BIOMES AND PROTECTED AREAS
IN THE ORANGE–SENQU RIVER BASIN


Drakensberg–Maloti Highlands


Highveld Grasslands


Southern Kalahari Savannah


Nama-Karoo


Succulent Karoo

The Orange–Senqu River basin can be broadly divided into five biomes that share similar physical features – climate, geology and soil – and plant and animal life.

A Drakensberg–Maloti Highlands At 2,200–3,482 mamsl, this is the coolest and wettest biome in the basin. It is characterised by alpine grasslands and low, woody heather communities. About 30% of the 3,100 species found here are endemic to these mountains.

This biome also supports a network of unique high-altitude bogs and sponges. These play a crucial role in the hydrological cycle of the Orange–Senqu through their retention and slow release of water, which stabilises stream flow, attenuates floods, reduces sediment loads and absorbs nutrients.

These fragile grasslands and wetlands are under pressure from cultivation, overgrazing and over-harvesting. Degradation and severe soil erosion are evident in some areas. Protected areas include the Lets'eng-la-Letsie Wetlands Protected Area, a Ramsar site, and the Maloti–Drakensberg Transfrontier Conservation Area.

B Highveld Grasslands (1,500–2,100 mamsl) Much of this relatively high-rainfall area of undulating grasslands in the east of the basin is under cultivation. It also covers the most densely populated part of the basin. The remaining natural grasslands are restricted to a number of relatively small protected areas, and are susceptible to invasion by willows, wattles and poplars particularly along rivers. Vleis form during the rainy season, and are important conservation areas. Three of these are internationally recognised Ramsar sites: Barberspan, Blesbokspruit and Seekoeivlei.

C Southern Kalahari Savannah (600–1,400 mamsl) This open, lightly wooded sandveld savannah is characterised by deep, wind-blown sands forming vegetated linear dunes interspersed with pans. Rains produce little runoff. Ephemeral drainage courses flow briefly after exceptional rains, but are subject to invasion by alien plants, in particular *Prosopis*.

The main form of land use in this sparsely populated area is extensive livestock farming; degradation is evident around water points and settlements. Wildlife is still relatively abundant and a large area is protected within the Kgalagadi Transfrontier Park.

D Nama–Karoo This arid biome covers a vast area on the central plateau (500–2,000 mamsl). It merges into Succulent Karoo in the west and Highveld Grasslands in the east. The dominant vegetation is grassy, dwarf shrubland, with trees along ephemeral watercourses. The grass–shrub ratio varies with soil and rainfall.

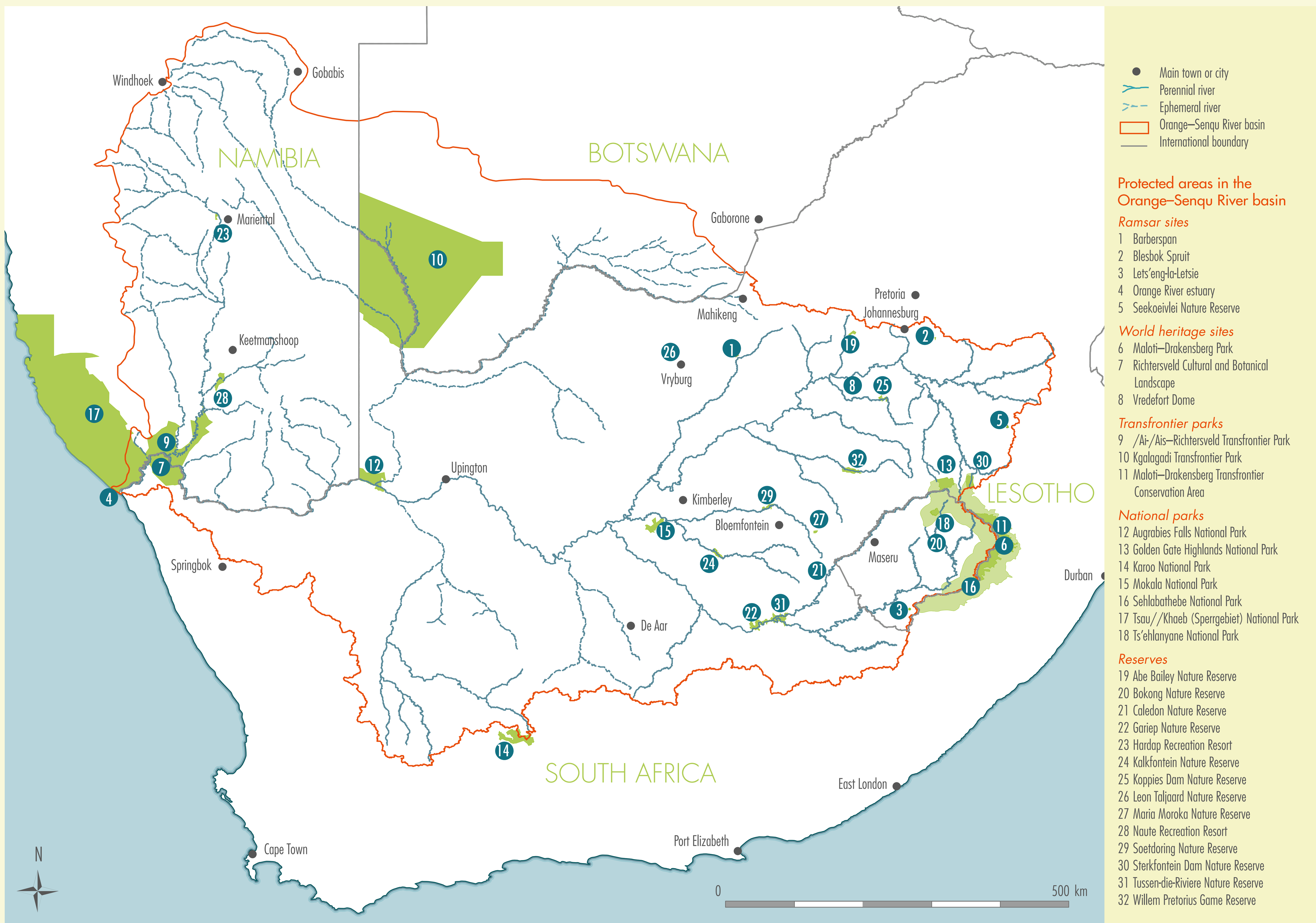
Extensive small-stock farming is the major land use. Sparse vegetation and fragile soils lead to erosion where overgrazing occurs. River courses and floodplains are susceptible to invasion by *Prosopis*. Only small areas of this biome are formally protected.

