Orange-Senqu Storytelling Mascots - Thabana Ntlenyana & Maluti

Finding Out More

Action Learning For a Living River

The Orange-Senqu River Learning Box

ORASECOM
THE ORANGE-SENQU RIVER COMMISSION

Background

The Orange-Senqu River Learning Box, Action learning for a Living River is an innovative and creative education response to the sustainable water resources management needs of the Orange-Senqu River Basin overseen by the **Orange-Senqu Youth River Learning and Programme Development (OSYRL&PD)**

The development of this project has been undertaken by the Orange-Senqu River Commission (ORASECOM). The project is being implemented by WESSA (the Wildlife and Environment Society of South Africa) in partnership with Mokolodi Nature Reserve in Botswana; the National Curriculum Development Centre (NCDC) in Lesotho, the Desert Research Foundation; Namibia (DRFN) in Namibia; and WESSA; Northern Areas Region in South Africa.

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Sharing the Water Resources of the Orange-Senqu River Basin

Prepared by:

In partnership with

In collaboration with

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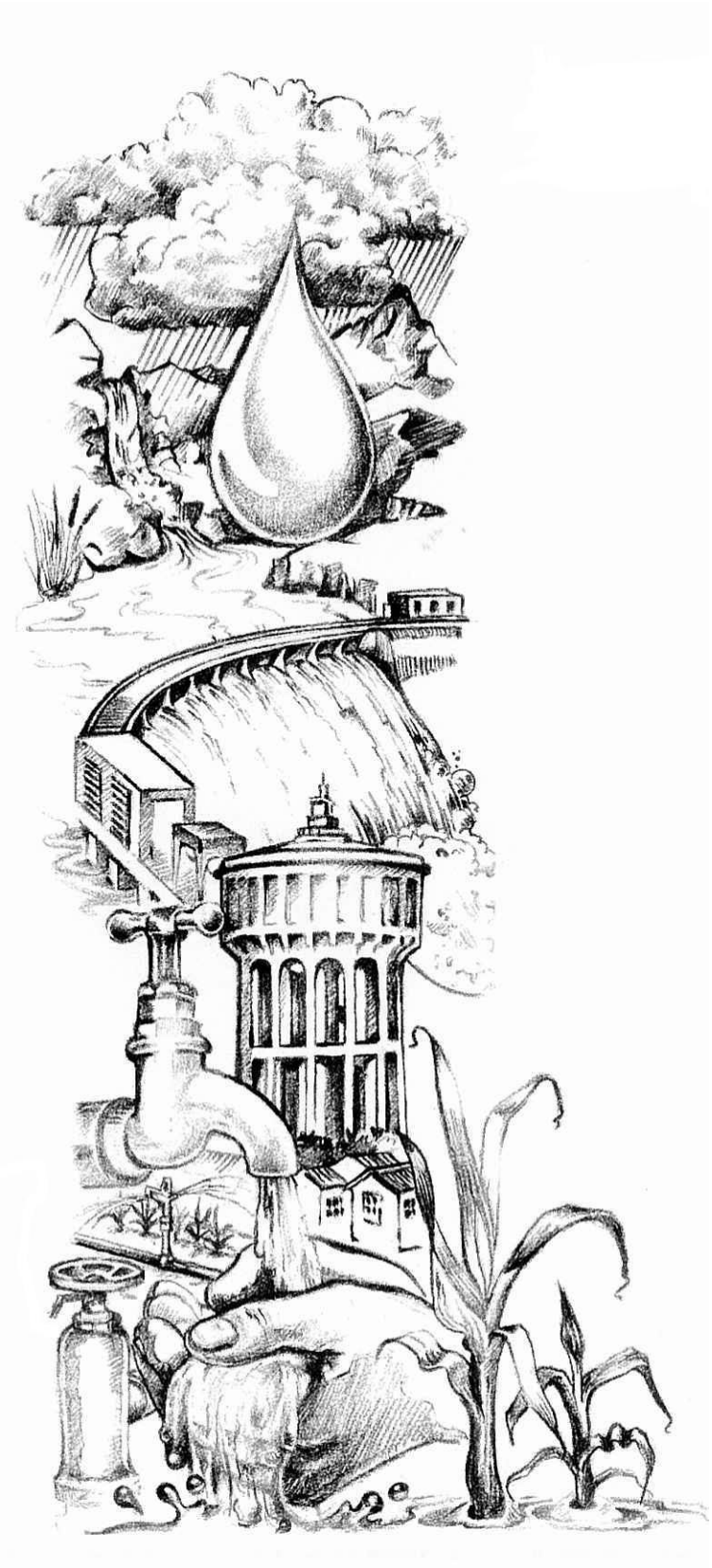
Enviro Fact: The Importance of Water



What is water and why is it important?

Imagine all the world's rivers, lakes, dams, seas and oceans! Think about clouds, rain, fog, dew, ice and snow! These are all made up of water in its **natural state**, a clear, odourless **liquid**. It's amazing to think that this **fluid** is made up of **gases** that are found in the air (one **oxygen** and two **hydrogen atoms).** The **chemical** name for water is **H2O**. Water can be found as a solid (ice), liquid (water) and a gas (water **vapour**). Water also forms the biggest part of the fluids of all living things on Earth. You are made of nearly three-quarters water and can live for only three days without it! So water is life!

How much water is in the world?

The Earth's **surface** is covered by 71% water. Of this water, 97.4% is found in seas and oceans and only 2.6% is freshwater. The amount of drinking water is so small because 22.4% of freshwater is trapped in **groundwater** and 77.2% in **glaciers** and **polar ice**. This leaves only 0.4% of freshwater available in the immediate water cycle.

How much water is available for use?

If only 2.6% of water on earth is **freshwater** and of that freshwater, 99.6% is ice and groundwater then less than 0.4% of all freshwater is found in rivers, lakes and in the **atmosphere** and is available for use! An even smaller amount, 0.003% is found in living things and man-made products.

Does the Orange-Senqu Basin have a lot of water?

The Orange-Senqu Basin is an area that has very little water. The average rainfall in Southern Africa is just 450mm per year. This is half the world average of 860mm per year! There are four Sub-Basins in the Orange-Senqu River Basin. The **annual rainfall** in the Upper Orange-Senqu Basin varies from 600 mm to more than 1000 mm; in the Vaal Basin it varies from 400 mm to 800 mm. There is an average annual rainfall of less than 250 mm in the Northern Sub-Basin and in the Lower Orange River Basin the mean annual rainfall varies from 100 mm to 400 mm.

Where do we find surface water in the Orange-Senqu Basin?

The Orange-Senqu's inland surface **water resources** are the rivers, dams, lakes and wetlands. These water bodies, together with the rainfall and evaporation, form the water cycle. People's activities also influence this cycle. This controls the **quantity** and **quality** of the inland waters and the benefits and services they provide.

Upper Orange-Senqu

The Katse Dam (located in the Malibamatso River) and the Mohale Dam (located in the Senqunyane River) are two of the major **dams** in the Senqu catchment.

The Vaal River Sub-Basin

The Vaal River drains much of the central highveld of South Africa. The Vaal, Vaal Barrage, Grootdraai and Bloemhof dams are the major dams on the Vaal River. The **tributaries** of the Vaal River are the Klip, Wilge, Liebenbergsvlei, Mooi, Schoonspruit, Harts, and Riet Rivers.

The Northern Sub-Basin

The Fish River flows through the Northern Sub-Basin which is a very dry area with an average annual rainfall of <250 mm and includes the Hardap and Naute dams. The Molopo River is a 1 000 km long **fossil** river which river channel comprises a portion of the border between Botswana and South Africa. The fossil channel travels south-west until it meets the Nossob River, running south along the Namibia/Botswana border.

Lower Orange River Basin

The Lower Orange River includes the Orange River from the **confluence** with the Vaal River to the Orange River Mouth. The major tributaries draining into this section of the Orange River are: the Ongers and Sak rivers from the northern Karoo; the Kuruman and Molopo rivers from the Cape Province north of the Orange and the southern part of Botswana; and the Fish River from the southern part of Namibia.

1.2.3. Finding Out More

Enviro Facts: The Global Water Cycle

How does the sea get into the river?

When it rains, raindrops that fall on land either **evaporate** immediately or they **seep** into the ground. When rain lands in a river, the raindrop begins a long journey to the sea, where it evaporates to form clouds and then it returns to the earth again as a raindrop. This endless cycle moves water between the sky and the earth and enables life on our planet.

What drives the water cycle?

The sun is the motor of the water cycle. Its energy heats the surface of the Earth and causes water to go from a liquid to a gas, called **water vapour**. One third of the energy of the sun is used just to evaporate water. When water condenses back into rain, this energy is released again. So heat is **extracted** from the place where water evaporates. This leads to cooling. Warm dry air can absorb and transport more water vapour so it evaporates water much faster than if the air is cold and damp.

How old is water?

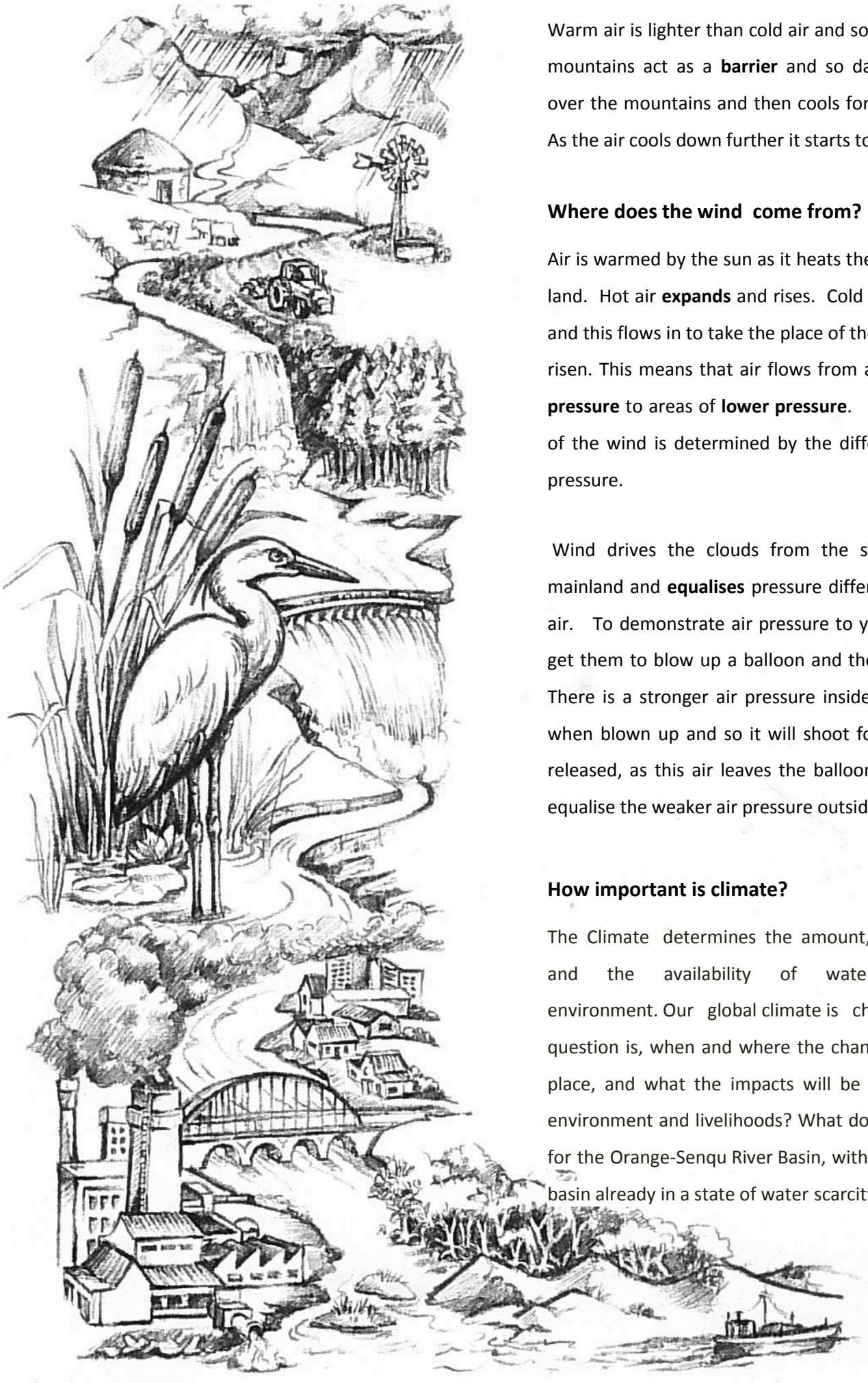
Water has been around for about 4.5 million years! That is almost as old as the world itself. It has been part of a cycle which has been **renewing** itself for all this time.

What helps evaporation?

Show your class what helps water evaporate by soaking two identical pieces of clothing in water. Squeeze the excess water out and hang one piece in a sunny windy place to dry. Hang the other piece in a cool shady place and observe them every half hour. Wind and hot dry air causes water to evaporate very quickly, and when that happens, warmth is extracted in the process. Water depends on wind, air, temperature and humidity to evaporate.

How do clouds form?

When a lot of water evaporates, the air becomes full of water vapour. The air is called '**humid'**. This warm and humid air now rises and as it does the water vapour cools down. High in the atmosphere there are **particles** of dust, pollen and salt and the water condenses to form droplets of water. This is because cold air cannot hold as much water as warm air can. Clouds are billions of particles coated in water. You can show your learners how this happens by placing a glass of cold water outdoors on a hot summer day. Water droplets will condense on the outside of the glass and 'rain' down the sides. On a very cold day, breathing out condenses water vapour and clouds of tiny water droplets form in front of our mouths.



Why does it rain so much in the mountains?

Warm air is lighter than cold air and so it rises. The mountains act as a **barrier** and so damp air rises over the mountains and then cools forming clouds. As the air cools down further it starts to rain.

Where does the wind come from?

Air is warmed by the sun as it heats the sea and the land. Hot air **expands** and rises. Cold air is heavier and this flows in to take the place of the air that has risen. This means that air flows from areas of **high pressure** to areas of **lower pressure**. The strength of the wind is determined by the difference in air pressure.

Wind drives the clouds from the sea over the mainland and **equalises** pressure differences in the air. To demonstrate air pressure to your learners, get them to blow up a balloon and then release it. There is a stronger air pressure inside the balloon when blown up and so it will shoot forward when released, as this air leaves the balloon in order to equalise the weaker air pressure outside of it.

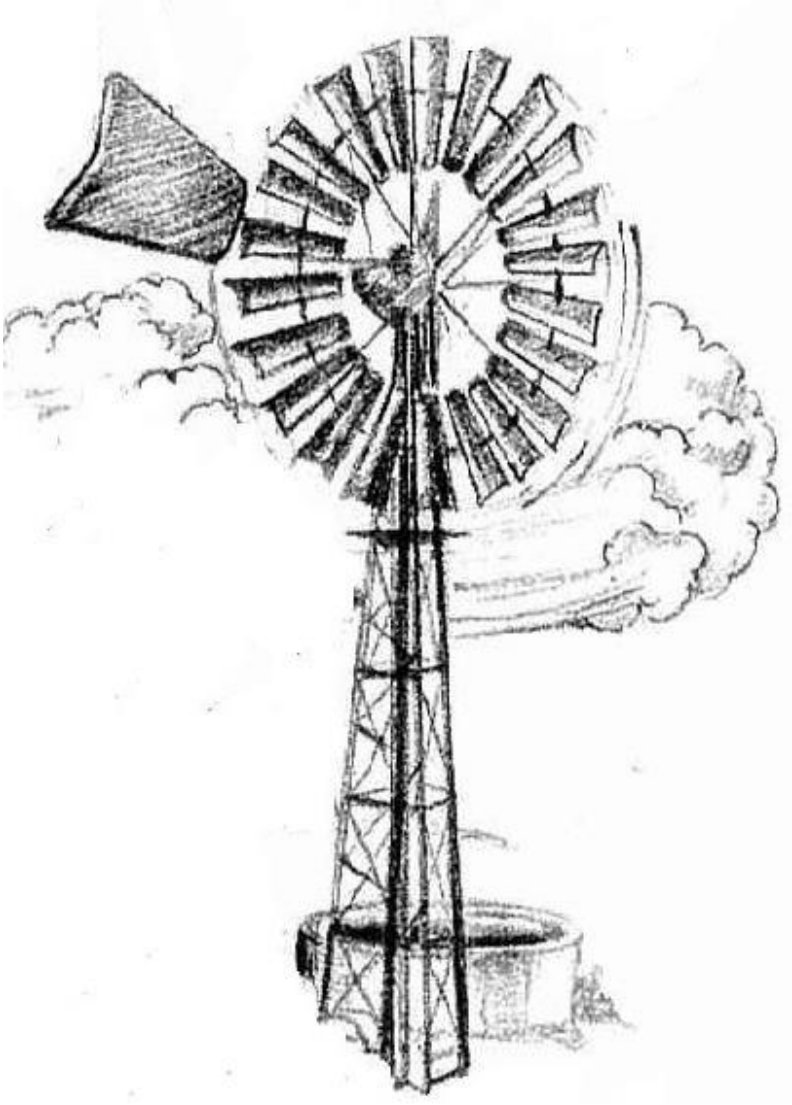
How important is climate?

The Climate determines the amount, distribution and the availability of water in the environment. Our global climate is changing. The question is, when and where the changes will take place, and what the impacts will be on our local environment and livelihoods? What does this mean for the Orange-Senqu River Basin, with much of the basin already in a state of water scarcity.

