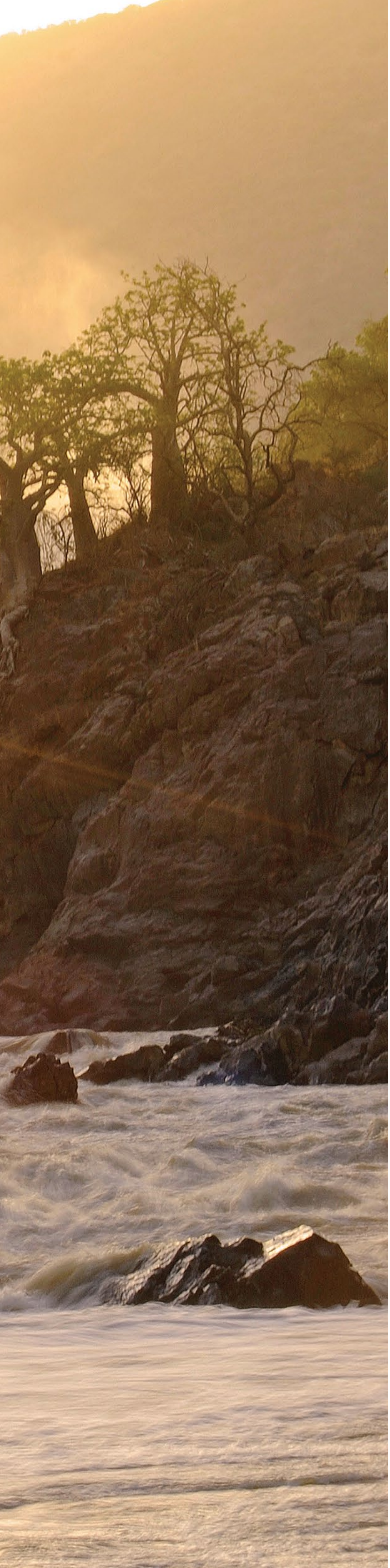


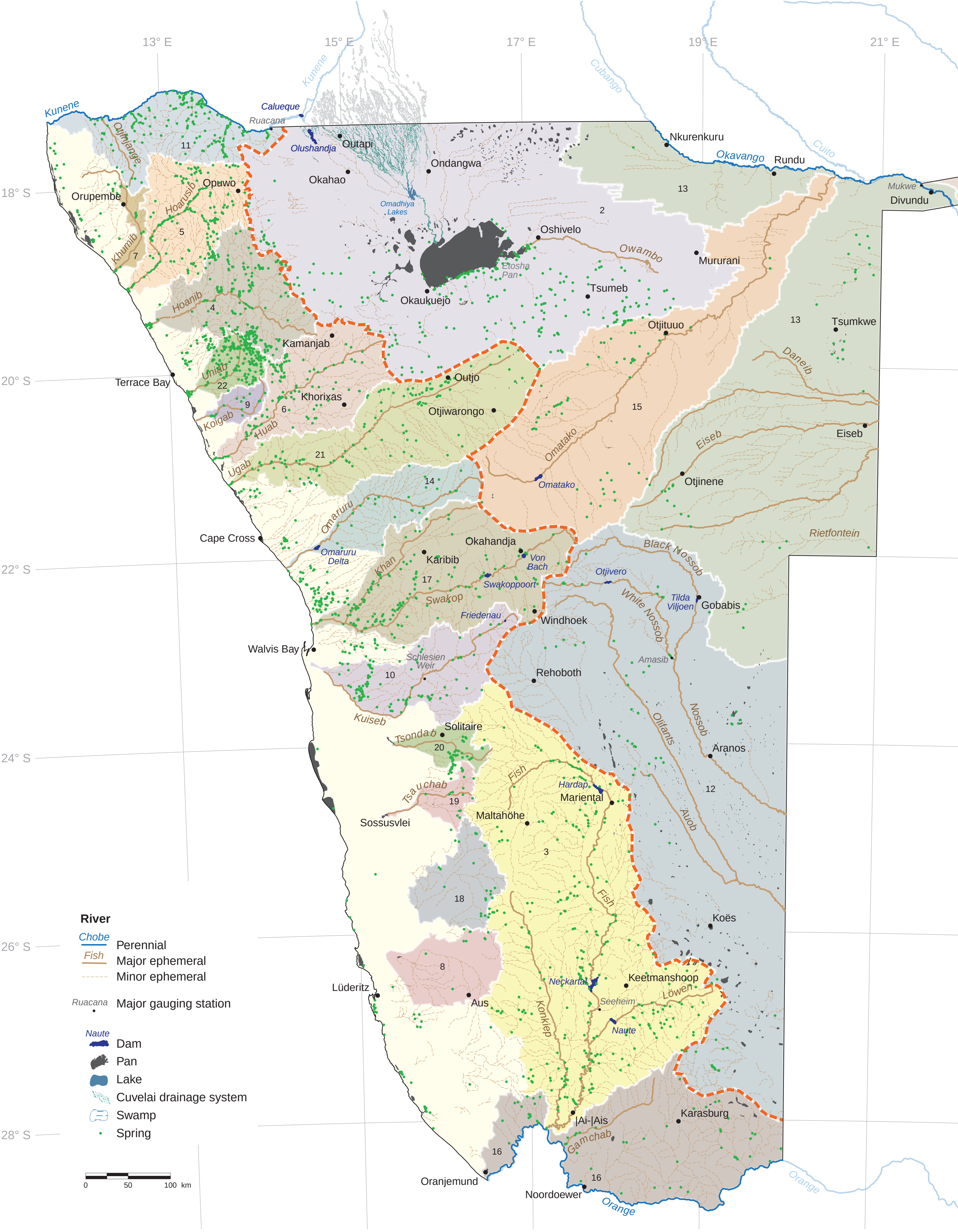
4 WATER
Namibia's freshwater resources

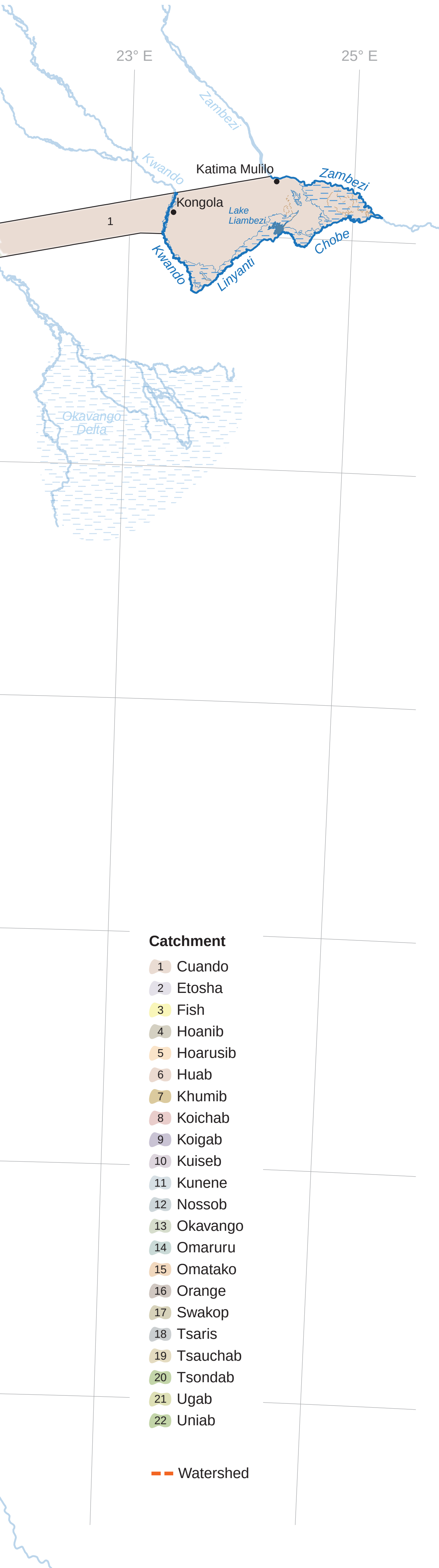
Namibia is predominantly arid and commonly referred to as the driest country south of the Sahara. Flowing rivers are mostly confined to the country's northern and southern borders. Other areas of open water are few and far between. But for short, often magical times there may be abundant water across the country's surface. Such times are restricted to the rainy season – usually those seasons with 'good' rainfalls.

Namibia's water – or lack thereof – is defined by three main factors. Firstly, the climate, manifested in low, variable rainfall (pages 88 and 92) and high rates of evaporation (page 102). The effects of warm, dry air and wind combine to produce high rates of evaporation, while the potential for rain depends mainly on inflows of moist air from the tropics to northern Namibia. Such inflows are blocked for much of the time by high-pressure air masses (page 74). Secondly, the combination of geology, soils and vegetation cover that make up the land's gradient and substrate determine whether the rain that falls flows away along watercourses, pools up to form pans or vleis, or seeps into the ground. Thirdly, how we use water resources influences how much water there is above and below the ground, how long it remains, and its quality.

Fresh water is an essential resource for almost every human domestic and economic activity. To meet these needs and to ensure that we have enough fresh water from one good rain season to another, Namibia has had to find, pump, store, purify, recycle and move water from where it is available to where it is needed. Advanced technologies have been developed to make all these activities possible.

This is the Kunene River cascading over Epupa Falls on Namibia's border with Angola. Namibia derives considerable benefits from this river's water, all of which comes from its catchment in central and southwestern Angola. Small volumes are pumped out of the river into canals and transferred along thousands of kilometres of pipelines that radiate across central-northern Namibia, providing water to more than 30 per cent of the country's population. Water from the Kunene River is also used to generate electricity at Ruacana, at times contributing 75 per cent of the power produced in Namibia. However, flow along the river – and therefore electricity generated – has decreased in recent years, forcing Namibia to spend billions of dollars of public funds to purchase costly power from other sources.


13° E
15° E
17° E
19° E
21° E
18° S
20° S
22° S
24° S
26° S
28° S
Kunene
Cubango
Okavango
Cuito
Calueque
Ruacana
Olushandja
Outapi
Ondangwa
Okahao
Omadhiya Lakes
Nkurenkuru
Rundu
Mukwe
Divundu
Opuwo
Orupembe
Otjinjange
Hoarusib
Khumib
Hoanib
Oshivelo
Owambo
Mururani
Etosha Pan
Okaukuejo
Tsumeb
Otjituuo
Tsumkwe
Daneib
Kamanjab
Outjo
Terrace Bay
Uniab
Khorixas
Otjiwarongo
Koigab
Huab
Ugab
Omatako
Eiseb
Otjinene
Cape Cross
Omaruru
Omaruru Delta
Okahandja
Karibib
Von Bach
Khan
Swakop
Swakoppoort
Friedenau
Black Nossob
White Nossob
Otjivero
Tilda Viljoen
Gobabis
Rietfontein
Windhoek
Walvis Bay
Schlesien Weir
Kuiseb
Rehoboth
Amasib
Solitaire
Tsondab
Olifants
Nossob
Aranos
Tsauchab
Sossusvlei
Maltahöhe
Hardap
Mariental
Fish
Auob
Koës
Lüderitz
Aus
Neckartal
Keetmanshoop
Seeheim
Löwen
Naute
Konkiep
|Ai-|Ais
Gamchab
Karasburg
Oranjemund
Noordoewer
Orange
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
River
Chobe Perennial
Fish Major ephemeral
Minor ephemeral
Ruacana Major gauging station
Naute Dam
Pan
Lake
Cuvelai drainage system
Swamp
Spring
0
50
100 km



Surface waters

While permanent – or perennial – surface waters are rare in Namibia, the country's surface has numerous features that have been shaped by water, hold it for varying periods of time and drain it away following good rains. These perennial and ephemeral wetlands are not only sources of water, but many are also important productive ecosystems, supporting a diversity of plants and animals.

Surface water comes in several forms:

- Flowing rivers that may have associated floodplains, swamps or marshes, deltas or river mouths.
- Natural, well-vegetated standing waters, such as swamps, vleis, springs and seeps.
- Natural standing waters, which have little or no wetland vegetation, such as lakes, sinkholes and pans, or constructed dams.

Like many of Namibia's westward-flowing ephemeral rivers, the Tsauchab never reaches the sea. It is best known for its terminus in the dunes at Sossusvlei.

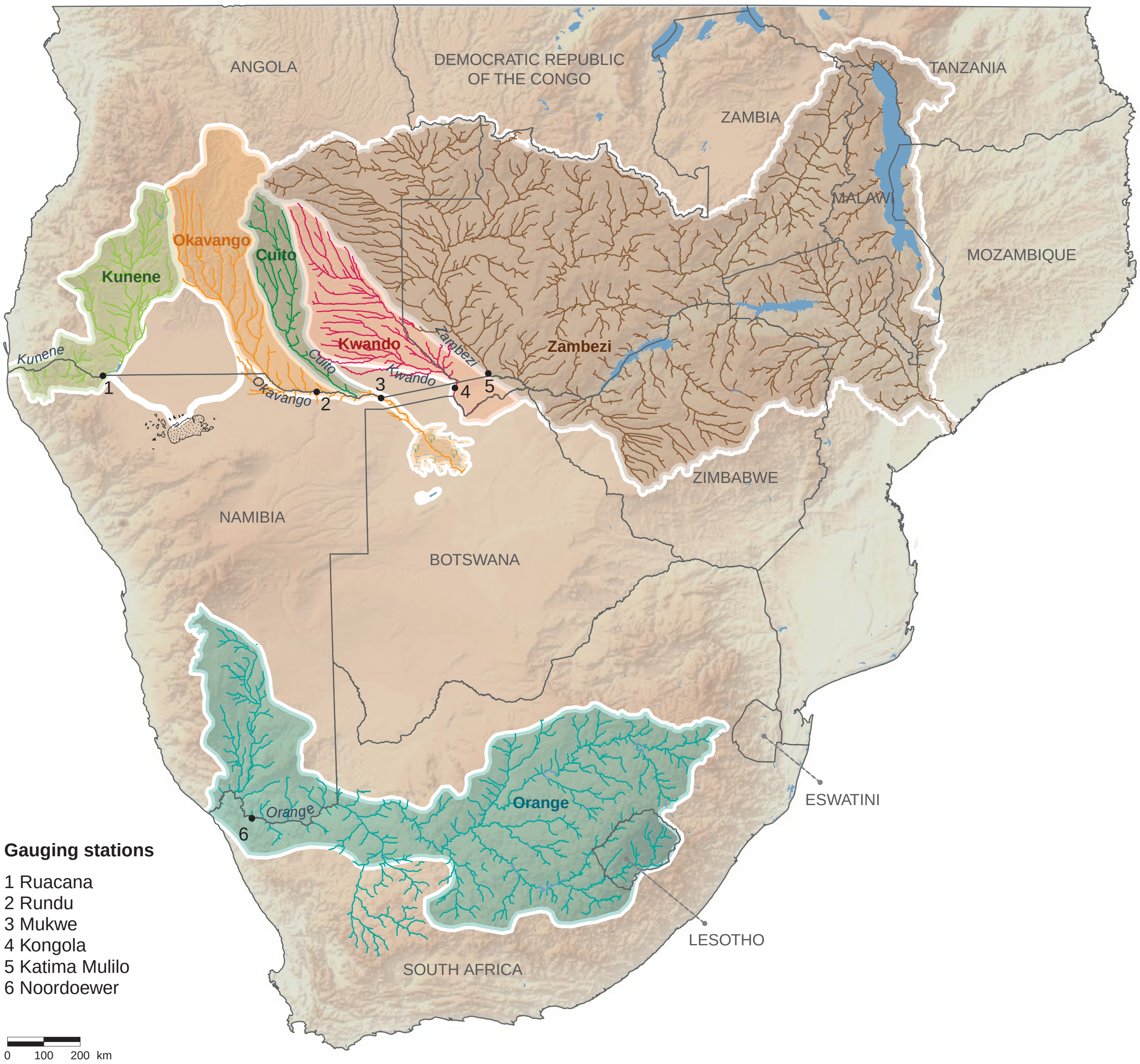
4.01 Namibia's surface waters and river catchments[1]

Only the rivers in the northeast and along the southern and northern borders of Namibia are perennial, carrying water all through the year. All other rivers and streams in the many catchments within Namibia's borders are ephemeral, only having surface water following good rains.