E Succulent Karoo (<800 mamsl) The vegetation of this arid biome is dominated by succulent, dwarf shrubs and is primarily determined by low winter rainfall (<100 mm of rain per year)and summer aridity moderated by coastal fog. The Succulent Karoo has the highest number of plant species for an arid area in the world and is consequently recognised as a biodiversity hotspot and centre of endemism. It is largely protected through park networks, including the /Ai-/Ais– Richtersveld Transfrontier Park and Tsau// Khaeb (Sperrgebiet) National Park, while the Orange River mouth is a declared Ramsar site in both Namibia and South Africa.

PROTECTED AREAS IN THE ORANGE–SENQU RIVER BASIN

Within the Orange–Senqu River basin, there are three transboundary conservation areas, an additional seven national parks, and a number of nature reserves. There are also five internationally recognised Ramsar sites, two biodiversity hotspots and three world heritage sites. Other areas are protected through private reserves and conservancies. However, the overall area that is formally protected is small in comparison to the size of this extensive river basin.

Many of the protected areas in the basin, especially the smaller ones, are associated with constructed water-supply reservoirs and natural aquatic ecosystems such as highland sponges, rivers and streams, pans and vleis, springs and the estuary. Preserving these aquatic ecosystems, their functions and the goods and services they provide, is essential to ensure the long-term supply of fresh water to the basin states. ▮



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IRRIGATION

IN THE ORANGE–SENQU RIVER BASIN

In the Orange–Senqu River basin, approximately 3,800 million cubic metres (Mm^3) of water was required for irrigating crops in 2010. This constituted about 70% of the total demand for water in the basin that year.

Much of the irrigation in the basin is characterised by a sophisticated network of water storage and conveyance infrastructure serving a number of irrigation schemes. Expansion of the irrigation sector began in the 1930s during the Great Depression and continued for several decades. A number of large-scale schemes now exist, which include the early schemes, such as the Vaalharts Irrigation Scheme in North West Province of South Africa, as well as those established later on using flows from the Gariep and Vanderkloof dams.

Most irrigation in the basin takes place in South Africa, although, in recent years there has been a rapid expansion of the sector in Namibia. Rain-fed field and fodder crops – maize, wheat and lucerne – are interspersed with irrigated ones in eastern areas of the basin. In the western areas of the basin, in particular, there has been a rapid evolution to higher-value irrigation-supported products, such as grapes, vegetables and dates.

Along the banks of the Orange River, roughly 100 kilometres inland from where the river empties into the Atlantic Ocean, irrigation projects at Aussenkehr in Namibia take advantage of water from the river to grow grapes. Rainfall alone could not support such farming in this area, which receives less than 50 mm of rain a year, on average. The vineyards are emerald green against the beige desert.

© NASA Earth Observatory, 2010

Much of the riparian belt along the lower Orange River is under irrigation. In recent years, especially with the formation of water-user associations, operations and management of irrigation schemes are being privatised. Although these associations are still in their infancy, a trend towards improved management and efficiency of the system is emerging.

IMPROVING WATER MANAGEMENT IN IRRIGATION

When many of the basin's irrigation schemes were built, water was plentiful. The preferred conveyance of water was open earth canals; fields were flood irrigated. For years, irrigation has been seen as the biggest waster of water. While there is still a long way to go, in recent years there has been a significant improvement in the sector's performance. ▮

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Flood irrigation is still practised widely in the basin.

PILOTING BEST PRACTICES ACROSS BORDERS

The Noordoewer–Vioolsdrift Irrigation Scheme, which straddles the border between Namibia and South Africa on the lower Orange River, was built in the 1930s. Today, the scheme is managed by the Noordoewer–Vioolsdrift Joint Irrigation Authority (JIA), which was established through a bilateral agreement between the two countries shortly after Namibia's independence. The JIA consists of eight board members – three irrigators and a government official from each country – and a small maintenance team. It operates and maintains the canal and inverted siphon distribution system using its own funds.

The farmland is privately owned. Over the years the many small farms have been consolidated into larger ones belonging to fewer farmers. Collectively, they grow vegetables, fodder crops and high-value fruit – grapes, dates, pomegranates, mango and citrus – under various irrigation methods.

The Orange–Senqu Strategic Action Programme implemented a project with the JIA to demonstrate how practices, methods, tools and devices, and knowledge and information can contribute to improved water-use efficiency and pollution control.

Working at institutional and farm levels, the project showed how measuring different variables – such as atmospheric demand, soil moisture, pump and irrigation system efficiencies, canal flow and off-take, and water quality – can assist farmers to make informed decisions for efficient farming. It also highlighted the importance of extension and support services, especially in remote areas, and the need for clear policies and incentives for farmers to invest in more-efficient systems. A water management plan drafted with the JIA and farmers will be used by them for implementing strategies to improve the scheme's water efficiency in the future. ▮

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Measuring variables, such as soil moisture, and moving to higher-value crops, such as grapes and vegetables, are two of a number of trends towards improved water efficiency in the sector.