1.3.3. Finding out more

Enviro Facts: Groundwater

What happens when it rains?



When it rains on land, part of it evaporates immediately back into the air as water vapour. Some rainwater flows into lakes and rivers and back into the sea. A large amount of the rainwater seeps into the ground and is **absorbed** (taken up) by plants. This water then **evaporates** back into the air through the leaves. Plants act as an important stop-over on the journey of the water cycle. All the leaves of the world's plants have a combined huge **surface** area. This means that plants evaporate very high quantities of water.

How much water is evaporated from plants?

Of all the water that is evaporated on earth, 45% comes from plants, 41% from the sea, 13% directly from the soil and only 1% from lakes and rivers.

What is groundwater?

A further amount of the rainwater **infiltrates (seeps)** into the ground and remains under the earth's surface as groundwater. This water is held in **porous sedimentary layers** and **rock fractures**, anywhere from a few metres to hundreds of metres underground. This forms a source of drinking water. This water may stay out of the water cycle for a long time. It can come to the surface again in the form of **springs.** In the polar region, rain water falls as snow. Because it is so cold, the snow does not melt right away. Over the years thick layers of ice have formed that can be over a kilometre deep. It can take thousands of years before the ice in polar caps and glaciers melt and go back to the sea. No drop of water can completely escape the water cycle. Sooner or later all of them evaporate and then return to the earth as raindrops.

Why are plants so important for ground water reserves?

When water falls to the earth as rain or snow it can take one of five different paths. If it rains in a **forest** or **savannah**, a quarter of the rain evaporates straight away from the surface of the ground and trees. One fifth flows directly into streams and rivers, the rest seeps into the ground. If rain falls on an area that has no trees and grass, then twice as much goes directly into runoff water. This means that in areas that have good vegetation like forests, savannahs and **grasslands**, these areas can store a lot of water.

How does groundwater move?

Gravity causes groundwater to move. Even in dry riverbeds like the lower stretches of the Nossob or the Molopo Rivers, shallow groundwater can flow several hundred meters a day. Along the way it sustains a rich variety of plants that tap into the **sub-surface** waters with deep roots. There may be other groundwater layers under the first layer of groundwater, separated by watertight layers. This very deep groundwater can be thousands of years old. For a very long time it has not been part of the water cycle. Groundwater is formed not only through rain but also from flowing water through the seepage of river water.

Does all water go back to the sea?

When water seeps into the ground it is filtered and enriched with minerals. This water can remain underground as groundwater or if there are layers of solid rock then it can come to the surface again as springs. All the water of the Orange-Senqu River Basin ends up in the Atlantic Ocean. If people pollute rivers then this pollution ends up polluting our oceans as well!

What about groundwater in the SADC region?

In the world, 94% of all available freshwater supplies come from groundwater. The SADC region has a population of approximately 250 million people, and groundwater meets 60% of their daily needs, especially in rural areas. In the Orange-Senqu River Basin the figure is possibly close to 70%. So ground water is a very important source of water. It is usually thought of as a cheap and sustainable source of clean water in rural areas. But there are some serious challenges to using and managing the resource, especially in the face of development. Gaborone once had Botswana's most productive boreholes. Then in 1997, the boreholes had to be closed. The waste from 3000 toilets and an industrial area had seeped into the groundwater.

1.4.3. Finding out more

Enviro Facts: Birth of a River

What is a spring?

A spring is formed when groundwater hits a barrier that it cannot infiltrate or flow through, like an **impermeable** rock layer. This means that the aquifer fills up to the point of overflowing onto the land surface. A spring can be a very small outflow of water called a seep, that only flows after a lot of rain has fallen or much bigger outflows of water. Springs are sources of cool, clean drinking water and should be protected from being damaged or polluted by people or animals.

What are the headlands of a river?

The headlands or headwater of a river are the upstream areas of a **watershed**. When it rains, water infiltrates the ground and this water makes its way slowing through the ground and around the rocks to recharge the **aquifer**. The mountains or hills in the headlands also act like an umbrella, channelling the excess water as **runoff.** The runoff water flows into the folds between the hills. These are called **drainage lines**.

What is the watershed?

The watershed is the point at which water flows downhill into a particular valley by gravity. It is the highest point that separates the path that runoff will take, some flowing into the valley on one side of the watershed and some into the valley on the other side.

When is a river born?

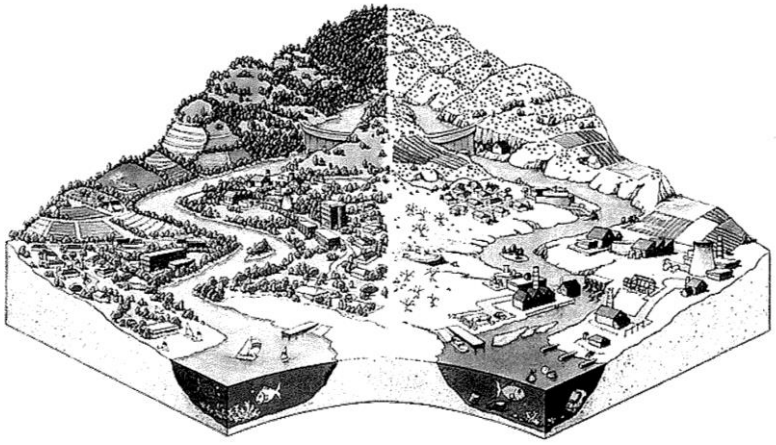
Some rivers are born from springs and fed at first from runoff rainfall which later collects in the valley bottom in wetlands that act as a **sponge**, slowing and storing water and releasing it slowly to feed the river all year round. These rivers are called **perennial** rivers. Some rivers only flow in the rainy season for a short time. These rivers are called **seasonal**, or **ephemeral**.

What happens along its path to the sea?

Water runs very fast downhill and in areas where there are no plants or rocks to slow down the running water, it will carry **topsoil** away and create **erosion gullies**. Plants and trees need the **nutrients** that topsoil provides for healthy growth! Topsoil has taken millions of years to form, just like the mountains and hills. On the way down to the sea the little river runs around rocks and spills over waterfalls and rapids. At the bottom of the valley the river gets much flatter and landscape widens out. The river makes curves and bends, called **meanders**. Here up in the mountains where there are no farms, towns or cities, the water is crystal clear and it is free from pollution.

What is a river catchment or basin?

A river **catchment** or **basin** is the piece of land which collects the water when it rains and feeds a river system. Catchments or basins can be very big and feed huge rivers like the Orange-Senqu, while others can be small and feed little streams. River catchments or basins are separated by watersheds. Whatever happens in the catchment affects the river.



What are wetlands?

Along many rivers you will find **wetlands**, marshes, bogs, swamps, vleis and sponges. These are all examples of wetlands. Wetlands are important because they store water and reduce flood damage by acting as a giant sponge. Wetlands filter water so that water leaving the wetlands is cleaner than the water entering it. Many different kinds of plants and animals live in wetlands.

Where does the river enter the sea?

Rivers flow into an **estuary** or **river mouth** before entering the sea. This is also called a **delta**. These are important places because they act as a **nursery** for the young of many fish, prawns and crabs. Estuaries are good nurseries because they offer protection from most **marine predators**, and are warmer and richer in food than the open ocean.

What does a healthy catchment do?

A healthy catchment provides clean water for drinking, farming and industry. It provides **habitat** (food and shelter) for wild animals and birds. It also provides grass (grazing) for livestock farming like cattle and goats. These are some of the many **'goods and services'** that a basin provides for people, plants and animals.

How can a basin be unhealthy?

In undisturbed catchments, the natural plant cover is still in place. Plants are important because they slow the water down as it flows over the land as runoff. Plants prevent soil erosion as their roots hold soil in position. This allows more of the rain to soak into the ground and move down through layers of rock and soil, filling pools of underground water. Things that change the way the soil, water, plants and animals in a catchment work together, can make the basin unhealthy.

1.5.3. Finding out more

Enviro Facts: Humans in the Water Cycle

Can we survive without water?

Human beings are part of the water cycle. Did you know that 75% of your body is made up of water. We drink about 2.5 l of water a day and lose 2.5 l of water in sweat, breath and urine. A person can only survive 3 to 4 days without drinking water. All life needs water to survive.

What do we need water for?

People in the Orange-Senqu Basin rely on the river as a source of water for industry (mining and manufacturing), agriculture, energy, tourism, conservation and residential uses. This includes cooking, cleaning, showering and washing clothes. Farmers use water to grow crops like mielies and factory owners use water to produce **industrial goods**. A small percentage of water is used in **mining processes** in the Orange-Senqu Basin. Water is also used to produce electricity for cooling the coal burning towers and also for hydro-electricity.

Where do we get water from?

People take water from streams, rivers, lakes and springs, and also from deep underground the ground as groundwater. Only a small amount of the water on earth is suitable for people to use. We learnt in Unit 1 that the amounts of salt water and fresh water on earth are very unequal. 97.4% of the water on our planet is salt water. Only 2.6% is freshwater. The amount of drinking water that is available is so small because 22.4% of freshwater is trapped in groundwater and 77.2% in glaciers and polar ice. This leaves only 0.4% of freshwater available in the immediate water cycle.

How do people impact on fresh water?

The basin is degraded environmentally by things like water pollution, erosion and alien invasive plants and continues to be threatened by the activities of people in the basin. Clean water is a very scarce resource and people should use it sparingly and protect it against pollution. Unfortunately many people don't see water as important and a lot of our fresh water, rivers and oceans are polluted with litter, **sewage** and man-made waste materials, many of them very **toxic** (poisonous) to life.

Can we treat polluted water?

Some waste water can be **purified** by **filtering** it and other **chemical processes** before it is allowed to return to the water cycle. **Mining** often results in a change of **PH** (acidity in the water) as well as increased metal content, Industry often pollutes water sources with poisonous chemicals. These polluted waters are not possible to treat. Many **Waste Water Works**, used to treat sewerage, are not working properly because of the large number of people living in and around cities. This means water has increased **nutrient** and **organic** loads and carrying organisms that spread disease. Rainwater running off agricultural areas often carry extra **fertilizers** and **agro-chemicals** into rivers.

What is the effect of pollution on freshwater and rivers?

Many **germs** can make people very sick. Germs from diseases like cholera and dysentery grow very fast in water. These germs are found in human faeces (poo) that can wash into the river if people go to the toilet near the river. **Cholera** gives people a runny tummy and makes them feel very sick and weak and can kill them. Waste, litter and chemical pollution can also make people, animals and plants very sick too.

What can we do to keep rivers water clean?

Everyone lives in a river catchment basin. When there were fewer people, our river basins were clean and healthy and full of life. Today there are over 7 billion people living on our planet. It is important for us to know that we must not pollute water by dumping waste, littering or allowing human faeces, animal waste and chemicals to enter the river.

What can we do so we don't make people living downstream sick?

Washing clothes in rivers can make people downstream sick from germs and chemicals. We can carry buckets of water away from the river to wash our clothes and babies' nappies. We must build toilets away from rivers in places where storm water does not wash into rivers. We must never urinate or defecate (poo) close to or in a river or stream.

How can we make sure our water is safe to drink?

A simple way of purifying (cleaning) water is to add a teaspoon of Jik (5 ml) to every 25 litres of water and leave it overnight. Jik is a very strong chlorine chemical that kills all the germs (bacteria), making water safe to drink. Another way of killing all the germs is to boil the water. Leave the water to cool. Harvested rain water should be covered over to prevent bird droppings and animal manure from getting inside. Always wash your hands before drawing water and remember to use a clean cup or bucket.

2.1.3. Finding out more

Enviro Fact: The Geography of the Orange-Senqu Basin

The Orange Senqu River Basin is the largest river basin south of the Zambezi River. It covers an area of about one million square kilometres.

This **trans-boundary** river covers the whole of Lesotho, a large part of South Africa and southern regions of Botswana and Namibia. The Senqu flows from its **source** near Thabana Ntlenyana (3 482 m) in the Lesotho highlands (the tenth highest peak in Africa). It becomes the Orange River at the Lesotho border and travels through central and western South Africa. Here it forms the southern border of Namibia and finally joins the Atlantic Ocean near Alexander Bay.

The table below shows the land covered by the Basin in the four **riparian** states of the Orange-Senqu River:

Area and Percentage of the River Basin for the Four Riparian States

Country	Area in each country(km2)	Percentage of Basin
Botswana	79,000	7.9%
Lesotho	34,000	3.4%
Namibia	245,000	24.5%
South Africa	642,000	64.2%
Total	1,000,000	

Orasecom, 2009

The basin includes most of the industrially developed parts of the region and about 27 storage dams. It is the most developed trans-boundary river Basin in Southern Africa. It is important for the four countries to work together in order to manage the water resources in the Basin wisely. Problems that need addressing include **water quality**, the supply of water and pollution control.

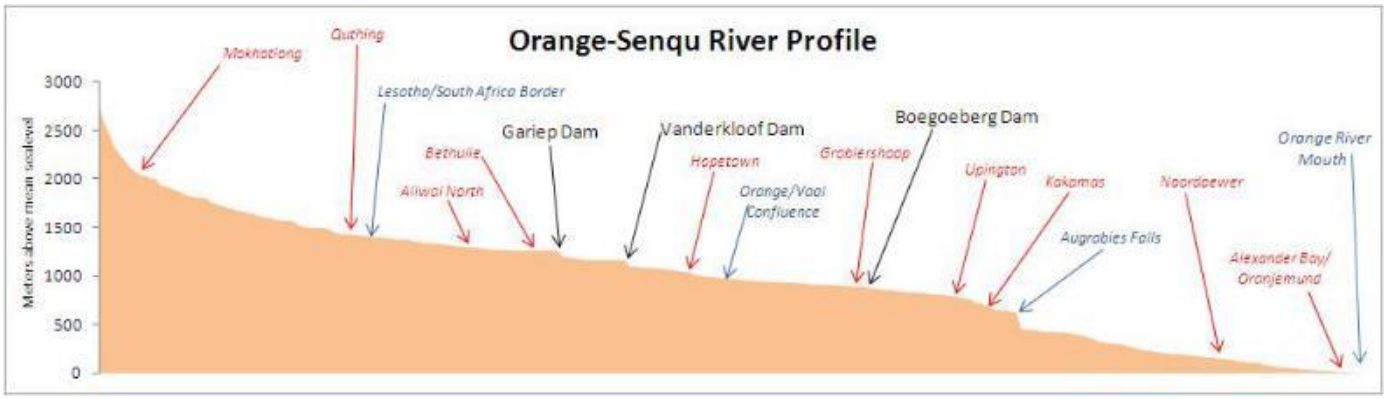
The Landscape of the Basin

From the river's source in the Highlands of Lesotho, 3 300m above sea level, to the border with South Africa, the **landscape** of the Orange-Senqu River is steep. After reaching the border the landscape has more rolling hills.

In Botswana the Molopo sub-Basin is fairly flat, with a gentle landscape throughout. Here the river only flows from time to time.

In Namibia the major tributary of the Orange-Senqu is the Fish River. This is a **seasonal** or **non-perennial river**. When this river flows, it passes through deep valleys before joining the main-stem of the Orange River, close to the river mouth. Further upstream there are two rivers, the Nossob and Auob Rivers that join close to the border with South Africa and Botswana, before they join the Molopo **channel**. Like the Molopo, these rivers do not often flow and surface water does not reach the main river.

The downstream parts of the river in South Africa often run through deep and steep valleys. These areas include the north western Karoo, Richtersveld and the area to the west of the Augrabies falls.



One River - Four Nations

The Basin includes the central part of South Africa, which makes up nearly half its surface area, the whole of Lesotho (where the main river is known as the Senqu), the southern portion of Botswana, and drains most of the southern half of Namibia.

There are six main **geographical** regions covered by the Orange-Senqu River Basin - these are: The Great Escarpment Mountains; the Highveld; the Nama Karoo; the Southern Kalahari; the Namaqua Highlands and the Southern Namib Desert.

2.2.3. Finding out more

ENVIRO FACTS: The Upper Orange-Senqu Basin

Does this area have the most rainfall?

The Senqu River, with its **tributaries**, drains most of the Lesotho Highlands. To the east, the sub-basin has very high mountains that are 3 000 meters above sea-level. This is the highest area of the whole Orange-Senqu River Basin. This sub-basin has much more rainfall than the rest of the basin. It averages between 600 mm to more than 1000 mm per year. This sub-basin is hot in the summer with high levels of **evapotranspiration** (plants releasing water vapour from their leaves)

What dams are found in the Upper Senqu basin?

The two biggest dams in the Orange-Senqu catchment, the Katse Dam (located in the Malibamatso River) and the Mohale Dam (located in the Senqunyane River) are found here.

What is the Lesotho Highland Water Project about?

A very important **water scheme** called the Lesotho Highlands Water Project (LHWP) that is made up of the Katse and Mohale dams as well as the Matsoku Weir. These water bodies have giant tunnels that join together to transfer water in tunnels to the Vaal River system in the Upper Vaal catchment. Phase one of this water scheme was finished in 2005 and it is also used to generate electricity for Lesotho (**hydro-electricity**).

What are the features in the Upper Senqu River?

The uppermost part of this river system includes the river **headwaters** and small streams high in the mountains. The mountainsides and rivers are very steep, with lots of **rapids** and **waterfalls** and often there are areas of soil **erosion**, and these **sediments** are carried downstream. These streams generally don't spill over their banks and so don't have any **floodplains,** although during the wet season the land around the river may be quite wet.