A watershed divides Namibia from the northwest to the southeast, as shown on this map. Hydrological conditions to the west and east of the divide are very different because of their dissimilar topography, geology and soils (pages 34, 50 and 148). In the west, surface waters are drained rapidly along well-defined watercourses over steep and rocky landscapes until they reach their gently sloping, sandy western extremities; these rivers lend themselves to storage dams. Springs and seeps of groundwater sustaining green oases are also a feature of these southern- and western-flowing ephemeral rivers. By contrast, drainage to the east of the watershed is over gently sloping, sandy substrates along poorly defined watercourses. Much of this slow-moving water soaks into the sands before it has travelled much distance. Heavy rains in this area also fill clay-based, shallow depressions forming a mosaic of pans.

All of Namibia's perennial rivers carry water from catchments with higher rainfall far beyond its borders. Nevertheless, they provide water to most people in Namibia's densely populated northern areas, supply several irrigation schemes, and generate up to 40 per cent of the country's electricity. Namibia's reliance on foreign supplies of water places the country in a vulnerable position.

Perennial rivers

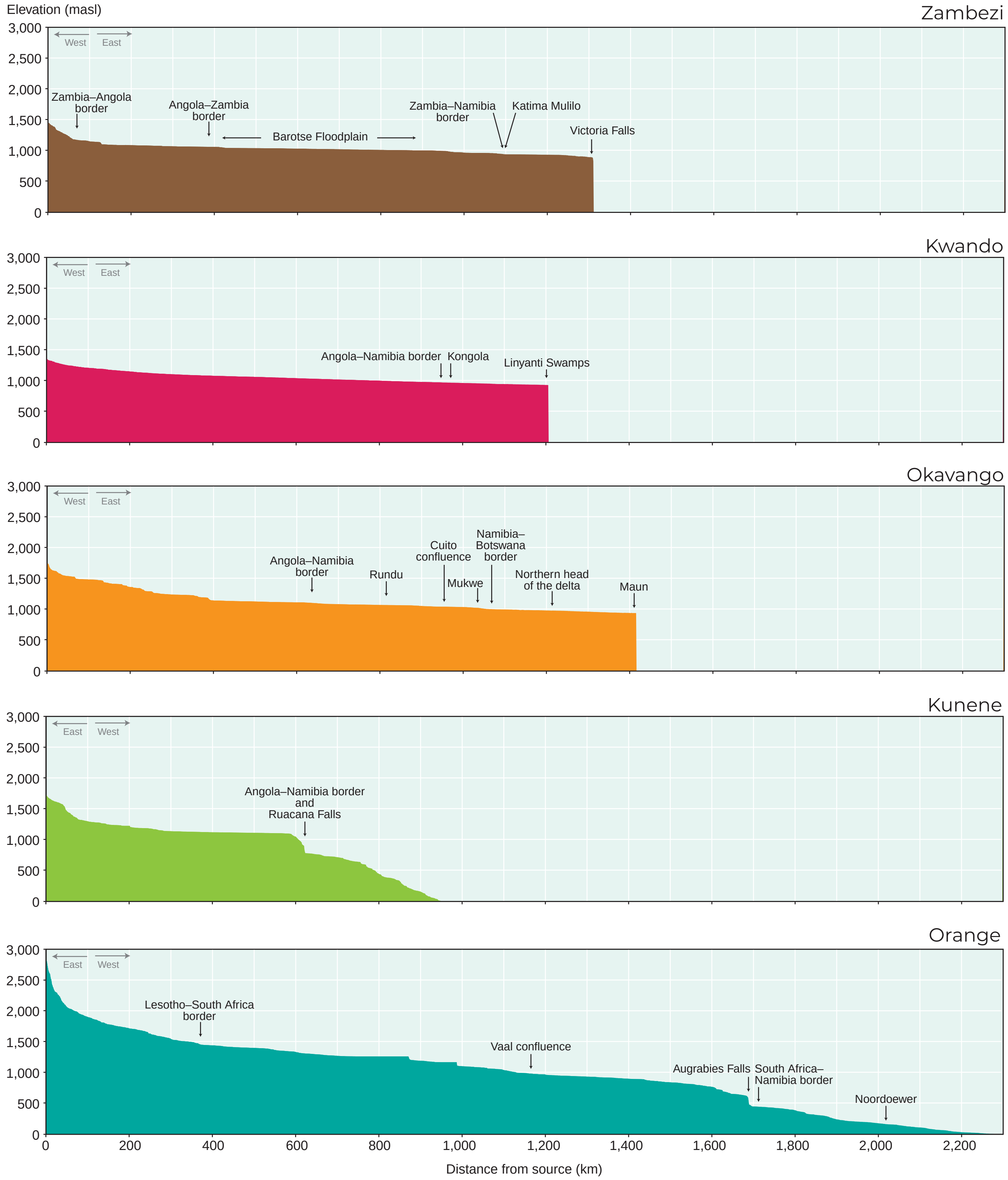


4.02 Namibia's perennial rivers and their upstream catchments[2]

Flowing from west to east in northeastern Namibia are the Okavango (to which the Cuito, another perennial river, merges), the Kwando, and the Zambezi rivers. Flowing from east to west is the Kunene River in the north and the Orange in the south. The Okavango (with the Cuito) and the Kwando end at about 950–900 metres above sea level (figure 4.03). The Okavango ends in the Okavango Delta in Botswana and the Kwando in the Linyanti Swamp in northeastern Namibia, although they may push through to other rivers and wetlands beyond these terminals in years of exceptional flows. The Zambezi River flows on for hundreds of kilometres to the Indian Ocean, while the two westward-flowing Kunene and Orange rivers flow to their estuaries at the Atlantic Ocean.

The Okavango, Kwando and Zambezi rivers flow over the sands of the Kalahari Basin (page 50) for much of their journeys. This tempers their energy, as do the shallow gradients of their courses. Their flows are slow and meandering, spreading into wetlands along their margins. When it rains, much of the water does not run off directly into these eastern rivers, but instead soaks into the ground, where it permeates slowly, constrained by the gentle gradient, sandy soil and the vegetation that holds the soil in place. Acting like a sponge, the hilly headwaters slowly feed the rivers throughout the year and flatten their peaks of flow. Floods from heavy rainfalls are thus moderated while some flow is maintained during long dry periods. Seasonal peaks and troughs are much less pronounced than those of rivers that come from and along steeper, rockier and denser surfaces, such as the Orange and Kunene.

The upper catchments of the Kunene and Okavango rivers are close to each other on Angola's Central Planalto, and they carry about the same total volume of water each year. Yet the Kunene's westward flow is over shallow soils and rocky ground and is more volatile than that of the eastward-flowing Okavango which is moderated by its gentle gradient and sandy sponge.

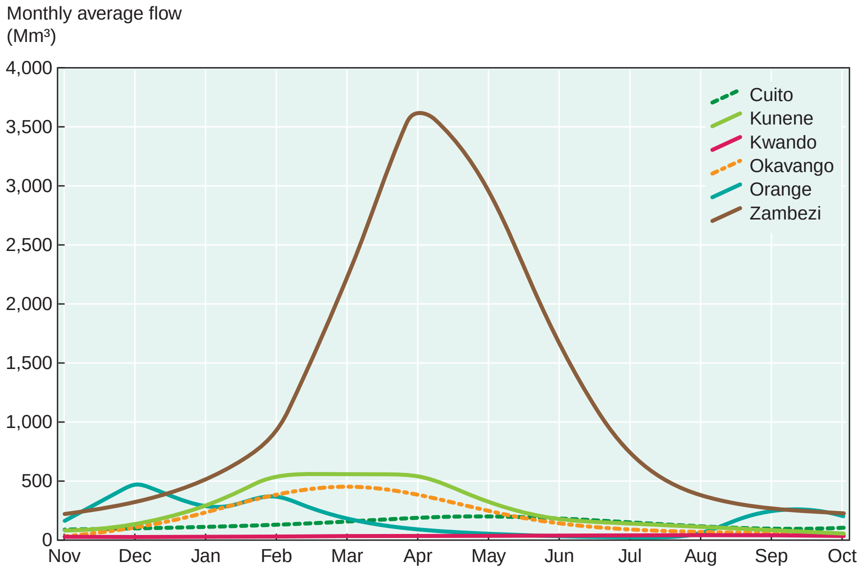


4.03 Elevation profiles of Namibia's perennial rivers[3]

These profiles show the elevations in metres above sea level (masl) of Namibia's perennial rivers from their sources: the Zambezi River to Victoria Falls; the Kwando and Okavango rivers to their base levels in the Kalahari Basin – the Linyanti Swamp and Okavango Delta, respectively; and the westward-flowing Kunene and Orange rivers to their mouths.

	Zambezi*	Kwando	Okavango	Kunene	Orange
Altitude at headwaters (masl)	1,476	1,291	1,753	1,729	3,300
Altitude at base level (masl)	881	931	935	0	0
Length (km)	1,311	1,206	1,416	951	2,280
Average gradient (m/km)	0.45	0.30	0.58	1.82	1.45

*Victoria Falls is considered the base level or termination point of the Zambezi for this purpose.



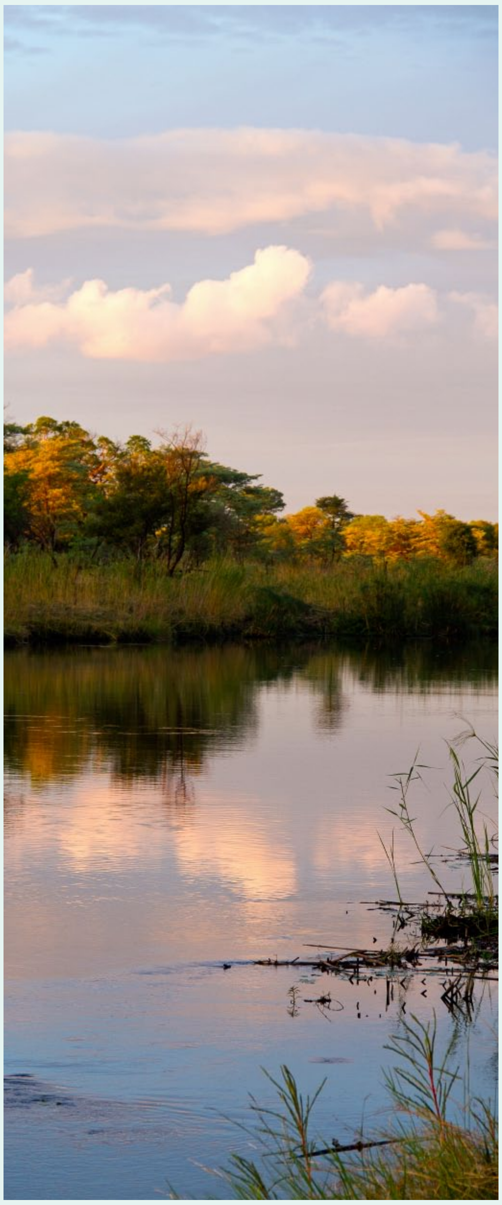
4.04 Seasonal variation in the flow of perennial rivers[4]

The average volumes of water (in millions of cubic metres) that flow in Namibia's perennial rivers vary throughout the year. The Zambezi dwarfs all of Namibia's other rivers. By contrast, the flow of the Kwando is barely visible above the horizontal axis at this scale. In addition, the Kwando's flow is extremely stable during the year; average monthly flow varies by less than 20 per cent between the months with the highest and lowest flows. The Cuito's flows are also rather steady, only rising and falling two-fold in an average year. By contrast, average flows along the Kunene, Zambezi and Okavango (as measured at Rundu) in the summer months are many times greater than winter flows. The average monthly flow of the Orange River at Noordoewer shows a less distinct seasonal pattern than expected because high demands on the water of this river system, and the damming of it upstream, have reduced the amount of water reaching its lower reaches and altered its pattern of flow.

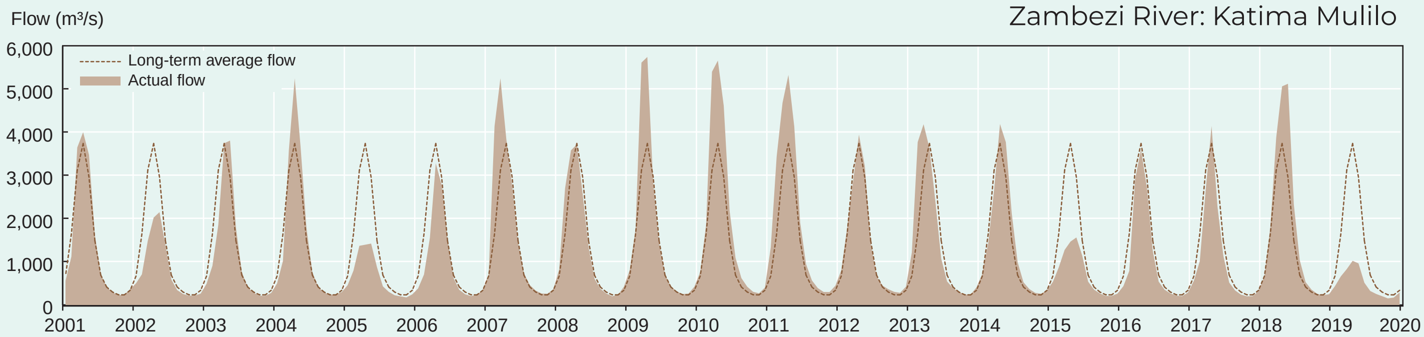
The Kwando is the smallest of Namibia's perennial rivers, and has by far the steadiest flow. It drains deep Kalahari sands, and descends only 400 metres along its entire course. Broad stretches of reedbeds, sedges and floodplain grasslands in shallow water flank much of the Kwando's narrow channel. Ten or more kilometres in breadth, this stable wetland landscape slows the flow of water along its length; large volumes of water are lost to evaporation and transpiration, with the result that the Kwando delivers rather little water by the time it enters Namibia and finally ends its journey in the Linyanti Swamp.