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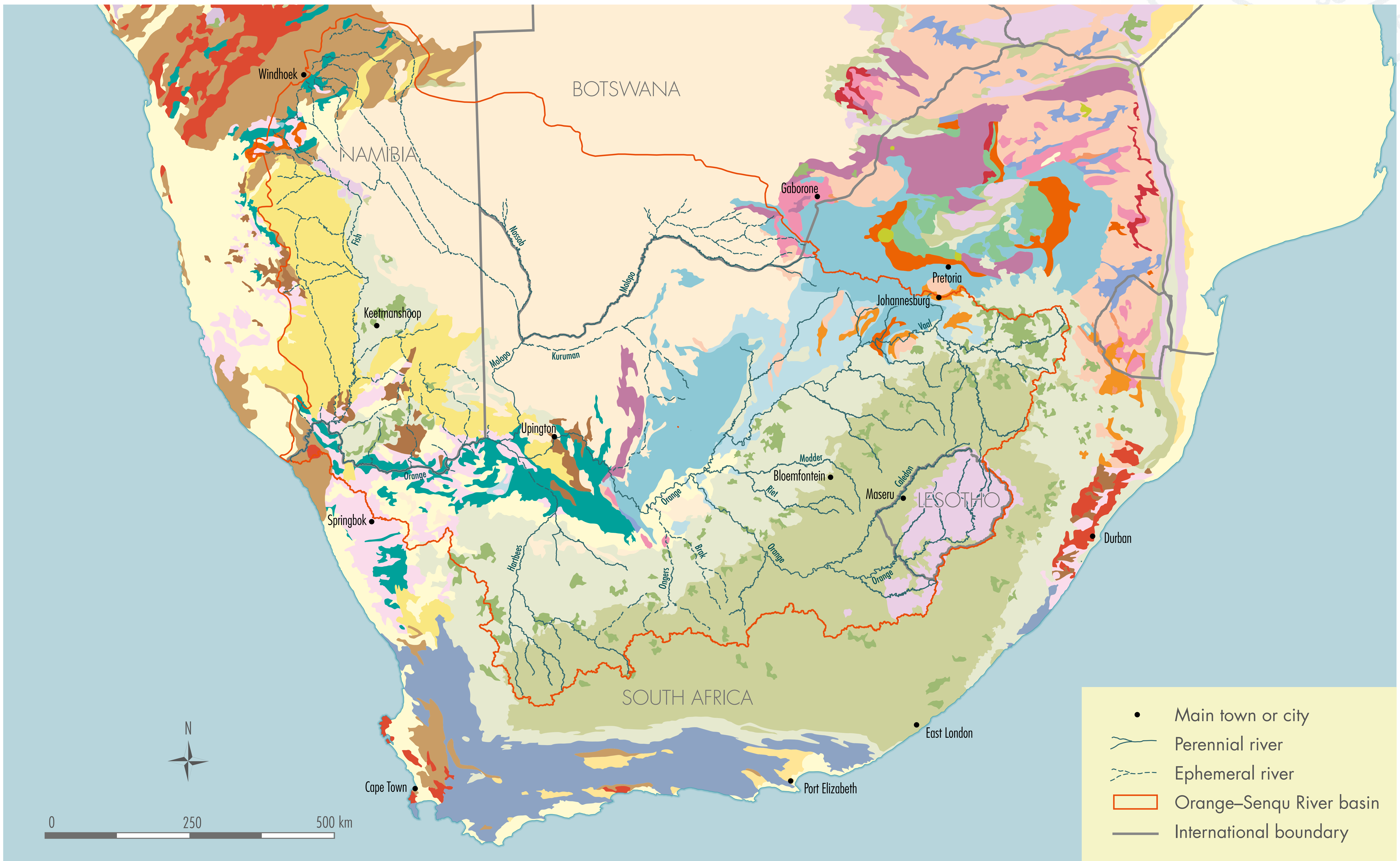
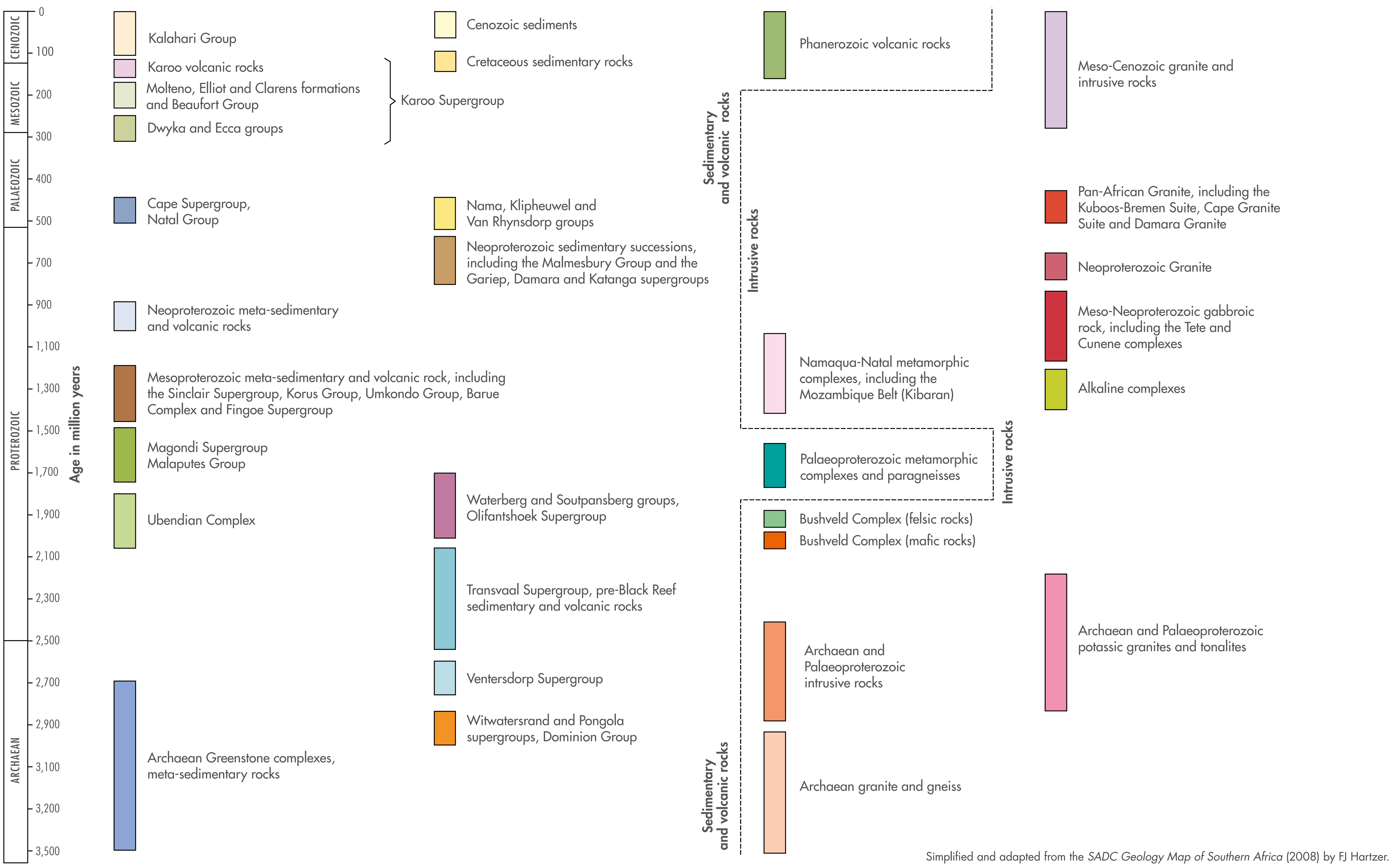
A GEOLOGICAL MAP
OF THE ORANGE–SENQU RIVER BASIN





Simplified and adapted from the *SADC Geology Map of Southern Africa* (2008) by FJ Hartzer.

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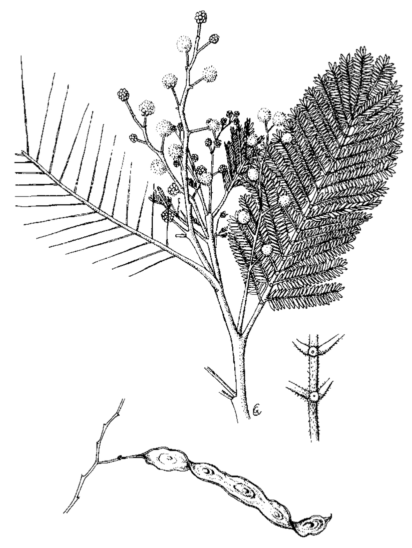
INVASIVE ALIEN PLANTS

IN THE ORANGE–SENQU RIVER BASIN

Photo © UNOPS/Leonie Marinovich. Drawing by G Condy, first published in Zimmermann, 1991, © SANBI.