ENVIROKIDS: In PART TWO of the *EnviroKids* article (Volume 33, No. 3) you can find out more about the upper Orange-Senqu Basin. It starts in Lesotho's mountains as the Senqu River, and flows through the Orange-Senqu Sub-Basin that includes Lesotho, (often called The Kingdom in the Sky), and part of the Free State to where the Vaal River joins the Orange.

2.3.3. Finding out more

ENVIRO FACTS: The Vaal River Basin

Where does the Vaal River start?

The Vaal River is the biggest tributary of the Orange-Senqu River. It starts near Breyton, in Mpumalanga Province and is 1 120 km long. It drains much of the central **Highveld** of South Africa. The Vaal sub-basin at its highest point is about 2 000m above mean sea-level. The river flows west and joins the Orange River just past Kimberley.

How much rain does this region get?

The rainfall in this sub-basin falls in between the high rainfall area of the Upper Senqu basin and the low rainfall of the Lower Orange River sub-basin. This means that the area receives an average yearly rainfall of about 400 mm to 800 mm. In summer it is much hotter and so there is much more **evapotranspiration** from the leaves of grass, plants and trees.

What are the major dams and tributaries of the Vaal?

The major **dams** on the Vaal River include: the Vaal, Vaal Barrage, Grootdraai and Bloemhof. Some of the tributaries of the Vaal River include the Harts, Vals, Waterval River, Bamboes Spruit, Blesbokspruit, Mooi River, Renoster River, Riet, Schoornspruit, Klip and Wilge Rivers.

What is the water used for?

Water from the Vaal River is used for the **industrial** needs of the **Johannesburg Metropolitan Area** and a large part of the **Free State**. The river is part of the **Vaal-Hartz Water Scheme** and is a major source of **irrigation**. Water drawn from the Vaal River supports 12 million people living in Gauteng and surrounding areas.

ENVIROKIDS: In PART ONE of the *EnviroKids* article *(*Volume 33, No. 4) you can read about the Vaal River Sub-Basin that falls entirely within South Africa. The Vaal River starts in the east near the Drakensberg highlands, and joins the Orange River in the Free State just beyond Kimberley. It has many side branches (tributaries) that rise on the Witwatersrand and in the Free State. Articles included as separate resource in Orange-Senqu River Learning Box.

2.4.3. Finding out more

ENVIRO FACTS: The Northern Sub-Basin

How much rain does this region get?

The Northern Sub-Basin is a very dry area with an average annual rainfall of <250 mm. The land is characterised by desert and dry river beds and **canyons** like the 160km long and 550m deep Fish River Canyon, which have spectacular scenery. It is a difficult area to travel to and tourists visiting the area need 4 x 4 vehicles to gain access to these far-away places.

What tributaries are there in this Sub-Basin?

The Fish River is 650km long and starts in the **Naukluft Mountains**. The river flows 150km to the Hardap Dam near Mariental where the dam stops the rivers' flow. Downstream tributaries feed the lower part of the river when it rains. In the winter the river can dry up completely. The Fish River joins the Orange River at the border with South Arica about 100km from where the river mouth enters the Atlantic Ocean. There are two dams on the Fish River, the Hardap and Naute dams.

The Molopo River is a 1 000 km long **fossil** river that starts near **Mafikeng** in the North-West Province of South Africa. Part of the river channel runs along the border between Botswana and South Africa. The fossil channel travels south-west until it meets the Nossob River, running south along the Namibia/Botswana border.

The Nossob River is a seasonal river that starts north-east of the Namibian capital of **Windhoek**. It is about 740 km long to where it meets the Molopo River. The Nassob River drains an area of about 100 000 km.

What are the water challenges in this region?

There is very little surface **moisture** in this region because of the very low rainfall and high rates of evaporation. There is a high groundwater table which provides enough water to enable grasses and other vegetation typical of the Kalahari to grow and some **waterholes** for wildlife. People in this region use boreholes or wells to get water.

ENVIROKIDS: In PART 4 of the *EnviroKids* article (Volume 34, No. 1) you can read about the Northern sub-basin. The area is drained by **seasonal** rivers that only flow for a while after it has rained, and then dry up. The sub-basin includes the desert-like parts of three nations Namibia, Botswana and South Africa. Articles included as separate resource in Orange-Senqu River Learning Box.

2.5.3. Finding out more

ENVIRO FACTS: The Lower Orange-Senqu Basin

Where does the Lower Orange-Senqu start?

The Lower Orange River includes the Orange from where it joins with the Vaal River to the Orange River Mouth.

What does the river look like here?

The lower section of this river system (extending to the mouth) is fairly flat, with a larger river channel and gentle rapids except through Augrabies gorge. Mostly the main channel meanders across the landscape.

What are the main tributaries along this section?

The main tributaries that drain into this section of the Orange River are: the Ongers and Sak rivers from the northern Karoo; the Kuruman and Molopo rivers from the Cape Province north of the Orange and the southern part of Botswana; and the Fish River from the southern part of Namibia. These rivers are draining the very dry areas of the Northern Sub-Basin.

How much does it rain here?

This sub-basin has lower rainfall as compared to most parts of the basin. The mean annual rainfall varies from 100 mm to 400 mm. Little of the surface runoff water is usable because rainfall is so very low and does not fall very often.

What is water used for?

Water is taken out at various points along the river mainly for irrigation, as well as some water for urban use and **stock** watering purposes.

What is at the Orange River Mouth?

The Wetlands at the Mouth of the Orange River are an important resting place for a large number of **Migratory** Birds. Because of this it has been declared a **RAMSAR site**. Many **Semiprecious** stones and a big variety of naturally polished pebbles make this an ideal hunting ground for rock and gemstone collectors.

ENVIROKIDS: In PART FIVE of the article in *EnviroKids* (Volume 34, No. 2) included herewith you can read about the Lower Orange River sub-basin. It falls within South Africa and Namibia and extends from where the Vaal and Orange rivers join, all the way to the river mouth at the Atlantic Ocean. Articles included as separate resource in Orange-Senqu River Learning Box.

3.1.3. Finding out more

Enviro Fact: Wetlands

A **wetland** is a place between dry land and a water body where the soil is waterlogged for all, or part, of the year. The water may be flowing or standing, and fresh, **brackish** or salt.

Waterlogged soil is usually dark and has little or no air (oxygen) in it. This is called **anoxic**.

Many wetlands are rich in **nutrients** and have a lot of different kinds of land and water animals and fast-growing plants. Wetlands can be deep or shallow, tiny pools or huge swamps. Some mountain wetlands are just patches of wet ground called **sponges** or **seeps**. These are places where rainwater collects and is slowly released as the start of a river.

Healthy wetlands provide us with clean water, and are full of plants and wildlife. Wetland plants all depend on sunlight for energy to make their food, and on animal wastes, bacteria and fungi to provide the nutrients for growth. The animals in turn, depend on the plants or on one another for their food. As long as we protect the plants and the animals, the entire wetland will remain healthy.

Why are wetlands so valuable?

- Wetlands act as sponges, holding water back in summer and releasing it very slowly in winter. This ensures a more steady flow of water in a river downstream. They also help to replace groundwater.

- Wetlands slow down fast flowing water and so they reduce the possibility of damage caused by floods. They also stop soil **erosion** as the plant roots hold the soil.

- Wetlands are nature's way of cleaning dirty water by acting as a filter, trapping sediments, dissolved nutrients and even germs. The water leaving a wetland is cleaner than the water entering it.

- People use wetland plants like reeds, for thatching, basket weaving and traditional medicine. Wetlands are also used for fishing, bird watching and game viewing as they are beautiful areas.

People do not always take good care of wetlands as they are drained, dammed, overgrazed, burnt, mined for their soils, and polluted by chemicals and litter. This destroys wetlands and their natural functioning.

The Convention on Wetlands of International Importance was adopted in the Iranian city of Ramsar in 1971 and is known as the Ramsar Convention. It is an **intergovernmental treaty** that provides a recognised framework for national action and international **co-operation** in the conservation and wise use of wetlands and the natural resources associated with them.

Ramsar Sites in the basin

Five Ramsar sites have been identified in the basin:

- **The Orange River Mouth** drains into the Atlantic Ocean, however at times the drainage is blocked by **sandbars**. The 2000 ha site was named a Wetland of International Importance in 1991 and is home to up to 60 bird species. The Orange River Mouth Ramsar site is shared by Namibia and South Africa.

- **The second Ramsar site is the Seekoeivlei Nature Reserve.** As the largest wetland in the African Highveld, it supports a large number of local and migratory birds. The Nature Reserve is found in the floodplain that drains into the Klip River and eventually into the Vaal River.

- **The Barberspan Nature Reserve** covers 3 118 ha. The Barberspan is the largest of a series of grass pans in the fossil Harts River Basin. 320 bird species have been seen there and it is important to the existence of several rare and endangered animals and plants.

- **Lets'eng-la-Letsie** is a source of the Quthing River in Lesotho that contributes 3% of the total flow to the Senqu River. The Lets'eng-la-Letsie wetland consists of a man-made lake resulting from a small dam built on the Mohlakeng River.

The area was declared a protected area in 2001 because of its importance as a tributary to the Orange-Senqu River system, its high natural mountain biodiversity and the relatively undisturbed state of the high mountain wetland.

- **Blesbokspruit,** one of the larger wetlands found in the Highveld region of South Africa, is situated close to the Orange-Senqu River Basin boundary, near the town of Springs in the Gauteng Province, It is approximately 1600 m above mean sea level. It has a high conservation value because it helps purify water in this region which is affected by industrial and domestic effluents.

More about wetlands in South Africa

Certain wetlands within the Orange-Senqu River Basin are of particular interest due to their geographic location, and their ecological importance.

The wetlands at the Orange River Mouth (Alexander Bay wetlands) (South Africa & Namibia)

The Orange River Mouth area can be described as having an ***estuarine***, ***basin***, as well as **plains wetlands**. The site has sand banks or channel bars covered with **pioneer** vegetation, a **tidal basin**, a narrow floodplain, pans, the river mouth and a salt marsh on the south bank of the river mouth with a braided channel system during low flow months.

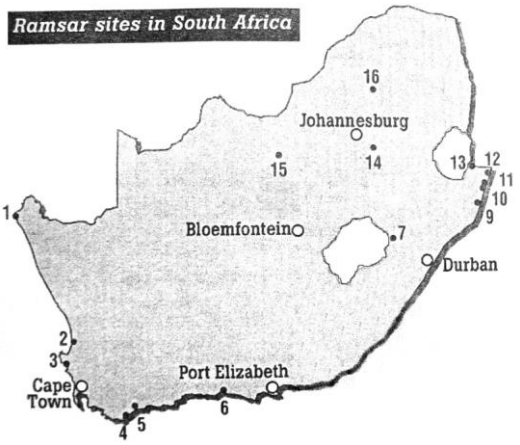
The Orange River usually flows directly into the Atlantic Ocean, but when the river is low, a sand bar can form across the mouth to block the river. The river then rises in level and spills over into the salt marsh area. The river mouth and the surrounding pans and salt marsh provide a big area of sheltered shallow water which large numbers of wetland birds love. Water birds use the Orange River Mouth wetland for breeding and also as a stopover on migration routes.

The Natal Drakensberg Park wetlands

This area has a lot of high altitude mountain wetlands (alpine wetlands). Names for these wetlands include tarns, springs, bogs, marshes and streams. Broadly these are classified as permanent rivers and streams and include waterfalls, permanent and seasonal marshes and ponds that have vegetation growing in waterlogged soils for at least most of the growing season. Other forms of wetlands found here are **peatlands**, freshwater springs, seasonally flooded meadows and sedge marshes. The Drakensberg catchments consist of an ***inter-connected system of wetlands***. These wetlands range from open water bodies such as mountain tarns, a variety of marshes, to a fine network of stream and river courses. These wetlands are found right from the high altitude areas and down to the valley floor.

Ramsar sites in South Africa:

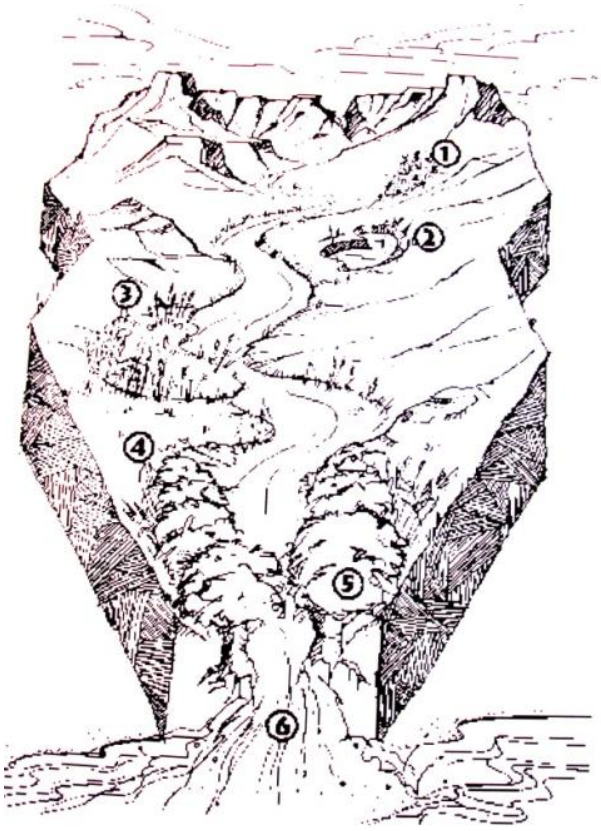
The map shows the 16 wetlands recognized by the Ramsar Convention that are of international importance.



The 16 sites of South Africa recognized by the Ramsar Convention	
1. Orange river mouth 2. Verlorenvlei 3. Langebaan Lagoon 4. De Mond State Forest 5. De Hoop Vlei 6. Wilderness Lakes 7. Natal Drakensberg Park 8. Seekoeivlei	9. St Lucia System 10. Lake Sibaya 11. Tongaland 12. Kosi Bay System 13. Ndumu Game Reserve 14. Blesbokspruit 15. Barberspan 16. Nylsvlei Nature Reserve

Adapted from:
http://www.orangesenqurak.org/river/ecology+biodiversity/aquatic+ecology/aquatic+habitats.aspx?print=1
http://www.dwaf.gov.za/orange/environm.aspx
http://www.environment.gov.za/branches/bioconservation/17ramsar/natal_drak/natal_drak_ris.htm

Where to find the different types of wetlands:



Wetlands have particular positions in the landscape

1. Stream Source Setting

These wetlands can be found in steeper valleys just below the watershed. These settings are easily overlooked as "wetlands" because they are often the only green patches in an otherwise dry landscape. Unfortunately these areas are overused, especially by animals, and many are just the **dongas** on our hillsides. - The Drakensberg Park has many examples of stream source settings.

2. Basin Setting

These are wet pans, dams and lakes which can occur in all positions in the landscape and can be seasonal or permanent. They are not always recognised as "wetlands" especially when the seasonal wet pans are in their dry condition. Ramsar sites that are basin settings include; Barberspan, Lake Sibaya and De Hoop Vlei

3. Plains Setting

These wetlands occur in all the lower parts of the landscape. Plains wetlands are some of the most recognisable of wetland systems and are commonly referred to as **vleis, marshes and swamps.** - A Ramsar site that is a plains setting is Blesbokspruit.

4. Streambank Setting

These wetlands are on the banks or shallow areas of the channels, streams, rivers and dry water courses (including dongas) that occur throughout the catchment. They connect many wetland settings to each other, from mountain to sea.

5. Estuarine Setting

These wetlands include ***Estuaries***, ***Lagoons***, and ***Non-tidal, open river mouths***. - Ramsar sites that are estuarine settings include:- Orange River Mouth Wetland, Kosi system, De Mond State Forest, St. Lucia system, Verlorenvlei and the Wilderness Lakes.

6. Marine Setting

This setting includes the: ***Inter-tidal zone*** (the rocky and sandy marine shores), the ***Sub-tidal zone*** (the permanent marine shallow waters and coral reefs less than 6m deep at low-tide) and Coastal ***bays*** (the coastal inlets without feeder streams or rivers). - Ramsar sites that are marine settings include Langebaan and the Turtle Beaches/Coral Reefs of Tongaland.

Adapted from:
http://www.wetland.org.za/ckfinder/userfiles/files/3_5_1-%20Wetland%20Fix%20-%20Part%201.pdf

3.2.3. Finding out more

Enviro Fact: Stream and Pond Life

Rivers and wetlands are full of life. A water eco-system is closely linked to the surrounding **habitats** (places where animals live) and human activities. Healthy streams and ponds/dams usuallly have a wide range of **organisms** living in them. These can be found in different areas such as:

- On the surface of pools and fast flowing water;
- under the water, shallow and deep;
- on and under **vegetation**;
- under rocks;
- in the mud on the bottom, amongst **decaying** matter.

Scientists can quickly assess the quality of a river and its catchment by looking at:

- Stream bank vegetation
- The colour, smell and taste of the water,
- The types of water life; and finally
- By **chemical tests**

To quickly judge river water quality, pick up ten medium sized rocks, brush off all of the organisms (**macro-invertebrates**) that are underneath them into a container and then see:

- What organisms live in the water (species present)
- The variety of different kinds of water life (diversity)
- The total number of each type (populations)

Clean water with **balanced proportions** of different kind of plant and animal life usually indicate a healthy system.

Questions to guide observation

Common questions to guide the observation of plants and animals that live in and near water are:

- What is it like? (adaptation)
- What is it doing? (behaviour)
- With what does it interact? (interdependence)
- Where is it found? (distribution)
- How much or how many are there? (abundance)
- How many different types are there? (diversity)

What do we focus on?