4.05 Flow rates of perennial rivers[5]

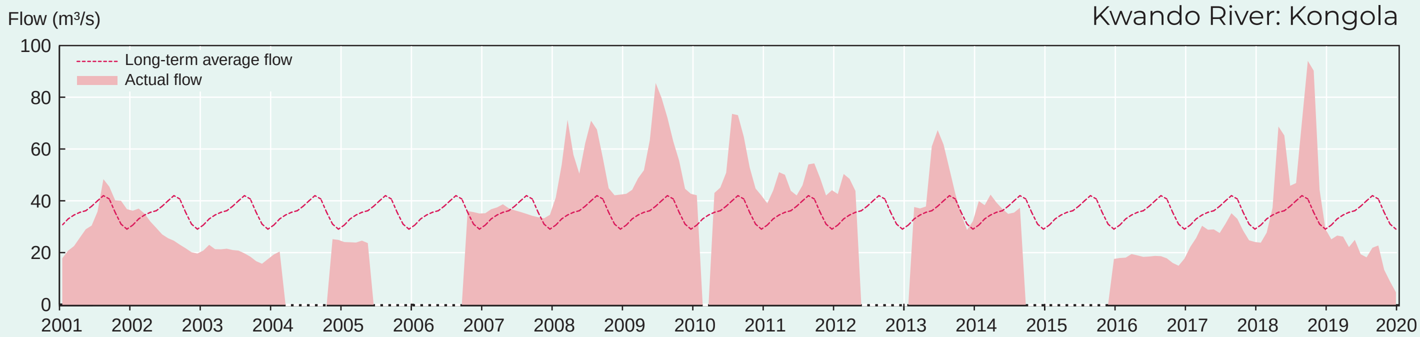
The solid colours on these charts show the volumes of water in cubic metres per second between January 2001 and December 2019 carried by the Kwando at Kongola, the Okavango at Rundu (before the Cuito confluence), the Cuito (its volume is the difference between volumes in the Okavango recorded at Rundu and Mukwe below the Cuito confluence), the Kunene at Ruacana Falls, the Zambezi at Katima Mulilo and the Orange River at Noordoewer. The dotted line indicates the long-term average flow rate at the same points on those rivers. Gaps in the records for the Kwando are due to an absence of data, not an absence of flow. Note the different scales used on the vertical axes. Tick marks on the horizontal axes mark January as the start of each year.



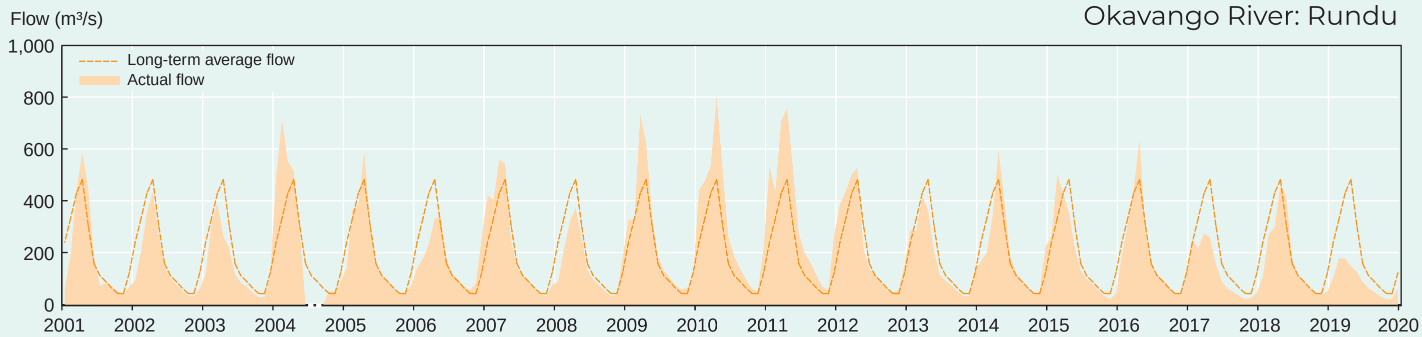
Zambezi River: Katima Mulilo



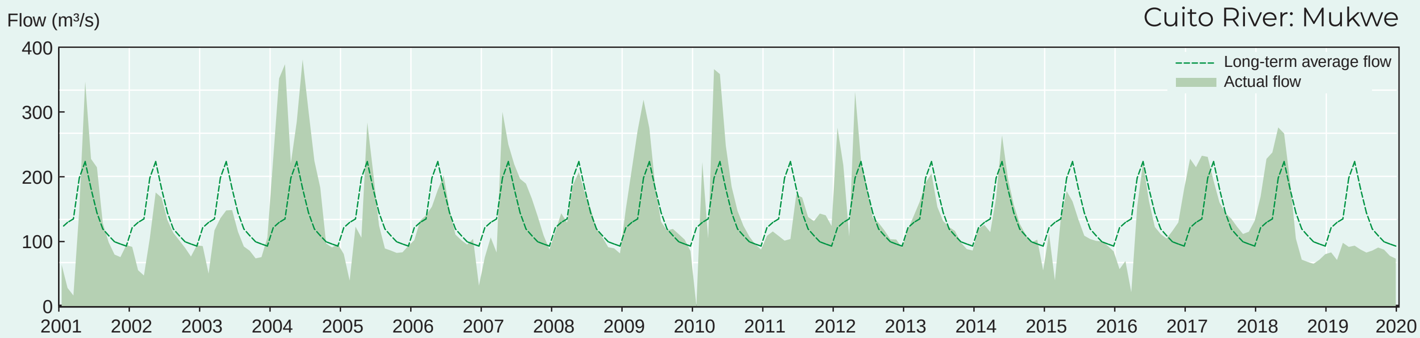
Kwando River: Kongola



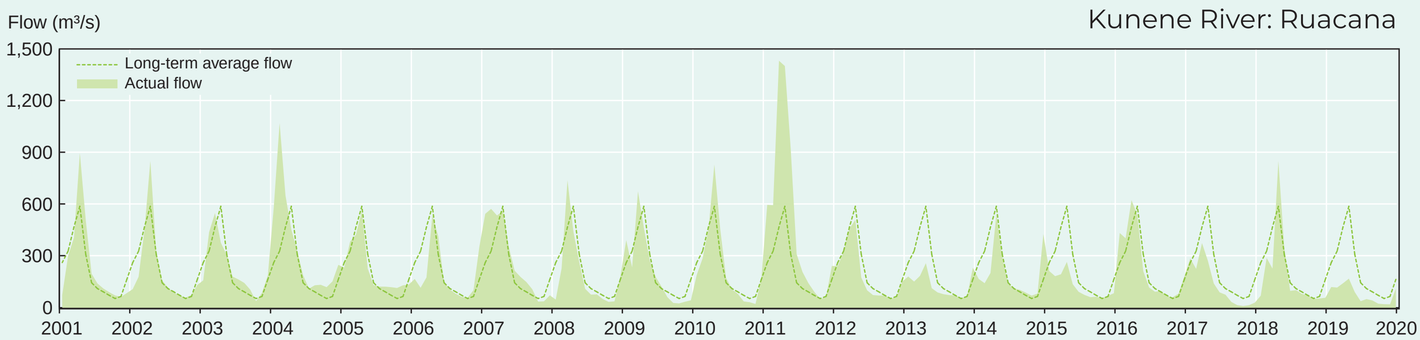
Okavango River: Rundu



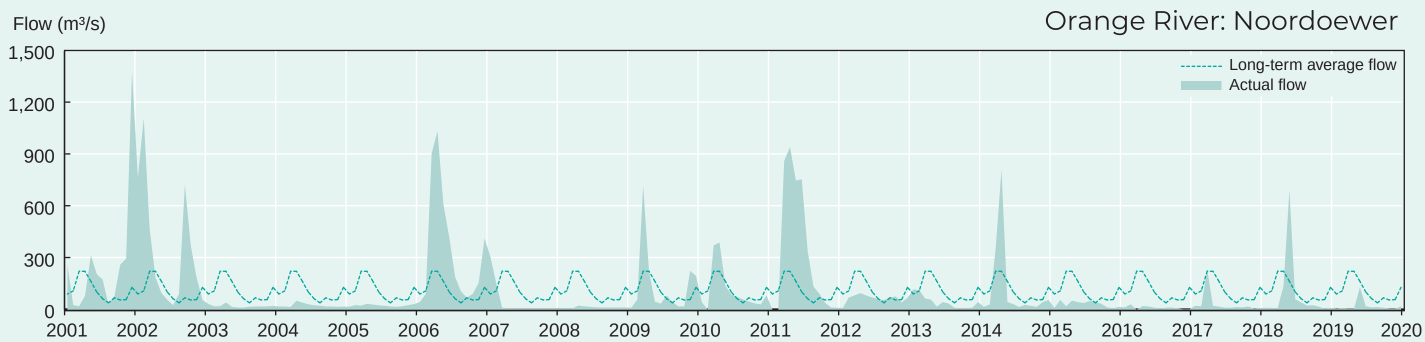
Cuito River: Mukwe

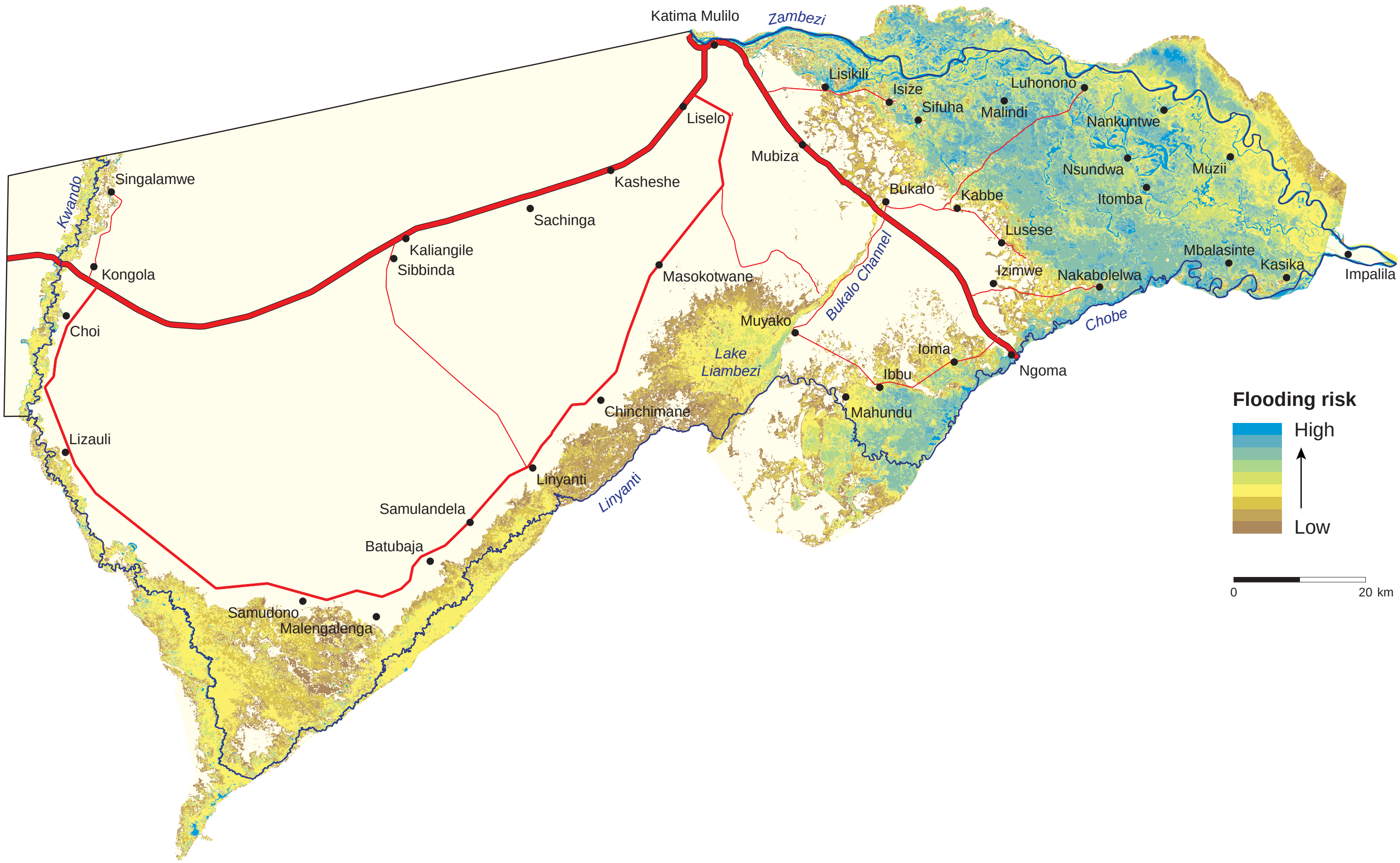


Kunene River: Ruacana



Orange River: Noordoewer





4.06 The frequency and risk of flooding in eastern Zambezi[6]

The Zambezi River regularly floods across much of the eastern Zambezi Region. Areas close to the Zambezi flood earlier than those close to the Chobe River and Lake Liambezi. The floods usually start in February, March or April and then last for several months. As the water encroaches, people living in the floodplains often leave the area, only to return when the expanses of water have receded. Crops grown in the relatively fertile soils of the floodplains are lost if they are inundated before harvesting.

Flooding along the Kwando River and Linyanti Swamp also occurs, but less frequently.

Disruptions to life and the costs of public money spent on evacuation and emergency relief could be reduced if attention was paid to the risks of flooding in different areas, perhaps with settlements being kept away from areas known to flood most often, such as those shown in this map. This assessment of risk was based on floodwaters visible in satellite images taken between 2000 and 2011.

Only small islands remain when floodwaters are at their highest in eastern Zambezi. Although the lives of local people are disrupted, the floodwaters bring many benefits, such as spawning grounds for fish, breeding areas for waterbirds, nutrients to the soils, and fresh green grass for cattle, buffalo, zebra and other grazing mammals.

Hundreds of channels, meanders and oxbow lakes formed by floodwaters over tens, perhaps hundreds of thousands of years cover much of the eastern floodplains between the Zambezi River at the top and Chobe River below. Most of the flooding occurs when the Zambezi overflows its banks, from where the floodwaters then spread south.