Prosopis glandulosa var. *torreyana,* the honey mesquite. Originally from North and Central America, *Prosopis* is cultivated for fodder and shade. It invades riverbeds, banks and drainage lines in the arid and semi-arid western areas of the basin.



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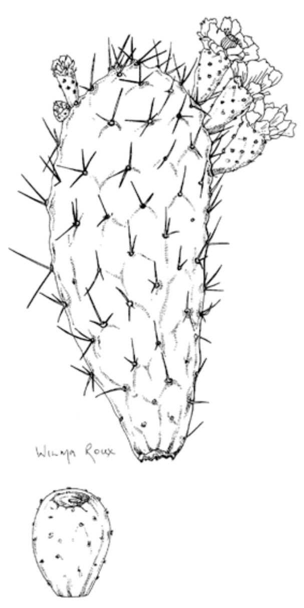
Acacia dealbata, the silver wattle. Like its relative, black wattle (*Acacia mearnsii*), these Australasian trees are cultivated for shelter and shade and for providing fuel and construction wood. The plants invade grasslands, roadsides and watercourses in the eastern areas of the basin.

Photo © Teboho Maliehe. Drawing by S Burrows ©, first published in Henderson, 1995.

Salix babylonica, the weeping willow. Introduced from Asia as an ornamental plant and source of shade, this tree invades eastern areas of the basin.

Photo © Javier Martin/Wikimedia Commons. Drawing by ME Connell, first published in Phillips, 1938, © SANBI.

Datura stramonium, the common thorn apple. Originally from tropical America, this weed invades wastelands, cultivated lands, roadsides, river banks and riverbeds. It is found throughout the basin.



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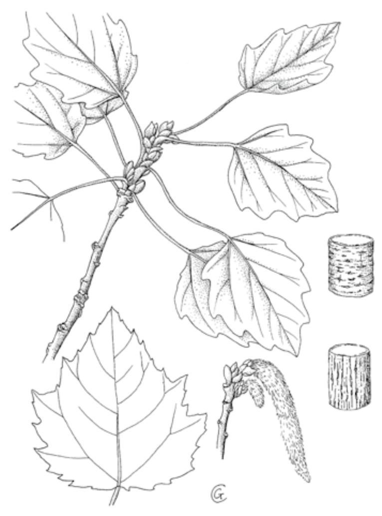
Opuntia ficus-indica, the sweet prickly pear. This Mexican plant is cultivated for fodder, its edible fruit and as hedging. Like many of the cacti, it invades many habitats, but especially dry and rocky savannah and Karoo habitats.



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Populus x *canescens*, the grey poplar. Originating from Europe and Asia, the grey poplar is cultivated as a source of timber, shelter and as an ornamental plant. It invades vleis, river banks and dongas in the eastern areas of the basin.

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Nicotiana glauca, wild tobacco. Introduced from South America as an ornamental plant, this small tree invades roadsides, wastelands, river banks and riverbeds throughout the basin.

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Eucalyptus camaldulensis, red river gum. This is the most widespread of the Australian gum trees in the basin. Originally introduced for shelter, timber, firewood and as an ornament, it invades watercourses mostly in the eastern areas of the basin.

Plant species introduced from other geographical areas that establish themselves and propagate are known as invasive alien plants. They usually have adverse ecological and economic effects on the habitats they invade and on the indigenous vegetation found there.

TAKING HOLD

The invasion of alien plants is closely associated with habitats that have been altered or degraded. This might, for example, have been caused through excessive wood-fuel collection, overgrazing, excavation for small-scale mining, or clearing for agricultural fields. Other factors include reduced water quality and reduced volumes and timing of river flows. Such disturbances to the natural habitat creates a niche for alien species to take hold and proliferate.

Alien plants, in turn, transform the ecosystems they invade by:

- using excessive amounts of resources, especially water
- altering the chemical composition of the soil
- promoting or suppressing fire
- stabilising sand movement and/or promoting erosion.

These changes make it difficult for indigenous species to compete with the alien invasives. Biodiversity is lost, habitats and plant communities become less resilient to natural disturbances and stresses, such as floods and droughts, and the land becomes less productive. ▮

THE CULPRITS

There are invasions of alien plants throughout the Orange–Senqu River basin in a variety of habitats, but particularly along watercourses. The number and types of alien invasive species and their extent and distribution varies across the basin.

The number of invasive alien plant species is highest in the higher-rainfall areas of the Vaal and upper Orange–Senqu areas of the basin. Fewer species have been recorded from the more arid, western areas.

In the higher rainfall areas of the upper catchment, the most common woody invasive species are the weeping willow (*Salix babylonica*), silver wattle (*Acacia dealbata*), black wattle (*Acacia mearnsii*), syringa (*Melia azedarach*), poplar (*Populus* species), pine (*Pinus* species) and gum (*Eucalyptus* species) trees, as well as wild briar (*Rosa rubiginosa*).

Towards the more arid areas of the basin, the primary invasive plants are *Prosopis* (mesquite) and *Eucalyptus* species and a variety of shrubs and herbs, such as *Datura* species (thorn-apples), *Nicotiana glauca* (wild tobacco) and *Ricinus communis* (castor-oil bush), as well as *Opuntia* species (cacti). ▮

REDUCING OUR WATER RESOURCES

Invasion of areas by alien plants alters the water balance. These plants increase transpiration, change soil mositure regimes, and reduce runoff and groundwater recharge. ▮

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DECLINING WATER QUALITY
IN THE ORANGE–SENQU RIVER BASIN

The key water quality issues in the Orange–Senqu River and its tributaries have been identified as:

- **nutrient enrichment**, primarily linked to increased phosphorus and nitrogen concentrations
- **increased salinity** from acid mine drainage and irrigation return flows
- **microbial contamination** from urban settlements and poorly operated wastewater treatment works
- **elevated sediment** loads in run-off from degraded lands.

At a time when the types and sources of pollution are increasing, reduced volumes of water in the system due to increased abstraction prevent their effective dilution, compounding the water quality problem. Although a common problem throughout the Orange–Senqu River basin, pollution and declining water quality are most severe in the Vaal sub-basin.

Both underground as well as surface water resources are subject to declining quality.

