme needs to be done before development begins, to make sure that the area is properly used and conserved for future generations. Such a study is called an ***Environmental Assessment (EA).***

Environmental Assessment - study of living things and the area in which they live, to find out what environmental impact a proposed development will have, to work out ways to avoid or reduce negative impacts and to assist with the careful planning of a new development.



In what way do you think game reserves help to protect the river system and to bring in money from tourists?

Activities

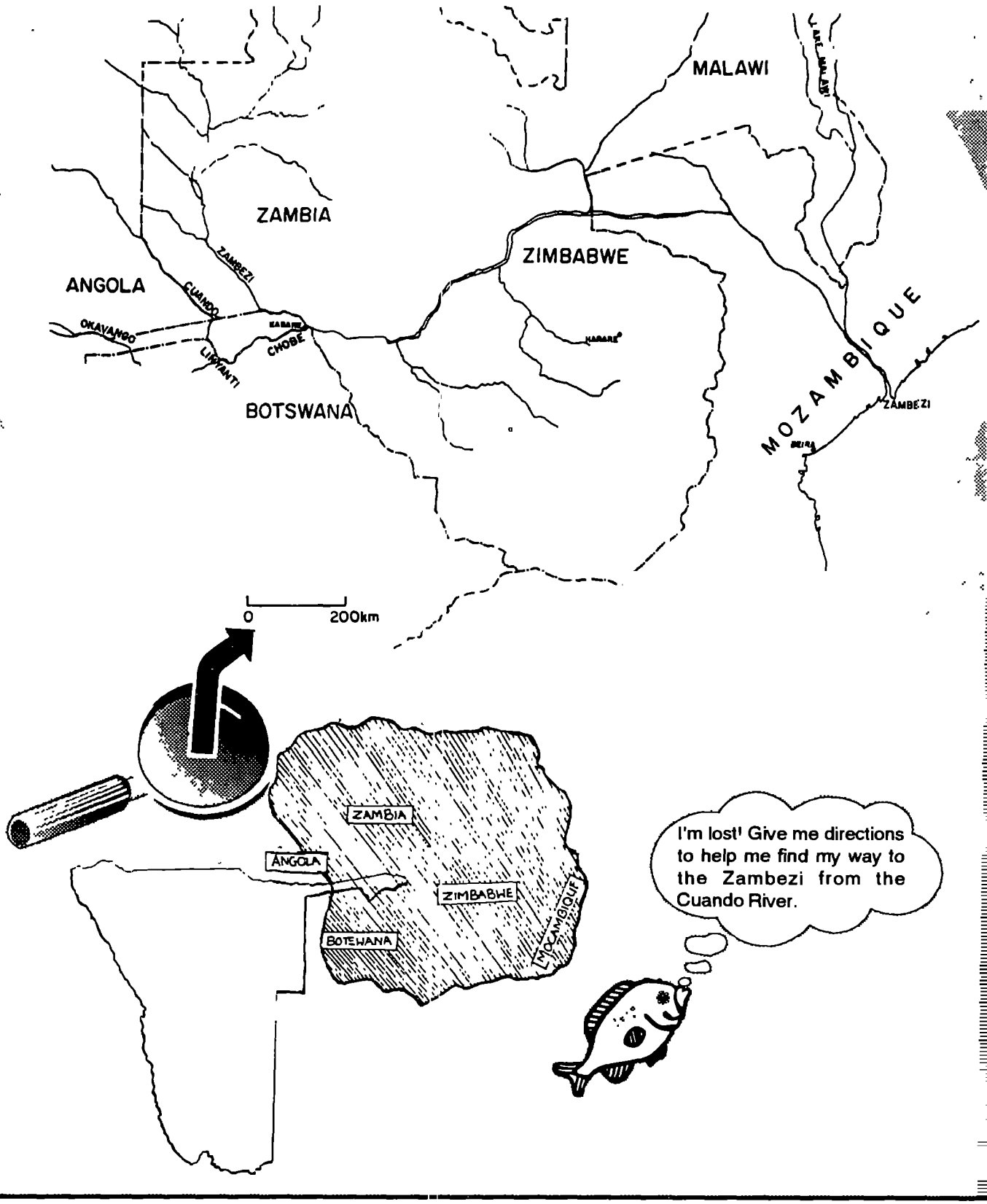
Draw a class poster to show the three different habitats of the Okavango River:
1) the fast-flowing river where small fish seek shelter in papyrus mats and large predatory fish, for example Tigerfish, search the open water for food;
2) the permanent swamp, in Botswana and Mahango Reserve, where clear nutrient-rich lagoons provide vital breeding and feeding grounds for many species of fish;
3) the seasonal swamp on the floodplains of the river - sometimes dry fertile ground and sometimes shallow waterways supporting many fish species during the flood.
Colour the poster and label the different aspects of each habitat. Draw in the uses that people have for the three habitats. Then discuss in class how people in the area could use their water and land resources constructively. Suggest how abuse of the resources could be controlled.

Collect $10. Order a colour poster "Fishes of the Okavango" for your classroom from: J.L.B.Smith Institute of Ichthyology,
Private Bag 1015,
Grahamstown 6140, R.S.A.
Put the poster up on your classroom wall. Have a class discussion about the different types of fish.

- Which fish do you recognise?
- Have you caught any of these fish? When, where and how?
- Where and how do these fish breed?
- Why are the fish important to the people in the area?
- How can they be protected from overuse?

Pretend you are living in the year 2050.
Divide your class into two groups, one is called "happy ending", the other is called "sad ending".
1) The "happy ending" group acts out for the class all the good care that was taken of the Okavango River for the last 50 years. Try to think of all the ways in which the river could be protected: no clearing of vegetation along the banks, no overgrazing or deforestation, controlled hunting and fishing, no water pollution, controlled water removal for irrigation and the Eastern National Water Carrier, can you think of others? Show how good care of the river makes a happy ending for the people of Namibia.
2) The "sad ending" group acts out for the class all the damage that has been done to the Okavango River during the last 50 years. Show why there is soil erosion, why trees and grass are scarce, why there are hardly any birds, fish or wild animals, why there is very little water flowing in the river and this water is polluted. Show how this damage to the river system will affect the people of Namibia.
After these two short plays have been acted out, make a class statement about how the Okavango River should be cared for now and in the future in order to have a "happy ending". Decorate the statement to make it look interesting and hang it in your classroom. Show it to your friends.

THE ZAMBEZI WATER REGION



Where does the water come from?

The Zambezi River, with its **tributaries**, forms the fourth largest river system in Africa, stretching over areas of Zambia, Angola, Namibia, Botswana, Zimbabwe, Tanzania, Malawi and Mozambique. It rises in Zambia and flows eastwards for 3000 kilometres to the Indian Ocean. In Namibia, the Zambezi River, together with its tributaries, the Cuando and Chobe Rivers, forms an important river system in Caprivi. The Cuando (or Kwando) is one of southern Africa's more unusual rivers. Rising in Angola, it comes down from the mountains onto a huge **floodplain** where it winds through large marshlands of reeds and grasses and channels. It empties into a great swamp, then emerges as the Linyanti River which in turn empties into Lake Liambezi, a lake that fills only during periods of high rainfall and is otherwise dry, vegetated and even farmed in parts. The Chobe River flows from the south-east corner of the lake and winds along a flat floodplain to join the Zambezi River. The Cuando River flows so slowly that its summer flood waters only reach Caprivi in May/June, after the floods of the Zambezi River. Therefore, at the height of the Zambezi River's flood in March/April, its waters push up the channel of the Chobe River or up the Bukalo Channel, reversing the flow back towards Lake Liambezi. The spill over from the Zambezi during high floods helps to fill Lake Liambezi. However, this lake dried out completely in 1985 and has not refilled since then.

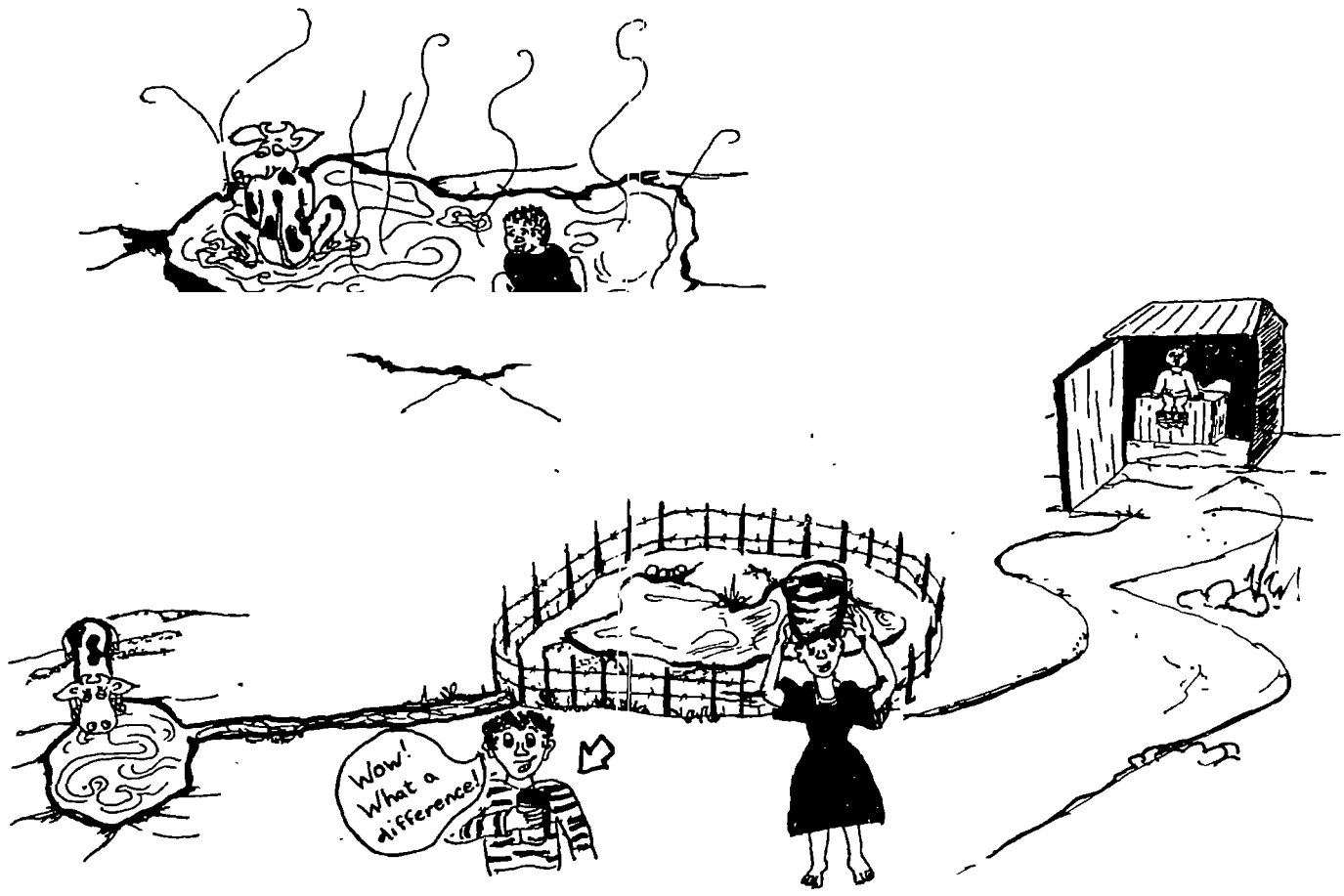
The rainfall in Caprivi is the highest in Namibia, averaging 700mm a year, which creates a lush area of grassland, woodland and waterways.

Water supply facts:
Most of the people (70%) in this region live near the perennial rivers and therefore use surface water. 70% of the area depends on perennial river water and 30% depends on groundwater.

How do the people in the area get their water?

Many people live along the rivers and main roads in the area, and the number of people living in the town of Katima Mulilo is increasing rapidly. The traditional water sources were the rivers, pans and ponds, but now more boreholes and hand-dug wells are being put in to support the growing population. Hand-dug wells, which are not supported with concrete rings, often collapse because of the sandy soils. The wells can become polluted if they are not fenced off from animals and if toilets are not built a distance away from wells. The people living on the floodplain follow the seasonal water by moving to the low ground for the dry season and to higher ground in the wet season, digging wells for water when necessary.

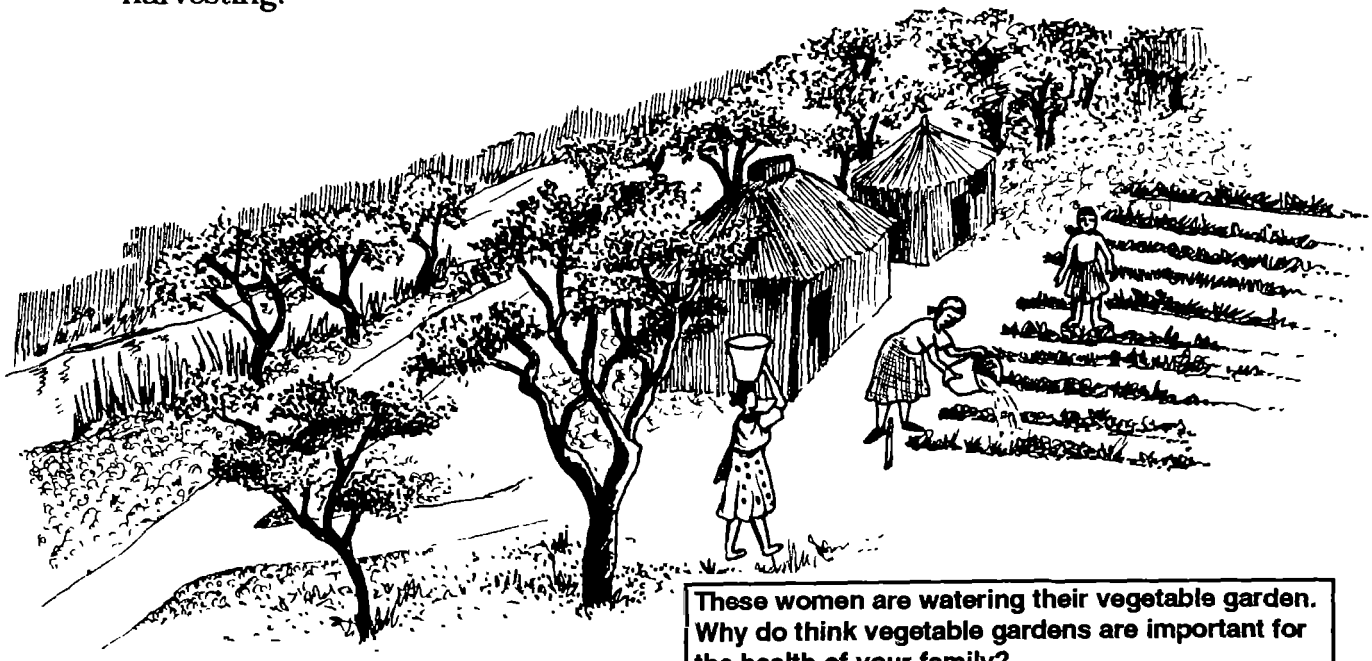
A pipeline carries water from Katima Mulilo to Kongola, with outlets on the way for the local people and their animals. The 1992 drought has affected the region and many people have moved to Katima Mulilo or to places where there is more water. The Government attempts to assist people in the rural areas with water during drought periods, for instance by using water tankers to take water to areas short of water.