The Zambezi floodplains and Impalila Island are as far east as one can be in Namibia. The Chobe has no catchment, but fills when the Zambezi is high enough to push some of its water up the Chobe, sometimes as far west as Lake Liambezi. As the Zambezi drops, water in the Chobe River flows back eastwards into the Zambezi River. The Chobe thus has the unusual distinction of flowing both ways. Another special feature is the eastern tip of Impalila Island which marks the point where four countries meet: Zambia, Zimbabwe, Botswana and Namibia. [17.70° S, 25.04°E]

Ephemeral rivers

Ephemeral rivers often look much the same: dry, sandy watercourses lined by thick bush and trees. But there is a great deal of variation in Namibia's ephemeral rivers. The starkest difference is between the rivers to the west and east of the watershed (figure 4.01). To these two groups can be added a third – the Cuvelai, an ephemeral drainage system sandwiched between the west and east in northern Namibia (figure 4.09).

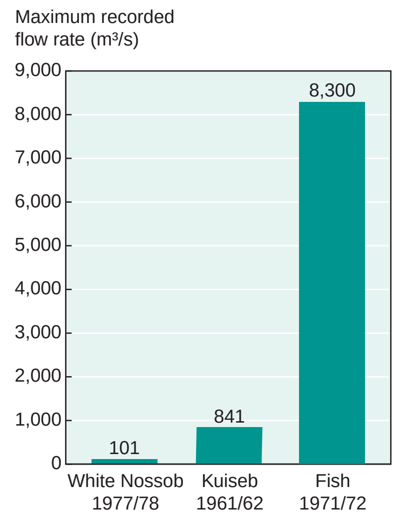
The rivers to the west of the watershed divide flow westwards – except for the Fish River which flows southwards – and tend to function as we expect of 'typical' rivers. They start as small fast-moving streams with a strong hierarchy of tributaries and clear paths of flow along ruts and channels down steep highland slopes. When they flow, their energy in these upper reaches is significant, eroding the surrounding landscape and carving characteristic boulder-laden riverbeds. As they make their way downstream to gentler gradients, their flows slow and their beds widen before their waters enter the Atlantic Ocean or percolate into the Namib's sands. Compare the Swakop, Kuiseb and Tsauchab Rivers in figure 4.01: the Swakop has a clear mouth into the sea at Swakopmund; the Kuiseb disappears into a sandy delta south of Walvis Bay but occasionally breaks through to the lagoon at Walvis Bay, while the Tsauchab completes its journey in Sossusvlei, some 55 kilometres east of the coast (as the seagull flies). South of Sossusvlei, no ephemeral rivers reach anywhere near the coast.

By contrast, the rivers to the east of the divide flow in an easterly direction and start as larger, slower, sandier rivers. Along their lengths these eastern rivers drop little in elevation, and so have lower energy and limited erosional potential. Many of the smaller rivers and tributaries are often poorly defined and hard to see, and might not flow for decades or even centuries – or may only flow for short distances. All of these rivers wander across thick Arenosol sands (page 148) until their sluggish flows fizzle away as the water seeps into the porous sand below. While there is little flow above ground, these rivers do recharge groundwater and, in some areas, form pans which become temporary oases.

Namibia's ephemeral rivers have two defining features. Firstly, they are usually dry (indeed, many Namibian children grow up believing that normal rivers are rivers of sand). Secondly, their water flows are extremely variable from one year to the next; long periods without any flow are punctuated by occasional, short-lived flows. The largest floods most frequently occur during February and March, when they recharge dams and groundwater reserves. But they are also unpredictable and potentially hazardous: almost every year people, vehicles and animals are swept away by flash floods. This is the Kuiseb River at Homeb in August 2021 (top) and in March 2018 (bottom).

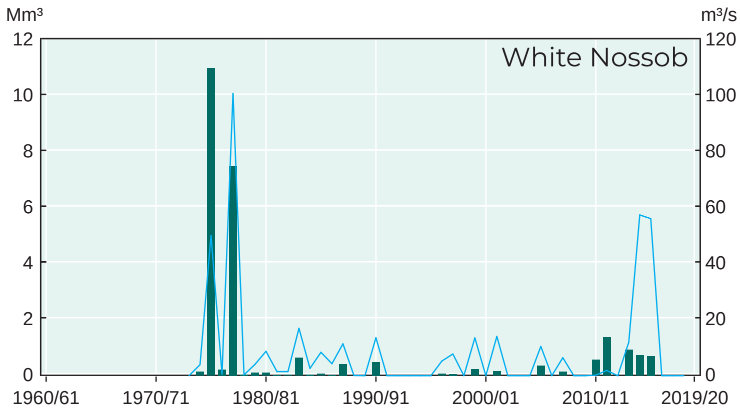
4.07 Maximum recorded flow rates in three ephemeral rivers[7]

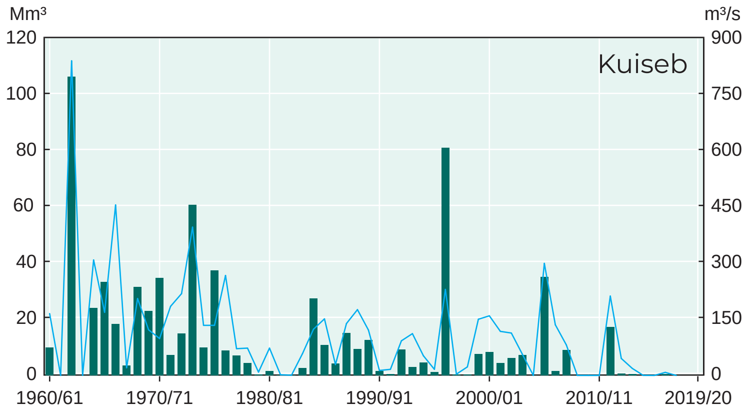
Despite being dry most of the time, ephemeral rivers can have very high rates of flow. The maximum flow rate recorded on the Fish River (at Seeheim) was 8,300 cubic metres per second during the exceptional rainy season of 1971/72. This is almost nine times more than the maximum flow ever recorded for the perennial Okavango River over the past 75 years, and illustrates the volatile nature of Namibia's ephemeral rivers. The gently sloping, sandy landscape of the Nossob catchment produces slow rates of flow along the river and has an unremarkable maximum flow rate of 101 cubic metres per second recorded in 1977/78 at Amasib. Any water that reaches the Nossob seeps away into its sandy riverbed during its slow journey southeast. Flows along the Kuiseb normally disappear into its sandy riverbed between Gobabeb and the coast, but occasional floods break through to the sea south of Walvis Bay.

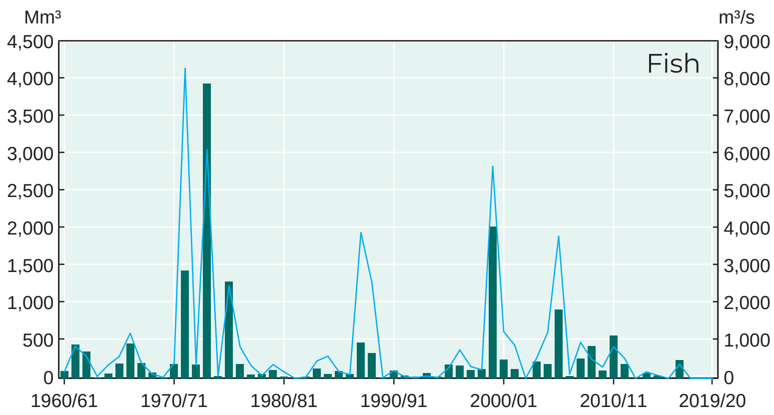


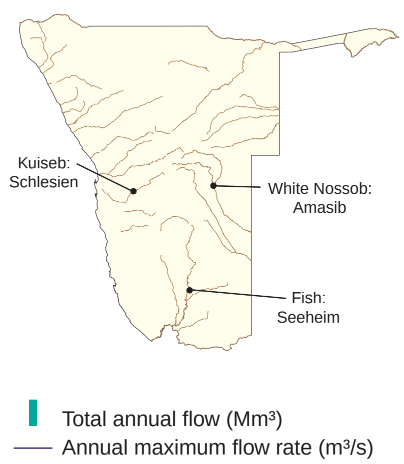
4.08 Total annual runoff and peak floods in three ephemeral rivers[8]

The graphs show the maximum flow rates (lines, in cubic metres per second) and total annual volumes of water (bars, in millions of cubic metres) recorded at gauging stations along three ephemeral rivers – the Fish River at Seeheim, the Kuiseb at Schlesien and the White Nossob at Amasib. This type of information is of particular use when designing a dam or determining intervals between flood events. The eastward-flowing Nossob River and the westward-flowing Kuiseb have more zero-flow years than the southward-flowing Fish River. The Fish has a more constant annual flow provided by its large catchment on rocky and sparsely vegetated Nama Karoo terrain. Consequently, the Fish River and its tributaries supply the country's three largest dams – Neckartal, Hardap and Naute – although they flow through some of Namibia's most sparsely populated areas.



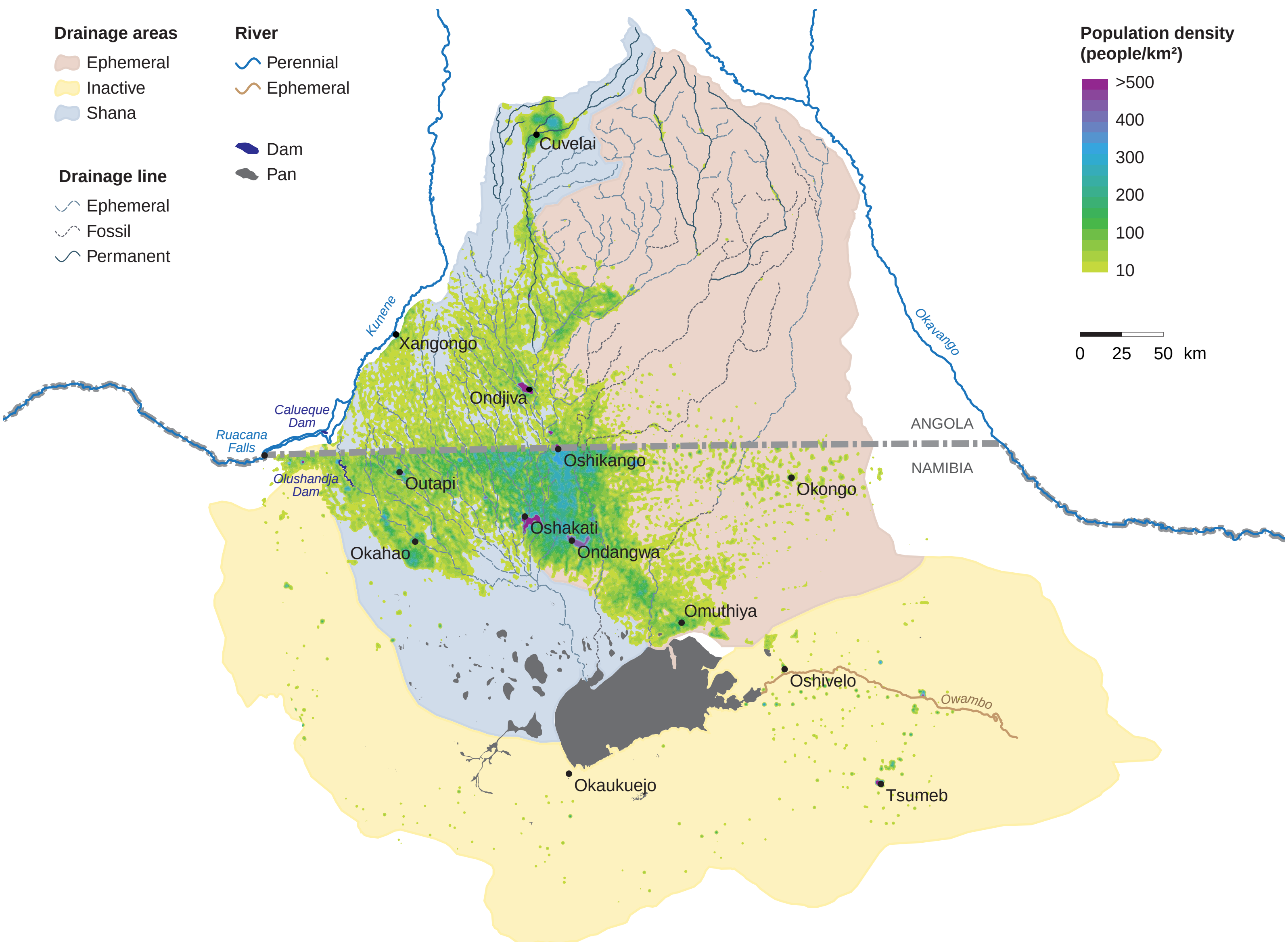






The Cuvelai

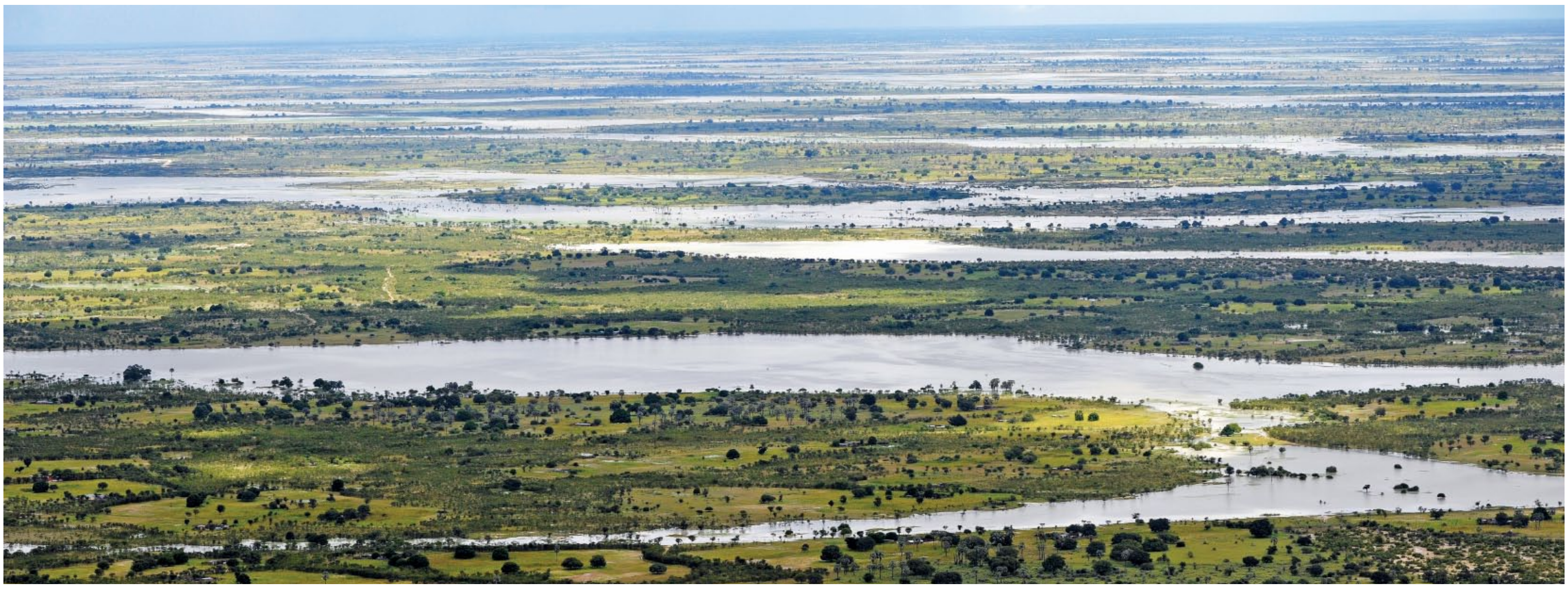
The Cuvelai is a large flat, basin-shaped landscape. About one third of the basin lies in Angola while the southern two thirds are in Namibia. The formation of the Cuvelai Basin – often referred to as the Owambo Basin by geologists – is a consequence of processes which occurred when the supercontinent Gondwana was formed about 550 million years ago (page 54). The most remarkable feature of it is the network of channels, locally known as iishana or simply 'shana', a hydrological feature that is perhaps globally unique. It is within this drainage area where most people in the basin (and indeed Namibia) live because its soils are relatively fertile.