THE URBAN POLLUTION CHALLENGE

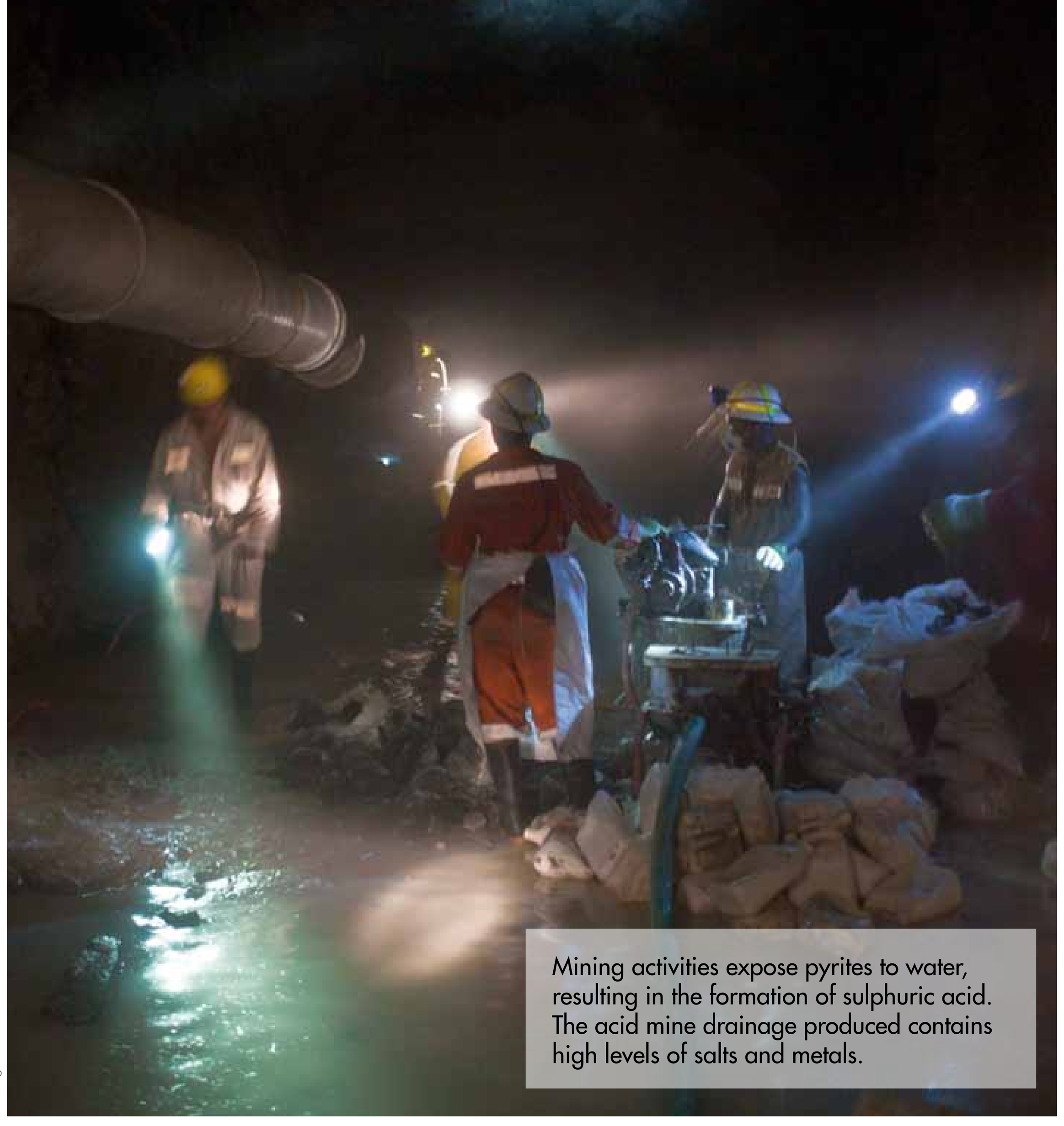
One of the immediate causes of excess nutrients and microbial contamination is human waste in runoff. The underlying causes of this are the lack of sewerage infrastructure in informal settlements and sewage plants that are poorly operated and maintained.

The costs of providing and maintaining services to treat water should be recovered through services payments. Often, the poor struggle to pay for these, while many commercial enterprises, as well as government agencies, are behind on payments. In larger centres, cross-subsidisation can help provide the resources to effectively provide wastewater services. This is not possible in smaller towns, yet the cumulative impacts of these small towns on the water resources can become significant – as is the case in the middle Vaal River. Consequently, there is a growing challenge to maintain waste and other services with insufficient financial and human resources and limited opportunities for cost recovery.

To encourage local authorities to improve their services in supplying safe drinking water and adequate sanitation services, South Africa's Department of Water Affairs has introduced a certification programme – the Blue Drop for water quality and the Green Drop for sanitation services. Gaining certification indicates that the responsible service provider has achieved the highest possible standards in minimising risk to public health and the environment.

Most wastewater treatment works discharge treated sewage directly into the river. If the works are not operating to standard, these water resources become contaminated.

ACID MINE DRAINAGE



Mining activities expose pyrites to water, resulting in the formation of sulphuric acid. The acid mine drainage produced contains high levels of salts and metals.

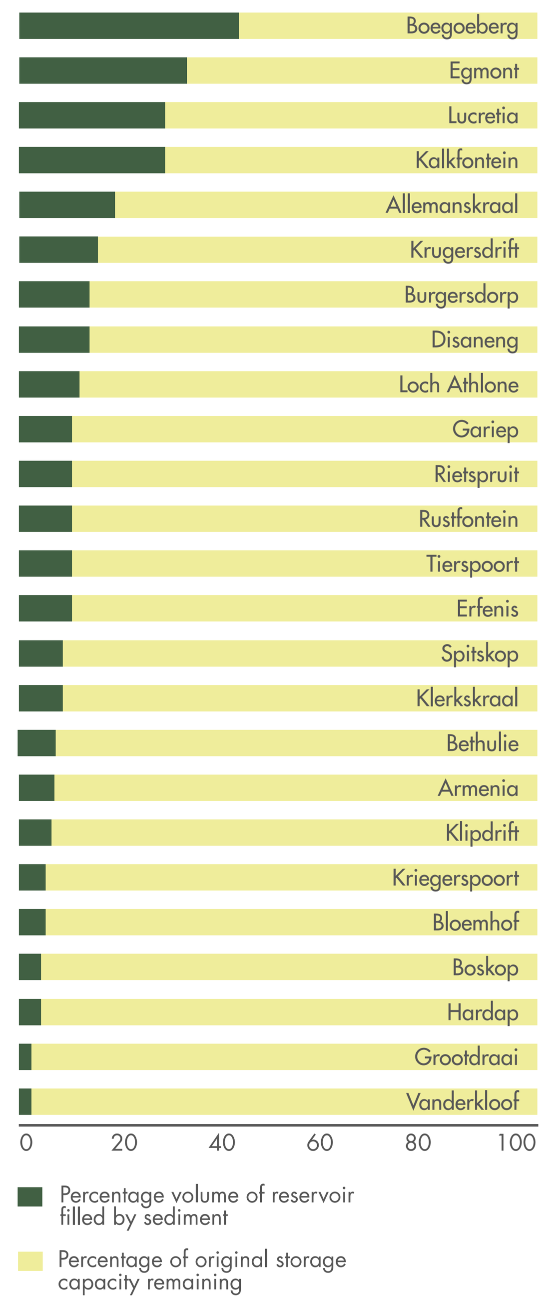
Mining activities increase salt concentrations in water through acid mine drainage. Acid mine drainage into the Vaal system from abandoned and decommissioned mines with inadequate closure is a problem that has been building up for decades and has reached critical proportions.