Write captions for these scenes, explaining how water can be kept clean and safe!

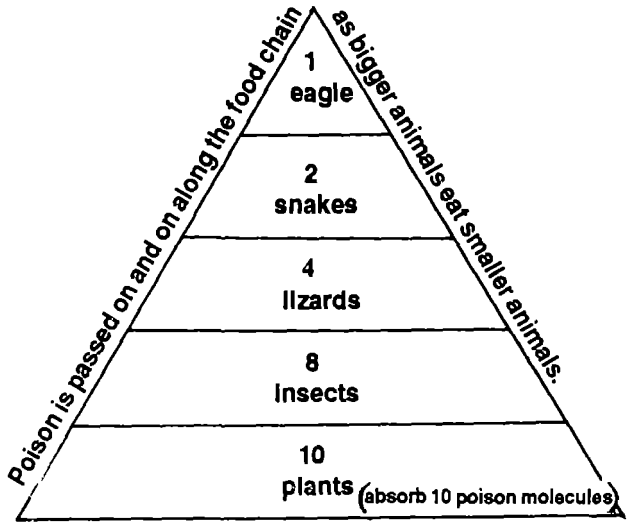
How is water used in the area?

In much the same way as the Kavango people, the people of Caprivi depend on the flood patterns of the rivers for their survival. They live off the fish from the rivers, and use the floodplains for crop growing, stock farming and fish harvesting.



These women are watering their vegetable garden. Why do think vegetable gardens are important for the health of your family?

Irrigation projects, including rice and sugar cane farming, may increase because of the large amount of water in the region.



How does the animal at the top of the food pyramid end up with the 10 poison molecules?

Diseases linked to water kill thousands of people each day in Africa. Malaria and bilharzia are common diseases in the Zambezi Water Region. These diseases are caused by parasites that depend on water for part of their life cycle. Diseases caused by dirty water include cholera, typhoid and dysentery.

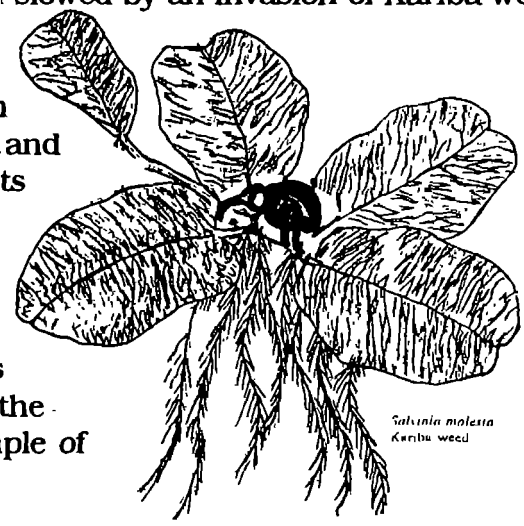
Poisons used to control diseases end up in the water sources and cause environmental problems. They are passed along food chains until they accumulate in the higher predators. *What do you think a food chain is?* Use the food pyramid above to describe how poisons accumulate in the bigger animals as they prey on the smaller animals.

Things to think about!

The rich wildlife in Caprivi is declining because of uncontrolled hunting. Game reserves in the area prevent the total disappearance of some species, but the authorities need to work together with the local communities to ensure the survival of wild animals and birds in the future.

The increase in the cattle population has led to **overgrazing** and therefore to **erosion**. Erosion also increases where trees are chopped down for firewood and where winter grass is burnt off to provide new grass which is then overgrazed.

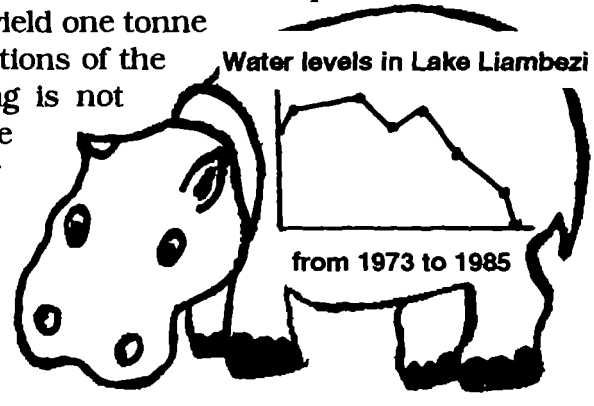
Since the early 1970's, river flow has been slowed by an invasion of Kariba weed (*Salvinia molesta*), a water plant from Brazil, throughout the river system. This floating fern forms dense mats on which other plants can grow, blocking out the light and reducing the oxygen in the water. These mats can become so thick that rivers actually stop flowing. A careful study of the problem was done and the weed is now controlled by an imported beetle that attacks the growth tips of the plant. This prevents new leaves from growing and the weed dies off. This is a successful example of ***biological control.***



Biological control - control of a problem through a natural agent rather than a chemical agent.

Irrigation schemes need to be carefully assessed for their impact on the environment. For example, the high evaporation rate causes salts to be drawn to the surface in irrigated fields and after a few years these fields become unproductive. Also, fertilizers used on poor soils such as those in Caprivi, tend to make the soils saline (salty) and unproductive in the end. Fertilizers washed into rivers may cause very fast growth of Kariba weed, and the beetle may not cope with such growth.

The overuse of fish resources in the Chobe River has become a problem since the drying up of Lake Liambezi (which could yield one tonne of fish per day) in 1985. The fish populations of the Chobe River may never recover if fishing is not controlled in some way. Mosquito nets have become popular fishing nets, but with their fine mesh they catch even the tiny fish and therefore interfere with the breeding cycles of the fish.



Activities

Divide your class into three groups. Each group will design a poster about a different water-linked disease:
1)malaria 2)bilharzia 3)diseases in dirty water.
Each poster will show how the disease is caused and how it spreads amongst people. Very importantly, it should show how the disease can be prevented. Display the posters for all the school children to study.

If you live near a river, interview the people who catch fish in the area. Ask them questions such as:

- How long have you been fishing here?
- Is it easy or difficult to catch fish here?
- Has it changed since you started fishing?
- What do you use to catch the fish?
- Would you use a mosquito net to catch fish?
- What problems could mosquito nets cause for smaller fish?
- What will happen if too many fish, including young fish, are removed from the rivers?
- What will people eat in the future if there are not enough fish for them?

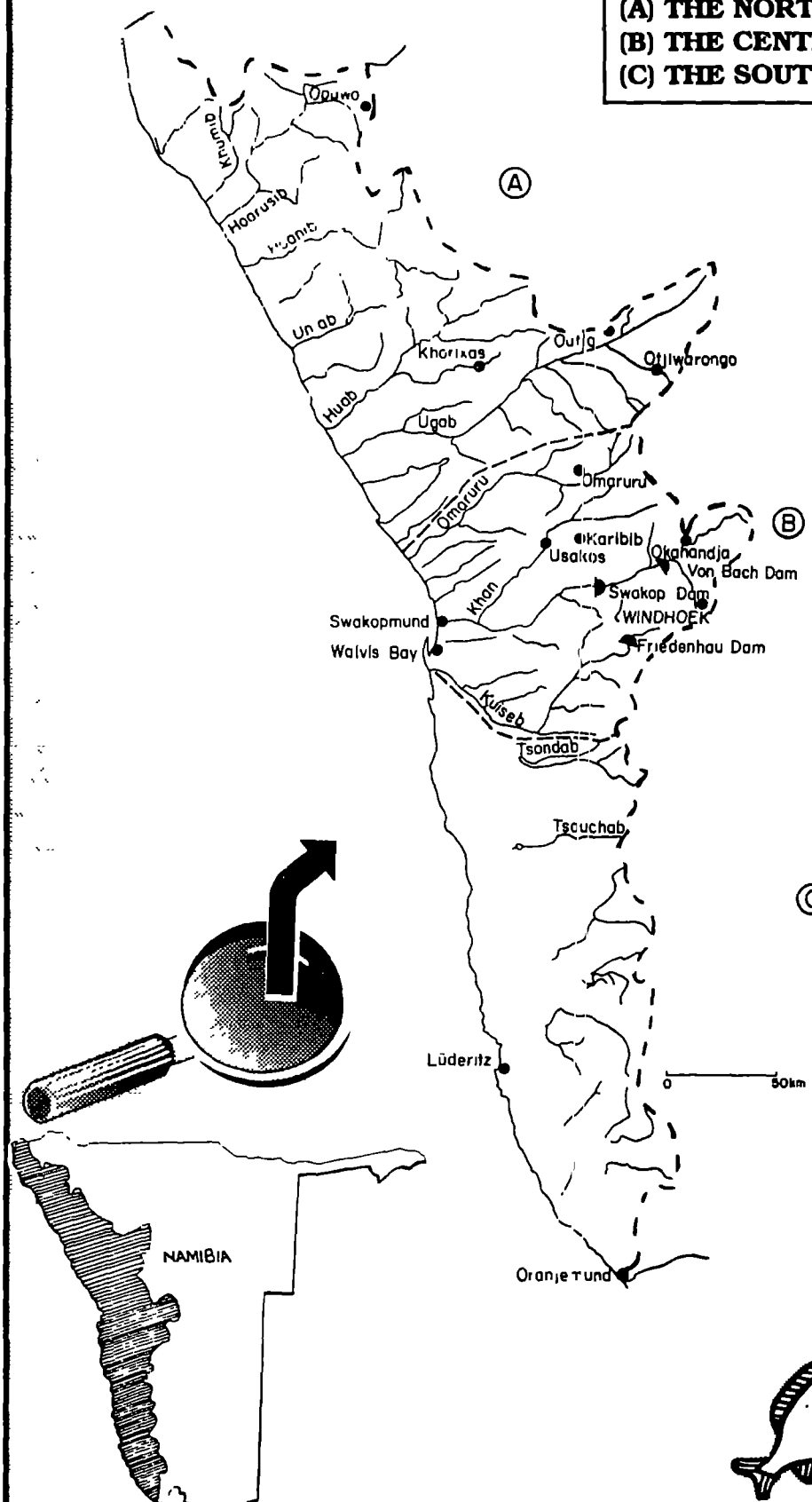
Write up your findings and discuss them in class.

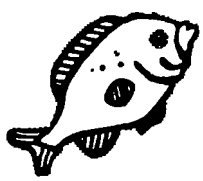
Try to grow your own vegetable garden. Decide first on a watering method that will not waste water, then find a mulch that will prevent evaporation. Plant a few vegetables and tell the class about your progress.

Pretend you are a farmer in the Zambezi Water Region. You have 100 cows. You are worried because they are getting thin, there is not much grass and the rains will only come in three months time. The cattle paths are very deep and last season's rain washed a lot of soil away. The grass did not grow well because of this. Think of all the possible ways of solving these problems and discuss them in class.

THE NAMIB WATER REGION

This region can be divided into three areas:
(A) THE NORTHERN NAMIB AREA,
(B) THE CENTRAL NAMIB AREA,
(C) THE SOUTHERN NAMIB AREA.





I have hatched in a wetland pool on an ephemeral river. What are the dangers I may face living in such a river?

(A) THE NORTHERN NAMIB AREA

Where does the water come from?

The rivers of the northern Namib, south of the Kunene, are all **ephemeral**, with dry sandy or rocky riverbeds for most of the year. The larger rivers have underground water flowing slowly under their sandy riverbeds. This underground water source supports woodlands and, in places, **wetlands**. These vegetated sections along the larger watercourses offer shelter to the people and wildlife living in this dry part of the country.

The larger rivers are all capable of flowing to the Atlantic Ocean, but do not reach the sea every year. They rise in mountains in the semi-arid region of Namibia which usually receives less than 300mm rainfall a year. This means that the amount of **runoff** is limited, and the rivers only flow sufficiently to reach the sea in years of above-average rainfall.

The Hoanib is the only river in the area with a large **floodplain**, which supports wetlands in good rainfall years. Big dunes cross the river upstream of the mouth and often prevent floodwaters from reaching the sea. These floodwaters supply the wetlands and two dune oases (pools where groundwater reaches the surface) which are connected to the Hoanib River **aquifer.**

The Ugab River has a very large **catchment area** and can flow for some months after good rains. There is a **lagoon** at the mouth, as well as several wetlands along its lower course.

The Uniab River has a small five-fingered **delta** with a large wetland area. There are several permanent vegetation-fringed pools, and a waterfall on one of the five channels near the sea.

Floods on these rivers can be very powerful. For example, in 1982 the water dammed up behind the sand dunes that had crossed the Uniab River in the preceding dry years. The flood broke through the dune barrier in a wave of water two to three metres high and 1000 metres wide and rushed to the sea, washing the road, water pumps and wild animals into the Atlantic Ocean. The smaller rivers in the area flow only after exceptionally high local rainfall events.

Groundwater, originating from river floodwaters, may occur in fracture zones (faulted areas) in this rugged region, resulting in natural springs, for example in the Sesfontein area.

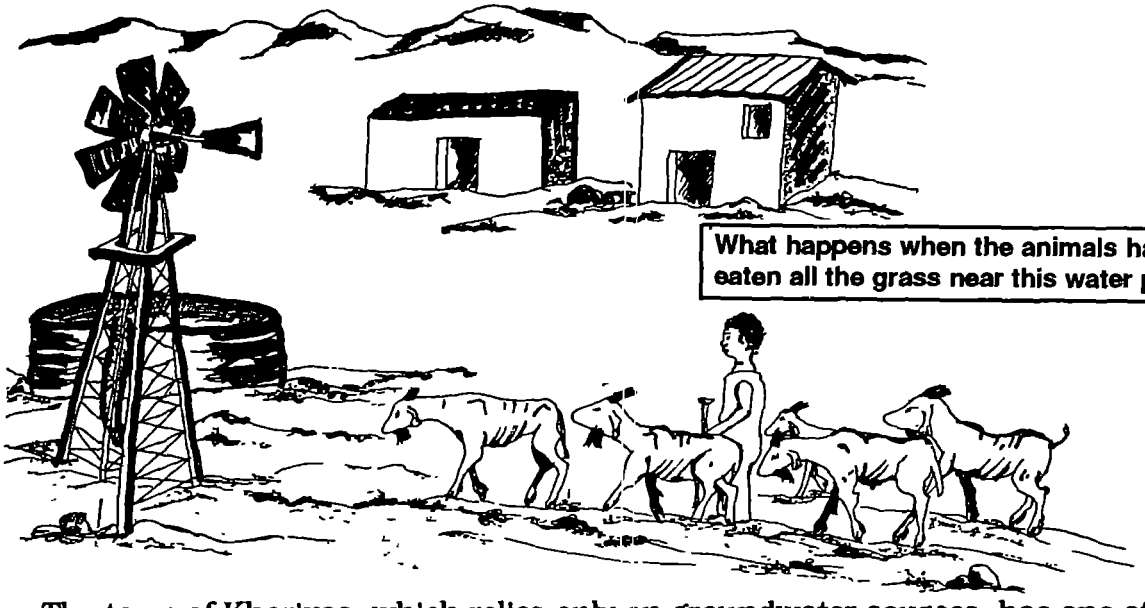
Water supply facts:
In the total Namib Water Region, 10% of the population depends on water from dams on ephemeral rivers. The remaining 90% depends on groundwater.