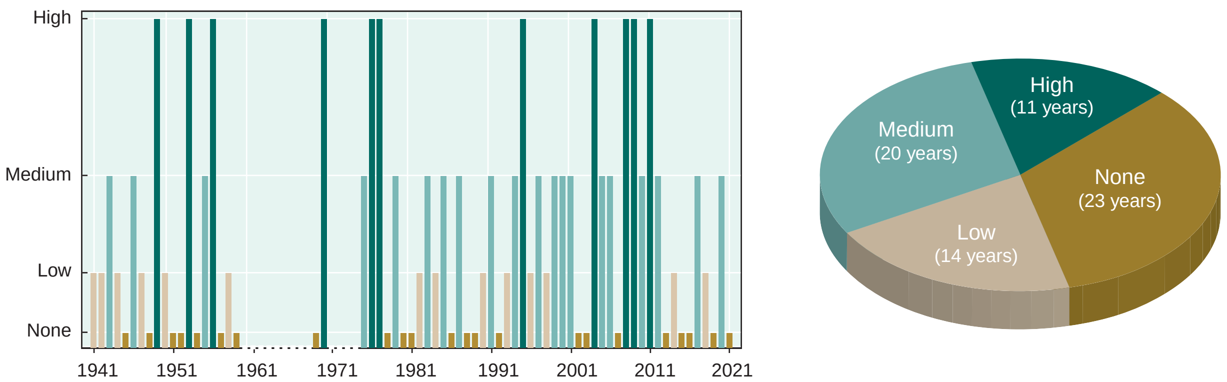
4.09 Owambo Basin and Cuvelai Drainage system[9]

In Angola, much of the Cuvelai Drainage stretches between the Kunene River (called Rio Cunene in Angola) in the west and the Okavango River (Rio Cubango) in the east. It is from this upper catchment in southern Angola that the Cuvelai receives most of its water. From there, about 100 channels (iishana) cross into Namibia and then progressively merge into the Omadhiya lakes from where water sometimes flows south into Etosha Pan, its final destination. As a result of gentle gradients, water flows slowly, but infiltration is limited since most of the channels have beds of impermeable clay or saline soil. The channels vary in width from less than ten metres to over a kilometre. Surface water flows are entirely contained within the Owambo Basin, with all water either evaporating or seeping into the ground; river basins with these characteristics are called 'endorheic'.

To the east and south of the Cuvelai Drainage are two areas where there is little surface water and few people live. The north-eastern area has a few ephemeral drainage lines and a deep cover of aeolian sand which holds little water and few nutrients. Following good rains, water may flow along the drainage lines but the flows seldom go far or reach the network of iishana channels. Much of the inactive drainage area to the south and west is rocky, in part of Otavi Group dolomites (figure 2.16) in gentle hills which overly karst aquifers (page 127), and partly of flatter areas dominated by calcretes which formed from calcium carbonates that dissolved out of the dolomites. There is little surface water in this southern area.



It is usually hard to find much surface water in the Cuvelai, but that changes every few years. This is the Cuvelai in March 2011 when large areas were flooded, either by water flowing through its network of channels (top) or by local rain filling the thousands of tiny pans that dot the landscape (bottom).



4.10 Frequency and severity of flooding in the Cuvelai between 1941 and 2021[10]

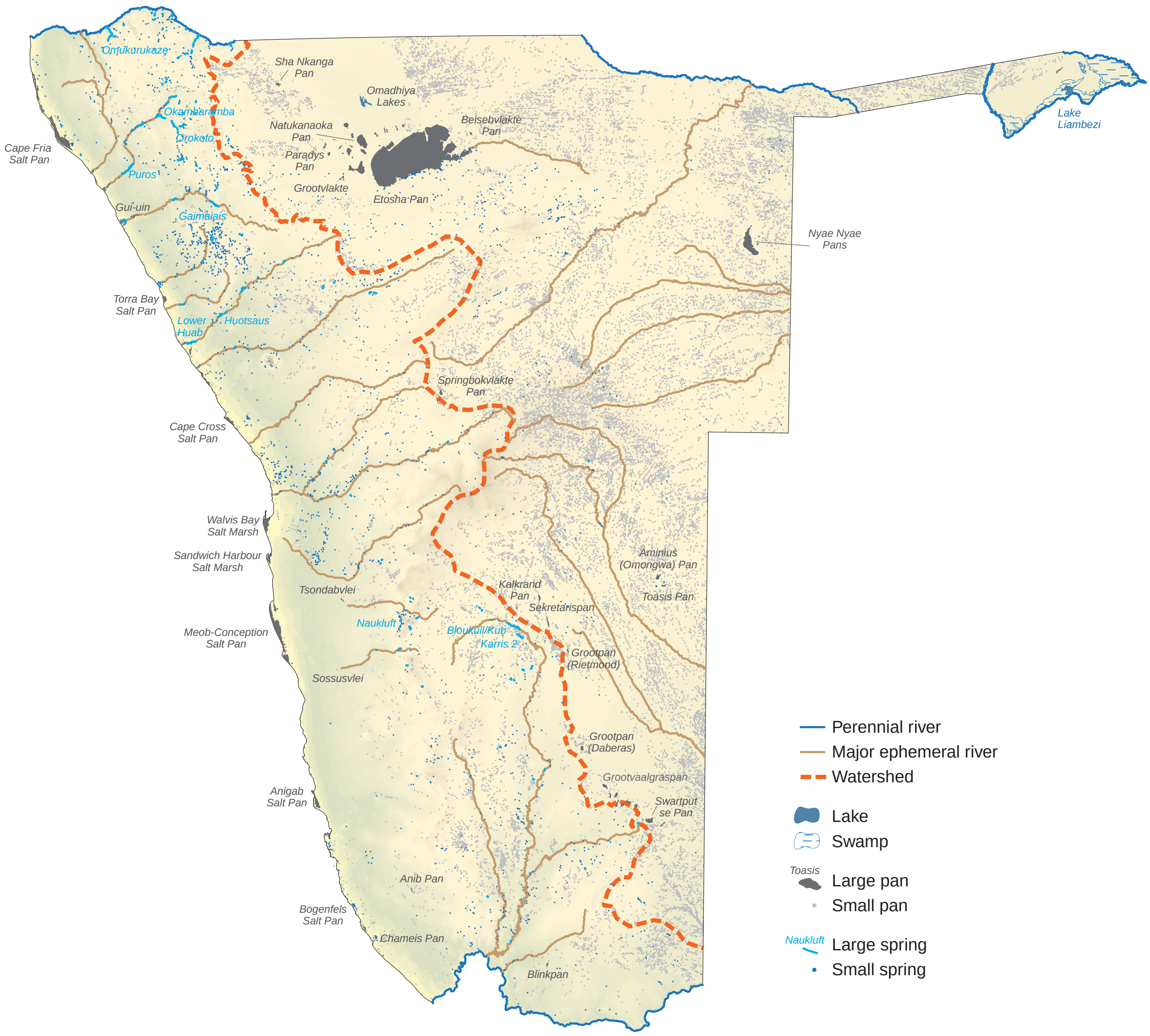
Following exceptionally wet seasons, a large part of the Cuvelai is transformed into a vast wetland. Such flooding events are known as 'omafundja' and they bring great quantities of fish to the southern reaches of the basin, but they can also be destructive, damaging roads and buildings, destroying crops and even causing drownings.

Estimates on the extent of flooding are available for 68 of the past 81 years. During these 68 years, there were no significant water flows in 23 of them (34 per cent), small flows in 14 (21 per cent), medium flows in 20 years (29 per cent) and major flows in 11 years (16 per cent). Omafundja – medium or major flows – thus occurred almost every second year on average, with major floods reported at an average interval of six years.

Pans, lakes, marshes and springs

Although little surface water is normally visible anywhere in Namibia, there is a great and surprising number of features that hold water at times. These include the tens of thousands of pans that dot the landscape, thousands of springs that bring groundwater to the surface, and small marshes that spread out from rivers, dams and certain springs. Least of all are Namibia's only two lakes: the Omadhiya complex of lakes in the central-northern regions and Lake Liambezi in Zambezi.

Collectively, these waterbodies support much life, including plants, livestock, large wild mammals, birds, amphibians, fish, crustaceans, insects and other smaller organisms.

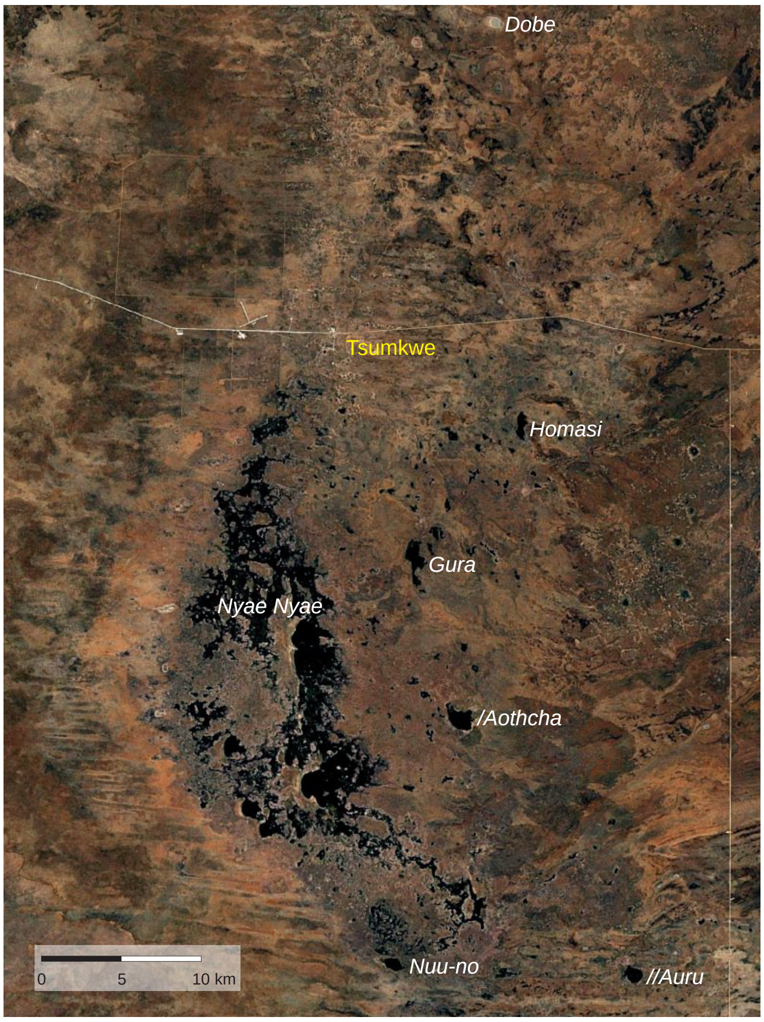


4.11 Springs, pans and vleis[11]

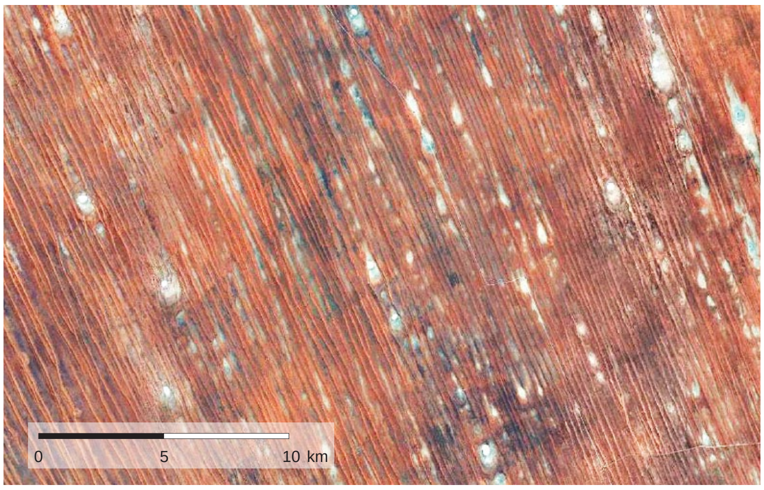
Pans and springs occur predominantly in eastern and western Namibia, respectively. Most pans are in the flat, sandy landcapes east of the watershed, while the majority of springs are in rocky, steeper areas west of the watershed, which also divides the flows of most ephemeral rivers. In total, about 2,500 springs bring groundwater back to the surface, while approximately 25,000 pans have formed where impervious layers slow the seepage of water into the ground. Most springs and pans do not have names, but many of the bigger ones do, names that are often familiar: Grootfontein, Otavi, Aigams, Witvlei, Etosha, Nyae Nyae and Tsandi, for example.

While Namibia is well-endowed with springs and pans, marshes and lakes are not abundant. Scattered areas of reeds, papyrus and other large aquatic plants form marshes in certain flat areas alongside the Okavango, Kwando and Zambezi rivers, and also form the only substantial marshland in the Linyanti Swamp. Smaller reedbeds also grow in seepage zones close to dams and certain springs.