The geology of the Witwatersrand exacerbates this problem – the overlying, highly permeable dolomitic rocks allow water from the surface to seep into abandoned workings. Over time, the rising acidic water table contaminates the near-surface groundwater. Ultimately, the water will reach surface water, decanting into rivers and streams (a process that has already started in places). The symptoms are now being addressed, but require enormous amounts of fresh water until more sustainable solutions are identified and implemented.

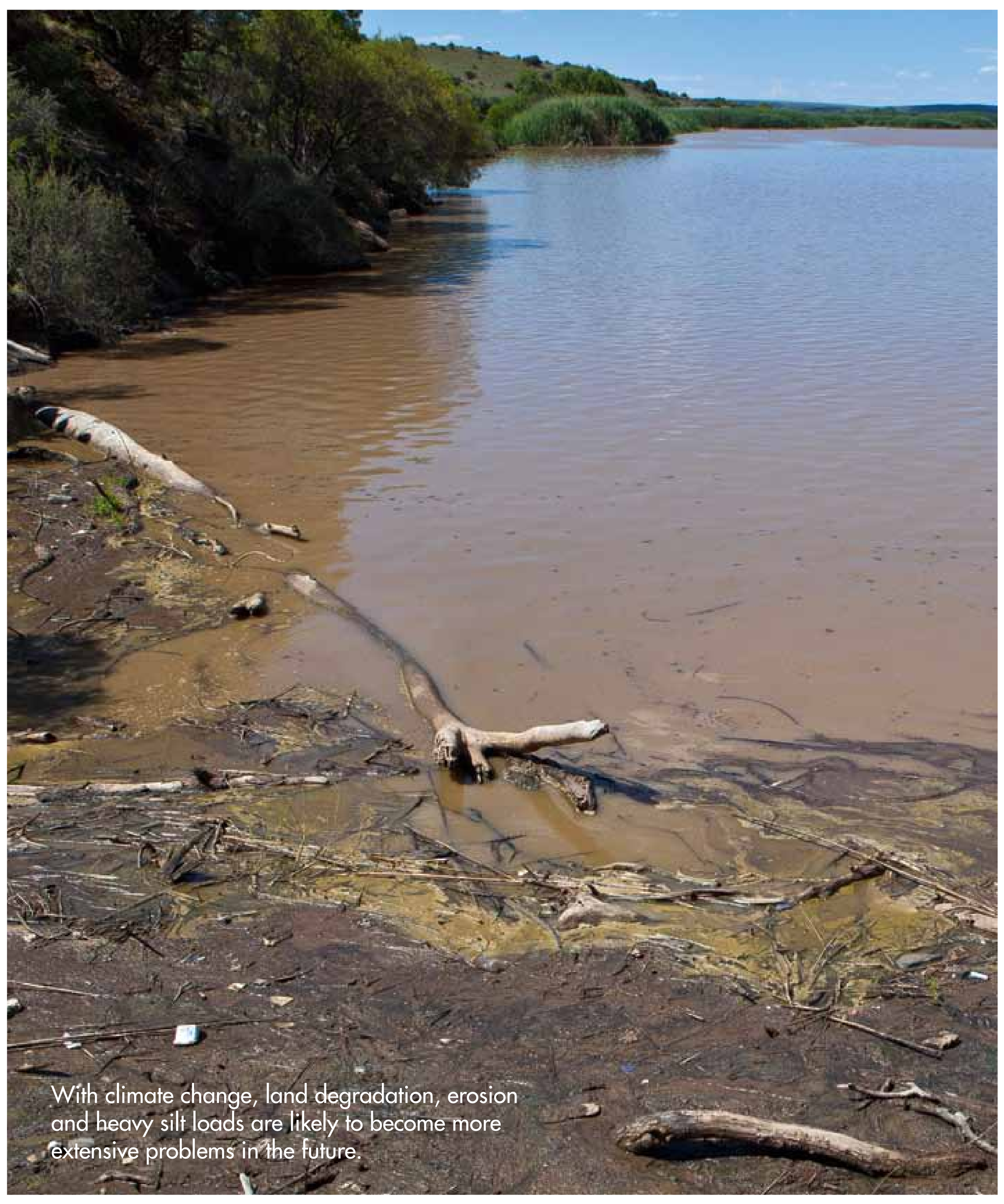
SEDIMENTATION

Water quality in both rivers and reservoirs is greatly affected by suspended sediment concentration resulting from erosion through land degradation. Loss in storage because of sedimentation reduces the ability of reservoirs to supply water for domestic, industrial, irrigation and hydropower uses, and to control floods. The sediment itself, or the pollutants associated with it, also affects water quality.

Over 80% of the dams in the Orange–Senqu River basin have lost up to 20% of their storage capacity due to sedimentation, while 4% of them have lost 40–50%. The Welbedacht Dam on the Caledon River, however, lost one third of its storage capacity within three years of being commissioned. Average annual storage loss due to sedimentation in South African reservoirs is approximately 0.3%, reducing their long-term sustainability.



Storage of reservoirs lost as a percentage of their original storage capacity. Gariep Dam has by far the highest volume of deposited sediment.



With climate change, land degradation, erosion and heavy silt loads are likely to become more extensive problems in the future.

OTHER POLLUTANTS

Radionuclides, heavy metals and persistent organic pollutants (POPs), do not pose a basin-wide risk currently, but do show high concentrations in localised areas. In a recent basin-wide survey of POPs and a subsequent follow-up survey, levels of PFOS, PAHs and PCBs were identified as issues of concern in some areas that require further study.

Where they are present, POPs and heavy metals are stored in the muscle and fat tissue of organisms. Concentrations gradually build up over time and up the food chain through a process known as bio-accumulation. Being at the top of the food chain, fish-eating birds, such as this grey heron (*Ardea cinerea*), are at risk of building up high levels of POPs and heavy metals, making them susceptible to the effects of these pollutants.

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HARNESSING THE WATER RESOURCES

OF THE ORANGE–SENQU RIVER BASIN

The Orange–Senqu is one of the largest river basins in southern Africa. It rises in the rain-fed highlands of Lesotho, travelling westwards for 2,300 km through increasingly arid climes to the Atlantic Ocean. Its largest tributary, the Vaal River, rises in the Highveld Grasslands of eastern South Africa, while smaller ephemeral rivers in the lower reaches contribute relatively little runoff to its surface waters. This natural trend of water availability – high in the east to low in the west – has helped determine patterns of settlement and economic development, but has not been the only factor.

Water in the basin is used for irrigation, urban domestic and industrial activities, mining, power generation, and rural domestic and farming activities. Of all the water demand in the basin in 2010, about 93% was in South Africa of which 70% was from the irrigation sector.