Patterns of interdependence and the life-giving systems and processes of the environment can be used as the focus for an investigation. Factors that degrade the environment should also be explored. These include **siltation** and **chemical pollution** with **nutrients** and **poisons.** A wide variety of animal species in a stream usually indicates good water quality. Some species cannot tolerate even the slightest amount of pollution. If these creatures are found alive in a stream, it menas that the water is clean and probably drinkable.

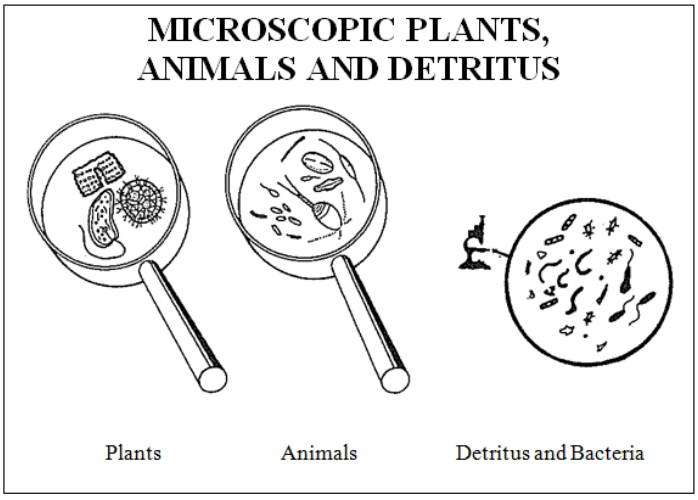
Freshwater plants

Freshwater plants occur

- In mud and in shallow water (eg bulrushes)
- Floating on the surface of water (eg water lily)
- Under water (eg ***Nitella***)

Freshwater plants are essential for the survival of the animals which live in water.

- Plants are eaten by **herbivores** like tadpoles
- Leaves under the water form a habitat (home) for many small creatures
- Plants produce oxygen



Water contains tiny plants (**phytoplankton**), tiny animals (**zooplankton**) and small pieces of old leaves, roots and dead animals (**detritus**)which are mixed together to form a 'soup'. This slimy film on rocks and on plants is food for many water animals.

Microscopic Plants (phytoplankton)

Algae may be single-celled (e.g. Chlamydomonas) or have groups of cells (e.g. Volvox). When they occur in abundance the water is usually green. Water may be brown/orange in colour due to numerous microscopic diatoms or it may be red due to an alga Haematococcus.

Microscopic Animals (Zooplankton)

Tiny animals like amoeba, paramecium, daphnia and Cyclops live in rivers and in ponds. They feed on algae and detritus and are, in turn, an important source of food for larger organisms.

Dead Organic Matter (detritus)

This associated with bacteria and fungi which decompose it to form mineral salts. These are absorbed by phytoplankton and other water plants. Animals such as larvae, tadpoles, and crabs also eat detritus (rotting plants). These small particles, and the bacteria feeding on them, are food for animals and break down into minerals for water plants.

3.3.3. Finding out more

Enviro Fact: Biodiversity

Biodiversity is the number and variety of living organisms on Earth. It includes the millions of plants, animals, and **micro-organisms**, the **genes** they contain. Biodiversity also refers to the **evolutionary** history and potential they contain as well as the **ecosystems**, **ecological processes**, and landscapes of which they are an important part. Biodiversity therefore refers to the life-support systems and natural resources upon which we depend.

The main components of biodiversity

- **Genetic diversity** refers to the variation of genes within species. These are genetic factors which give rise to particular characteristics. This makes it possible to develop new breeds of crop plants and domestic animals, and allows species in the wild to adapt to changing conditions.
- **Species diversity** refers to the variety and abundance of species within a geographic area.
- **Ecosystem diversity** refers to the variety of ecosystems found within a certain political or geographical boundary, or to the variety of species within different ecosystems.

Biodiversity under threat

People have been changing Southern African ecosystems for thousands of years, but the rate of change increased rapidly with agricultural and industrial development. Many plant species, birds and frogs, freshwater fish and mammals are threatened. In addition, many important ecosystems have been **degraded**, and ecological processes damaged. Growing human populations and the consumption of resources will continue to impact on biodiversity.

Causes of biodiversity loss

- **Habitat loss**. All plants and animals rely on their **habitat** for food, water, shelter, and living space. Increased agricultural, industrial and urban development, afforestation, mining and dam building is destroying species' habitats.

- **Pollution**. Various forms of pollution contribute to the loss of plants and animals. For example, scavenging birds are vulnerable to poison baits put out by farmers in an attempt to control stock predators.

- **Wildlife trade**. Trade in wild plants and animals threatens many species with extinction. Despite laws passed to protect threatened species, the illegal trade in wildlife continues.

- **Alien species**. When an **alien species** is introduced to an area, it may have advantages such as few **predators** and **pathogens**, which allow it to survive better than indigenous species, and may thus threaten these local species with extinction.

- **Poaching and hunting**. This is often, but not always, linked to trade in, or commercial use of a particular species. The African wild dog, for example, has been in conflict with stock farmers for a long time and has been hunted relentlessly.

- **Protection of southern Africa's biodiversity.** Red Data Books, or RDBs, are lists of threatened plants and animals specific to a certain region. These lists were started in 1963 by the IUCN (International Union for Conservation of Nature). RDBs document biodiversity losses of different species and are important for guiding the conservation activities of governments and conservation organisations. The Convention on International Trade in Endangered Species, or CITES, was signed by 175 countries, including Botswana, Lesotho, Namibia and South Africa. CITES controls (and in some cases prohibits) trade in threatened species. Botswana, Lesotho, Namibia and South Africa are also signatories to the Convention on Biological Diversity.

The Convention on Biological Diversity has three objectives:

1. the conservation of biological diversity;
2. the sustainable use of biological resources
3. the fair and equitable sharing of benefits arising from the use of genetic resources.

3.4.3. Finding out more

Enviro Fact: Ecology

What is an eco-system?

All living things interact with other living things and with their surrounding environment. A **community** of living things functioning together with all of the non-living physical factors of the surrounding environment is called an **ecosystem**. All organisms require energy and **nutrients** to live, grow, and reproduce. Plants get energy from the sun, but animals get energy from the food they consume. Organisms living in an ecosystem depend on each other to get the energy and nutrients they need to live. Human actions that affect the natural world can change entire ecosystems because of the links between living organisms and their environment.

What is the study of ecology?

The term 'Ecology' comes from a Greek word 'oikos' referring to a 'house' or 'home'. Ecology is about how living organisms (**biotic**) (including people), and non-living things (**abiotic**) in the natural environment, work together. The proper functioning of these ecological processes are essential for life on Earth. Some of the processes are simple, others complex, with a lot more interaction going on.

Trophic levels: A Trophic level is a name for the feeding levels in an eco-system i.e. it is about who eats what. All organisms (plants and animals) need food which provides them with the nutrients they need to grow and maintain healthy cells and for processes like digestion and respiration and for movement.

Trophic Levels can be divided into:

- **Primary producers** - all green plants which produce their own food from air, water and sunlight (during photosynthesis) as well as from chemicals absorbed in solution from the soil.
- **Primary consumers** - all green plant eating animals (herbivores)
- **Secondary consumers** - all meat eating animals (carnivores)
- **Tertiary consumers** - meat eating animals that eat other meat eating animals.
- **Reducers** - animals, such as worms, crabs, vultures or carrion eaters, that feed on any dead organic matter.
- **Decomposers** - fungi and bacteria which break down organic matter into its inorganic parts for re-use by plants.

Food chains: A food chain shows the flow, or the transfer, of energy from organism to organism. Each organism in the chain provides food for the next one in the chain, and energy flows in this way. A plant takes energy from the sun and by a process called **photosynthesis**, and changes it into food energy. When an insect eats the leaf of the plant, some of the plant's energy is transferred to the insect. When a spider eats that insect, it gets energy from the insect. This is a very simple explanation of the interactions in a food chain because very few organisms eat only one type of food. The overlapping of different food chains is called the food web.

Food webs: A food web is an interlocking pattern of food chains. Food webs are based on green plants. Green plants make their own food using photosynthesis. All animals depend on green plants to live and grow. **Herbivores** eat the leaves, fruit and seeds from green plants, while **carnivores** feed on the herbivores and omnivores to survive.

Fish species of the Orange-Senqu River

Fish play a big role in contributing to the biodiversity of the system. Despite being the third largest river in Southern Africa the Orange Senqu has at least 33 fish species which is relatively low for freshwater fish species diversity. At least fifteen (45%) of recorded species are indigenous to the Basin.

3.5.3. Finding out more

Enviro Fact: Estuaries – The River Mouth

How does a river find its way to the sea?

The Orange River **Estuary** is a Ramsar site - a wetland of international importance - and South Africa's second most important estuary for **conservation**.

Uppercourse river (small river): From the small mountain streams the river started out flowing through a steep valley. After snows and heavy rain the stream carries so much water and flows so fast that it drags gravel and stones with it. The stones that are dragged along with the stream slowly dig the river bed deeper.

Midcourse River (medium river): When it reaches the valley floor, the mountain stream deposits its stones. The valley it flows in becomes shallower and the riverbed now consists mainly of gravel. When it floods the river takes a great deal of grit and gravel with it and deposits it as islands or on the banks.

Lower course (large river): When the Orange-Senqu river reaches the **plain** the river becomes a lowland river. The water runs slowly; it only has enough strength to carry sand and very fine gravel. The river develops a **meandering** course

The delta When the river reaches the sea the riverbed no longer has any gradient. The water does not have the power to transport its large amount of sand, and deposits it, forming sandbanks. Between these sandbanks, the river has to find its way into the sea and it divides into many arms. During floods, the land between the arms is flooded and this enables the development of a **salt marsh**.

How important is the Orange River Estuary?

The Orange River Mouth is the sixth most important coastal wetland in Southern Africa The 2 000 hectare site supports up to 60 bird species of which 14 are listed as **endangered**. The river mouth and adjacent areas provide a large area of sheltered shallow water that attracts large concentrations of wetland birds that breed there or stopover on **migration routes**. The area supports 33 mammal species including the cape clawless otter. The Namaqua barb is a **red data species** which is found only in the lower reaches of the Orange-Senqu. The Orange River Mouth drains into the Atlantic Ocean from time to time when it is not blocked by sand-bars. In 1991 it was declared a Wetland of International Importance (according to the **Ramsar convention**)

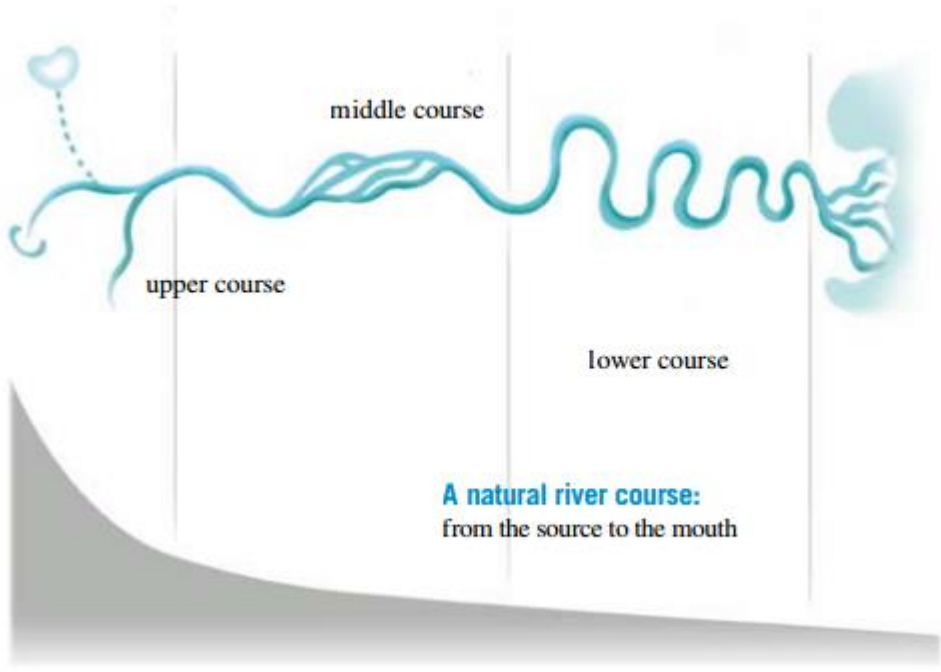
The Orange River Mouth – a Ramsar Site Under threat

The Orange River mouth is a protected wetland. For millions of years it supported a rich diversity of crabs, snails and fish and migratory birds. The natural rhythm of the river ensured the existence of the salt marshes. In winter the salinity in the marshes would increase and in summer strong floods would open the mouth and reduce salinity. About fifty years ago this rhythm was broken when several large dams were built in the upper Orange-Senqu basin and the rivers flow became uniform. This had a serious impact on the estuary and biodiversity and birdlife declined dramatically since the mouth is now blocked with high sandbanks.

This has raised the salinity level in the estuary and many animal species have disappeared. Since 1995 the area has been placed on the "Montreux list" of endangered wetlands. A management plan for the Orange River Mouth Ramsar site was developed in 2013 that identifies a number of actions which need to be taken to restore the site.

There are plans to build a new dam on the Orange river, 350km upstream at Viooldrift. This dam will result in even less water reaching the mouth, but the flooding pulses released from it could help overcome the problem of the sandbanks in the river mouth. The biodiversity of the salt marshes could then have a chance to recover.

Other negative impacts on the Orange River mouth have been from the neighbouring diamond mining operations. The town of Alexander Bay is situated just outside the former floodplain area. The north bank of the Orange River forms the border between SA and Namibia.



A natural river course: from the source to the mouth (adapted Danube Box)

4.1.3. Finding out more

Enviro Fact: Sustainable Livelihoods

The term **livelihood** is used to identify a relationship between the people and the biophysical resources of the Orange-Senqu River basin. Livelihood is a primary activity that individuals engage in to obtain the income, food, water, shelter, clothing and other materials needed to satisfy and sustain the well-being of families and other members of a social group.

Livelihoods include any choice for making a living, carried out independently or as part of a group effort where there is interdependence between the group members. Specific livelihoods are often embedded in particular cultural traditions and are based on specialised skills, technology and knowledge that are passed down from generation to generation. Livelihoods are closely associated with gender, age and the expectations of civil society.

After many attempts to promote development, developing countries are turning to a new model to reduce and alleviate poverty without compromising the natural assets of the country. These new methods are collectively termed **Sustainable Livelihoods.** A livelihood includes the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks while maintaining or enhancing its capabilities and assets and not undermining the natural resource base.

The Orange-Senqu River basin provides numerous natural resources and sustainable livelihoods to people living in the basin. **Artisanal fishing, subsistence farming, eco-tourism** and collecting food and medicine from the wilds within the basin are important sources of income, especially for the rural people of the basin. These livelihoods allow people to work close to their homes and to build a sense of stewardship for the basin.

1. Subsistence Farming.

Lesotho is primarily a country of subsistence farming, with most people growing food for their own consumption and where possible, maintaining small to medium-sized herds of livestock (cattle and goats). Maize, wheat, and sorghum are the main crops, along with peas, beans, and potatoes. Most of the good farming areas are in the northwest lowlands, surrounding the capital of Maseru.

The rest of the country is either too mountainous or generally too dry to produce high crop yields. These areas are also characterised by fragile soils, where pressures from increasing cultivation and grazing have led to degradation of fields and pastures. Loss of vegetative cover from firewood removal, animal browsing and overgrazing has led to widespread and obvious gully erosion of hillsides.

Food production in Lesotho has been shrinking for years due to erratic rainfall and soil erosion, while HIV has weakened subsistence farming communities. Lesotho imported an estimated 70% of its cereal in 2004, mostly from neighbouring South Africa.

In Botswana, Namibia and South Africa, there is both a commercial agricultural sector and a traditional, mainly subsistence, sector. The portion of Botswana that falls within the Orange-Senqu River basin contains rural settlements mainly reliant on subsistence livestock farming. **Overgrazing** of fragile ecosystems in the Kalahari is resulting in less palatable plant species becoming established. This is because utilisation of land by livestock production has increased from 13 000 km² in 1950 to around 32 000 km² by 1990, enabled by the exploitation of groundwater.

About 70% of the Namibian population depends on agriculture, mostly subsistence farming in communal areas. Like Botswana, Namibia is also struggling with land degradation due to overgrazing, which is further compounded by agricultural practices that result in the depletion of soil nutrients. Livestock farming dominates agricultural practices in the Orange-Senqu River basin part of Namibia. In South Africa also, subsistence farming is mostly restricted to communal lands or the former homelands. Up to 2.5 million households subsist in this sector, having to farm on 13% of available agricultural land.

In the lower Orange-Senqu, stock farming, mainly of goats and sheep, is important to the local economy. Land is owned communally and access to almost all grazing is open to the members of the associated communities. Households in other parts of the basin, normally women-headed, practice labour-intensive small-scale agriculture.

2. Artisanal Fisheries

Artisanal fisheries can range in size from little more than active subsistence fishing, where part of the catch is regularly sold, to much larger operations. Livelihoods based on artisanal fishing can be a reflection of activities that have traditionally been part of a family or other social group and are now organised within local co-operatives. At the more informal end of the artisanal fishery, livelihoods are based on the same type of traditional equipment, skills and knowledge that support the subsistence fishery, with products that are sold and consumed as part of the family economy. The middle range of artisanal livelihoods is somewhat more market-focused, but it is at the upper end of the fishery where the major livelihood shift takes place.

Artisanal freshwater fishing along the Orange River is limited to the Richtersveld area of the Northern Cape Province of South Africa, the region around Aussenkehr in Namibia and Lesotho. Artisanal fishing is carried out for food security and livelihood purposes; subsistence fishing differs from artisanal fishing because it is not part of the cash economy.