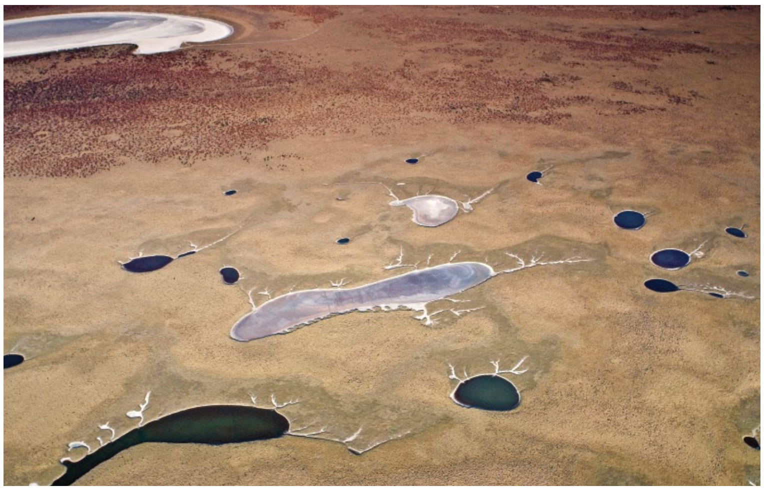
Namibia's largest pan, Etosha, was once a vast lake extending north of the border into Angola, and was fed by the Kunene River. Through river capture processes several million years ago, the Kunene's watercourse was diverted westwards along its present route to the Atlantic Ocean. Nowadays, most water in Etosha Pan comes from local rain or from flow along the Ekuma River from the Cuvelai drainage system or flow along the Omuramba Owambo. An astronaut in a space shuttle took this photograph looking west across Etosha towards the Atlantic Ocean in the background. Other pans lie along the Atlantic coast. Like Etosha, these are saline pans, their salt having been carried onshore by sea breezes. Etosha's salt accumulated from minerals carried down the Cuvelai drainage system in water that then evaporated. Other saline pans are clustered around Etosha (page 120).



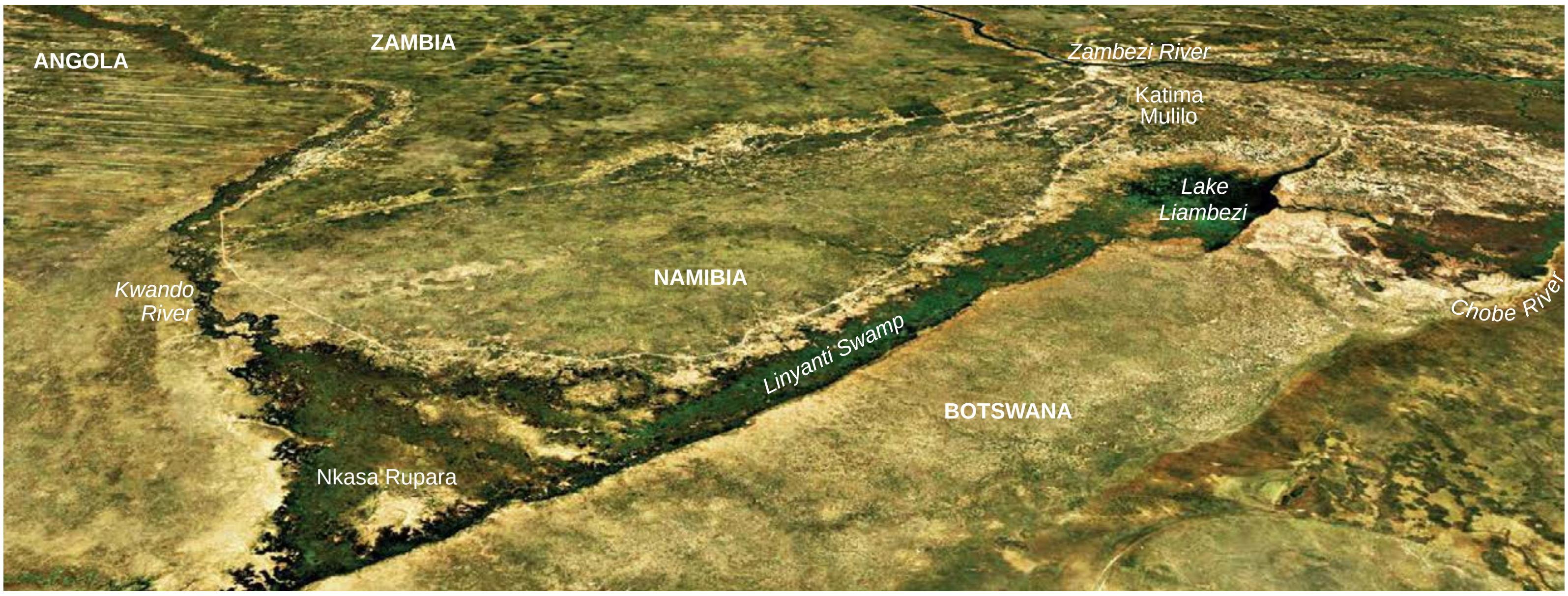
Hundreds of pans fill around Tsumkwe in years when rainfall is above normal. The best-known of the pans is Nyae Nyae, although all the pans in this area are often collectively called by this name. When flooded, this concentration of wetlands supports an extraordinary abundance of life made possible by rich supplies of soil nutrients that have accumulated during the preceding dry years. With accumulated rainwater, dormant eggs, seeds, pupae and spores then hatch and emerge, creating a great supply of frogs, insects and other invertebrates that attract tens of thousands of birds to feed and breed. Indeed these pans may be one of the most important breeding areas in Africa for various species of grebes, crakes, rails, ducks, geese, moorhens, gallinules, terns, herons, egrets, storks and snipe. Where many of these birds live at other times is a mystery, however. [19.74° S, 20.53° E]



Thousands of pans lie sandwiched between dunes in all the active and inactive dune fields in Namibia (page 40). The white pans visible here lie in interdune valleys around Aranos and Gochas in the eastern and southeastern areas of the country. Most of these pans are underlain by saline soils and very seldom have water. However, when heavy rains fall many waterbirds are attracted to feed on the tiny crustaceans that then hatch from eggs that have survived for years, perhaps decades, in the pans' salty sediments. [24.86° S, 19.29° E]



Pans in Namibia are found predominantly in areas with very shallow gradients and are formed through successive processes of ponding, leaching and evaporation. Salts in the soils dissolve and accumulate over time in the shallow depressions; the salts help solidify the pan surfaces.



Although both the Omadhiya lakes (top) and Lake Liambezi (bottom) fill temporarily, they have very different characters. Liambezi is largely supplied by the Bukalo Channel from the Zambezi River and backflow of the Chobe River. The lake was reported to have water in 1879, and then filled again during the 1950s. It was dry from 1985 until the summer of 2005/06, when it filled again and remained a lake until 2014. The lakes of the Omadhiya system hold water more frequently and regularly. Their water is supplied by channels of the Cuvelai drainage system. One of its lakes – Lake Oponono – gets its water from the Etaka Canal, which is probably an ancient channel of the Kunene River. Both Liambezi and the Omadhiya lakes support large commercial fisheries at times.

While the Linyanti is Namibia's only significant swamp, other marshes are found along the Okavango, Zambezi and Kwando rivers and around wetlands scattered elsewhere in the country, including large springs and man-made dams, such as Hardap near Mariental. Parts of Nkasa Rupara National Park (seen here) can support substantial areas of reeds, sedges, lilies and other aquatic plants. In effect, Nkasa Rupara is a delta in bringing to an end the flow of the Kwando River, in just the same way that the Okavango Delta is the terminus of the Okavango River. Both deltas are bounded by geological faults that stem the flow of the rivers (page 39). The line of trees in the background grow along the Linyanti Fault.

Most springs emerge from underground water trapped in rock fractures or between layers of impervious rock. Where the fractures or impervious layers are exposed at lower altitudes, gravity feeds water to the surface. Springs are therefore most common on the sides of hills, mountains or along valleys or beds of rivers from where the spring water may flow for hundreds of metres, even kilometres, forming permanently vegetated pools or streams. More rarely, geothermal heat can create pressure that drives water to the surface where it emerges as hot springs, such as those at ǀAi-ǀAis and Warmbad.

Water in this spring in the Ehi-Rovipuka Conservancy in northwestern Namibia emerges from hills of tufa which are formed from minerals dissolved out of dolomite rocks. Birds, wildlife and livestock depend heavily on this and similar spring waters because there are no other natural water sources in the area.

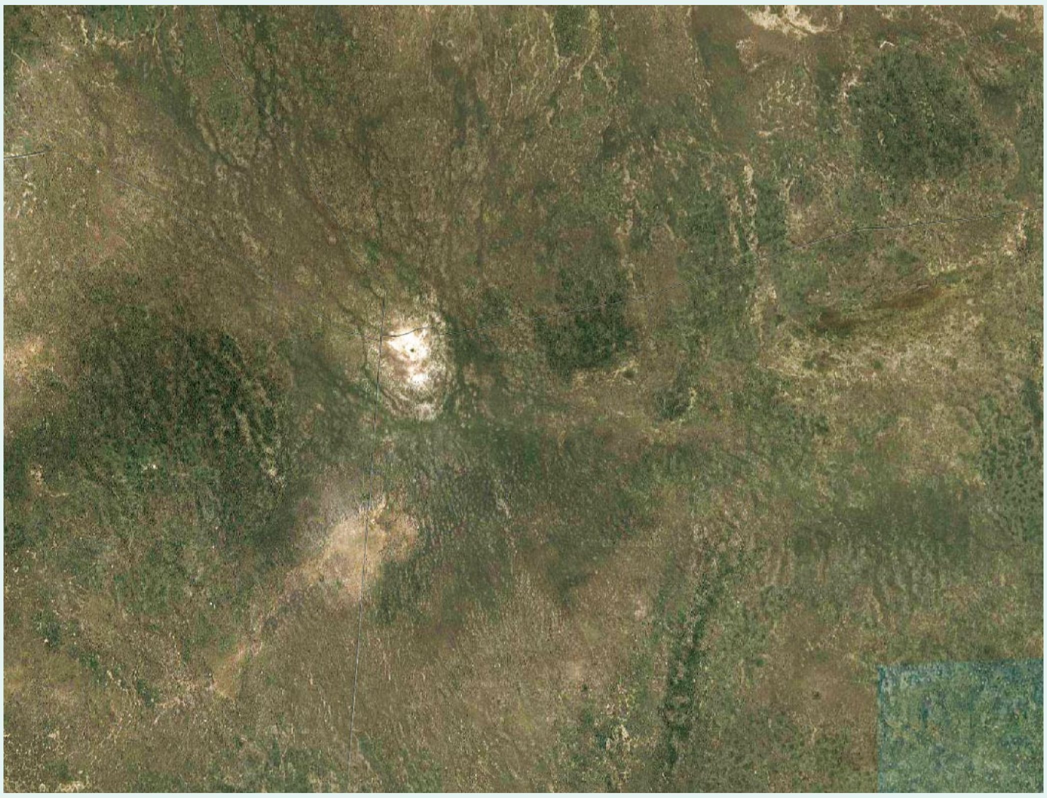
This is one of the springs near Okashana on the Andoni Plains just north of Etosha National Park. The slightly brackish water it offers quenches the thirst of many cattle, springbok, blue wildebeest and other animals that graze here in King Nehale Conservancy. The amount of water that gushes out of this fountain hardly varies.

One of many small springs that bring life to the extremely parched landscapes in southwestern Namibia. This is Kaukasib, a spring southeast and inland of Lüderitz in the Tsau ǁKhaeb (Sperrgebiet) National Park.

Groundwater, a vital hidden resource

Groundwater is a critical water resource for Namibia, and during periods of low rainfall it becomes all the more important. Much of it is now pumped from deep aquifers, but water from springs and hand-dug wells has been a vital source of water in Namibia's interior for aeons. But groundwater has become particularly valuable over the past 130 years as Namibians established themselves in permanent homes and villages across the country, often far from any other water source.

Not all groundwater resources are equal though – there is a great deal of variation in their availability and quality. Some are plentiful and fresh, while others are brackish, dry up intermittently or are difficult to reach. Hidden from view, groundwater remains somewhat intangible and poorly understood by many of us. Our understanding of how much there is in an area, how deep it is, where and how it is recharged and how to safely and sustainably abstract it requires a good knowledge of geology and aquifers, and long-term monitoring.

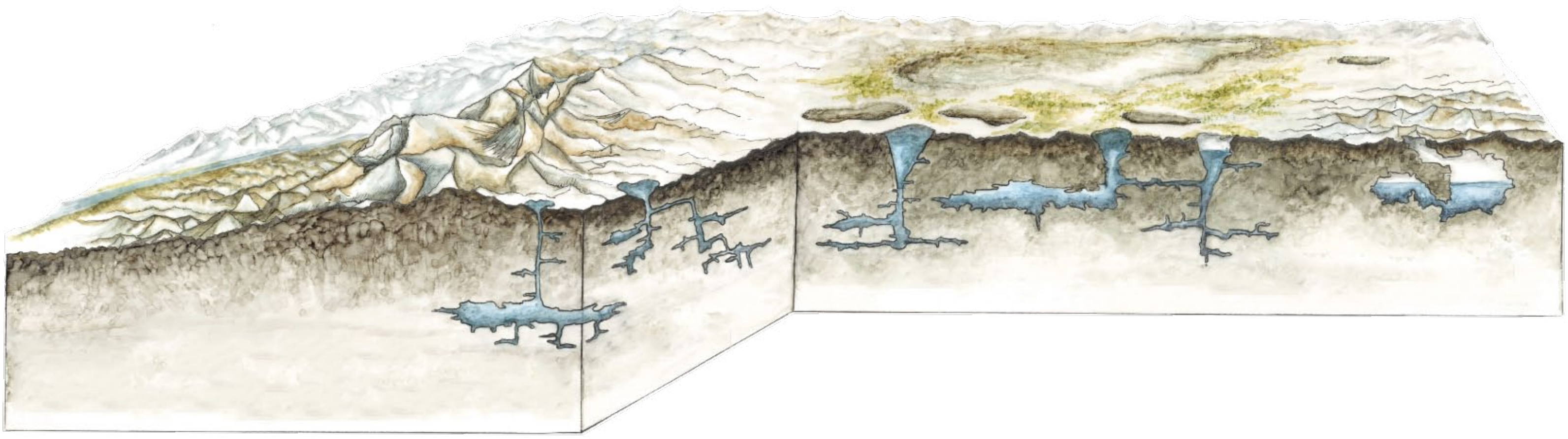


Artesian springs bring groundwater to the surface. Some, such as the one here at Gobaub in Etosha National Park, have probably supplied water for tens of thousands of years to wildlife and people living in a vast surrounding area. Attracted by the water, concentrated activity has led to the clearing of vegetation around the Gobaub spring, for example by elephants that trample plants and often push over trees. This makes Gobaub visible from hundreds of kilometres above Earth. The actual spring is the tiny black point in the centre of the pale bare area, which has a diameter of about 500 metres. [19.31° S, 16.42° E]