Water supply to meet these demands – not least of all the most economically active and densely populated eastern area of the basin – has been assured through the construction of numerous dams and a series of inter- and intra-basin transfer schemes.

SECURING WATER RESOURCES FOR THE FUTURE

Dams and transfer schemes play an important role in the development of the area, but have significantly altered the natural flow of the river.

The volume of water currently reaching the mouth of the Orange–Senqu is estimated to be about 40% of the natural average annual runoff of 11,300 Mm^3, and is less variable from one year to the next. The frequency, size and duration of floods are also reduced.

These changes in flow adversely affect the health of the river, the resources and ecosystems it supports and the services they provide. To secure water supply for the future, it is essential that the river system is managed effectively, efficiently and sustainably by taking into account flow requirements to maintain its ecological functions. Such an integrated management approach is promoted by the Orange–Senqu River Commission (ORASECOM). ▮

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The estuary of the Orange–Senqu River is a haven for wetland birds and recognised as a wetland of international importance. This Ramsar site is however under threat. Mitigation is largely dependent on managing flow patterns, particularly seasonality.

THE BASIN'S CONCRETE GIANTS

There are six reservoirs in the basin with storage capacities of over 1,000 Mm^3 and more than 50 other important supply reservoirs, as well as hundreds of smaller ones. ▮

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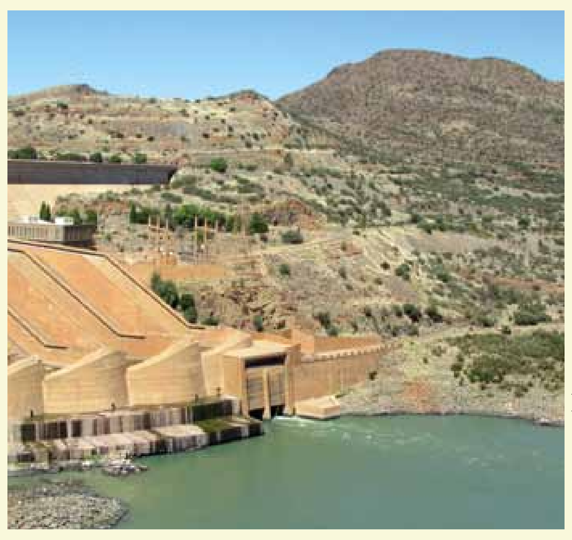
Constructed in the 1930s, the Vaal Dam is the main source of water to the Gauteng economic hub. It receives water from Vaal catchment runoff and the headwaters of the Orange–Senqu via the Lesotho Highlands Water Project, as well as other transfer schemes from the well-watered Tugela and Usutu catchments on the eastern side of the Drakensberg Mountains.



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The Vanderkloof Dam supports requirements to the mouth, about 1,400 km downstream, by controlling flow. Like the Gariep Dam, it is also used to generate electricity and supplies water to users in the area, particularly for irrigation.

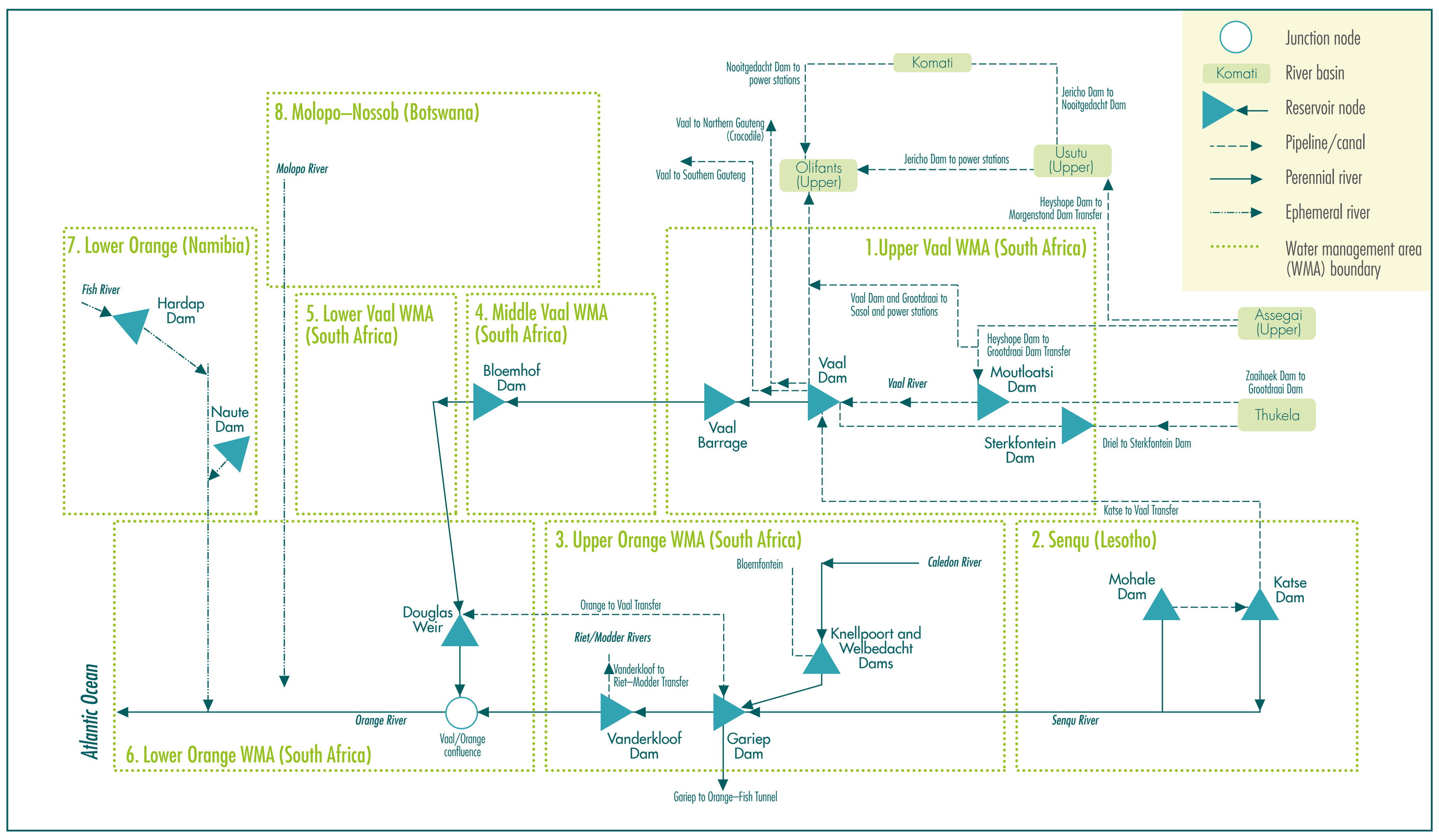
Storage capacities of the basin's largest reservoirs