Indigenous freshwater fish diversity in the Orange River is poor despite the river's large size; only fifteen indigenous fish species have been recorded to date. The most common indigenous species of fish are yellow fish. Exotic species introduced are Rainbow trout, Brown trout, Common carp, Largemouth bass and Bluegill sunfish. In Lesotho fishing is exclusively subsistence, and targets both indigenous and exotic species.

In addition to these freshwater in-stream fisheries, there are some very localised examples of small scale aquaculture in the region, such as Naute Aqua, located at the Naute Dam in Keetmanshoop, Namibia.

3. Ecotourism

Parks and nature reserves are important elements of community-based natural resource management and employment, including Ecotourism. Across southern Africa, reserves and parks offer an alternative livelihood to subsistence farming. People are able to find work near their homes, eliminating the need to travel to the urban centres for work. In the Orange-Senqu River basin there are quite a few protected areas.

These areas are significant tourist destinations and contribute to the national and local economies of all four countries.

Some examples follow.

Lesotho

Lesotho, on the one hand, has to meet serious environmental challenges like soil erosion. On the other hand this country is a paradise of national parks and nature reserves.

- **Sehlaba-Thebe National Park**

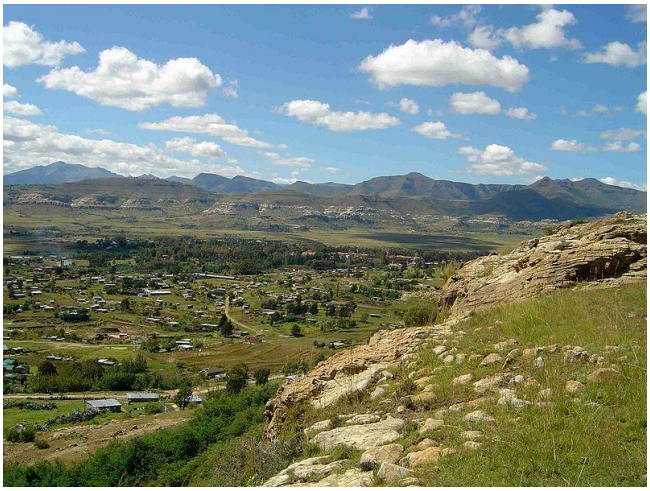
Wikipedia Commons

This area was proclaimed a "Wildlife Sanctuary and National Park" and therefore a protected area on 27 February, 1970. It is situated in Qacha's Nek, has an area of 6 475 ha and lies at an altitude between 2 300 and 2 500 m. It has subsequently been established that the Park contains several important rock art (archaeological) sites.

- **Masitise Nature Reserve:** This nature reserve also includes an archaeological site and historic mission cave house. It is a proclaimed National Monument in the Quthing District. It is a small reserve of about 20 ha, 3 ha of which is thickly wooded.

National University of Lesotho (Roma Campus):

This university campus was declared a bird sanctuary by the council of the University on 3 April 1965. It has an area of about 95 ha and is situated in the Highveld Grassland Zone, but the area has been modified by the introduction of exotic trees and the creation of water areas.



Source: Martin Schärli Wikimedia Commons

There are other initiatives to include some important areas of biodiversity into the official national listing of national parks and nature reserves. Two such areas are along the border with South Africa - the Maloti Drakensberg Area and the Letšeng-la-letsie protected area in southern Lesotho.

- **The Maloti-Drakensberg Trans-frontier Conservation and Development area Programme:** This is a World Bank-financed project intended to aid conservation of biodiversity values in the Maloti-Drakensberg area, and to help development of the people in the adjacent areas along the border between Lesotho and South Africa. The programme is a joint initiative of the Governments of Lesotho and the Republic of South Africa. It is a trans-boundary conservation and development programme aimed at establishing protected areas while promoting sustainable tourism in the Maloti-Drakensberg mountains.

The Maloti-Drakensberg mountains are an extremely important water catchment area with the alpine and montane grasslands hosting a myriad of wetland systems. These fragile systems are crucial to the delivery of one of the area's most important ecosystem services, perennial flows of high quality water. With this area being one of the few in southern Africa where the long-term annual average precipitation exceeds the long-term annual average evaporation, it is easy to understand its importance as a water catchment. The Lesotho Highlands Water Scheme has been well publicised and is completely dependent on the water that drains out of this area into rivers such as the Senqu and Mokhotlong. The bulk of KwaZulu-Natal's water flows from these mountains in rivers such as the Tugela, Mkhomazi, Mzimkulu and Mzimvubu.

- **Letseng-la-letsie:** This is an important wetland area in southern Lesotho. Efforts are currently underway to engage support for designating the area a protected site. The Conserving Mountain Biodiversity in Southern Lesotho project provides financial support. The project is financed by the Global Environment Facility (GEF) and is implemented by the United Nations Development Programme (UNDP). The National University of Lesotho has undertaken a comprehensive Environmental Impact Assessment for the establishment of a protected area at Letšeng-la-Letsie
- **Katse Botanical Garden.** The "Lesotho Highlands Water Project" has significant impact on the environment in the mountains of the country. It is very important that this unavoidable impact is compensated by the creation of nature reserves and other measures. Accordingly, the government of Lesotho has proclaimed several wetlands in the mountains as protected areas, and the "Lesotho Highlands Development Authority" (LHDA) has created a miniature paradise on a hillside above Katse Dam: Katse Botanical Garden – one of the highest-lying botanical gardens in the world.

http://www.katse-accommodation.com

The establishment of Katse Botanical Garden was an explicit wish of the people there and is included in the project agreement. The aim was to preserve the flower, shrub and herb diversity of the regions that were being flooded by the LHWP, so that people could continue using these plants and could protect the natural heritage they represent.

South Africa

- **Augrabies Falls National Park:** *Aukoerebies* is a Khoi name for "the place of the Great Noise", where the Orange River thunders its way 60 m downward in a spectacular waterfall, downstream of Upington. Augrabies Falls are arguably the most impressive waterfall along the Orange River. The 28 000 ha of the Nature Reserve, on both the northern and southern banks of the Orange River, provide a sanctuary to diverse species from the very smallest succulents, birds and reptiles to Springbok, Gemsbok and the endangered Black Rhino. Careful development has made Augrabies Falls a very attractive eco-tourism destination providing a considerable amount of jobs in the park administration, hotels, lodges and restaurants.

South Africa / Botswana

- **Kgalagadi Transfrontier Park:** The Kgalagadi Transfrontier Park was established in 1998 as a cross-border merger of two national parks in the southern Kalahari desert, one in Botswana and the other in South Africa. The park contains no fences or border controls, but the countries apply different approaches to park management.

Amada44 Wikipedia Commons

Kgalagadi means “land of thirst”. The average annual rainfall is just 200 millimetres and the plants and animals of this park normally depend on groundwater. The water quality in the boreholes varies. In one place the water may be sweet, in another brackish. At the same time different animals have different preferences. Certain antelope species are indifferent to what water they drink, most birds like their water sweet. But even in dry years, the animals of the Kgalagadi Transfrontier Park always find enough water. If necessary, they eat wild melons, “tsammas” (Citrullus lanatus), prickly yellow “springbok cucumber” (Indigofera alternans) and other fleshy succulents.

South Africa / Namibia

- **Ai-Ais Richtersveld Transfrontier Park:** In 2003 an agreement between South Africa and Namibia established the Ai-Ais/Richtersveld Transfrontier Park. The Park covers 6 222 km² and lies in two protected areas on both sides of the Orange River that marks the border between the two countries: the South African Richtersveld National Park and Namibia's Ai-Ais Hot Springs Park, which includes the Fish River Canyon.

There is an unusual feature of the Richtersveld Park that combines eco-tourism with strong involvement of the local population and thus tries to make eco-tourism also socially sustainable: South African National Parks (SANParks) doesn't own the park, but leases the land from the local community. SANParks pays a fee into a development fund, which benefits the Nama community living here. At the same time representatives of the community assist in managing the park.

Namibia

- **The Sperrgebiet National Park**

There is still diamond mining going on in a small portion of the "forbidden area" (Sperrgebiet) in the extreme southwest of Namibia. And as yet only a small part of the mining area has been fully rehabilitated. The responsible company, Namdeb, is busy attending to serious scars in the forbidden area, which in 2008 was proclaimed as the Sperrgebiet National Park. This is designed to attract eco-tourists and to supplement the neighbouring Ai-Ais Richtersveld Transfrontier Park. Besides offering secluded beaches, towering dunes and vast, stone-strewn plains it will hold a multitude of succulents and animals www.thegef.org

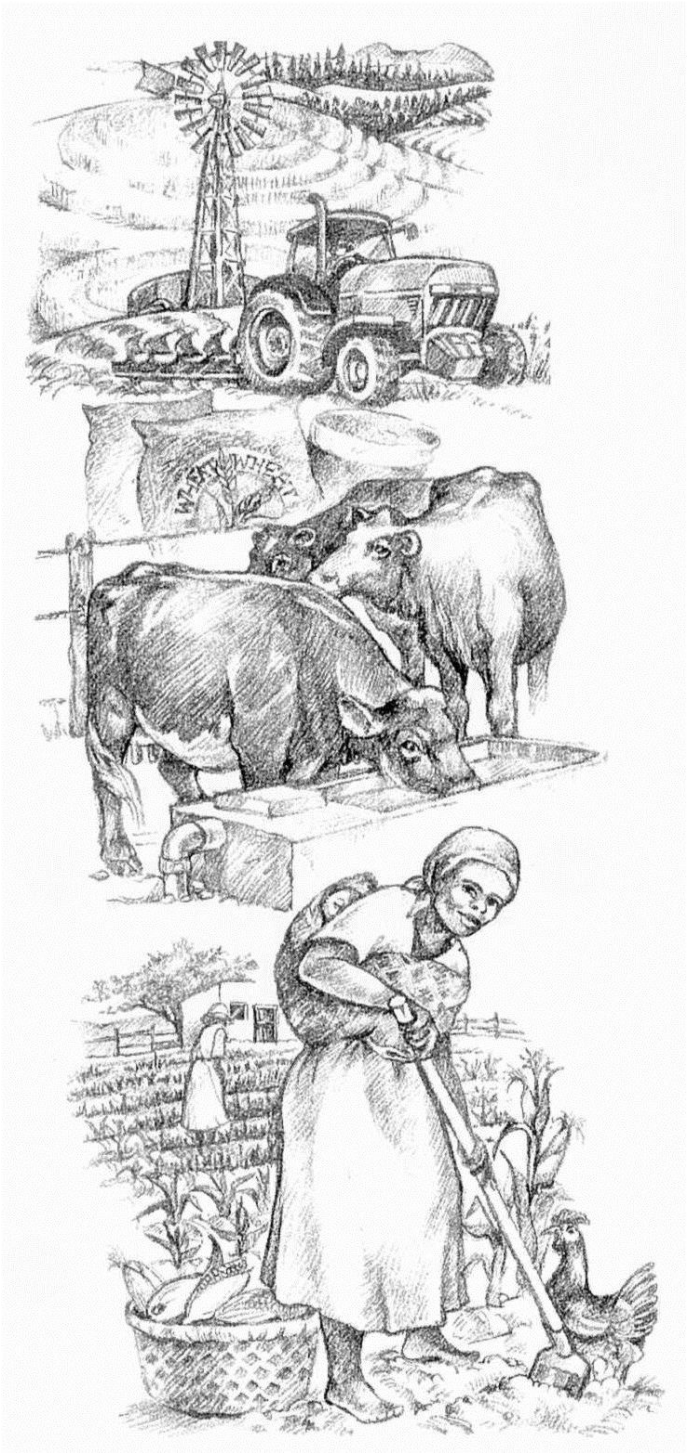
Namibia / South Africa

- **The Orange River Mouth:** The Orange River Mouth is a trans-boundary area of extensive salt marshes, freshwater lagoons and marshes, sand banks, and reed beds, shared by South Africa and Namibia. The Orange River Mouth is a Ramsar site, but due to degradation in this important wetland area, it has now been placed on the Monreaux Record (a list of wetland sites). The pressures placed on the wetland ecosystem are related to various land uses such as the adjacent diamond mining activities and flow regulation of the Orange River as a result of dam construction upstream. The area is important for resident birds and for local, migrating water birds.

Adapted from the Orange-Senqu River Awareness Kit

4.2.3. Finding out more

Enviro Fact: Food Security



Food security is "when all people, at all times, have **physical, social and economic access** to sufficient, safe and nutritious food which meets their **dietary needs** and **food preferences** for an active and healthy life." (FAO 2001).

Malnutrition. The World Health Organisation (WHO) recommends a **minimum dietary consumption** of 2 100 kilocalories per day, including a daily protein intake of 56g and 48g for the average adult man and woman respectively.

The Food and Agriculture Organisation (FAO) defines **undernourishment** as food consumption of less than about 1 900 kilocalories per day. Undernourishment may lead to malnutrition, which reduces human well-being by impairing physical functioning, the ability to work and learn, and processes such as growth, pregnancy, and resistance to disease.

Malnutrition is defined by the WHO as "the cellular imbalance between supply of nutrients and energy and the body's demand for them to ensure growth, maintenance, and specific functions".

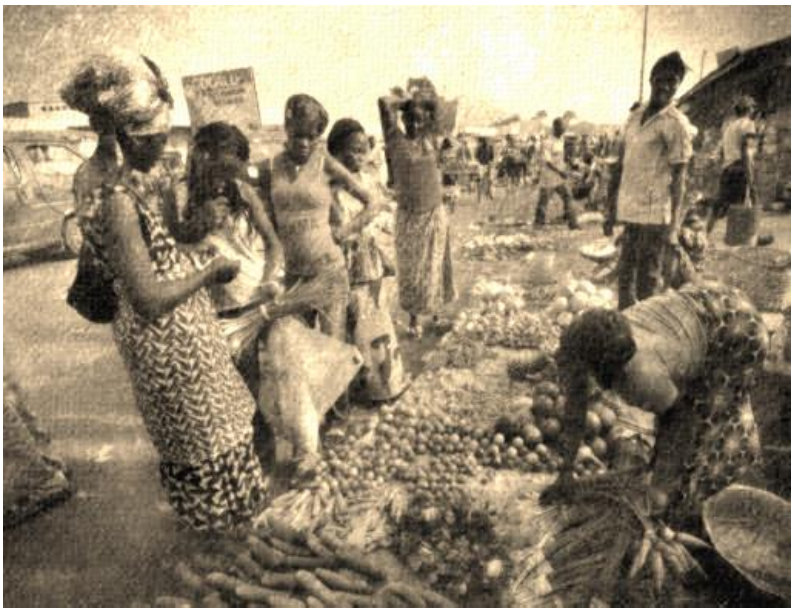
Food security in the Orange-Senqu River basin. Although there is enough food produced in the Orange-Senqu River basin for the entire population, poorer inhabitants still suffer from undernourishment and even malnutrition because of social inequalities and differences in income.

According to the FAO publication *"The State of Food Insecurity in the World"* (2009), the undernourishment rates for the four basin countries during the period of 2004-2006 were: Botswana: 26%, Lesotho: 15%, Namibia: 19%; estimates for South Africa around 5%.

On average, livestock farming in the Orange-Senqu River basin provides enough meat to supply sufficient dietary protein for a population three times its current size. This does not mean that that there is sufficient protein available, as livestock are in many cases seen as social assets rather than production assets. Export opportunities also mean that red meat is largely unaffordable, particularly to the poor.

A similar trend has been observed for cereal. Although the Orange-Senqu River basin produces 20% more cereal than is required by its population, half of the cereal produced in the agriculturally intensive "maize belt" is either exported or used as fodder in areas of surplus, and not distributed to areas of deficit in the basin.

Erratic rainfall does not allow for extensive crop production in most of the basin. As a result, many households still rely on produce purchased from urban markets. South Africa is the only Orange-Senqu River basin country that generally meets food demand through domestic production. Namibia, Botswana and Lesotho regularly have to import maize to meet annual demands. In an average year, Namibia produces approximately 50% of its cereal crop requirements domestically.



Vulnerability. Poor people spend most of their resources on purchasing or producing food for subsistence. Pursuit of food security frequently involves trade-offs, such as reduced expenditure on healthcare and education. This in turn further undermines the capacity of individuals to improve living conditions or increase their resilience to stress and shock, thus increasing their vulnerability. Enabling communities to break this cycle of poverty is the key to addressing food security over the long term.

The impact of Climate Change on the Orange-Senqu basin requires adaptation measures to enable people to cope with growing crops suited to new climate conditions, lower availability of water and other environmental stresses.

Adapted from the Orange-Senqu River Awareness Kit

4.3.3. Finding out more

Enviro Fact: Soil Conservation

Erosion will remove the topsoil first. Once this nutrient-rich layer of soil is gone, few plants will grow in the soil again. Without soil and plants, the land becomes desert-like and unable to support life - this process is called desertification. It is very difficult, very expensive, and often impossible to restore desertified land.

Economics and soil erosion

To understand soil erosion we must be aware of the economic factors affecting land users.

What is soil erosion?

Soil erosion is a natural process. It becomes a problem when human activity causes it to occur much faster than under natural conditions, and it impacts on the lives of people and their environment.

Wind and water are the main agents of soil erosion. The amount of soil they can carry away is influenced by a number of related factors: rainfall intensity, speed of flowing water and blowing wind, slope steepness, how susceptible the soil is to erosion and soil cover.

Why are plants important?