How do the people in the area get their water?

Not many people live in this area. The coastal area falls mainly into the Skeleton Coast Park and people cannot visit the area freely. The inland region is very dry, with small settlements and one larger urban centre, Khorixas.

The wetlands in the ephemeral riverbeds, inland from the Skeleton Coast Park, provide homes for small communities of rural Damara-speaking people. Some use irrigation for crop growing, while others depend on the river vegetation to provide grazing for their animals when the veld grass becomes scarce.

Most farms in the northern Namib have boreholes with windmills providing a fairly reliable water supply. However, natural springs do occur in some places, for example Sesfontein, Fransfontein and Warmbad, and the nearby communities get their water directly from these springs.



What happens when the animals have eaten all the grass near this water point?

The town of Khorixas, which relies only on groundwater sources, has one of the highest growth rates in Namibia. This can be attributed to repeated droughts causing loss of crops and livestock, thus forcing rural people to seek a living in a town where there may be more opportunities for work. This growth rate caused a sharp rise in the amount of water needed and extra boreholes had to be drilled over a wide area to supply water to the town. Consequently, the water table dropped dramatically and water is now pumped from groundwater near the town that occurs in dolomite and limestone rocks. Becauseof the action of water, these rocks dissolve into underground caves and the water flows through fractures or cracks in the rock formations.

The Government is looking into building a dam at Zebraskop on the Ugab River to supply the growing water needs of Khorixas and nearby communities. An ***Environmental Assessment (EA)*** will be done as part of the planning for this dam.

Environmental Assessment - study of living things and the area in which they live, to find out what environmental impact a proposed development will have, to work out ways to avoid or reduce negative impacts and to assist with the careful planning of a new development.

How is the water used in the area?

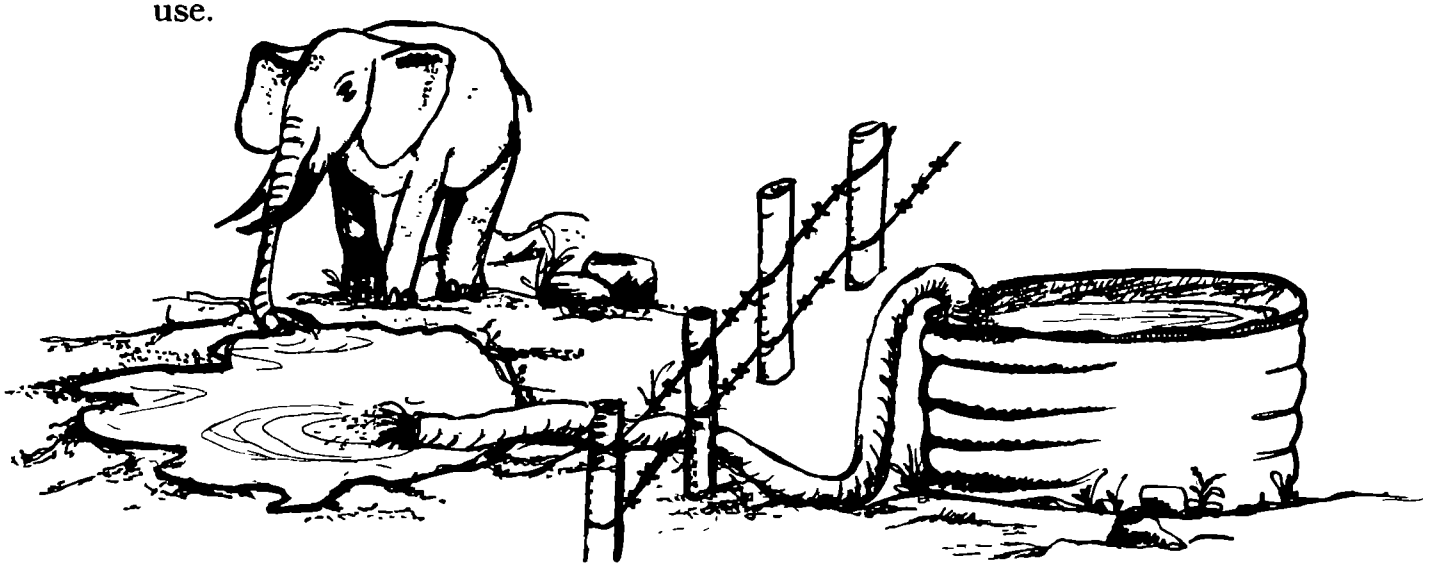
In Khorixas, water is supplied mainly for household use and for small industry.

In the smaller Damara settlements, water is used mainly for drinking water for people and their animals. Informal mining operations in the area also need water.

What do you think the people in smaller settlements consider to be the most important reason for settling in an area? Describe why ephemeral ponds and rivers are of utmost importance to these people and their animals.

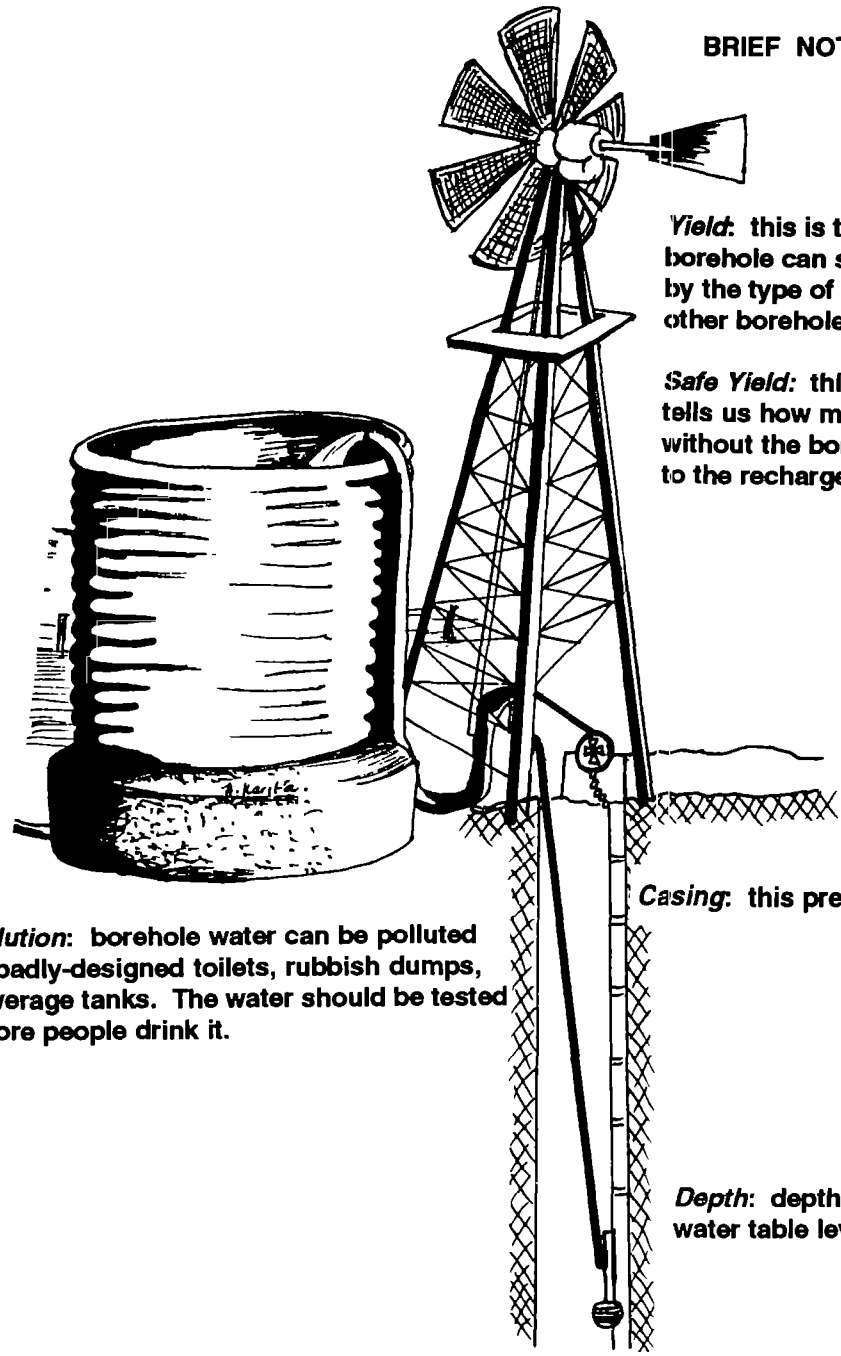
The wetland areas are used by wild animals, including rhino, elephants, lions and giraffes: animals that would never have survived in this arid area without these river oases providing water and food. Because of the presence of these wetlands and wild animals, there is great potential for tourism in the area. As tourism increases more money will be brought into the area.

When there is little water available, the wild animals, especially elephants, approach the boreholes and waterholes used by people. Animals such as elephants may damage these water points in their attempt to get at the water. This conflict between people and wild animals can be solved by creating water points especially for the wild animals and fencing off the others for domestic use.



Things to think about!

The overuse of water in the upper reaches of ephemeral rivers decreases the amount of water available for these systems downstream. Artificial water points, such as boreholes and dams, attract people and their stock, often causing overgrazing and hunting of wildlife in the area. Thus, the building of dams and the drilling of boreholes should be carefully controlled and the local people involved in caring for their scarce water resources in such a dry region. The storage of water in dams and **reservoirs** is a problem in this semi-arid region because much water is lost to evaporation.



BRIEF NOTES ON BOREHOLES

***Yield*: this is the amount of water that a borehole can supply. This is influenced by the type of aquifer and the number of other boreholes in the area.**

***Safe Yield:* this is important because it tells us how much water can be pumped without the borehole drying up. It is linked to the recharge of the aquifer by rainfall.**

***Casing*: this prevents the sides from collapsing.**

***Pollution*: borehole water can be polluted by badly-designed toilets, rubbish dumps, sewerage tanks. The water should be tested before people drink it.**

***Depth*: depth varies according to the water table level.**

***Reservoirs:* there is less evaporation when the reservoir is deep and narrow rather than wide and shallow. Explain why.**

Activities

Divide your class into two groups:
1)pupils who live in town,
2)pupils who live out of town.
Each group explains to the class:

- how they get their water,
- where it comes from,
- whether it is purified (cleaned),
- how they can use their water more carefully.

Sketches can be used to show where the water comes from.

Take a walk into the veld near your school. Name all the living things you see, plants and animals. Remember that ALL living things need water for survival. Now work out where the living things get their water from and how they survive when water is scarce. Work out when it will rain again and imagine what other plants and animals will appear after rain. What will happen to the different types of life if there is a long dry period?

Brighten up your classroom or home with this water cycle experiment! Take a large glass or clear plastic container. Add soil and plant a few healthy plants in the container. Water the plants once and seal the container so that no air gets in. Make notes of what you see happening in the container and explain to your teacher or friends: how long it took for the water to evaporate, once the water condensed what happened to it, what happened to the plants - did they get sufficient water? Now draw a sketch of the water cycle, using your experiment as a model. Keep this experiment going for as long as possible.

(B) THE CENTRAL NAMIB AREA

Where does the water come from?

The rivers in this area are **ephemeral** and only flow in the summer rainy season. Their **alluvial aquifers** are recharged (refilled) from river flow during floods after rain events. In many places this water is pumped from underground for use by the people. Almost no surface water is used from ephemeral rivers except where it is captured in dams.
Three major ephemeral rivers rise in the central area:
the Omaruru, Swakop and Kuiseb Rivers.

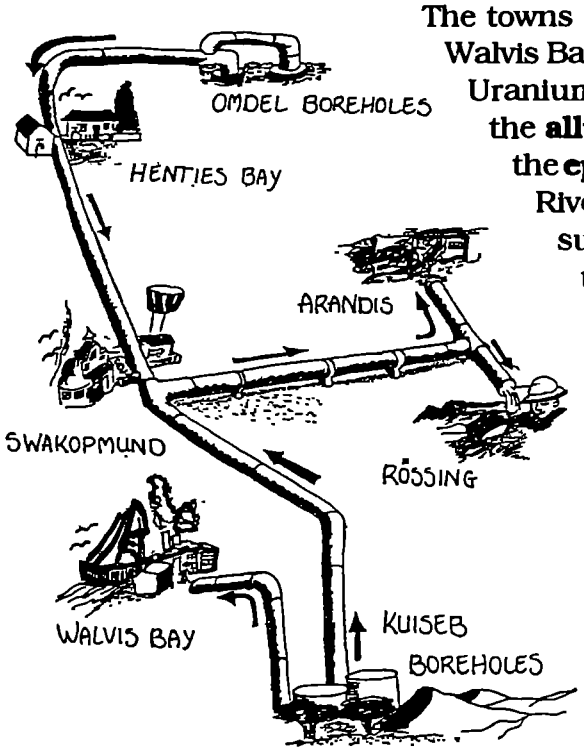
The Omaruru River has its **source** in the Etjo mountains and winds its way between scattered hills for 250 kilometres to a large **delta** at Henties Bay. Underneath the Omaruru Delta is a huge alluvial aquifer, stretching 40 kilometres upstream of the mouth. There are smaller aquifers upstream, providing water for local use.

The Swakop River rises in mountains near Windhoek. Water from its irregular floods is stored in two major dams, the Von Bach Dam and the Swakoppoort Dam, and from there is pumped to various large centres. The river also supports smaller communities from its underground water. Floodwaters hardly ever reach the sea at Swakopmund as most of the water is caught in the dams upstream, but a small **lagoon** occurs at the mouth of the river.

Windhoek was built around a series of natural springs, which occur close to the source of the Swakop River. This aquifer is recharged from rain water collecting along cracks (fractures) in the rock formations of the Auas Mountains. This water is still used to supply part of Windhoek's water needs.

The Kuiseb River rises in the Khomas Hochland west of Windhoek and has many farm dams and one larger dam, the Friedenau Dam, along its upper course. The river has good underground water flow and supports plentiful vegetation, especially in the Namib Desert. Underground water leakage from the Lower Kuiseb River may even extend under the southern dune field of the Namib and contribute to the fresh water seeps at Sandwich Harbour. The Kuiseb River's flood waters very seldom reach the sea, but sink into the sandy riverbed before they get to the large delta. The huge sand sea to the south of the river is controlled by the floods which wash away the invading sand dunes nearly every summer. But near the coast, the dunes actually cross the riverbed to form a narrow dune belt between Walvis Bay and Swakopmund. The large aquifers in the Lower Kuiseb River provide water to the coastal towns and Rössing Mine, and fresh water seepage supports a big reed bed **wetland** south of the Walvis Bay Lagoon.

How do the people in the area get their water?