	Storage, Mm^3	
Dam	Live	Dead
Gariep	4,710.0	632.9
Vanderkloof	2,173.2	1,015.4
Sterkfontein	2,482.3	134.7
Vaal	2,442.5	167.3
Katse	1,518.6	431.4
Bloemhof	1,229.5	0

Source: SANCOLD, 2009 and ORASECOM, 2007a

RESERVOIRS IN THE ORANGE–SENQU RIVER BASIN

STORING AND MOVING BULK WATER

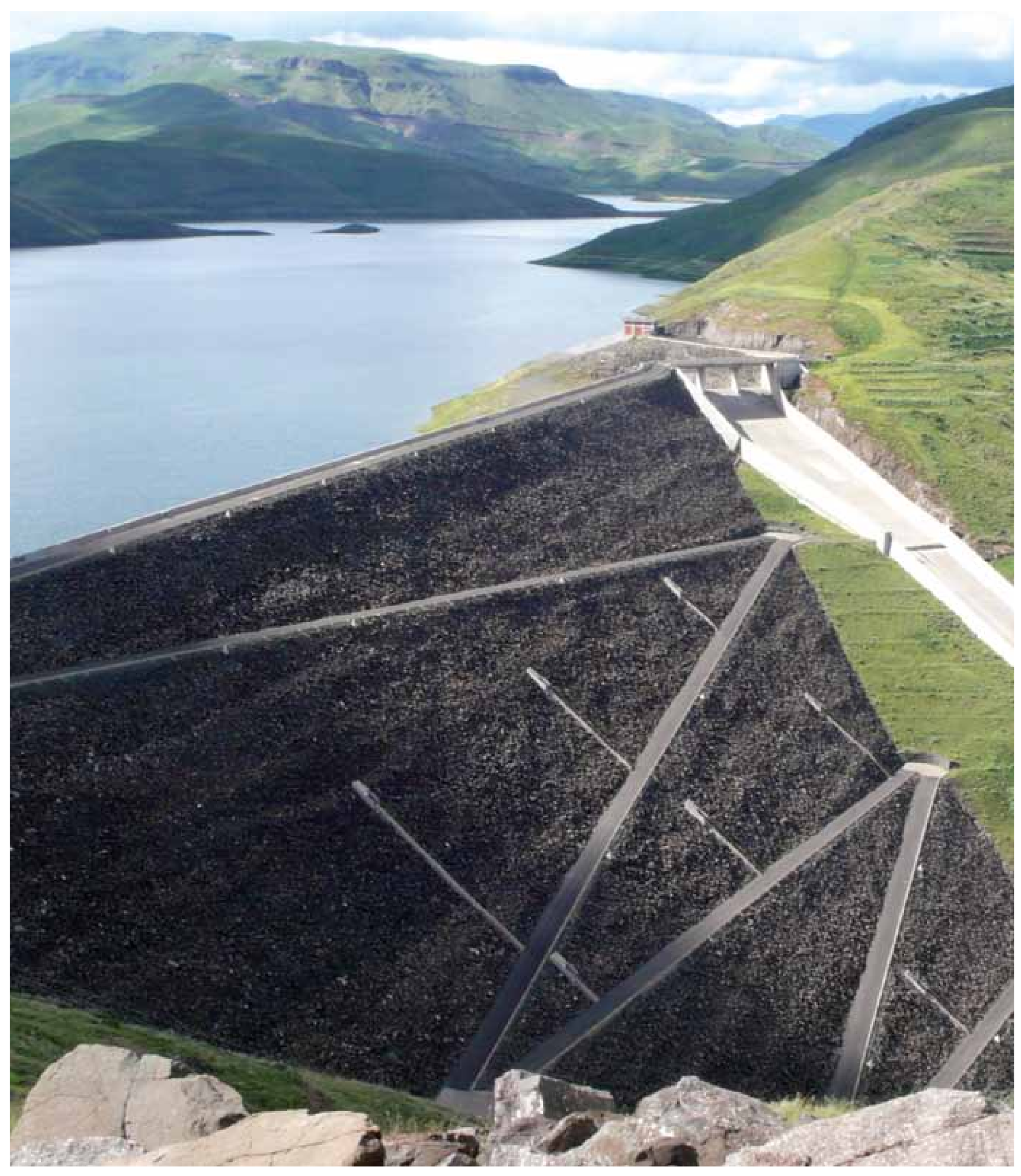


This schematic diagram provides an overview of the larger dams and transfer schemes in the Orange–Senqu River basin. These store and move bulk water to drive the most economically active area in southern Africa, support large-scale irrigation and meet the domestic needs of 19 million people. The dams and transfer schemes are mostly on the upper Orange–Senqu and Vaal river systems, but also supply water to irrigation schemes along the lower Orange where, away from the main river, groundwater is often the only source of water.

Lesotho Highlands Water Project

The Lesotho Highlands Water Project (LHWP) is an ambitious water transfer and hydropower project developed in partnership between the governments of Lesotho and South Africa. It augments South Africa's water supply by transferring water from the Katse Dam in the Lesotho Highlands to the Vaal Dam, and generates electricity for Lesotho. Five phases to the project were envisaged. The first phase, completed in 1998, comprised the construction of the Mohale, Katse and Muela dams, the Matsoku Diversion Weir, a hydropower station at Muela and a number of transfer tunnels between the dams and to the Vaal River sub-basin.

The second phase of the project foresees the construction of the Polihali Dam, a water transfer tunnel to the Katse Dam and a 1,200 MW pumped-storage scheme in Lesotho. Currently, 777 Mm^3 of water is transferred from the Katse Dam to the Vaal per year. ▮



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The Mohale Dam on the Senqunyane River, a tributary of the Senqu in Lesotho, is the second largest dam in the LHWP.

Produced for ORASECOM by the Orange–Senqu Strategic Action Programme using material from the *Orange–Senqu River Basin Transboundary Diagnostic Analysis* and *Orange–Senqu River Basin Infrastructure Catalogue*. The latter report provides detailed schematics of the dams and transfer schemes in each sub-basin, and a comprehensive description of these built structures | For further information on ORASECOM and its projects, please visit http://www.orasecom.org.

The Orange–Senqu River Commission (ORASECOM) was established in 2000 by the governments of Botswana, Lesotho, Namibia and South Africa to promote equitable and sustainable development and management of the water resources of the Orange–Senqu River basin. The Commission provides a forum for consultation, cooperation and sharing information between the countries.

The Orange–Senqu Strategic Action Programme was a four-year ORASECOM project. It assisted the basin states in identifying threats to the water resources of the Orange–Senqu and in developing a basin-wide plan for sustainable management of its water and related natural resources. The project was funded by the Global Environment Facility (GEF) through the United Nations Development Programme (UNDP) and was executed by the United Nations Office for Project Services (UNOPS).

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