Plants provide protective cover on the land and prevent soil erosion for the following reasons:

Plants break the impact of raindrops before they hit the soil, improving rainfall infiltration into the soil, reducing the amount and rate of runoff and therefore the soil's ability to erode.

Plants slow down water as it flows over the land (runoff) and this allows much of the rain to soak into the ground.

Plant roots hold the soil in position and prevent it from being washed or blown away.

Plants in wetlands and on the banks of rivers are of particular importance as they slow down the flow of the water and their roots bind the soil, thus reducing erosion. The loss of protective vegetation through deforestation, over-grazing, under-grazing, ploughing, and fire, makes soil vulnerable to being swept away by wind and water. In addition, over-cultivation and compaction cause the soil to lose its structure and cohesion and it becomes more easily eroded.

On commercial farmlands, overstocking, over-resting (plants become moribund [dieback] and unproductive), careless burning, mono-cropping, and the ploughing of marginal lands unsuitable for cultivation, have led to soil erosion and desertification.

Frequently these practices have been unwittingly encouraged by the state offering subsidies which made it profitable to exploit the land in the short-term. Economic pressure (caused, for example, by falling commodity prices and rising input costs) can also drive some farmers to over-exploit their land.

Preventing soil erosion

Preventing soil erosion requires political, economic and technical changes. Political and economic changes need to address the distribution of land in southern Africa as well as incentives to encourage farmers to manage their land in a sustainable manner.

Technical changes include:

- the practice of conservation tillage on cultivated land;
- the use of contour tillage, the construction of contour banks for runoff control, and the use of wind breaks;
- avoiding excessive cultivation that will exhaust soil organic matter;
- ensuring that there are always plants growing on the soil, and that the soil is rich in humus (decaying plant and animal remains) - this is the glue that binds soil particles together and is significant in preventing erosion;
- the use of cover crops and crop rotations;
- withdrawal of low potential land from annual cultivation by establishing a suitable perennial (plants which grow and live for more than a single year) crop;
- allowing indigenous plants to grow along the river banks instead of ploughing and planting crops right up to the water's edge;
- encouraging biological diversity by planting several different types of plants together; and,
- conservation of wetlands.

Did you know?

Soil erosion costs lots of money annually including costs for purification of water whose poor quality is caused by the siltation of dams. Soil loss is partly responsible for farmers abandoning the land in many areas.

The loss of nutrients from soils is very high. The commercial farming sector spends lots of money each year on fertilisers. The subsistence farming sector in many instances cannot afford this cost and operates with inadequate fertilisation. In both cases, improved land management practices would result in reduced loss of fertility and more effective use of natural soil fertility.

Land degradation in southern Africa causes loss in grazing and arable potential – millions of hectares of rangeland are moderately to severely degraded by bush encroachment, while loss of topsoil through erosion and mining makes commercial farming financially unviable in many areas.

What are the three major soil types?

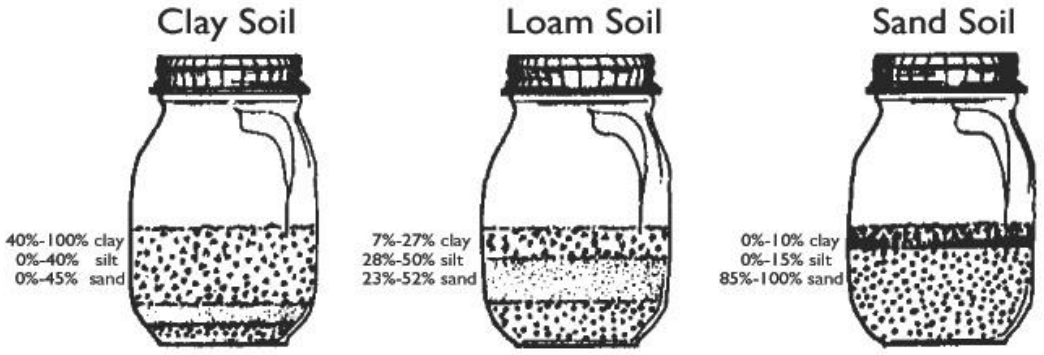
Fill a jar two thirds full with water and add soil until the jar is almost full. Put the lid on and shake it well, until all the clumps of soil have gone into solution with the water. Start taking measurements as the soil particles start settling out. The first to settle are the larger particles. After one to two minutes mark the sand level on the jar. Leave the jar undisturbed for several hours. The finer silt particles will settle out on top of the sand. Often, the layers are slightly different colours, which shows various types of particles. Mark the silt layer after a few hours. Leave the jar overnight and measure the settled clay particles. It may take a few days for some soils to settle. This drawing shows the proportions of sand, silt and clay for the three major soil types.

What are the soils in the Orange-Senqu Basin?

There are two main dominant soil types that can be found in the areas of the Orange Senqu river basin:

Mountain Black Clay - These types of clays are usually shallow at high altitude and are easily eroded by surface runoff, cultivation and overgrazing.

The remaining larger portion of the Orange-Senqu River basin is covered by sands or weakly developed soils (UNDP-GEF 2008)



4.4.3. Finding out more

Enviro Fact: Mineral Reserves and Energy

Places where mineral resources exist and where the mining of these has been worked out to be economically viable are called **mineral reserves**.

The **extraction** and **processing** of minerals play an important role in the economy of southern Africa. The presence and extraction of **precious** and **non-precious** metals and **gemstones** have driven development in the SADC region for centuries, with positive and negative outcomes in social, cultural and environmental terms.

The region, including the four basin states of the Orange-Senqu basin, has a rich variety of mineral resources most of which are economically mineable and are being extracted. Several others have been identified as probable mineral reserves. Shale gas and Coal bed methane are two non-renewable resources for which exploration rights over large areas of Botswana, Namibia and South Africa are currently being awarded.

Mining in the Orange-Senqu River basin is well developed and contributes significantly to the economies of Botswana, Namibia and South Africa. The predominant minerals found in the basin include gold, diamonds, uranium, base metals (copper, manganese and iron), semi-precious stones and industrial minerals.

Gold, diamonds, uranium and coal mining are of particular economic importance, but the extraction and processing of these minerals have serious negative water quality impacts. Recently, there have been many concerns about water from abandoned and closed mines polluting water supplies for human and agricultural uses. This is called acid mine drainage. This acidic water has poisoned much of the wetlands and streams in the Gauteng area of the upper Vaal Sub-basin and is threatening the Orange-Senqu system. No-one is taking responsibility for this serious problem because the mining companies that used to operate these abandoned mines are no longer in business. If used for irrigation this water kills crops and builds up in the soil, making it unable to sustain life.

Although mines use relatively small amounts of water compared to agriculture, water supplies must be reliable due to the large costs associated with disruption to extraction and processing. This increases water consumption by this sector.

Botswana was named the world's largest diamond producer in 2010, with diamond mining accounting for 70% of export earnings in the country. Mining contributes at least 35 % of the **GDP (Gross Domestic Product)** in Botswana with copper, soda-ash and nickel amongst other important commodities mined. Despite this, the physical characteristics (**geology**) of the country still present a challenge in exploring all available mineral reserves. Several mineral resources including asbestos, chromite and manganese located in remote areas remain unexploited. The latest data on mineral reserves dating as far back as 1999 indicates that some coal reserves have successfully been mined over the last decade.

In **Lesotho**, mining is not a dominant contributor to the economy, and makes up less than 1% of the GDP.

Namibia is one of the world's largest diamond producers and uranium exporters. Although uranium is not produced within the Orange-Senqu River basin, a majority of diamond mines are located in the basin. The mining sector only employs 3% of the population, but it accounts for over 9% of the GDP, and generates more than 50% of foreign exchange earnings in Namibia.

In **South Africa**, mining accounts for 7% of the GDP and South Africa is a major player in the gold mining industry. It is also a leading producer and exporter of various metals including antimony, chromites, fluorite, gems and industrial diamonds, manganese, platinum, vanadium and vermiculite.

The mining and industrial sectors use less water in the Orange-Senqu River basin than the agricultural and urban sectors. Several of the largest mines in South Africa are located in the Orange-Senqu River basin. In Lesotho industry represents 49% of the total water use.

Off shore oil and gas fields have been found off the coast of Namibia and exploration for shale gas mining is currently underway in Botswana and applications have been made over parts of South Africa. The process of extracting shale gas or coal bed methane is known as '**fracking**'. This process requires very large quantities of water, which together with sand and a large number of toxic chemicals is pumped at high pressure into wells drilled about 5km into the earth. This breaks up the rock and releases the shale gas. This fracking waste water has to be stored and treated in evaporation ponds. It is highly toxic and radioactive. Scientists are investigating what the impacts are likely to be although in other countries these have included pollution of underground aquifers and areas around the mine, as well as streams and rivers through polluted runoff and chemical spills. This process of gas extraction, 'fracking' is banned in many countries.

Environmental activists are calling to ban 'fracking' in southern Africa. Clean renewable energy is needed to replace our dependence on fossil fuels.

4.5.3. Finding out more

Enviro Fact: Dams & Transfer Schemes

A dam is a **reservoir** of water that collects behind a man-made wall or **weir** and that acts as a barrier across a river or stream. Dams are built for several reasons including:

- To collect and store water to supply for domestic, industrial, mining and agricultural uses.
- The controlled release of water from a dam is also used to generate electricity (**hydro-electricity**).
- To divert water into a transfer scheme, which could be a canal, pipe or other channel that takes the water to another catchment where it is released into a reservoir, dam or river.
- Dams can also be used as flood control.

Historically, from way back in time, dams were built as reservoirs that ensure a supply of water to communities and for irrigation for growing food. As these communities grew and industries developed, dams were built to operate **water-wheels**. The development of electrical power increased the use of dams for generating hydro-electricity and being able to transmit this power over long distances meant that building dams in remote places became economically viable. Flood damage to human activities downstream resulted in demands for dams to be built for flood control. To this day a lot of investment is put into creating dams that can expand the economic growth of regions.

What dams are there in the Orange-Senqu basin?

Table : The major dams of the Orange-Senqu River basin.

Dam Name	**WMA/Country**	**Full Storage Capacity (Mm^3)**	Surface Area (km^2)
Gariep	Upper Orange	5 500	370
Vanderkloof	Upper Orange	3 200	
Combined: Vaal, Grootdraai, Sterkfontein, Saulspoort and Vaal Barrage	Upper Vaal	5 655	
Vaal	Upper Vaal	2 536	320
Grootdraai	Upper Vaal	364	
Bloemhof	Middle Vaal	1 269	223
Katse	Lesotho	1 520	36
Naute	Namibia	84	
Hardap	Namibia	294	

Source: ORASECOM 2007d

Botswana

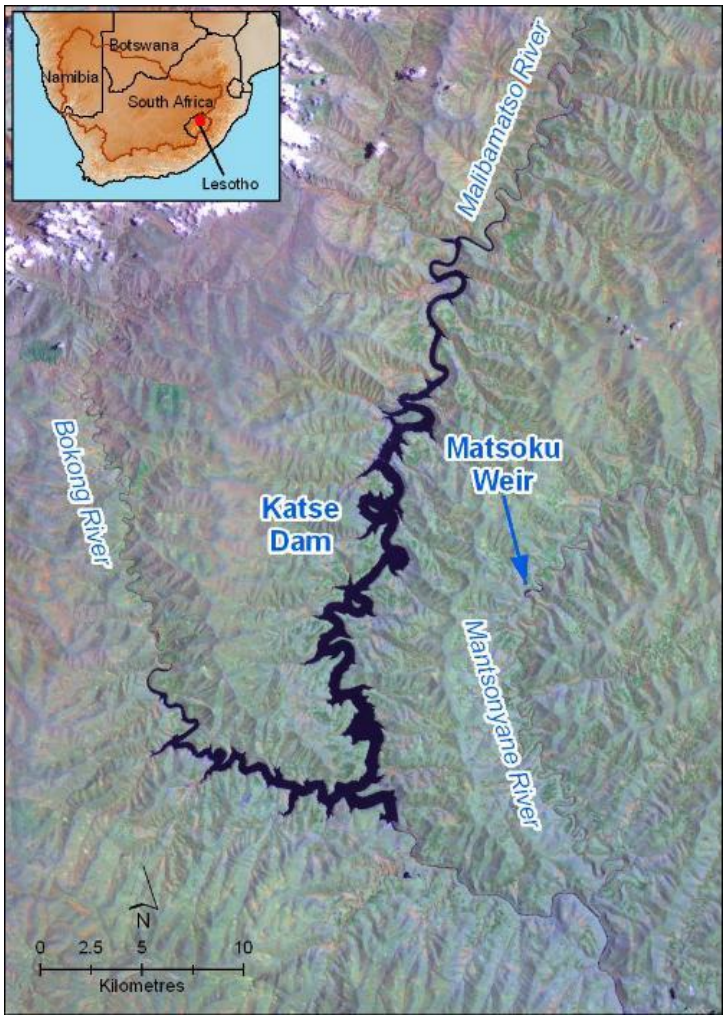
There is no major infrastructure such as dams or weirs on either the Molopo or Nossob rivers or along the border of Botswana (ORASECOM 2007d) The villages rely on a reservoir which is usually supplied from a well or borehole. This water is usually gravity fed to homes through public standpipes of to yard/home connections.

Lesotho

The two major dams in Lesotho are the Mohale and Katse Dams. These two dams, together with the Matsoku Weir and the **transfer tunnels** between the two dams and one to South Africa, form Phase 1 of the Lesotho Highlands Water Project.

What dams make up the Lesotho Highlands Water Project?

The Katse Dam is the highest dam in Africa at 1995m above sea level and the second biggest on the continent. It forms the main collecting storage reservoir in Lesotho from which all transfers to South Africa are made through about 80km of concrete lined tunnels. The dam is very narrow, winding and deep and has a storage capacity of 1520 **Mm3**.



Katse Dam, Lesotho is the keystone in the Lesotho Highlands Water Project.
Source:Hatfield 2009 (OrangeSenquRAK)

Mohale Dam

The Mohale Dam is located on the Senquyana River and is about 145m high with a capacity of 947Mm3. This dam forms the main storage reservoir for Phase 1B of the Lesotho Highlands Water Project.

Muela Dam

The Muela Dam and Hydropower Plant was completed as part of Phase 1A of the Lesotho Highlands Water Scheme. Here the water being sent to South Africa, powers an underground hydroelectric power station that generates electricity to supply the needs of Lesotho**.**

Other smaller dams in Lesotho include the Lionel Collet (Thaba Phatsoa) near Hlotse, the Sebaboleng Dam near Maseru, the Maqalika Dam just downstream from Seboboleng, which supplies the city of Maseru, and the Rasebala Dam which is situated near and supplies the town of Mafeteng.

Namibia

There are six major dams in Namibia, with the Hardap and the Naute dams being two of the largest. These dams are used for urban and irrigation supply.

Naute Dam

The Naute Dam is located on a tributary of the Fish Fiver and supplies water for the urban consumption of Keetmanshoop. There is a 44km long purified water pipeline from the dam to Keetmanshoop. There is also a gravity fed irrigation scheme downstream of the dam.

Hardap Dam

This dam is located on the Fish River and it supplies gravity fed water to Mariental.

South Africa

The two main dams that form part of the Orange River Project are the Gariep and the Vanderkloof Dams. These are found in the **Upper Orange Water Management Area (WMA)** and were built to promote and stabilize irrigation along the Orange River and eastern Cape, to generate hydro-power, supply water to towns and industry, to limit flood damage and to create recreation facilities that promote tourism in the interior of the country.

Gariep Dam

The Gariep Dam is the largest resevoir in South Africa. It supplies water to parts of the Vaal, Fish and Sunday's River catchments, downstream releases into Vanderkloof Dam and to irrigation schemes along the Orange River. The water transferred to the Fish and Sunday's River basin travels via the Orange/Fish Tunnel which is 82km long and one of the longest continuous water transfer tunnels in the world.

Vanderkloof Dam

Vanderkloof Dam is 130km downstream of Gariep Dam, on the Orange River. It is the second largest reservoir in South Africa. Water from the Vanderkloof Dam is either transferred through the Orange/Riet Canal to the Riet River basin or released downstream through two hydro-power generators.

In the Upper Vaal Water Management Area there are two major dams, the Vaal Dam and Grootdraai Dam. There are also several small to medium dams in the catchment that supply water to local towns and for irrigation.

The Vaal Dam

The Vaal Dam is located on the Vaal River about 56km south of Johannesburg. The Vaal Dam is the central storage reservoir for the Vaal River water supply system, which serves Guateng Province which is the industrial hub of South Africa.

Grootdraai Dam

The Grootdraai Dam is situated in the upper reaches of the Vaal River. It mainly supports the needs of **SASOL** I, II, and III plants at Secunda and various Eskom power stations.

Sterkfontein Dam

Sterkfontein Dam is located high in the Vaal dam catchment, a few kilometres from the edge of the Drakensberg **Escarpment**. The dam receives its water via the Tugela-Vaal Project which transfers up to 630 Mm3 of water per year from Kwazulu-Natal. This water is then released into the Vaal Dam via the Wilge River.

There are about eleven major dams in the Middle Vaal Water Management area which supply water mainly for irrigation with some supplies to urban, industrial and mining demands.

In the Lower Vaal Water Management Area the major dams are the Wentzel, Taung and Spitskop dams. These are all located on the Harts River, with the Vaalharts Weir on the Vaal River.

Vaalharts Irrigation System
Source: R Mckenzie www.dwa.gov.za

What are the positive impacts of dams?