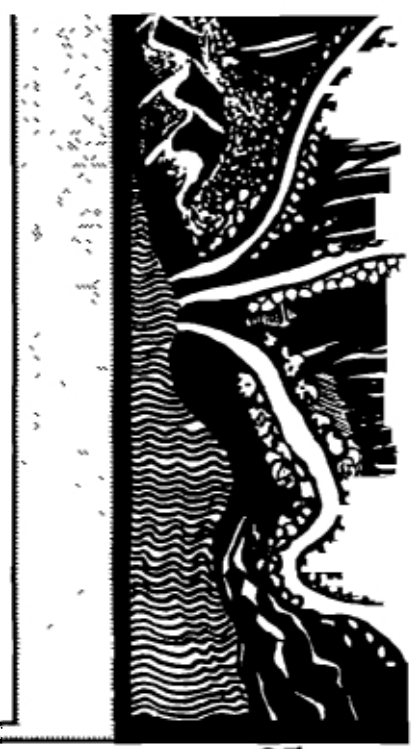
The towns of Henties Bay, Swakopmund, Walvis Bay and Arandis, and the Rössing Uranium Mine all depend on water from the **alluvial** (underground) **aquifer** of the **ephemeral** Omaruru and Kuiseb Rivers. Previously the Kuiseb River supplied the water to these centres but this demand has since been supplemented by the Omaruru Delta (OMDEL) scheme. The rapid growth rate of Swakopmund and Rössing Mine in the 1980's has now levelled off (due largely to less mining activity), which has resulted in a smaller demand for water. This demand could increase again with the development of tourism, fisheries and oil exploration in the area.

The Kuiseb River also provides water for stock farms in its upper reaches and to several hundred Topnaar people in ten settlements along the lower reaches.

The town of Omaruru draws its water from the **alluvial aquifer** in the Omaruru River. In former years, the Uis Tin Mine also drew its water from the Omaruru but this has since closed, leaving only a small community dependent on this water.

The aquifer at the **confluence** of the Swakop and Okahandja Rivers supplies water to the growing town of Okahandja. Extra water is pumped from Von Bach Dam to the town when needed. Half of Windhoek's water is pumped from Von Bach Dam into **reservoirs** (large water tanks of purified water) in the city. The Von Bach Dam is part of the Eastern National Water Carrier (ENWC) and will, in the future, have water pumped into it from the northern water resources when there is not enough water in the Swakop **catchment** to meet the Windhoek area's needs.

The Khan River, a **tributary** of the Swakop River, has water pumped from its underground system to supply the towns of Karibib and Usakos. However, the development of the Navachab Gold Mine near Karibib caused the water demand to increase, and most of the water is now piped from the Swakoppoort Dam. Usakos will eventually be linked to this pipeline as the Khan water source is unreliable. Rössing Mine uses saline (salty) water from the Kahn River for mining.



How is the water used in the area?

The coastal towns of Walvis Bay, Swakopmund and Henties Bay use the water mainly for household purposes, with demand increasing in recent years with the boom in the tourist industry. At Walvis Bay, fish factories and other small industries are also major users of fresh water. Rössing Mine uses most of the water supplied from the coastal area for its uranium production. During the early 1980's Rossing Mine succeeded in cutting the fresh water consumption on the mine by half, by recycling some water, by using brackish water from the Khan River and by reducing production.

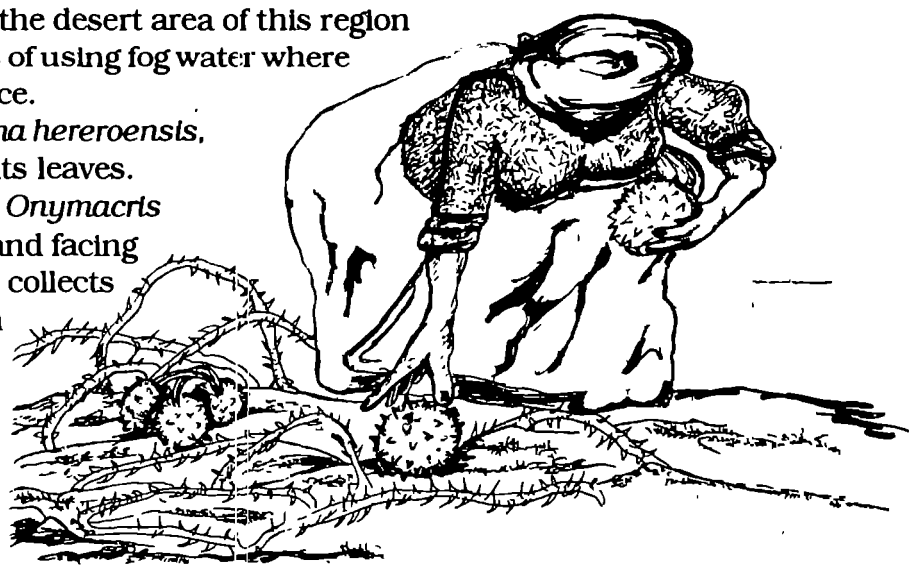
The Navachab Gold Mine is the main consumer of water from the Swakoppoort Dam, while the nearby town of Karibib uses water mainly for household purposes.

The town of Omaruru pumps water from the Omaruru Riverbed for household and irrigation purposes and some industry.

The coastal wetland areas: the lagoon at the mouth of the Swakop River, the large reed bed area south of Walvis Bay, the wetland at Sandwich Harbour are all dependent on underground freshwater seepage and support a wide variety of birds and other wildlife.

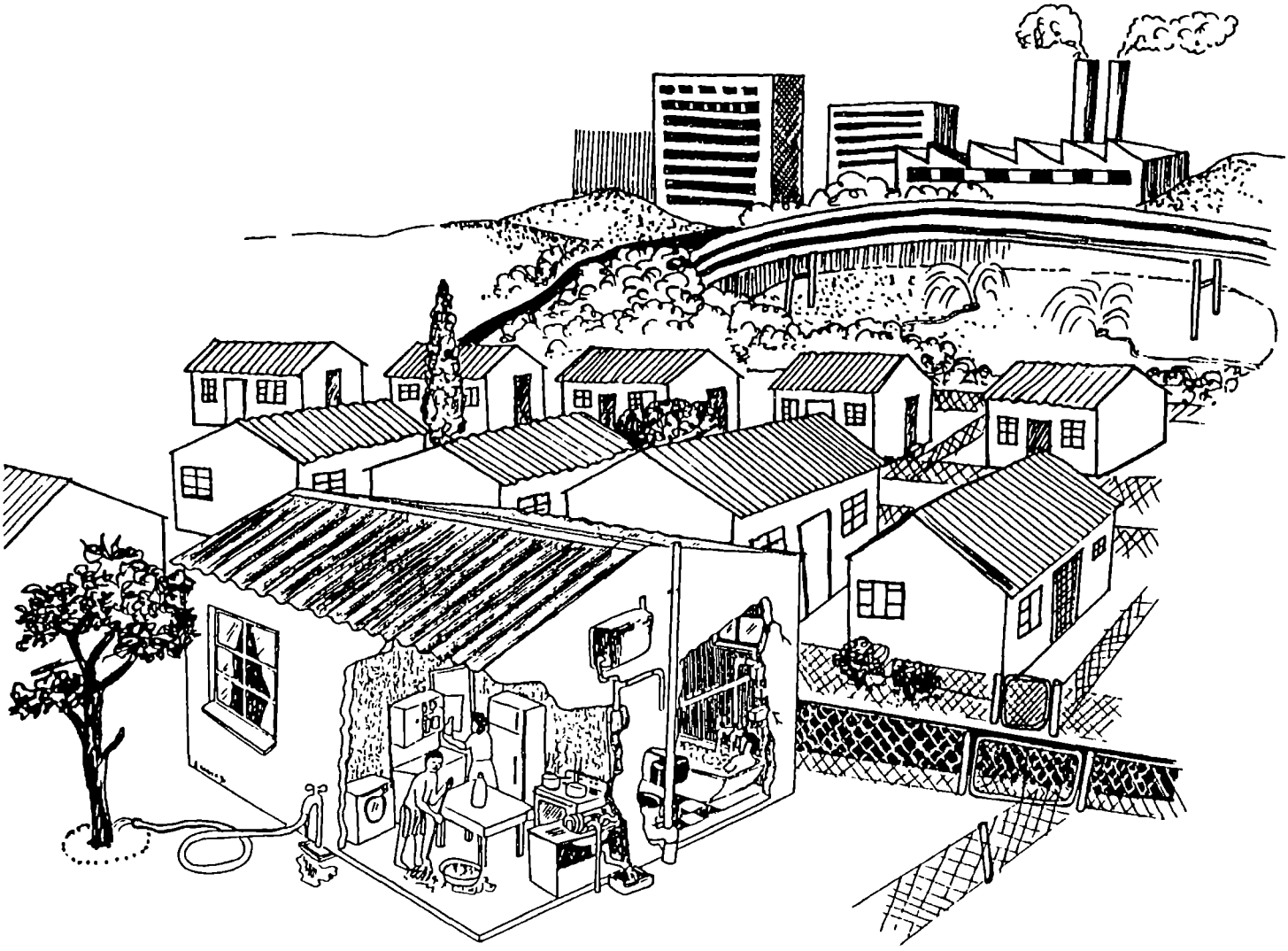
Further upstream in the rivers, small communities use the **alluvial** water for farming, and wildlife occurs where underground water supports enough vegetation. The Topnaar people in the Kuiseb depend on the river not only for their water, but also for food, such as !nara plants. Their animals eat the leaves and pods of the trees in the riverbed.

Wild plants and animals in the desert area of this region have developed special ways of using fog water where rain or groundwater is scarce.
A dune succulent, *Trianthema hereroensis*, absorbs fog water through its leaves.
One type of dune beetle, *Onymacris unguicularis*, does a headstand facing into the fog-bearing wind, collects the water on its back, then sucks up the water as it drips into its mouth.



This woman is collecting !nara melons. Find out how she prepares them to help her family survive in the desert.

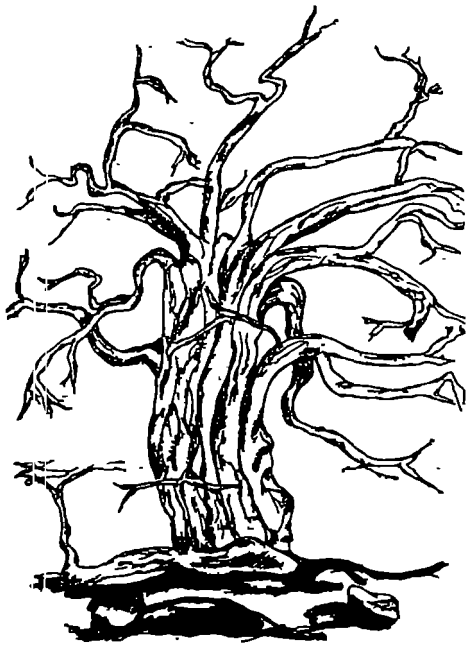
Windhoek is a rapidly growing city. Many people from rural areas (about 500 people per month) come to Windhoek in search of work and better living conditions, to attend schools and for hospital treatment. Water in this area is used for household purposes as well as for gardens and industry. The higher standard of living in a large centre results in people using more water for their basic needs than is the case in the rural areas. Thus the water supply system of the central region of Namibia must be constantly upgraded in order to keep up with the increasing water demand. It is also important for people to realize the importance of conserving their water in order to prevent future water problems, especially in dry years. Water tariffs in Windhoek have been increased which has encouraged people to use less water. Considering that only 5% of Windhoek's water comes from boreholes in the area, and the rest comes from distant dams on ephemeral rivers, it is crucial that water is used as sparingly as possible here. The recycling of water has become increasingly important in Windhoek, and at the water reclamation (recycling) plant at Gammans, about 12% of the city's water is being recycled.



Write a newspaper article, using this picture to show how water is used in towns and how it can be conserved.

Things to think about!

The Kuiseb River alluvial aquifer is an example of a groundwater resource that has been overused. Alone it no longer is able to meet the water demand of the coastal towns and Rössing Mine. During the period of no flow during the drought of the early 1980's, many mature trees in the Kuiseb woodland died because of a lowered **water table**. Continued overuse of the Kuiseb River aquifer will show similar effects in the woodland along the Lower Kuiseb River. The Topnaar people depend on wells for domestic water, thus lowered water tables will also affect their existence and their stock farming activities along the Lower Kuiseb River.



In order to conserve the underground water supplies in the Kuiseb system, the withdrawal of water has been reduced and the Omaruru Delta (Omdel) Scheme was built to help supply water to Henties Bay, Swakopmund and Rössing Mine. However, the Omaruru aquifer could also become overused. Therefore, other options must be considered:-

1. One option is ***desalination*** of sea water in Walvis Bay and Swakopmund. This process of removing the salt from sea water may be necessary in order to meet water demand in the the coastal towns. Desalination is used throughout the world in order to conserve fresh water resources, but is not well established in Namibia yet. This process needs a lot of electricity which has to be imported into Namibia. It would therefore be an expensive option.

Desalination - removal of salt from sea water or salty groundwater in order to make it drinkable for people.

2. Another option is to improve the rate of recharge (refilling) of the underground aquifers from the irregular flood events. In order to conserve Omaruru River flood waters that would otherwise be lost to evaporation or to the sea, a dam has been built on the Lower Omaruru River to trap silt-laden water during floods. The silt settles out in the quiet water behind the dam wall. The clear water is then pumped downstream to sand-filled basins, where it sinks into the sand and is stored then pumped out later via boreholes. Thus an important aquifer is recharged with floodwaters for use in future.

3. A survey of the groundwater under the dune field south of the Kuiseb River is being undertaken using modern scientific methods. The use of such groundwater sources if viable would have to be managed carefully to ensure that coastal wetlands in the Kuiseb Delta and at Sandwich Harbour are not destroyed.

Underground water is pumped from the Omaruru River near the town of Omaruru for irrigation purposes. This may cause damage to the river system if more water is abstracted than can be recharged, and when water is polluted by farmers using fertilisers and pesticides.

The combination of bad farming methods and prolonged droughts in the Kuiseb and Omaruru catchments has reduced the vegetation cover in these areas. Consequently, during the rains, particularly intense storms with high run-off, much soil is washed into the Kuiseb and Omaruru Rivers. This soil often forms a thin layer on the river bed that seals off the sands and prevents water recharge. This action means that most of the floodwaters pass over the underlying aquifers with little recharge (refilling) taking place. Control on the use of the land and water resources in the rural areas has become necessary if the environment is to be conserved.