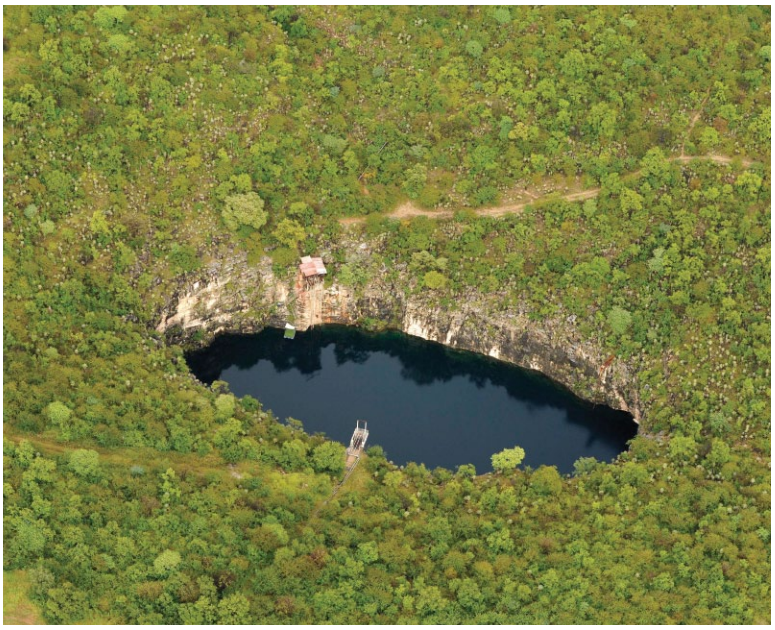
Types of aquifers and their productivity

Below a certain depth, the water table, all pores and other open spaces are normally filled with water in zones called aquifers of which there are two main types. Porous aquifers hold their water in tiny spaces or pores between grains of sand, gravel, sandstone or conglomerates, while fractured aquifers hold water in gaps where hard rocks are jointed, dissolved or broken (figure 4.12). Certain types of rock dissolve in contact with this groundwater widening the gaps and forming underground caves, some of which hold subterranean lakes. The rich aquifers in the karstveld are formed in such rocks. Sometimes, one aquifer, separated by an aquiclude, overlays another; examples are the Ohangwena aquifer that straddles the border between Ohangwena and Angola, and the Auob and Nossob aquifers in the Stampriet–Aranos area. The characteristics of these vertically separated aquifers and the water they contain can differ substantially.

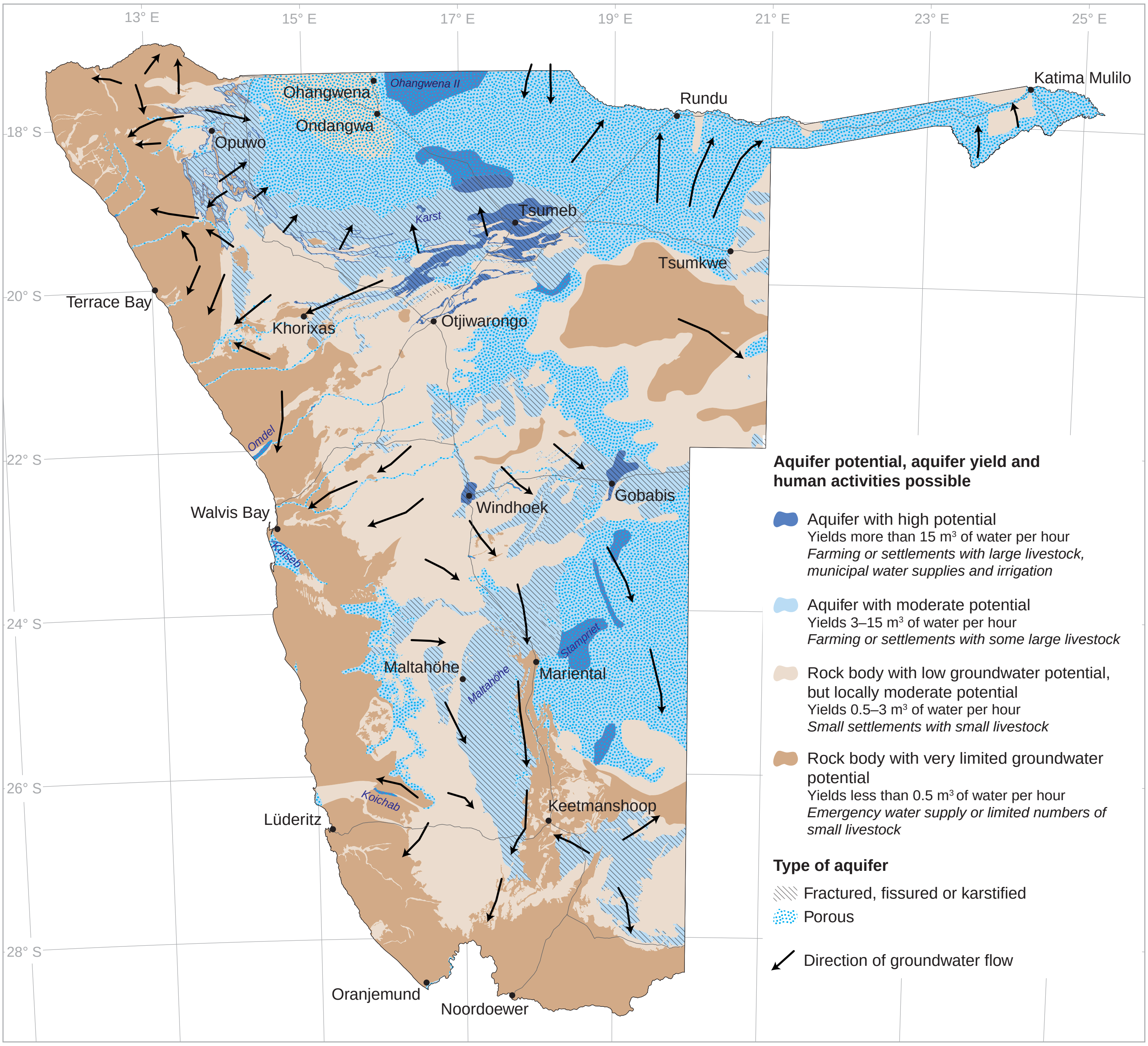
Groundwater, like surface water, generally follows gravity by flowing from higher to lower levels. Along the way, salts dissolved from the surrounding rock or soil are picked up. The underground movement of water is, however, typically very slow. For example, groundwater takes an estimated 15,000 years to travel a distance of 15 kilometres from the Auas Mountains just south of Windhoek to the hot spring near the Alte Feste in central Windhoek (page 144). Water in this spring has a temperature of 80 degrees Celsius, not far below boiling point, which suggests that it has probably been circulating 2–3 kilometres below the surface. Rainwater that falls in one area may therefore recharge aquifers further down the catchment, and possibly far away, even across international borders. The management of aquifers then becomes the responsibility of more than one country.



The rich karst aquifers found around Tsumeb–Otavi–Grootfontein are in carbonate-rich rocks, such as dolomite and limestone. These rocks are dissolved by groundwater along existing joints and fractures, creating large openings and underground lakes over time such as those shown in this diagrammatic cross-section. This karst rock formation encircles southern and western Etosha and stretches up to Namibia's north-western border. Several springs on the edge of Etosha Pan are fed by water that seeps along joints of the Karstveld.



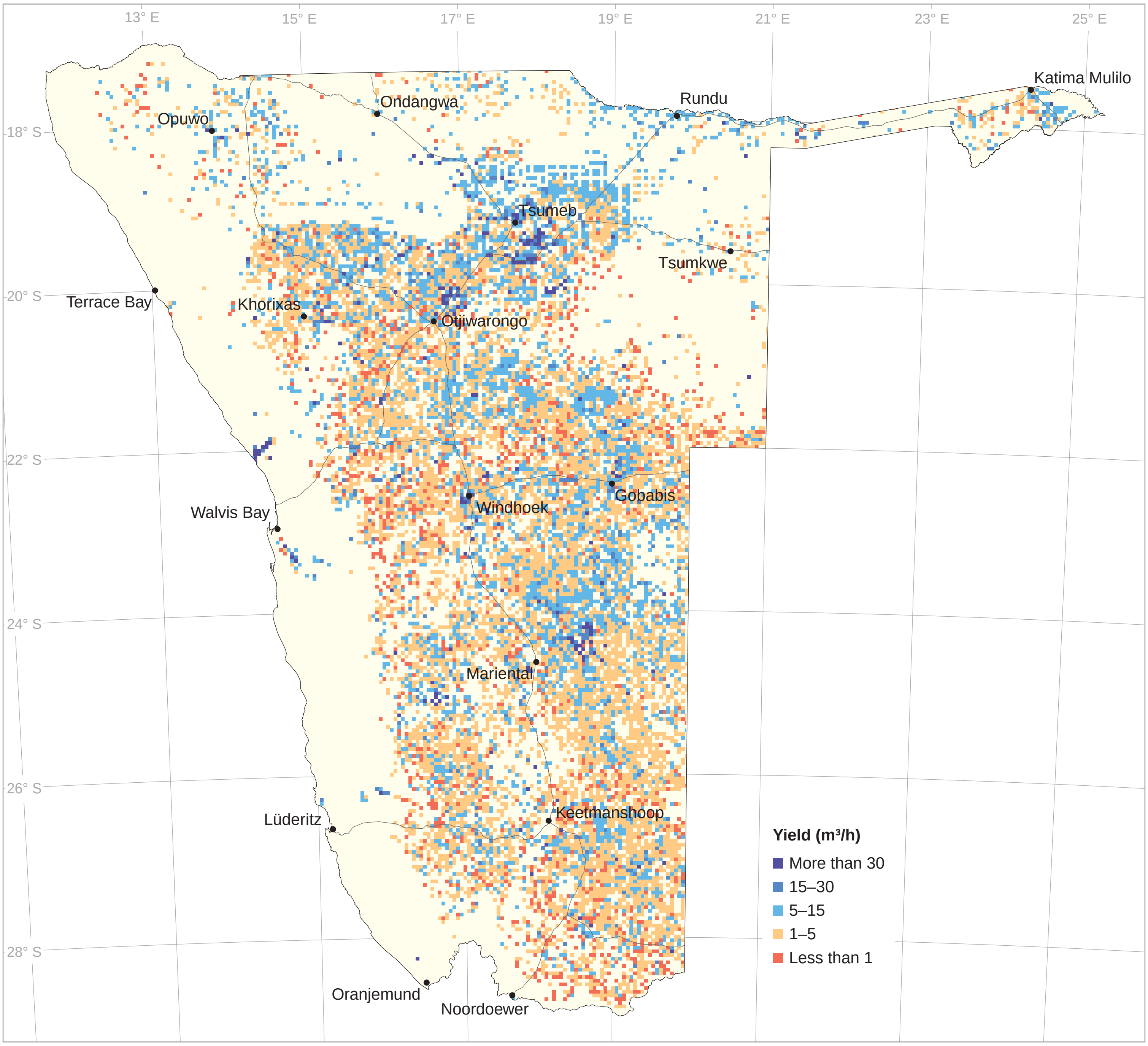
Seldom can we see water in an aquifer. Two exceptions are at Lake Otjikoto (left) and Lake Guinas (right) where the natural dolomite and karst rock roofs have collapsed to reveal underground lakes of water. To help understand this groundwater resource, water levels at Otjikoto have been monitored over the past 50 years (figure 4.14).



4.12 Major aquifer types, supply potential and direction of groundwater flow[12]

This map provides a view into a different aquatic world, one that is invisible underground. Water is stored in porous and fractured aquifers; some hold very modest amounts of water, while others have an abundance that is hard to imagine in such an arid environment. Among Namibia's richest aquifers are the karst, Koichab, Kuiseb, Maltahöhe, Ohangwena II, Omdel, Stampriet and Windhoek aquifers.

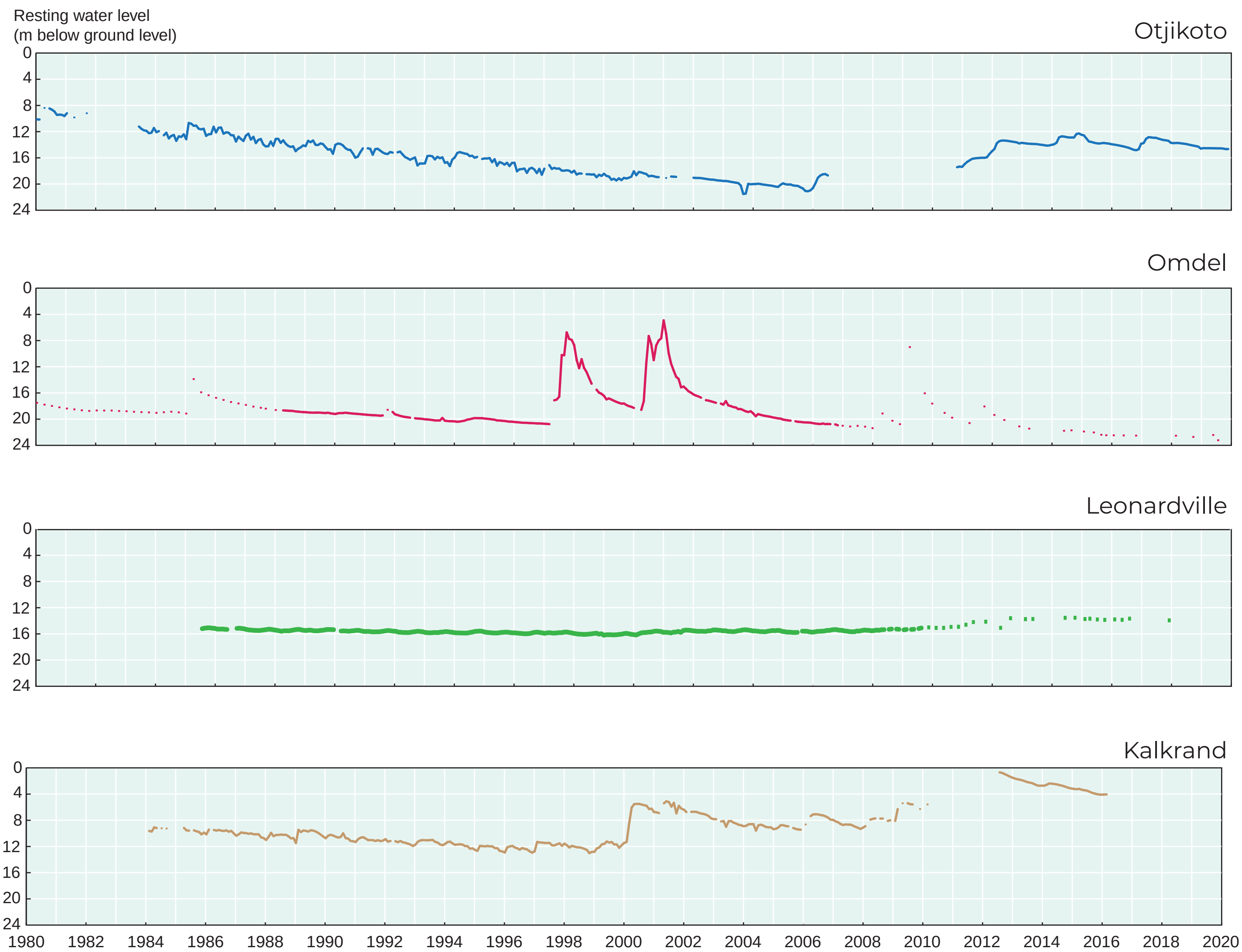
Significant volumes of water lie beneath the riverbeds of certain ephemeral rivers. This is true of the Kuiseb River which supplies Walvis Bay and Swakopmund with water pumped from its shallow aquifer at Rooibank. The Kuiseb also stops the northward march of Namib dunes (right) onto the gravel plains (left).