- Enable the collection and storage of water for human settlements, agriculture, industry and mining.
- Gravity feed water for irrigation schemes
- Generation of hydro-electricity
- Regulate seasonal flow and flood control
- Promotes eco-tourism and recreational activities

What are the negative impacts of dams?

- Loss of biodiversity in areas flooded by the level of the dam water.
- Displacement of families and communities affected by inundation
- Social impacts at time of construction
- Loss of agricultural land
- Loss of local heritage such as buildings and grave sites
- Impacts on downstream river flow (ecological reserve) and ecology
- Uncharacteristic flooding

What about flooding in the Orange-Senqu basin?

In the Orange-Senqu basin, flooding causes direct and indirect negative impacts. This is because the areas that are prone to flooding are human settlements or irrigated farmlands.

Frequent flooding occurs in Lesotho and this causes occational loss of life and damage to agriculture. In Namibia the roads and agricultural areas downstream of the Hardap Dam, near Mariental are subject to flooding.

In South Africa in the Vaal River system, towns downstream of the Grootdraai Dam and Vaal Dam experience flooding as do the formal irrigation schemes in this area. In the Upper Orange River system the towns of Aliwal North, Hopetown and Wepener are close to the river as well as most irrigation schemes.

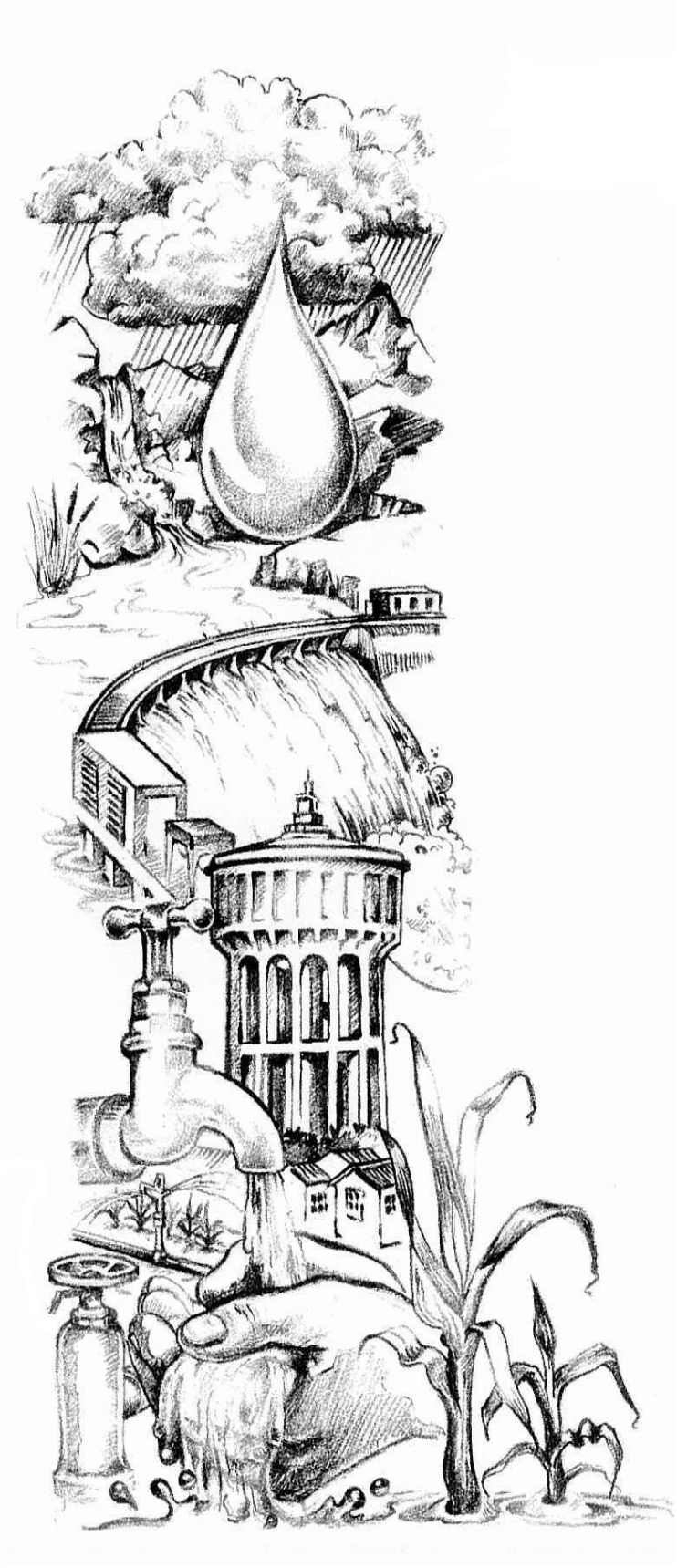
On the Lower Orange River, Upington, Prieska, Keimoes and Kakamas are all settlements that are prone to flooding.

Flooding on the Orange river near Hopetown February 2009
Source:Roux 2006 OrangeSenquRAK

5.1.3. Finding out more

Enviro Fact: Water Quality

What are the human impacts on Water Quality in the Orange-Senqu River basin?



Most experts agree that on the whole the supply of drinking water has improved over the past 20 years in the countries bordering the Orange River. Governments are seeking to supply even **remote** communities in the desert with water and most **informal settlements** today at least have a **communal water supply** or access to **potable groundwater**.

Higher consumption leads to lower quality of water. With an availability of less than
1 000 cubic metres of water per person per year, all countries of the basin (except Lesotho) are water-scarce countries according to UN standards.

As the population and economy (mining and industry around Johannesburg, commercial agriculture along the Caledon, Vaal, middle and lower Orange) grows, water is re-used more often. This means that there is less clean water in the river systems to dilute the pollution. This challenge, which mainly affects South Africa, grows bigger every the day.

For a long time, society in southern Africa has focussed on water quantity – building and improving infrastructure like dams etc. The issue of water quality has been largely ignored and relevant legislation (in South Africa starting in the early 1960s) has not been sufficiently enforced.

In the late 1990s experts from the National Committee on Climate Change and elsewhere started to warn that the situation could not continue. Population growth and current trends of socio-economic development would make it impossible for South Africa to sustain its traditional pattern of water consumption. Indeed, the experts cautioned that by 2030 South Africa's freshwater supply would no longer meet the growing needs of population and industry.

Despite this warning, agriculture, industry, mining and households keeps on using more and more water.

The supply is further strained by increasing levels of pollution, in some cases with highly **toxic substances** – especially in the densely populated region of Johannesburg, Pretoria and the Vaal Triangle.
Moreover, there are situations where problem substances found in water bodies are becoming more **concentrated** – for several reasons:

- Polluted water from large cities of the Orange River drains into the water storage dams lower down in the basin.
- Algae and bacteria, which can be very harmful grow faster in the dams because the water is standing still and is thus warmer.
- Because so much water is used in the Vaal catchment, there is not enough clean water in the system to dilute the toxins to safe levels.
- In South Africa the water treatment plants are old and not able to remove all toxins, and some of these end up in drinking water.

What are the main impacts?

The main man-made sources of water pollution in the Orange-Senqu River basin are:

- Erosion in the upper reaches of the rivers, mainly in Lesotho.
- Mining and minerals processing.
- Industrial effluent (waste water) that is not sufficiently treated.
- The wrong disposal of waste and other pollutants (unprotected landfills, illegal disposal, fuel spillage etc.)
- Domestic effluent (broken pipes and insufficient treatment in peri-urban, soak-aways in rural areas).
- Impact of agriculture (irrigation, redistribution of river waters, agricultural effluent).

How variable is water quality in the basin?

The water quality in the Orange-Senqu basin is highly variable due to a combination of factors both natural and brought about by people.

The mountain catchment of the Senqu River system is relatively undeveloped and the wetlands of the Lesotho Highlands help filter water so this area generally provides high quality water. As the river moves downstream it receives a variety of inputs from agriculture, industry and urban/rural domestic sources, in addition to the discharge of sediments from erosion and so the quality usually gets worse.

What are the main causes of poor water quality?

Water quality in the Orange-Senqu River basin is affected mainly by:

- **Salinity** – this is the balance of fresh water to salt water. Fertilizers, acid mine drainage, leaching from irrigated areas all cause changes in salinity.
- change of water temperature – the still upper level of dam water heats up and warm water promotes algal and bacteria growth.
- **microbiological** pollution – these are the algal and bacterial blooms that result from water that is nutrient rich.
- **Eutrophication** – this is when microbiological blooms have reached levels where all the oxygen in the water is depleted. This kills off all life in the water body which causes further purification of the water. i.e. it goes bad.
- **Microcystins** – These include Cyanobacteria, also known as blue-green algae. They can grow rapidly water bodies such as ponds, lakes, reservoirs, and slow-moving streams when the water is warm and nutrient rich. Many cyanobacteria species produce a group of toxins known as microcystins, some of which are toxic.

Source: www.freedrinkingwater.com

- **Endocrine** disrupting chemicals (EDCs) Endocrine disruptors are chemicals that may interfere with the body's endocrine system. They produce adverse developmental, reproductive, neurological, and immune effects in both humans and wildlife. EDC's are found in pesticides, metals, additives, even shampoos and similar products.

- **Persistent Organic Pollutants** (POPs) – These are chemical substances that persist in the environment, bio-accumulate through the food web, and pose a risk of causing adverse effects to human health and the environment.

- **Acidity** – acidity is an indication of increasing pollution and other environmental factors. Acid mine drainage, chemical effluent from industries and mining can all affect the pH of the water. (acid alkalinity balance)

- **Heavy metals** – the most common metal pollution in freshwater comes from mining. These can also come from coal-burning power plants via smokestacks in air, water and soils and in industrial effluent.

- **Radionuclides** – these include uranium, radon, tritium, strontium and radium and in minute concentrations form a natural part of all substances including water. Mining activities release radionuclides which pose a risk to human health as they are **carcinogenic** (cancer forming).

Adapted from the Orange-Senqu River Awareness Kit

5.2.3. Finding out more

Enviro Fact: Pollution

Pollution is an unwelcome concentration of substances that are beyond the environment's capacity to break down. These substances are harmful to people and other living things.

In an undisturbed ecosystem, all substances are processed through a complex network of **biogeochemical cycles**, such as the **nitrogen and carbon cycles**.

During these cycles, substances are taken up by plants and then move through the food chain to larger and more complex organisms. When the latter die, they are **decomposed** (broken down) into simpler forms to be used again as nutrients by plants.

Biodegradable substances are those that can be broken down by the environment's biological systems. Pollution occurs when the environment becomes overloaded beyond the capacity of these normal processing systems or with **non-biodegradable**, human-made substances. Examples include an excess of normally helpful substances, such as the nutrients, nitrogen and phosphorus. These substances are harmless and necessary for growth in tiny amounts, but are kill life in excessive concentrations. **Synthetic** (human-made) compounds such as **DDT (Dichloro-Diphenyl-Trichloroethane)** can be poisonous in the environment, even in **trace amounts**.

Some pollutants kill living organisms outright, other pollutants do not kill, but may cause long-term biological damage, interfere with organisms' reproductive cycles, or make them more vulnerable to disease. Sometimes these pollutants in prey species accumulate into **lethal** amounts in the predators that eat them, such as owls dying from eating mice with **sub-lethal** doses of DDT.

Types of pollution. Pollutants can be grouped according to the main ecosystem which they affect. One pollutant often affects more than one ecosystem.

POLLUTANTS AND MAIN SOURCE	HEALTH AND ENVIRONMENTAL EFFECTS
AIR	
Sulphur dioxide - burning of coal	Acid rain and respiratory problems
Nitrogen oxides - vehicle emissions Volatile hydrocarbons - vehicle emissions	Combine to form photochemical smog; causes respiratory problems
Carbon monoxide - vehicle emissions	Restricts oxygen uptake, causes drowsiness, headaches, death
Carbon dioxide - burning of coal	Displaces oxygen causing drowsiness, headaches, death
CFCs - aerosol, refrigeration, air conditioning and foam-blowing industries	Destroys ozone layer, which protects us from the sun's cancer-causing UV radiation
Methane - feedlots, rubbish dumps	Potent greenhouse gas
Noise - industry, traffic	Affects hearing, stressful
Asbestos dust - construction, mining, industry	Asbestosis, mesothelioma
FRESHWATER	
Sewage - inadequate sanitation	**Pathogens** cause typhoid, cholera, gastroenteritis; nutrients cause eutrophication (which can cause fish deaths from oxygen depletion)
Fertilizers – agriculture	Eutrophication
Silt - agriculture, construction, mining	Smothers aquatic organisms; affects light penetration reducing photosynthesis
Pesticides – agriculture and health services	Toxic, interferes with breeding of mammals and birds
Toxic metals – industry	Health and life threatening
Salinisation - industry, agriculture, landfills	Reduced crop yields, scale and corrosion in domestic and industrial water systems
MARINE	
Sewage - inadequate sanitation	Pathogens cause typhoid, cholera, gastroenteritis, nutrients cause eutrophication
Fertilizers – agriculture	Eutrophication
Oil spills	Smothers marine plants and animals
Plastics	Death of animals through suffocation or entanglement
Pesticides - agriculture, health services	Toxic, interferes with breeding of mammals and birds
LAND	
Solid waste is classified as hazardous (radioactive, pesticides, medical, poisons), or non-hazardous (domestic, urban, mining, industrial, scrap metal)	Hazardous waste is health- and life-threatening, non-hazardous is unsightly and disposal takes up much space
Radioactive materials from nuclear power stations, military, medical and engineering sources	Cancers, cell mutations, organ failure, interferes with breeding of animals, death

Dealing with pollution

In the past, most approaches to handling pollution could be summed up by the phrase 'dilution is the solution to pollution'. However, pollution levels have increased so much in amount and toxicity that this approach is no longer acceptable.

An alternative approach is **source reduction** (a reduction in the amount of pollution where it is produced).

- *Point source pollution:* Pollutants are produced from a stationary location, e.g. mines, and municipal sewage works.
- *Non-point source pollution:* This pollution cannot be traced to a specific spot. Common examples are car emissions, fertiliser runoff, packaging, and gases from aerosol cans. Some non-point sources can be addressed by laws, such as banning CFCs (chlorofluorocarbons), or requiring that car manufacturers install emission controls.

Polluter-must-pay principle

This means that a polluter should pay the costs of avoiding pollution, or remedying its effects. This principle is difficult to apply when the source of pollution cannot be identified, such as atmospheric pollution. The principle can be usefully applied following a pollution disaster, such as an oil spill from a tanker or requiring beverage producers to set up a can recycling programme.

Movement of pollution. Pollution does not stay in one place but moves around the world by air and water, as well as by living organisms. Some pollution is deliberately moved abroad. Companies restricted by pollution control regulations at home, sometimes move their industrial plants to other less restrictive countries, as was the case with the plant involved in the Bhopal chemical disaster. Or while remaining at home, they may sell products abroad, that are classed in their own countries as too dangerous for sale, such as **banned pesticides**.

How do some countries deal with land pollution?

In some cases, hazardous waste may also be shipped abroad, generally from industrialised countries to countries willing to accept such waste for a fee, despite the hazards. When such pollutants turn up again in the originating country, as when food is imported that contains banned pesticides, the process is said to be completing the 'circle of poison'. Some pollution is dumped illegally on land, in rivers or out at sea, by the polluters trying to avoid costly waste treatment.

What other impacts do air pollutants have?

Burning fossil fuels like coal add carbon dioxide and other greenhouse gases into the atmosphere. Carbon Dioxide is called a 'greenhouse' gas because it traps heat in the earth's atmosphere. This makes the earth get much warmer and this changes the way the climate works. The polar ice caps have started to melt much quicker than before and the sea level will rise. Both humans and plants and animals will be greatly affected by these changes. This process is called climate change.

5.3.3. Finding out more

Enviro Fact: Invasive Alien Species

Invasive Alien Species within the Orange-Senqu River basin can be grouped into **aquatic** and **riparian**, although some cactus species can grow in dry areas.

Aquatic species (living in water)

The most common aquatic invasive species in the Orange-Senqu River basin are:

- **Water hyacinth** from South America. It has spread from the Vaal to areas near the **confluence** with the Orange River and it is likely that there are invasions along the Lower Orange River. Water hyacinth is also present in Botswana but the impact is not yet significant.
- **Water fern** has also invaded sections of the Upper Orange-Senqu River and its tributaries.
- The introduction of two trout species (**Brown and Rainbow trout**) to the upper reaches of the Orange-Senqu River basin in South Africa and Lesotho has affected populations of indigenous minnow species in these areas.
- The **Giant reed** or Spanish reed is found in the Lower Orange River and in the Fish River downstream of the Hardap Dam in Namibia.

Riparian species (living alongside rivers)

Riparian vegetation (the zone of vegetation along the river banks) has been greatly disturbed along the Orange-Senqu River and most of its tributaries. **Indigenous** riparian woody plants such as Cape willow, buffalo thorn, wild olive and white karee have been weakened through small-scale **alluvial mining**; wood collection for fuel and building material; and agriculture. In addition, studies have confirmed that the riparian areas of all southern African rivers have suffered from **invasion** by alien plant species.

Tributaries of the Orange such as the Vaal and the Senqu Rivers start in wetter regions and here alien species are a greater problem. Typical riparian invasive plants are the **woody plant species** - Silver wattle, Black wattle, Grey poplar, Blue gum, Syringa, Jacaranda and Mesquite.

Acacias and Mesquite – Thirsty Invaders

Alien tree species that threaten groundwater can be found growing beside rivers as well as far away from them. Because of the scarcity of trees in South Africa, settlers from Europe introduced fast-growing Australian trees to provide wood for mining, construction and fire.