The large amount of water used in the growing urban area of Windhoek poses a challenge because there is not much local water and imported water is expensive and limited. During droughts, water shortages in the city become a serious problem, so people living there need to become aware of the value and shortage of their water. The use of water by industry also needs some control in order to prevent wastage, overuse and pollution. ***Find out what water reclamation is, how this process works and why it is so important for Windhoek.***

Draw up a poster using these HINTS, to show people how to save water:

HINTS FOR SAVING WATER IN URBAN HOUSEHOLDS

Find and fix leaks, as well as dripping taps: a dripping tap can lose up to 60 litres per day
Do not leave taps running longer than necessary.
Shower rather than bathing: a bath takes about 150 litres whereas a shower takes 40 to 50 litres of water.
Reduce the amount of water used in a flush toilet: by placing a brick or water-filled bottle in the cistern.
Washing machines and dishwashers should only be switched on when there is a full load: the same amount of water is used whether full or not.
Try to re-use water that is not too dirty, on your plants.
Do not wash dishes under a running tap: rather fill the sink after a meal.
Do not leave the tap running while brushing your teeth or shaving.
Do not use a hosepipe to wash your car: use a bucket and sponge.
Be careful of wasting water in your garden: do not water in the heat of the day

Activities

If you live in an area which gets some rain, work out different ways of collecting rainwater and make a poster, with sketches, explaining how to collect rainwater in a clean and efficient way. Show why this is a good way of conserving water. Could you start collecting rainwater at your school or at home? What percentage of your daily needs can be met using rainwater?

If you live in an area that gets a lot of fog, get a group of friends together and design a method of collecting fog water. Try different types of mesh screens, for example, and test for the best orientation to the wind.
Set up your fog collector and report to your class on its success.
Make a poster illustrating how the plants and creatures in your area collect fog and compare this with methods that people could use.

In the past, it was mainly the availability of water that made people decide to settle in a particular place. Divide the class into small groups of interviewers and interview the older people in the community, or study your history book, to find out:

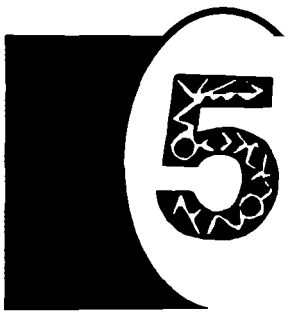
- why people first settled in your area,
- how the water situation has changed over the years,
- is there enough water for people in your area to survive in the future?

Discuss your findings in class and work out ways to teach the people around you to save water so that future generations can survive.

Write a letter to your nearest municipality and find out how the water needs in your area for the next five years are to be met.

Look through this chapter and pick out all the new words and words not often used. Work out the meanings of the words and make a crossword puzzle. Test it out on your friends.

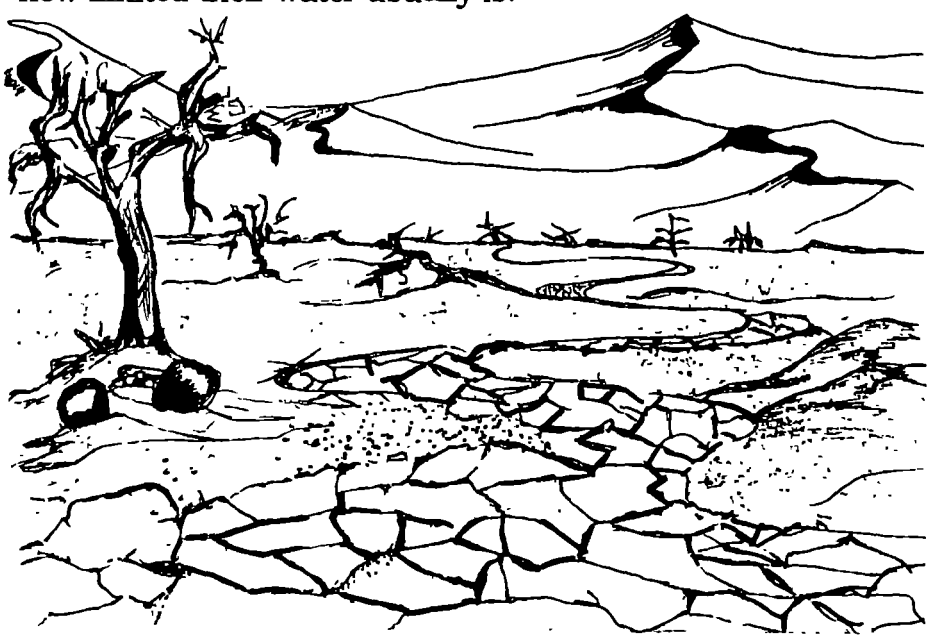
When rain falls in your area or a wet fog rolls in, what do you notice about the natural environment?
Do particular plants or animals react to the moisture?
Is there a different smell in the air?
Do you feel different in some way?
Does the place look different?
Write a short story about what you see, feel, experience on a wet day. Show how the rain or fog influences you and the plants and animals around you.



(C) THE SOUTHERN NAMIB AREA

Where does the water come from?

The southern Namib rivers rise in the mountains where rainfall is low. When there is enough **runoff,** these rivers flow into the Namib dune area and are blocked by the dunes to form small **ephemeral** lakes. Tsondab Vlei and Sossus Vlei may hold water for many weeks in good rainfall years and support some vegetation, although the many dead trees around them show how limited their water usually is.



The Koichab River, which ends at Koichab Pan, has a large **alluvial aquifer.** This aquifer extends under the nearby dunes and contains fossil water, that is, water that collected in the aquifer in ancient times and is no longer being recharged today.

How do the people in the area get their water?

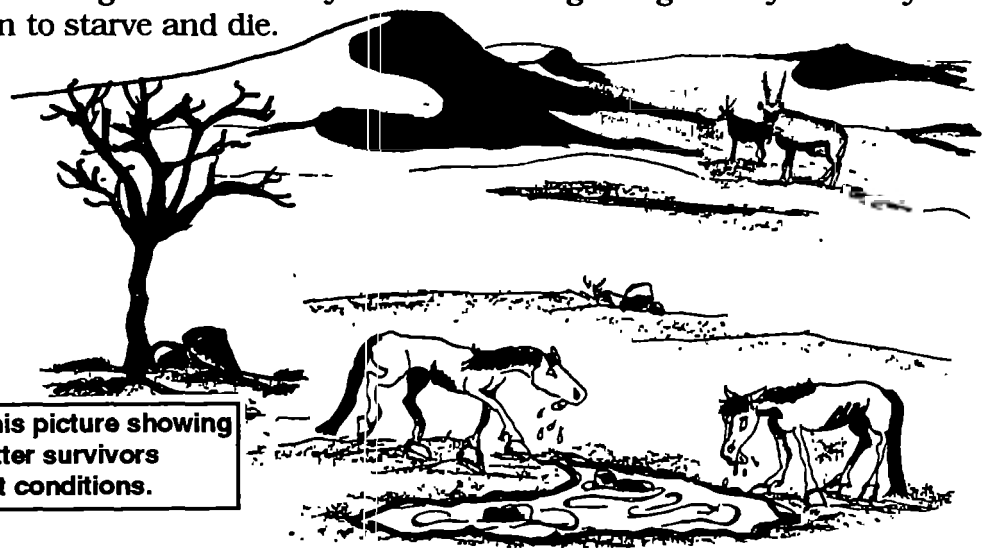
Very few people live in this area because it lies in the sand dune area of the Namib Desert. The only town in this area using much water is Lüderitz. Water is pumped from the Koichab aquifer to the town for household use, the seaweed industry, the fishing industry and a limited amount for domestic use at the diamond mine at Elizabeth Bay.

Farmers on the edge of the Namib Desert pump water from boreholes for their stock farming.

Things to think about!

The aquifer under the Koichab River poses a conservation problem as this is fossil water and will probably never be recharged under the present climatic conditions. The use of this water should be carefully controlled, and its users made aware of the need to conserve it.

Overgrazing often occurs in this very dry area. If boreholes make water available where there is little grass, the animals gather in the area. They overuse and trample the grass which may take years to recover. The wild horses in the Lüderitz/Aus area are an example of this problem. These horses have become used to the harsh desert conditions since their introduction to the area in the early part of this century. Then, during the dry 1980's, water points were put in and they gathered around these points instead of roaming the area. They exhausted the grazing and by the early 1990's, they began to starve and die.



Make a caption for this picture showing that gemsbok are better survivors than horses in desert conditions.

The wildlife in the area has adapted over a far longer period to the arid conditions in the desert. For example, the gemsbok and the springbok, although large animals, do not need to drink every day like a horse does, and so can wander far from water in order to look for food. Smaller creatures, from beetles to lizards to small mammals, that live in the coastal sand dunes actually drink fog water that settles on their bodies or on plants. During scarce heavy rainfall events, water collects in temporary waterholes or pans. A fascinating variety of creatures live in these pans, waiting for the rare wet events. Some small water animals can hatch, grow and lay eggs within a few weeks, before the pans dry out again. Their eggs are very hardy and survive in the mud of the pans until the next rains. Frogs buried deep into the sands emerge during the rainy periods to eat and lay eggs, hatch, grow and bury in as the water dries up again. Plants survive with little rain in the desert: their leaves may be small or hairy or thorny in order to lose less moisture. Some store water in tubers underground or in their thickened stems.

Find out how this "Bushman's Candle" plant is adapted to survive in the desert.

Thus, although few people can live in this desert area, many plants and creatures have adapted in interesting ways to the lack of water in their environment.

Activities

If you live in a town in this region, find out where to get this information:

- where does your water come from?
- how is the water pumped to the users?
- what is the water used for, for example, in industry?
- how much water, on average, do people use per day in their households?
- are the water-users, in industry and at home, aware of the scarcity of water in their region?
- how could water be more carefully saved in the region?

Discuss the answers to these questions in class and think of ways to make people more aware of the scarcity of water in this desert region. Draw a poster to put across your "water-awareness" ideas.

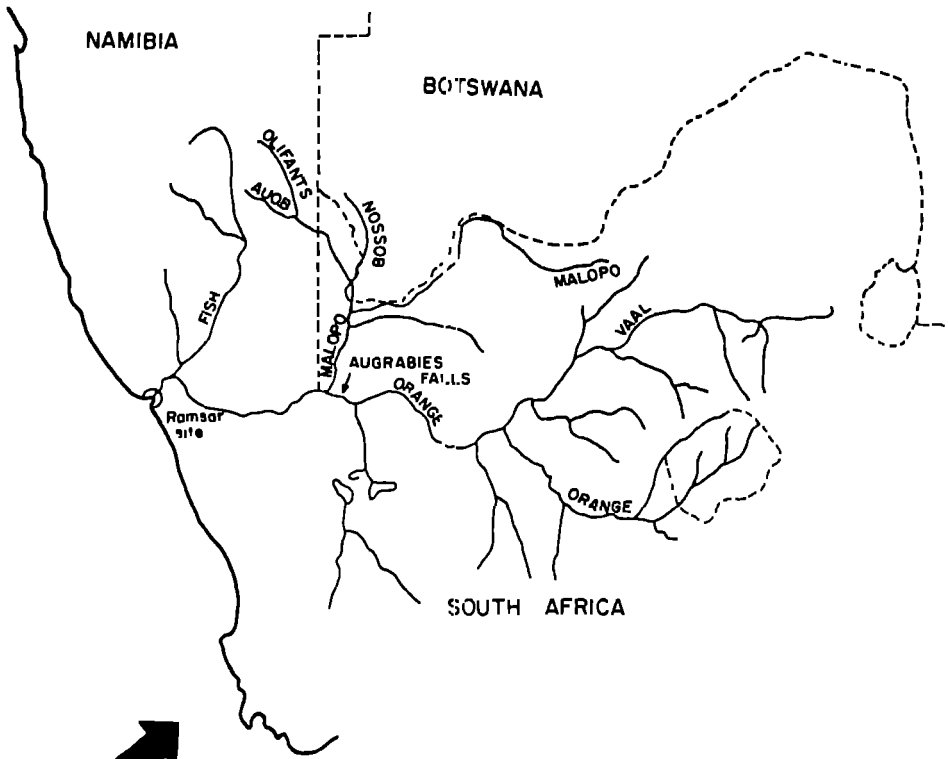
If you live out of town, draw a poster to illustrate where your water comes from and how you get the water. Show how people could use water more carefully in your area. Put across the message that it is important to save water in an arid area because all living things need water.

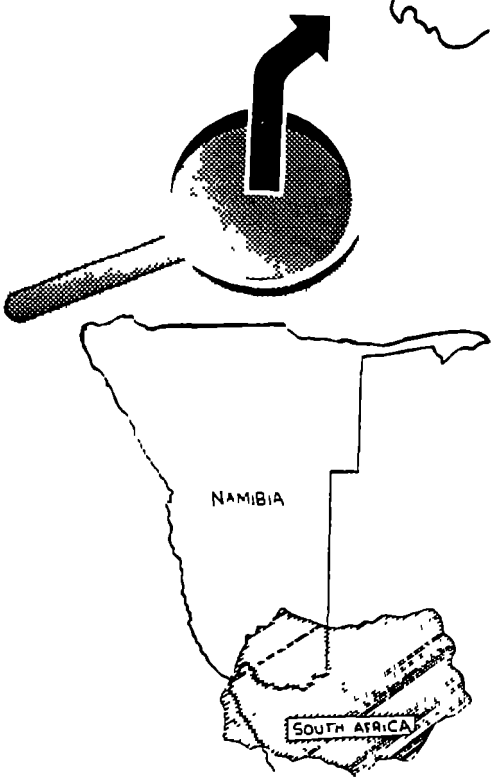
Write a story for children about the experiences of a plant or animal that lives in your area:

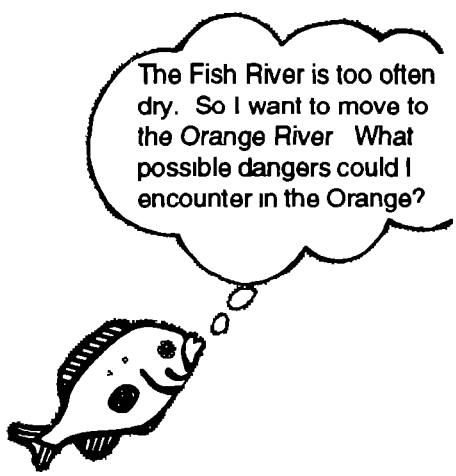
- why it needs water,
- how it gets its water,
- what happens when water is scarce,
- what effect people have on its survival.

Illustrate your story.

THE ORANGE RIVER WATER REGION







Where does the water come from?

The Orange River is the longest river south of the Zambezi. It rises in the mountains of Lesotho and flows for 2300 kilometres, westwards across South Africa to the Atlantic Ocean. The high rainfall at the **source** (1800mm a year) provides nearly all the water, 98,2% of the annual flow comes from **runoff** above the **confluence** with the Vaal River, and 1,8% is provided by the middle and lower sections of the river, where the rainfall is low. The river was named in honour of the Prince of Orange (of the Netherlands). The local people used the name, Gariep, meaning "thundering water".

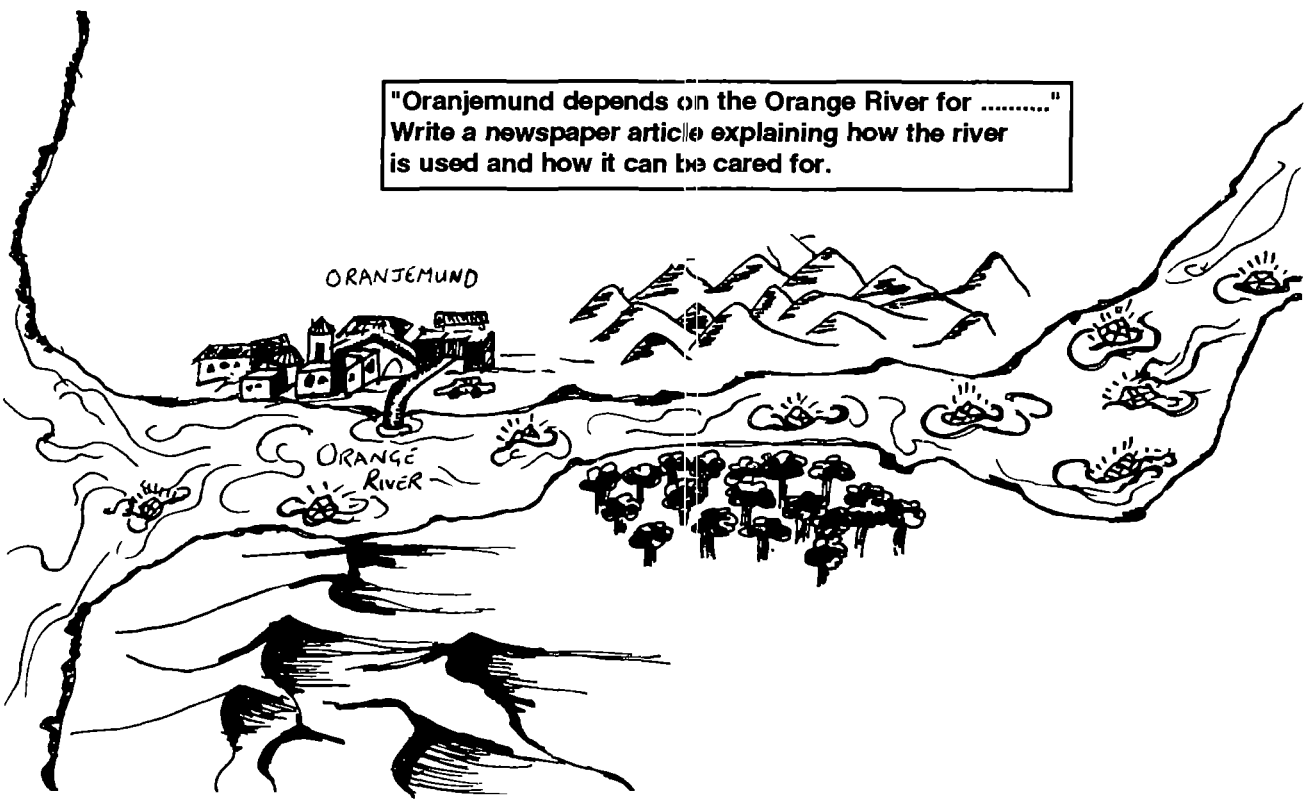
Several large dams have been built on the Orange River, which collect water to transfer it to various irrigation and industrial schemes. This influences the river flow downstream. Before these dams were built, the river would flood after good rains but was known to stop flowing along its lowermost course in the dry season (August/September). Nowadays the Orange River flow is regulated by storing extra water in the rainy season and releasing more water in the dry season. Only very big floods actually reach the lower Orange, for example, the major flood in 1988. The only **tributaries** that contribute significant amounts of water to the Orange after floods, are the Vaal and Caledon Rivers in South Africa and the Fish River in Namibia.

Until 1993, the border of Namibia was the high water mark on the north bank of the Orange River. It has been changed to run down the centre of the river, which means that Namibia now has equal rights, with South Africa, to use the water along its border.

Water supply facts:
Surface water is available only from the Orange River, and 10% of the population of the area uses this perennial water source. 90% of the area is dependent on groundwater, and 90% of the population lives in this area.

How do the people in the area get their water?

There are no dams on the section of the Orange River that borders Namibia, but there are several pump stations that transfer water to towns and irrigation schemes on both sides of the river. A pipeline of 107 kilometres transfers water to the South African towns of Pofadder, Aggeneys and Springbok. The mining towns of Rosh Pinah and Oranjemund take their water from boreholes sunk in the Orange River **alluvial aquifer.** Noordoewer, Aussenkjer and Alexander Bay as well as many farmers along the river, use the water for extensive irrigation projects and household purposes.



How is the water used in the area?

The Orange River offers great agricultural potential to the land on its banks because of its permanent water, and in South Africa it supports many large irrigation schemes. However, where the river borders Namibia, it flows through very dry, mountainous country which is mostly not suitable for farming. The water is used for irrigation schemes at Onseepkans, Pella, Aussenkjer, and other smaller irrigation projects and for household use in the towns. Further large agricultural schemes are being considered between Noordoewer and the coast. The large mining town of Oranjemund uses sea water for processing the ore. An interesting point here is that the Orange River has been responsible, over millions of years, for bringing diamonds down to the Atlantic coast, which in turn has attracted many people to the mines in this otherwise arid area.

What golden rules would you give these people which would encourage them to care for their environment?

At the Orange River mouth, a large wetland is used by many species of birds and other wildlife. This river mouth area has been declared a Ramsar site, which means it is an internationally important wetland because of the unique habitat it offers to the wildlife, particularly birds. Bird counts are done twice a year and show that a great variety of birds use the area for breeding and feeding. Herds of gemsbok migrate from the desert in the dry times to live off the floodplain grasses. Brown hyenas, jackals, seals and otters also live in the area. Residents of Alexander Bay and Oranjemund, who use this area for recreation, are being made aware of the importance of protecting the wetland.

This large permanent river offers great tourist potential. White-water rafting and canoeing expeditions are popular, the Augrabies Falls is a spectacular waterfall and the wetland at the river mouth reserve offers good bird-viewing.

Things to think about!

There are pollution problems from agricultural chemicals used in the upper reaches of the Orange River system, where irrigation schemes wash pollutants into the river. This affects the plant and animal life in the system.

People's interference with the normal flow pattern by building dams higher up the river has influenced conditions at the mouth. By regulating the flow throughout the year, flooding is reduced and the mouth rarely closes in winter to build up a lagoon. Because of this a large saltmarsh wetland on the south side of the Orange mouth remained dry for some years.

In 1993, after a long dry period inland, less water than usual was released from the dams on the Orange River. The river ran very low and the mouth closed, allowing the salt marsh to fill with water. The low level of the river is very noticeable in dry years because of the increased demand by irrigation schemes along the river.

When the river is low, there is a danger that salt water may invade the river system beyond the normal levels caused by sea water pushing through the river mouth during high tides. Too high a salt content would cause an imbalance in the living conditions of the plants and wildlife, many of which would no longer be able to survive in the area. The people living in the mining towns in the river mouth area would have problems with salty water. Careful monitoring will be necessary if the river system is to be conserved.

Much of the Lower Orange River falls into the winter rainfall region which results in fauna and flora that are unique to the area, animals and plants that have adapted to the aridity (dryness) and the little rain that falls in the winter months. Many plants go unnoticed during the summer then burst into flower after the first winter rains. Great stretches of sand and rock are covered by a varied mixture of fascinating plants, all specially adapted to cope with the dry desert conditions. The endemic (found only in this area) desert snail, *Trigonephorus*, hides deep under the sand during the hot dry summer months, then emerges during the winter months to feast on the new growth of the desert plants.

Activities

Make a visit to the Ramsar site wetland area. Walk along the banks of the river and make notes or sketches of the different birds and other animals that you see. Note also the different plants that you see. Find out the names of the birds and other animals and look up information about them in the library. Work out why the wetland area is important to them: what they eat, where they find shelter, where they breed. Put your findings together on a poster and show why it is important to conserve wetland areas.

DEPARTMENT OF WATER AFFAIRS
P/Bag 13193, Windhoek.
Place name..... .....
No.....Lab no. .....
Date.....Time..... .....
Water level..... . ..... m Rising/falling
Temperature . ...°C
River/Dam/Borehole/Pit/Spring/Canal\Other
. ...
Name and address of sampler..... . .
....

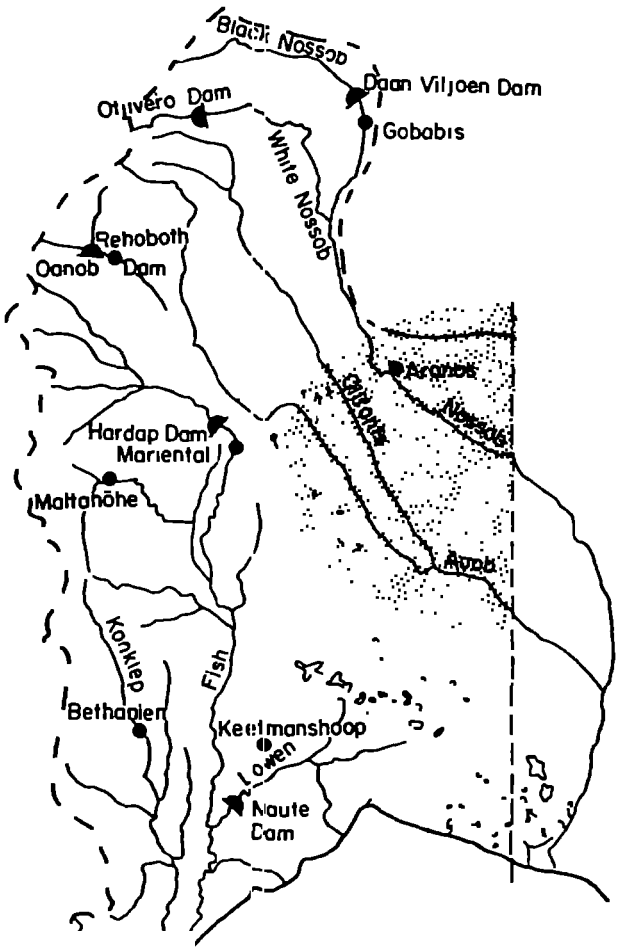
Water tests: make two labels like this one:
Get two glass bottles with lids. a) get a sample of water from your tap;
b) go to the Orange River and collect a water sample about one metre from the river bank.
Stick on the labels and send your samples to Windhoek for testing. When you get the results, discuss them in class and make a note of the quality of water that is pumped from the river and the quality of your tap water.

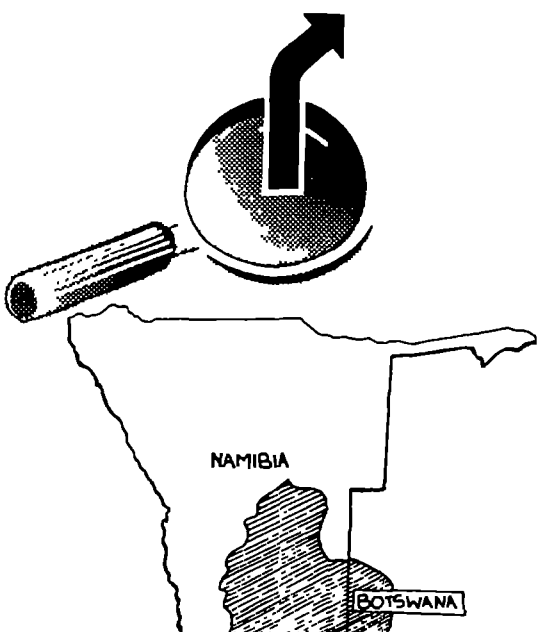
Go to the water department in town with the water test results, if you have them. Find out:

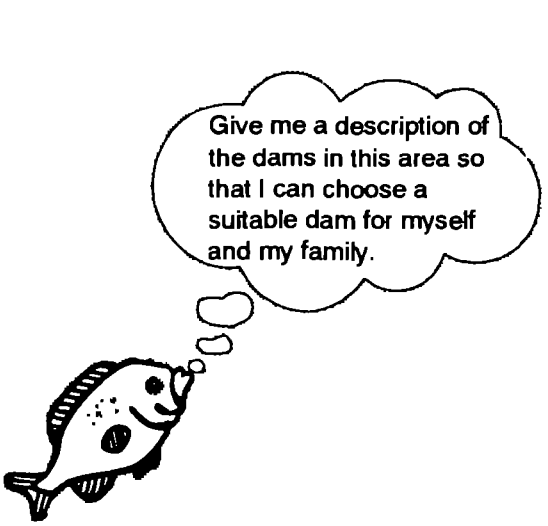
- where the water for the town is pumped from,
- how the water reaches the town,
- how and where it is purified,
- whether there are sometimes water shortages because the river is low,
- whether people in the town are encouraged to save water,
- how the water needs of the next five years will be met.

Put your findings together in a report and make suggestions about how people in the town could save water and could be made aware of the need to save water.

THE KALAHARI AND FISH RIVER WATER REGION







Where does the water come from?

Although the Fish River is part of the Orange River catchment, it has a significant influence on a large area of Namibia and so will be dealt with separately. The Fish River rises west of Rehoboth in the Nauchas Mountains and winds its way through rocky hills and plains and the massive Fish River Canyon, southwards for 805 kilometres to join the Orange River about 112 kilometres from the coast. This long **ephemeral** river has a big enough **catchment area** to cause fairly regular floods and to contribute water to the Orange River. Two major dams have been built on this system: Hardap Dam in the upper reaches near Mariental, and Naute Dam near Keetmanshoop on the Löwen River which is a large tributary of the Fish River. These dams depend on good rains in their catchment areas and usually receive some inflow every summer season. The Hom River is a small tributary of the Orange River which supplies Karasburg with water from the Dreihuk Dam. The **runoff** here is very poor and the dam has only been full once.

The Auob / Nossob River system comprises two rivers that rise in the mountains to the east of Windhoek and wind through hills and into the flat Kalahari area, through Botswana, to eventually join the Molopo River in South Africa. Water from the Auob and Nossob Rivers does not reach the Orange River anymore because the course of the Molopo is blocked by dunes in the south-western Kalahari. Although the runoff into these rivers is low, they support many farm dams and boreholes.

The Oanob Dam, on the Oanob River, was built near Rehoboth when boreholes in the area could no longer meet the demand of this growing centre. The Oanob River rises in the Khomas Highlands to the west and south-west of Windhoek and peters out in the Kalahari south of Rehoboth.

The town of Gobabis was established where springs occurred, but when the water demand increased, two small dams were built on the Black Nossob River. Further increases in the population led to the building of the Otjivero Dam, a silt dam, on the White Nossob River. This larger dam provides Gobabis with a long-term water supply.

Pans are a common feature of the Kalahari area, but these only fill with water after very good rains.

The main **groundwater** source is the Stampriet **artesian aquifer** which supports the town, Aranos, and farm boreholes. *Can you find this aquifer on the map and explain what it is?*

Water supply facts:
Surface water from dams serves 40% of the population, and this represents about 5% of the total area. 60% of the population depends on groundwater and this includes 90% of the total area.