Today these trees are a widespread problem. Their root systems allow them to out-compete indigenous species by reaching deeper groundwater, while other species cannot survive.

In many areas (like around Tsabong in Botswana), alien acacia trees have driven their roots so deep that they grow in large numbers, lowering the water table.

Even worse than the acacias is the rapid growth of **mesquite** in southern Africa. Several species of this shrub and tree were imported from Mexico, and until the 1960s they were considered a botanical improvement. This fast growing plant quickly greens desert and semi-desert landscapes. As a legume, it makes good fodder; its flowers provide excellent nectar for honey bees, and its wood is suitable for fences, furniture and charcoal.

While ideal for these purposes, mesquite has spread across southern Africa. Animals eat the pods, but excrete its indigestible seeds. The seed immediately begins growing and, in time, its roots extend horizontally for up to 30 metres. The extremely thirsty mesquite has been known to spread rapidly in areas fed by fresh and **saline aquifers**. As the plant spreads, it quickly displaces indigenous species.

Mesquite is so invasive that it is estimated to now occupy two million hectares in South Africa!

In many parts of the Orange River basin, it has created dense groups of trees (thickets), protected by its thorns which cause inflammation.

Along the Auob and Nossob Rivers, mesquite threatens to displace the endemic camel thorn tree species. Along the Fish River in Namibia, below the Hardap Dam, it is dense, difficult to clear, and impacts communities as it interferes with flood management. Along the lower Orange River, it rapidly over-grows landing sites for canoeists.

To make matters even worse, mesquite is extremely difficult to control. New shoots grow quickly from the stumps of the freshly cut plants following clearing efforts. It is largely resistant to herbicides, and no effective biological control methods have yet been discovered. This makes the campaign against its aggressive growth complicated and expensive.

There are probably a number of other exotic species that are currently not invasive but will become so in the future.

5.4.3. Finding out more

Land use change – Human Impacts on Biodiversity

The earliest impact on the resources of the Orange-Senqu basin was the decline of most of the large mammals, first through hunting and later because of farming and fencing. Cattle, goats and sheep have damaged large areas of grazing land and wetlands. This has caused erosion and changes in the kind and number of plants that are able to grow in these areas. Growing crops along river courses has introduced nutrients (an excess of food) and pesticides into wetlands. Run off from fertilizers has also increased salinity and changed the composition of riparian species. Alien invasive plants and animals have also changed the **composition** of the **natural eco-systems**.

Creatures in the water **(aquatic macro-invertebrates**) are good indicators of the health of an ecosystem and the composition of these creatures change as the ecosystem changes. In the Orang-Senqu River there are large numbers of **filter-feeders**, in particular the Blackfly *Simulium chutteri* . Downstream of Vanderkloof dam there is a drop in the presence of a **predaceous caddisfly**. Outbreaks of blackfly happen when there is a stable flow condition of water, particularly high winter flow, and when the water quality gets worse, and the vegetation encroaches into the stream.

A number of these aquatic invertebrates have also declined and possibly disappeared from the Orange River system altogether. These includes **mayflies**, snails, a large Elmid beetle, and a **leech** species which was known to be **parasitic** on hippopotami. Hippopotami are now extinct in the basin. By contrast, an invasive snail *Physa acuta* has spread dramatically.

Fish communities in the Upper and Lower Orange River are very different to what they were many years ago. Their ability to survive is getting worse because the river does not flow naturally, as it did before the dams were constructed. The poor water quality is also a cause of declining fish species. What happens in the stream and along the banks contributes to the loss of species.

The impacts of human activities on biodiversity can be broadly characterised as:

- Water quality
- Water quantity
- Alien Invasive Species
- Land use change

The main **human activities driving these impacts** are:

- Agriculture
- Mining
- Industry
- Infrastructure development
- Urbanisation

Human Activities

Driving Biodiversity Loss

Agriculture has a series of known impacts on biodiversity:

- Water quality from agricultural effluents (livestock and arable agriculture) can modify the nutrient cycle of aquatic and terrestrial ecosystems.
- Change of land cover, means that the percolation and runoff patterns change.
- Introduction of alien species into ecosystems that can out-compete indigenous species.
- **Pesticides and insecticides** can damage next door plant communities and the **chemical composition** of these substances can be **toxic** to life.

Mining has a series of known impacts on biodiversity:

- Water quality can be negatively affected by **heavy metals and acid mine drainage**, causing significant damage to ecosystems; poisoning fish and mammals as these metals built up in their systems.
- Water quantity can be reduced caused by altered movement of groundwater or reduced stream flow for operational mining and use in processing facilities.
- The groundwater table can be significantly lowered, surface water sources and surrounding soils irreversibly contaminated with associated biodiversity loss by the extraction of groundwater for the production of coal bed methane.
- Land change from mining activities causes very big disturbance to the landscape. Excavations for extraction, waste rock and **tailings ponds** all modify the shape and hydrology of the landscape.
- The contamination of water sources and soils with toxic chemicals and radioactivity and land disturbance by transportation networks required for hydraulic fracturing (fracking) and other unconventional gas extraction methods.

Industry has a series of known impacts on biodiversity:

- Water quality can be negatively affected by **industrial effluents**, causing damage to ecosystems; poisoning fish and mammals (accumulate in tissue)
- Some industrial activities use large volumes of water, which reduce stream flow.
- Land change from industrial activities causes disturbance to the landscape.

Infrastructure developments have a series of known impacts on biodiversity:

- Reduced or modified stream flow from storage dams limits or changes the availability of water for ecosystems.
- Water quality can be negatively impacted, particularly in terms of temperature
- Furthermore, water quality can be negatively impacted by **transportation networks** - spills and surface accumulation of fuels and automotive pollution (Ashton *et al.* 2001).

Urbanisation has a series of known impacts on biodiversity:

- Land cover change for **urban developments**, means that parts of the landscape are removed and replaced with infrastructure or housing.
- Changes to the water cycle can mean more or less water available for biodiversity due to the introduction of **hardened surfaces** preventing percolation.
- Water quality declines from sewage contamination and polluted run-off. Both are factors that can impact biodiversity.

The Socio-economic Consequences of Increased Invasion of Alien Species.

- A reduced **aesthetic "sense of place"**, affecting the tourism potential of the basin.
- A decrease in available water as a result of high water use by alien plants.
- Increased flood peaks as a result of degraded wetland and riparian systems.
- Increased cost of water as water quality and availability is harmed.
- Costs associated with eradication of invasive species.
- A decrease in production potential of land.

Source: UNDP-GEF 2008

Mapping the Human Footprint Index

The **Human Footprint Index**, is a study undertaken by SEDAC at Columbia University in the United States (Last of the Wild Data Version 2, 2005b), and the results are shown at the beginning of this unit. From this you can see the direct impact of human activities on the natural environment. It shows wide scale transformation in parts of the Orange-Senqu River basin through urbanisation and agriculture.

Climate change and land-use impacts

Climate change is said to be the result of increased emissions of greenhouse gases (GHGs) and will bring major changes to the global climate. Greenhouse gases cause higher global warming and changes to the composition of the gases in the atmosphere.

Climate records over the past fifty years show changes in rainfall, temperature and hydrological responses (evaporation, weather patterns etc) can already be detected in certain regions within southern Africa.

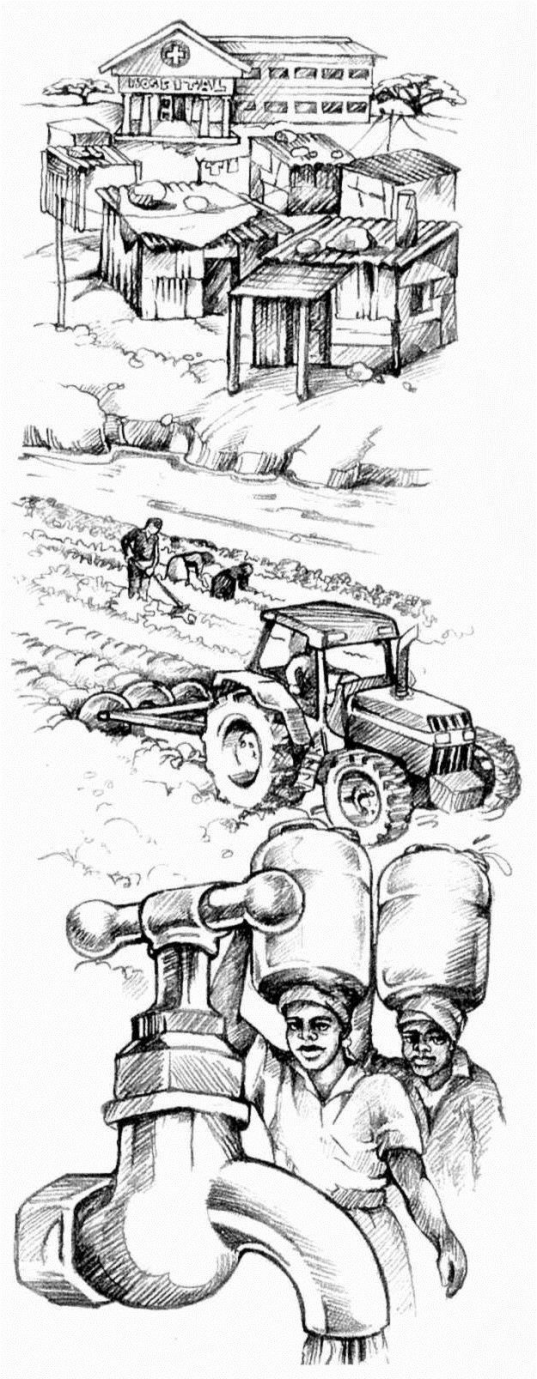
Climate Change Impacts

Not all areas show equal change, and in some areas have not experienced any change yet. The following predictions have been made with regard to water resources:

- In South Africa the potential for evaporation is going to increase by 10 – 20% and lead to higher irrigation demands.
- Soils will dry out more often which may result in less runoff per mm rainfall.
- There will be agricultural land-use changes because certain crops will no longer be able to grow in some regions.
- It will rain less often but with heavier rainfall events resulting in more groundwater recharge. (filling up of aquifers)
- Climate change will be accompanied by changes in land-use in the four countries and these will add to the existing complex land-use impacts.
- The impacts caused by Climate affects the availability of water within the Orange-Senqu basin and policies for adaption and solutions will need to be co-ordinated between all basin States.
- Climate change will impact on human health as vectors like mosquitoes can move into new areas and spread diseases like malaria and sleeping sickness.

5.5.3. Finding out more

Sustainable Development



Sustainable Development

Historically, development and conservation have been in conflict, because conservation has been understood as the protection of resources, and development as the use, or exploitation of resources. Recognising the need for both, the United Nations appointed, in 1987, a commission on environment and development to advise on development and conservation. In the commission's report called The Bruntland Report or Our Common Future, the concept of **sustainable development** was emphasised. The report's definition of sustainable development as "… development which meets the needs of the present without compromising the ability of future generations to meet their own needs", is one of many definitions of sustainable development, and is the most commonly used. Although there are many definitions, principles and criteria for sustainable development, the concept is seldom explained or deeply understood, and is thus difficult to put into practice.

Historical perspective

During the **Industrial Revolution**, development was associated with economic growth through industries such as mining, manufacturing and large-scale farming. **Industrialisation** began in Britain and spread to mainland Europe, North America and Japan, all of which became known as the First World. Characteristics of First World countries are high economic growth, many, varied job opportunities, and high incomes. The former Soviet Union and its satellite states, governed under the economic system of **communism**, became known as the Second World. Third World countries (now known as countries from the Developing World) such as those in Africa, South America and parts of Asia, have slow, if any, economic growth, with high levels of unemployment and very low incomes, but often large reserves of natural resources. In fact, the wealth of many First World countries is founded, in part on the **over-exploitation** of resources (natural and human) from the Developing World – something which economists warn does little to encourage developing nations to "live lightly on the land" while finding ways of developing their own economies.

Environmental problems

The environmental problems of the First World are associated with economic wealth, high **resource consumption** and industrialization. These have contributed to, for example, **ozone depletion** and climate change. Environmental problems of the Developing World, however, can be associated with poverty, high population growth rates, lack of food, shelter and water, and a lack of technical capacity.

Development as a solution?

Development' (growing the economy by making goods and selling lots of them) is usually seen by the First World as solving the terrible poverty and environmental problems of the Developing World. But many people question the wisdom of this approach. Thabo Mbeki, past president of the South African Republic said that he believed that Africa should use African resources, especially human, to achieve a strong, well-developed and competitive continent. He called this the 'African Renaissance'.

Our Earth's limited resource base?

Many if not most of the Earth's natural resources have a limited supply (**finite)**, and people say that these would not be able to support all the world's people if everyone had the high consumption patterns of people in First World countries. Mahatma Gandhi, when asked if, after independence, India would attain British standards of living, commented that "… it took Britain half the resources of the planet to achieve its prosperity, how many planets will a country like India require?"

Is a different type of development attainable?

Development is usually seen as economic growth, which depends on more and more use of energy and natural resources. This type of development is environmentally unsustainable. One alternative being suggested is **qualitative development**. This has few inputs and outputs and ensures maximum reuse, recycling and repair. There is little or no growth in throughput. Organisations would thus try to deliver the same high standards of service, but use fewer material resources such as **fossil fuels**, minerals and water to do so. Development programmes in countries from the Developing World probably need both quantitative growth (to address poverty), and qualitative development (to sustain the environment).

Development as a solution?

Developing World programmes that say that economic growth is a solution to widespread poverty think that resources will have a **'trickle down' effect**. This means that the benefits of economic growth will trickle down to all members of society. However, economic growth does not always benefit the poor in a country. Many development programmes now give special attention to human needs, improved participation in programmes, and the distribution of development benefits, rather than focusing all efforts on economic development. A more people-oriented development should empower people to take greater control over all aspects of their lives: social, political, economic and ecological.

Indicators of economic performance.

If we are to move towards sustainable development, we will need tools to help tell our performance. At present the performance of an economy is measured in term of its **gross domestic product (GDP**). The GDP is the total value of all the money transactions that take place. It is not a good measure to use to find out the effect of economic policies and practices on people and the environment.

Our understanding of sustainable development will change as situations and conditions change.

Sustainable development is not a model to be forced on people but is rather a process of learning how to live on the Earth. In the end the focus of sustainable living and sustainable development is to find a balance between the social, economic and **ecological parts** of our existence.

ORASECOM - Working as a Transboundary Team

The Orange-Senqu River Commission (ORASECOM) is an international organisation established by the Governments of Botswana, Lesotho, Namibia and South Africa through the Agreement for the Establishment of the Orange-Senqu Commission on 3 November 2000 in Windhoek, Namibia (Earle *et al.* 2005).

This is the first basin-wide agreement involving all four basin states and it begins by recognising the Orange-Senqu River System as a major water resource in the Region, and commits the four Member States to realising fair and reasonable use, and the principle of sustainable development with regards the river system.

Transboundary Water Management provides a framework for managing water resources across national boundaries. A River Basin Organisation is at the core of Integrated Water Resources Management (IWRM), and it is their mandate to get people to agree to work towards harmonising local, regional and national water policies. To be effective this water governance relies on national laws and institutions at the national, provincial and local levels that require water to be managed in accordance with the principles of integrated water resource management. Regionally, the Southern African Development Community (SADC) promotes Integrated Water Resource Management, through a number of tools of the water sector.

Each basin nation has a suite of laws that govern its water resources management. While South Africa has a good legal framework regarding water resources, the legal framework for Botswana, Lesotho and Namibia has been inadequate in the past according to Integrated Water Resource management principles, and new legislation in the future will ensure that all the basin nations are able to take the necessary actions at national and international level in order to meet what is expected of them internationally.

An urgent need for a basin wide agreement on the fair sharing of water resources is needed so that everyone can agree on a ceiling for the amount of water to take out the river. At the moment only 25% of the remaining water flow in the river is reaching the mouth. The system is managed as four components, Lesotho Highlands, Vaal River, Upper and Lower Orange and the Fish River. Water resource balances and development along the river are addressed separately.

ORASECOM brings all the stakeholders in the basin together as a team. They guide the strategy and development of projects that will achieve the goals that are set.

Some of these goals that have been undertaken or are envisaged for the future include:

- An assessment of Persistent Organic Pollutants, heavy metals and radio-nuclides in the Vaal and Lower Orange catchments.
- To establish basin-wide Receiving Water Quality Objectives (RWQO) and agree to develop short- and medium-term targets to meet the objectives.

- To improve compliance monitoring and enforcement
- To improve the water quality monitoring network throughout the basin.
- To identify pollution hotspots in the Vaal catchment where a big clean-up could result in better water quality and available water supply.
- Assess the water quality of the major aquifers in the basin.
- Get to know the scale and scope of land degradation better and to find out the link between land use management and how these impact on water resources.
- At the community level, various governance models, or ways of working together that can deliver best practice for linking rangeland
- and water resource management in various geographical regions.
- The eradication efforts of common invasive species need to be integrated in order to achieve success.
- The amount of water lost through these species needs to be studied.
- Climate change projections need to be included into water balance calculations.

Further OASECOM's role is to grow national and regional awareness for the scarcity of water and the need to put water use conservation measures in place. This is as part of a wider strategy to meet demand. ORASECOM also plays a role in helping organisations and communities increase awareness and understanding of the concepts of sustainable development, Integrated Water Resource Management, and environmental economics. They want all stakeholders, from river basin organisations to small community organisations, to see that economic development in the region must go hand in hand with sound environmental responsibility.

OrangeSenquRAK/OrangeSenquRiverBasinPreliminary DagnosticAnalysis