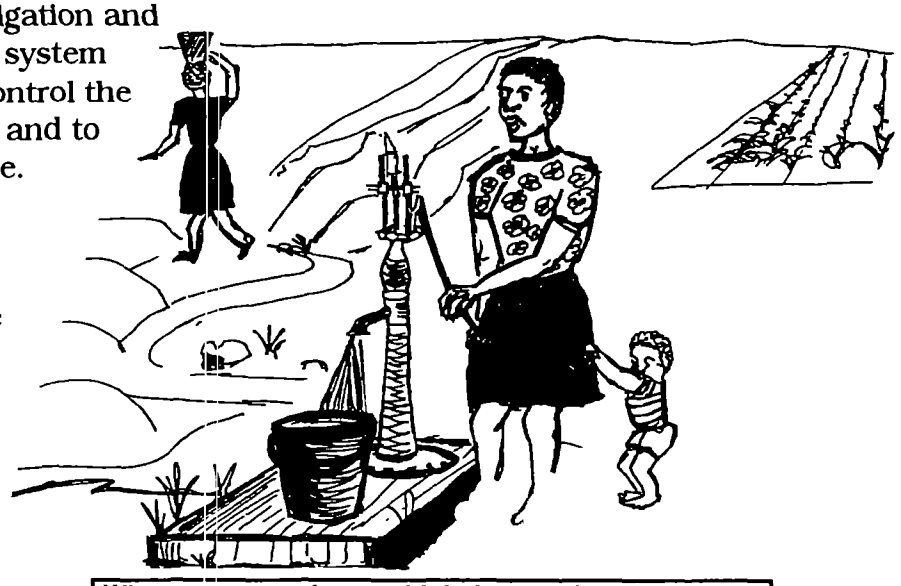
How do the people in the area get their water?

There are not very many people living in this area, mainly due to the limited amount of natural water in the region. The area is dotted with farms, most of which draw their water from boreholes or from small dams on the **ephemeral** rivers.

Many people have been forced to move to the towns because of drought and poor conditions in the rural areas. This has led to an increase in the demand for water in these towns, and State dams have been built to meet this demand.

- Mariental receives its water from Hardap Dam, the largest dam in Namibia, where the water is purified and then pumped for 16 kilometres to the town.
- Water is pumped for more than 100 kilometres from the Otjivero Dam to Gobabis where it is purified and distributed around the town.
- Rehoboth is one of the fastest growing centres in Namibia and is surrounded by many small farms that need water. The Oanob Dam now supplies most of the water to this centre. The water is purified at the dam and pumped to the town.
- Keetmanshoop is another growing urban centre which now draws most of its water from the Naute Dam. This dam usually has a good inflow from the Löwen River and maintains high water levels compared to the other dams in this region. The water is purified at the dam then pumped to the town.
- Karasburg has a water problem as the Dreihuk Dam usually has very low water levels and extra water from boreholes in the riverbed or from the small Bondels Dam is often needed.

Other settlements in this vast area depend on underground water from various **aquifers**. Water comes from the **alluvial aquifers** for towns such as Maltahöhe, Bethanien, Aranos and Gibeon. An extensive **artesian aquifer** provides the Stampriet area with water. Aranos is the only town using this water, and many farms depend on it for irrigation and household use. A permit system has been introduced to control the construction of boreholes and to conserve this water source. The water becomes more saline (salty) in the south due to the salt content of the underlying rocks. The Ai-Ais Springs in the Fish River Canyon are the result of water reaching the surface from thermal (hot) ground conditions.



What measures do you think the people using this water source take to keep their water clean and safe?

How is the water used in the area?

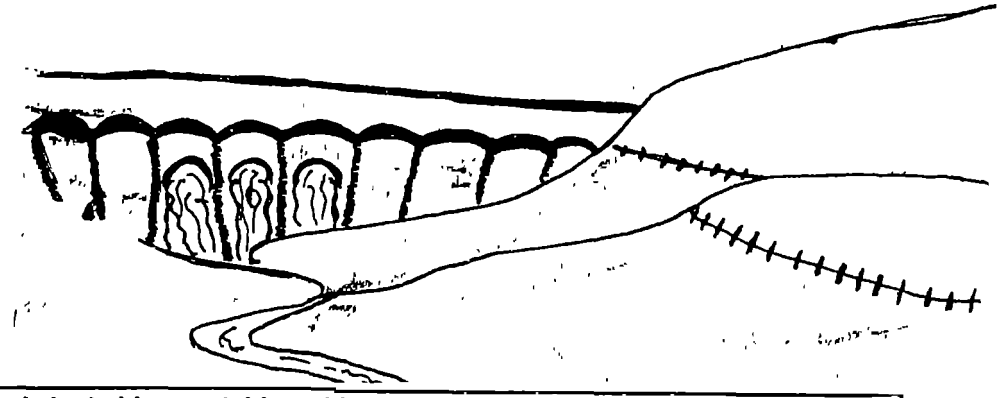
The soils in the region are mostly sandy and infertile in the Kalahari area and rocky in the mountainous western area. Therefore farmers use their water for fairly small herds of animals and very limited cultivation. Water from the dams is used mainly in households and for small industry as well as small-scale irrigation schemes.

Hardap Dam provides water in canals to smallholdings near the dam, where maize, vegetables and fruit are grown. Fish farming is practised on a limited scale, mainly to supply indigenous fish species to farm and State dams.

The Naute Dam also supplies irrigation water for vegetables and for palm trees.

Water from the Stampriet artesian aquifer supplies many farms with borehole water, and irrigation schemes in the area produce vegetables, melons, grapes and maize.

The many pans in the area fill with water after good rains and are used by wild and domestic animals for the short time that they are full. Many aquatic creatures (creatures living in water), such as snails, tiny shrimps and algae, live in these pans and have adapted to the arid conditions.



This farmer wants to irrigate his vegetables with water released from the dam.
What would you suggest is the best way of using the water: drip, flood or spray irrigation?
What kind of storage tank should he build: deep and narrow or shallow and wide?

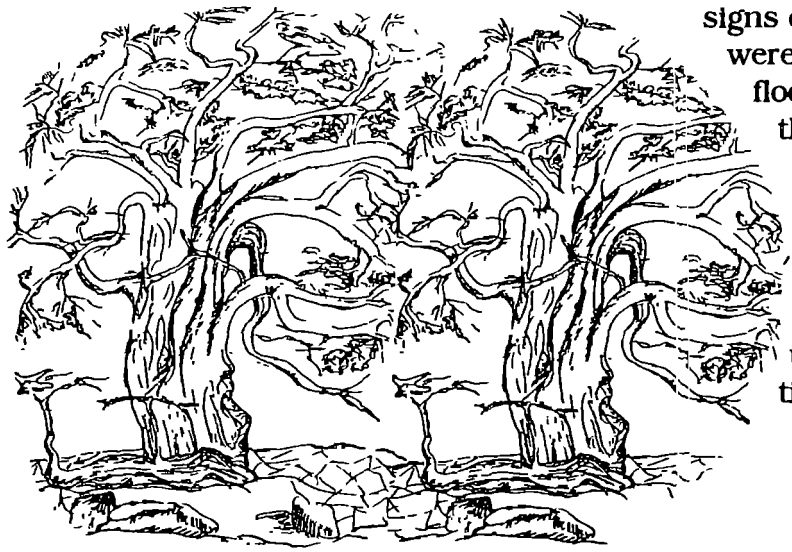
Things to think about!

The many farm dams built on the Black Nossob River affect the river because the downstream water supply is reduced and this changes the natural system. The animals and plants that have adapted to the ephemeral river can no longer survive with less water in the system.

The large State dams are important in that they provide a constant supply of water often at less cost than other water schemes. But they do affect the environment in that:

- they flood large areas of potentially useable land,
- they interfere with natural processes such as the downstream availability of water,
- they are built at huge expense yet often their use is reduced because the large surface area of water causes high evaporation thus losing much of the stored water, and they silt up eventually.

There are ways to manage the impact that dams have on the river system, for example, the camelthorn forests downstream of the Oanob Dam started to show signs of lack of water after they were cut off from the natural floods by the construction of the dam. Therefore the dam was designed to allow periodic water releases, similar to small floods, to provide water to these trees. A study has been undertaken to test the effectiveness of this plan.



In our arid country, evaporation and lack of water are crucial problems. We need to become more aware of using farming methods that use as little water as possible and reduce loss of water through evaporation. The Hardap Irrigation Scheme, for example, uses flood irrigation which is a low-cost, low-maintenance system **but** it wastes a great deal of water both to the soil and to evaporation. Drip irrigation would require only 10% of the present water usage and would reduce evaporation losses.

An interesting problem to consider is that of the water quality of the Stampriet artesian aquifer. In certain areas, saline (salty) water overlies the fresh water and could therefore contaminate the fresh water. To prevent this, farmers in these areas have been introduced to a new technique using a specially designed borehole which seals off the overlying salty water. Borehole drilling is carefully controlled through a permit system to ensure the best use of this valuable groundwater source.

Activities

In this region the Fish River Canyon is a landform that was shaped by water. Draw up a tourist information brochure, with illustrations, to show:

- how this landform developed over thousands of years,
- the important part that water played in its development,
- the opportunity that it now gives for tourism.

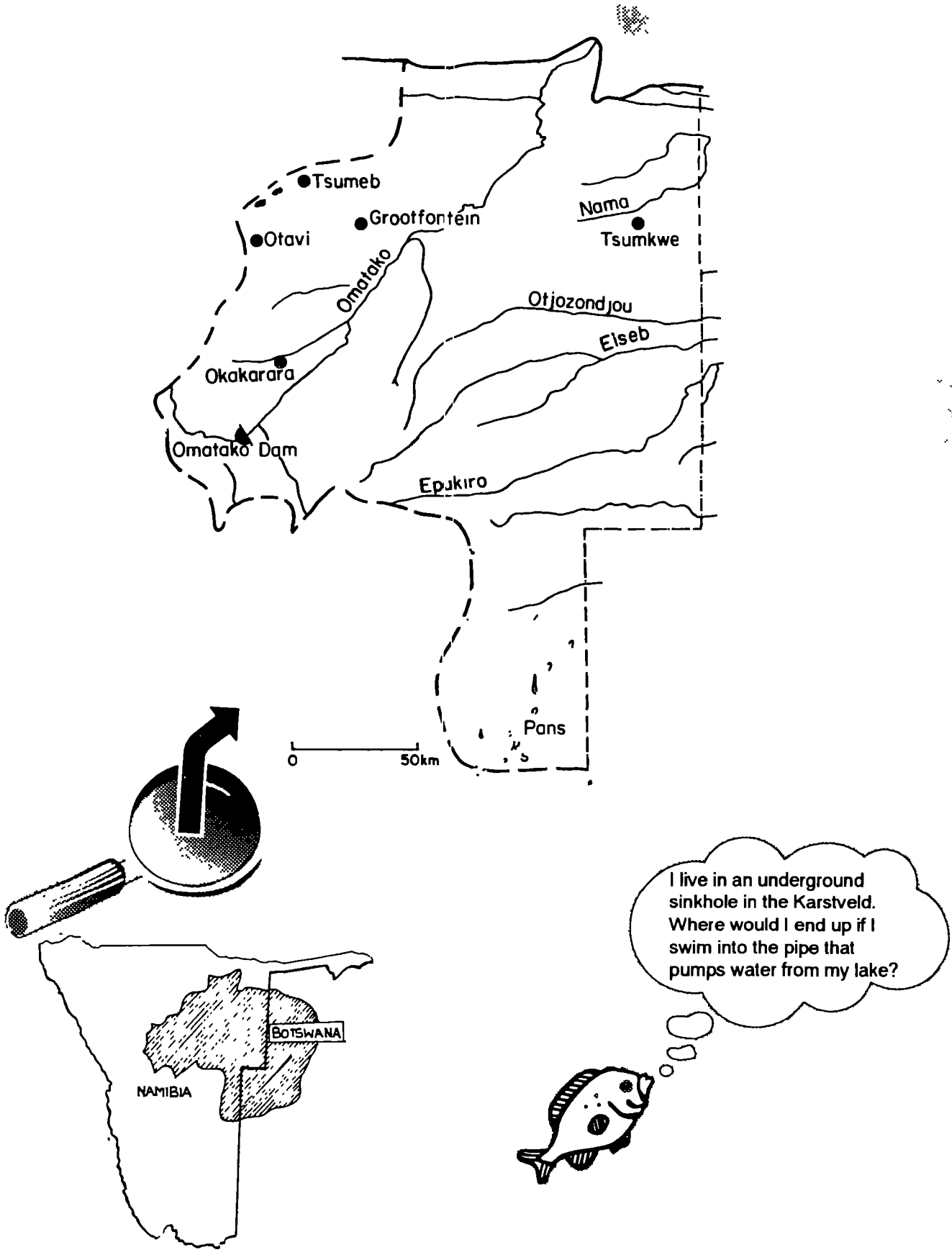
Advise tourists to be aware that they are visiting an arid area and that they should save water!

Start a class dictionary, using words relating to water that occur in this chapter. Give a description, with illustrations if possible, of the following: artesian water, aquifer, ephemeral, runoff, silt dam, aquatic, tributary, catchment, purification, irrigation, borehole.
Put the words in alphabetic order and add other words from other lessons during the course of the year. Make an interesting cover for your dictionary and give it to the school library.

Which type of dam or water tank is best for water storage in our hot, dry climate - deep or shallow? Put out deep and shallow water containers in the sun. Measure an amount of water and pour the same amount into each container. Record the time and the weather conditions. Later, measure the water from each container and calculate how much water has evaporated. Calculate how long it took for water to evaporate from each type of container. Plot the results on a graph. Report your findings to the class and explain why you got these results.

Pretend that you are a farmer who wishes to start irrigating fields for the production of vegetables for market. Find out about the different types of irrigation: drip, spray, flood irrigation. Decide which type to use considering that you have only one good borehole and live in a hot, dry area. Give reasons for your decision.

THE NORTHERN KALAHARI WATER REGION



Where does the water come from?

In this area the omiramba (shallow sandy rivers) thread their way towards the Okavango River in the north and the Kalahari area to the east. The Omuramba Omatako is the largest of the omiramba, rising in the Omatako Hills near Otjiwarongo and joining the Okavango River downstream of Rundu. The upstream portion flows during the summer rainfall months but its waters rarely reach the Okavango River. Rather, the floodwaters of the Okavango wash up into the Omatako, creating a **wetland** at the **confluence.** A large dam has been built in the upper reaches of the Omatako, to serve as a link for the Eastern National Water Carrier (ENWC), which will transport water from the Okavango River to the central areas of Namibia.

The smaller water courses in the east of the region have poor **runoff**, with most of the water sinking into their sandy riverbeds. There is very little surface water in the sandy Kalahari area. The little rainfall that does fall may be held for short periods in the many pans in the area, but generally disappears quickly into the sand or evaporates in the hot climate. **Groundwater** is more available than surface water here, but usually occurs at great depth. Many boreholes in the area are dry.

There are important groundwater resources in the Karstveld which is a huge system of water-filled underground caves and sinkholes. These caves develop as water seeps into and dissolves (eats away) the dolomite (limestone) rocks into cavities which then fill with water. Large underground lakes may form, such as the one at Dragon's Breath Cave, the largest lake of its kind in the world. Sinkholes form when the roof of an underground cave collapses, for example, Otjikoto Lake and Guinas Lake near Tsumeb.

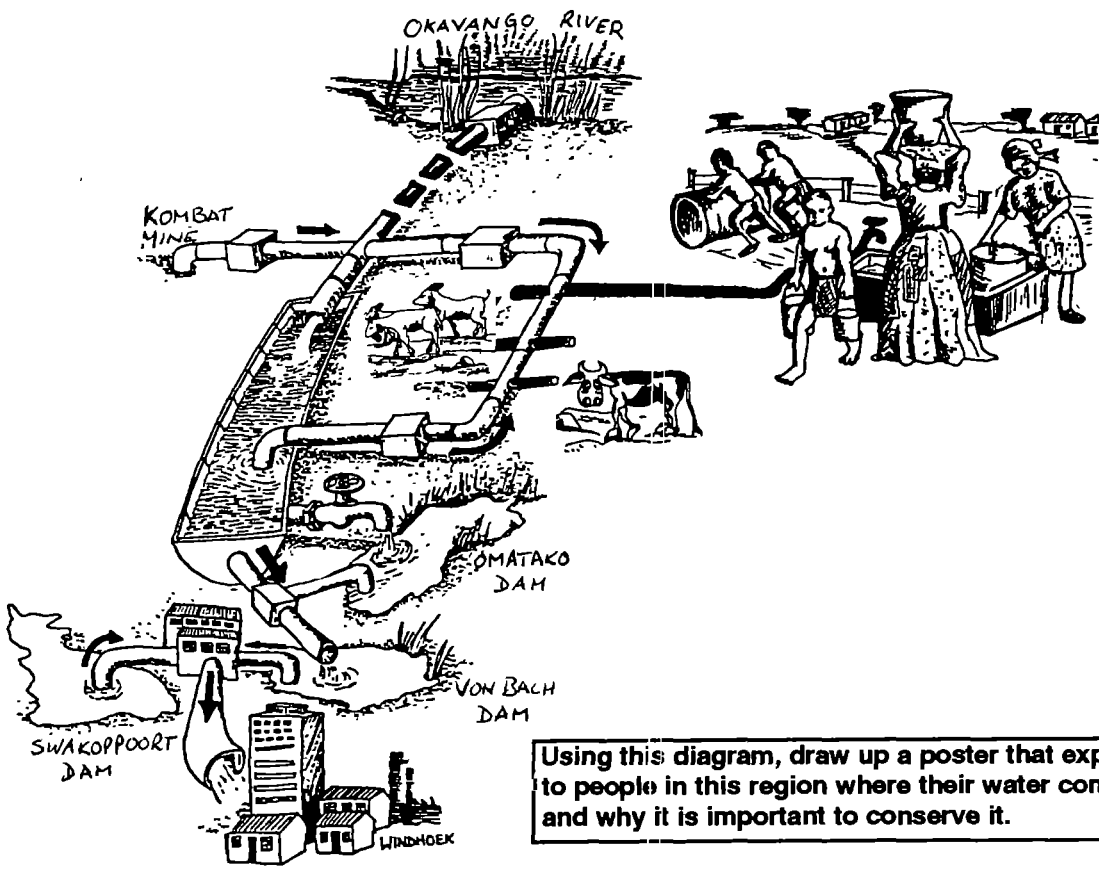
Can you find these lakes on the map?

Water supply facts:
The whole of this area is served by groundwater only. The Karst area incorporating Tsumeb, Grootfontein and Otavi is the major aquifer in the region. The Omatako Dam supplies surface water outside of the area to Windhoek via the Von Bach Dam.

How do the people in the area get their water?

The main centres in the Karstveld region, Tsumeb, Otavi and Grootfontein, all pump their water from underground reserves. The other large town, Otjiwarongo, also uses underground water which is pumped to the town. The many farms in the region make use of this underground water resource as well.

The Eastern National Water Carrier (ENWC) is a large water supply system which will eventually transfer water from the Okavango River to the Central Region of the country, as well as to consumers along its length. It already (1994) transfers water by canal and pipeline from the Kombat mine in the Karstveld region to Okakarara and Omaheke. The water is stored in reservoirs in Okakarara then pumped into a large pipeline network which supplies water to many farmers in Omaheke. Many Herero-speaking people in the region now depend on this imported water because surface and groundwater in the area is so limited. Further east there are small communities and farms using borehole water but only a limited amount of water is available there because the sand layer is thick and the water is very deep down.



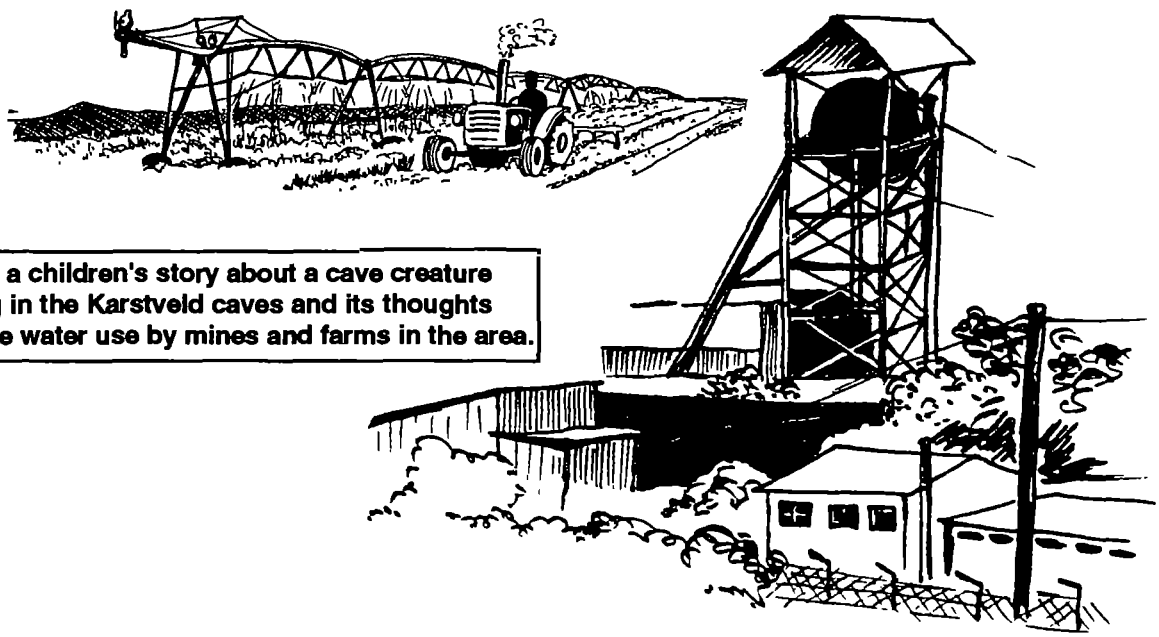
Using this diagram, draw up a poster that explains to people in this region where their water comes from and why it is important to conserve it.

At present Windhoek and the Central Region are supplied by water from three dams, the Omatako, Von Bach and Swakoppoort Dams. Water is piped from the Omatako Dam and the Swakoppoort Dam into the Von Bach Dam then purified at Okahandja before being supplied to Okahandja and Windhoek.

How is the water used in the area?

The extremely sandy dry conditions in the Kalahari region limit the possible activities of the people there. The water that is piped to the region is used for household purposes in the towns and for stock farming in the rural areas. The limited water further to the east is also used for stock farming.

In the Karstveld region, where water is more easily available, intensive stock farming is undertaken, with some crops being grown as well. In fact, the Karstveld region is the main maize-growing region in Namibia and can, in good rainfall years, supply all the country's "mieliemeel" needs. Water in the towns is used for small industry and household purposes. The copper mine at Tsumeb also requires water. The Kombat Mine actually pumps water out of the ground and into the Eastern National Water Carrier canal, the only operation that contributes water to the system rather than taking it out.



Write a children's story about a cave creature living in the Karstveld caves and its thoughts on the water use by mines and farms in the area.

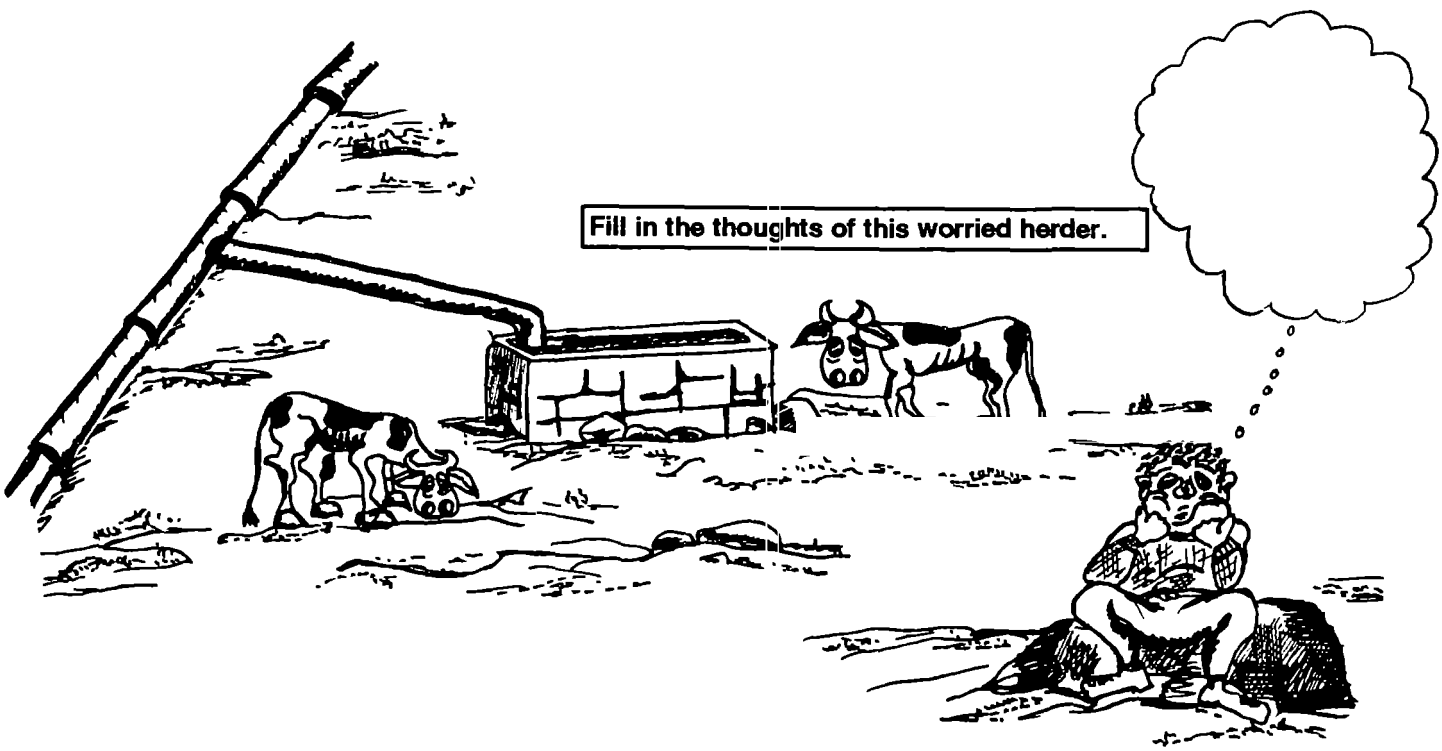
Two ***endemic*** fish species occur in the Karstveld waters: that means that they are not found anywhere else in the world. They are:

* the Otjikoto tilapia, *Tilapia guinasana*, which occurs in two sinkholes only, Otjikoto and Guinas lakes near Tsumeb:
* the cave catfish, *Clarias cavernicola*, which is found only in one small cave, Algamas Cave, near Otavi.

Both fish species are considered endangered and could become extinct if the Karstveld groundwater resources are too heavily used.

Things to think about!

There is always the danger of overusing what seems an unlimited source of water and this is certainly a problem in the Karstveld region. Huge amounts of water are being removed from this resource, water levels have dropped due to dry conditions during the past few years and recharge comes from rainwater and is slow. The water in the Eastern National Water Carrier was to be transferred all the way to the Windhoek area by 1991, but to date only water pumped out of the Kombat Mine is being used to meet the water demand in Okakarara and part of the Omaheke region. There is pressure by the Herero-speaking farmers in the sandy eastern areas for the pipelines to be extended, but there is little water available for this purpose. An artificial supply of water in a dry area usually leads to **overgrazing** as there is not enough vegetation for the stock to eat. This problem already exists where water has been made available and farmers have brought in more animals than the grazing can support.



The open canal section of the Eastern National Water Carrier between Grootfontein and the Omatako Dam (200km) has caused many animal deaths since it was built. Up to 17 000 animals a year, snakes (57%), amphibians (22%) and small mammals (19%), are being trapped or drowned in the canal. The only suitable solution is to put a lid on the canal, but this would be very expensive.

Water pollution is a problem in the Tsumeb area where chemicals from industrial activity could seep into the underground water system.

Activities

You have read that dolomite and limestone are special kinds of rock that dissolve in water. See how this works by putting a piece of chalk (also containing calcium carbonate) in a glass of water. Note what happens. How does this explain the formation of the Karstveld caves? Now add a little vinegar to the water to see how acid affects the process. Find out about acid rain and explain what would happen in the Karstveld area if acid rain was to fall there, for instance in the Tsumeb industrial area. Write up your findings in the form of a newspaper article.

Imagine that a farmer asks your class to advise him on the best soil type for growing crops. On his farm there are three different types of soil: clay, loam and sand. Try to collect samples of these three soils and put each type into a different container. Pour the same amount of water into each container and observe how each type of soil holds water. From this observation, what would you conclude about the best type of soil for crop-growing?

Do a class outing to the nearest watering point (at a well, pipeline or canal) where animals come to drink. What do you observe about the vegetation in the area around the watering point? How do you think the area will look in 10 years time? If you were a farmer in the area, what would you do to keep the vegetation in good condition for the future?
Have a class debate: one group believes in keeping down the number of cattle and goats in the area so that the grazing lasts longer; the other group believes in keeping as many animals as possible on the land and it is too bad if there is no grass for them in the future. After the debate, take a vote on the best method of farming in the area.

Activities

for all water regions

Pretend that the water supply in your region will not be able to meet the water requirements of your town, village or farm by next year.
a) Take steps to search for new water sources.
b) Find out what is needed to get this new water supply working.
c) Think about the environmental influences the new water system may have.
d) Decide whether it is necessary to establish a new water supply, or whether people should rather cut down on water consumption and use the existing water source more carefully.
e) Prepare a campaign to make the local people more aware of the benefits of saving water.

Write an article for your local newspaper called **"What is the true value of water?"**
Work out what it costs to supply water to your town or village. Perhaps ask the municipality or the local office of the Department of Water Affairs.
Find out what the costs are of the dams, pipelines and boreholes that may supply your water.
With all this information, try to calculate the actual cost per litre of your local water.
Compare this figure to what people are paying for their water.
Use your information to make people aware of the true cost of their water and encourage them, in you article, to bear in mind the true value of their water and to use it carefully.

Do a project on ***aquatic ecology*** in your region.
Find out about the plants and animals dependent on water, particularly those living part or all of their lives in water.
How are they adapted to life in water and what threats do they face?

Look at ***water pollution*** in your region.
What are the main causes of water pollution?
What is done to prevent water pollution and what should be done in future?
Prepare a poster to focus the attention of the community on the need for clean water.
Make people aware of how they can prevent pollution.