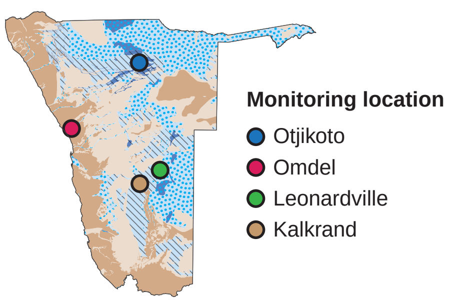


4.13 Borehole yields and their distribution[13]

Over the years, huge numbers of boreholes have been drilled in the search for water; the yields measured at the time of drilling are shown here. There is a high degree of local variation in the productivity of boreholes, especially in fractured aquifers. One borehole can tap into a small, rich aquifer, while others nearby yield little water. Nonetheless, even a relatively low yield of 1 cubic metre of water per hour may be adequate to supply a small village. Boreholes with yields of 15 cubic metres per hour or more can supply enough water to irrigate large fields or supply bulk water to towns, assuming that the aquifers tapped are regularly recharged.

The distribution of boreholes across Namibia is also reflected in this map. Most boreholes have been drilled on private farms. The comparative scarcity of boreholes elsewhere is due to several factors: the depth or salinity of the groundwater; high installation and operation costs; the presence of better sources of water; and, in some cases, the low priority given in the past to water supply in sparsely populated communal areas. The small number of boreholes in the Cuvelai, for example, is due to the salty deeper groundwater in that area, which is unsuitable for most uses, and which led to the development of supplies of clean, piped water from the Kunene River (figure 4.21).





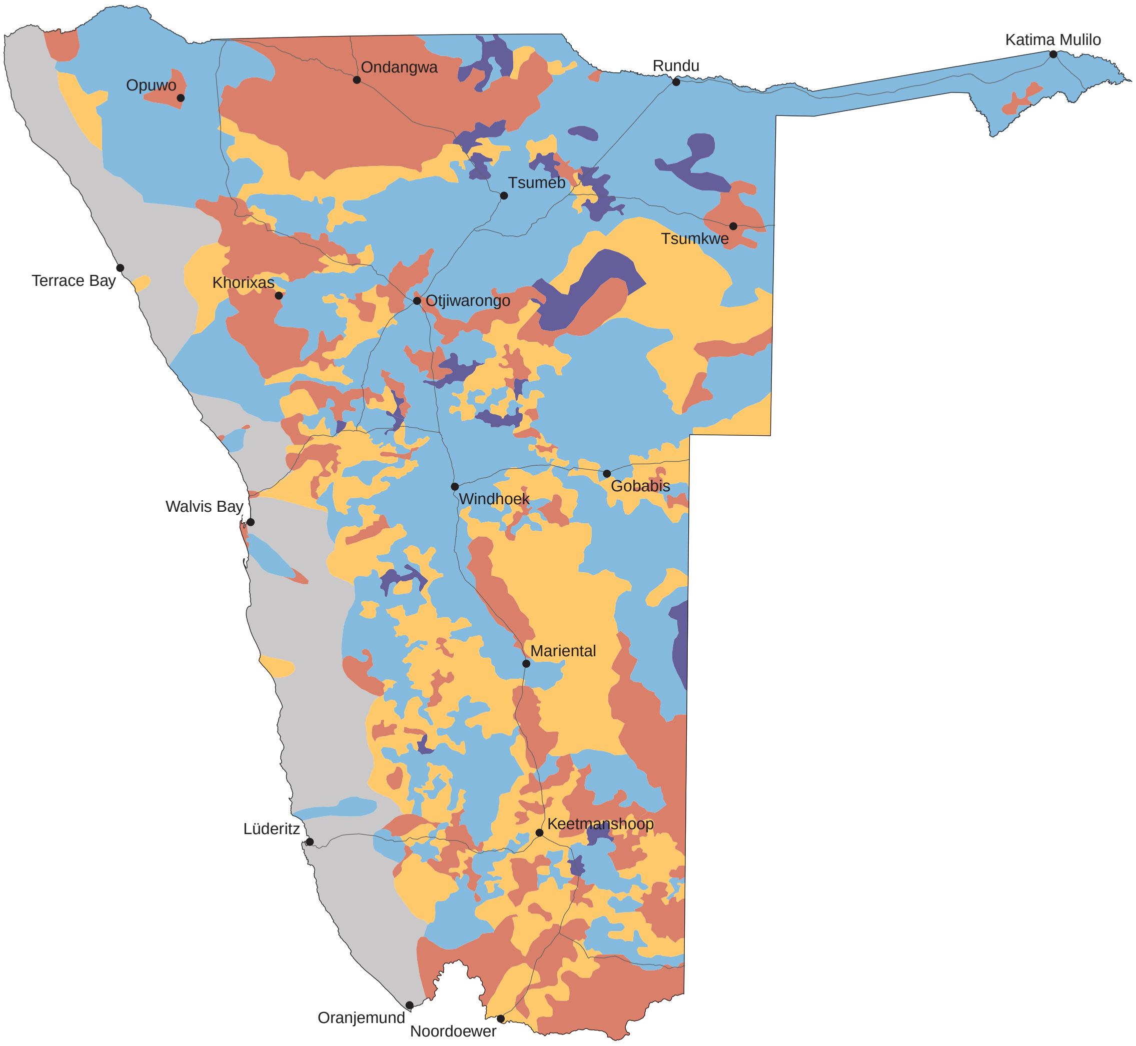
4.14 Monitoring groundwater levels[14]

Groundwater levels are regularly measured at selected monitoring boreholes around the country to determine water volumes and rates of recharge of these hidden resources. The graphs here show examples of how groundwater levels fluctuate from month to month, year to year and over much longer periods. Whilst the level of water below the ground at Leonardville remains fairly constant, elsewhere it changes quite dramatically. A drop in water level to greater depths below the surface may indicate that the rate of abstraction is higher than the rate of recharge. Depending on the characteristics of the aquifer, it may respond quickly even to small rainfalls, whilst the level of water in another aquifer might only show a change in water level after a number of good rainy seasons, such as those between 2000 and 2011.

Recharge of the aquifer under the delta of the Omaruru River (Omdel) has been enhanced by the building of an embankment wall across the river, which traps the water so that it can sink into the sand and aquifer below. Yields increased from 2.8 to 4.6 million cubic metres per year after this dam was built,[15] but the aquifer is only recharged when substantial flows come down the Omaruru River, as happened in 1997, 2001 and 2009. A more sophisticated way of recharging the Windhoek aquifer has recently been introduced, which involves pumping treated water piped from Von Bach Dam into the aquifer (page 144).

The reliability and long-term sustainability of boreholes depends on them being recharged at rates equal to or greater than the rates of abstraction. Land degradation reduces aquifer potential in different ways. For example, the loss of plants and erosion of topsoil accelerates runoff and increases soil compaction, thereby reducing infiltration and groundwater recharge (top). Invasive bush (middle) and alien plants often use greater amounts of soil moisture and groundwater than natural vegetation, thus reducing the availablilty of water for other uses.

In central-northern Namibia, two types of hand-dug wells have long been used to access shallow groundwater. Water is winched up in buckets in eendungu wells that can be as deep as 20 metres and are only dug in soils that are stable and firm (left). Shallower omifima wells are seldom deeper than 3–4 metres and typically cone-shaped because they are dug in loose sand (right). These omifima are often in clusters, many of which are clearly visible in Bing or Google Earth images.

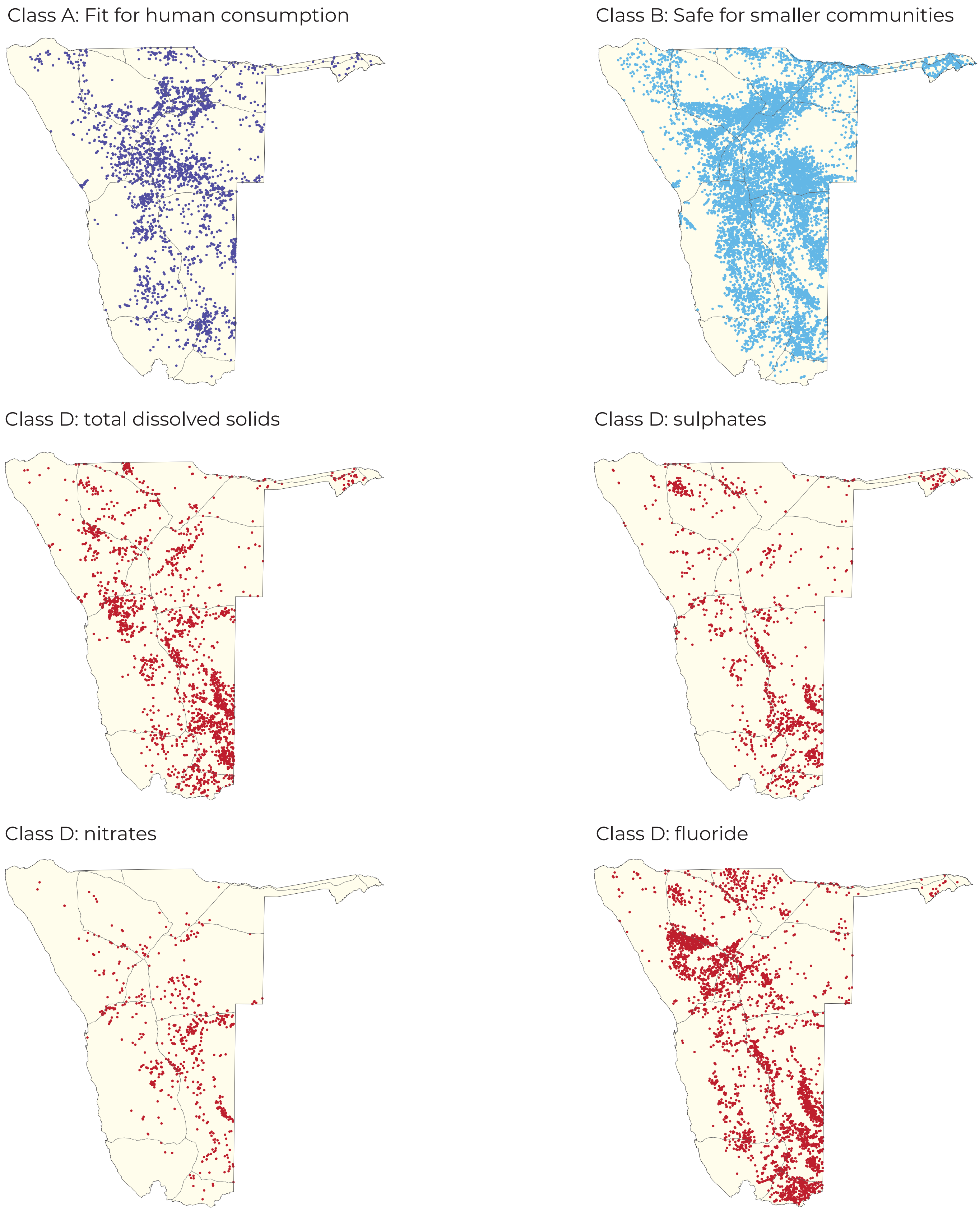


Water quality classification	Concentration (mg/l)			
	TDS	SO_4	NO_3	F
A: Fit for human consumption	0–1,000	0–100	0–6	0.7–1.5
B: Safe for farms and small communities	1,001–2,000	101–300	6.1–11	0–0.69
C: Usable for animals	2,001–5,000	301–1,200	11.1–110	1.51–2
D: Not suitable for any drinking water	>5,000	>1,200	>110	>2
Limited or no information				

4.15 Groundwater quality[16]

The chemical quality of groundwater varies greatly across the country and is largely determined by the type of rocks through which it has passed. However, the quality of water may also be changed by recharge, abstraction or pollution. In this map groundwater quality is disaggregated into four classes of drinking water.[15] Class A indicates that the water has low concentrations of ions and total dissolved solids, and is fit for human consumption; this is the case in just small pockets of the country. Class B is regarded as safe for farm use and for small groups of people. Class C can be used to water animals, but requires treatment or dilution for long-term human consumption; while Class D is not suitable for drinking.[17] Water quality data are not available for the remaining 12.3 per cent of Namibia. The most frequently measured chemical parameters of water quality, which are assessed using the Namibian Water Quality Standards values (in milligrams per litre) shown in the table, are total dissolved solids (TDS), sulphates (SO_4), nitrates (NO_3) and fluoride (F).

It is important to note that this map illustrates the general pattern of water quality. In almost all areas there are exceptions (figure 4.16). For example, some boreholes might deliver Class D water in an area where Class A water is the norm. The converse is true where Class D water predominates, but some boreholes deliver groundwater fit for consumption.



4.16 Boreholes and groundwater quality[18]

While boreholes delivering water fit for consumption (Class A or Class B) are widespread, there is also a high degree of local variation in quality – often from one borehole to the next. One or two chemical properties are often responsible for making the water of certain boreholes unsuitable for human consumption. These four maps each show the distribution of boreholes found to have high, Class D levels of one of four chemical properties that are routinely measured: total dissolved solids (TDS), sulphates (SO_4), nitrates (NO_3) or fluoride (F).

Total dissolved solids is a measure of the combined concentration of dissolved substances, especially inorganic salts containing calcium, magnesium, potassium, sodium, carbonates and chlorides. High concentrations of sulphates in drinking water can cause diarrhoea and dehydration. Water with a high nitrate concentration may impair the transport of oxygen in the blood, especially in small babies. Excess amounts of fluoride can lead to fluorosis, which can cause mild conditions, such as stained and pitted teeth, or even severe crippling skeletal conditions.

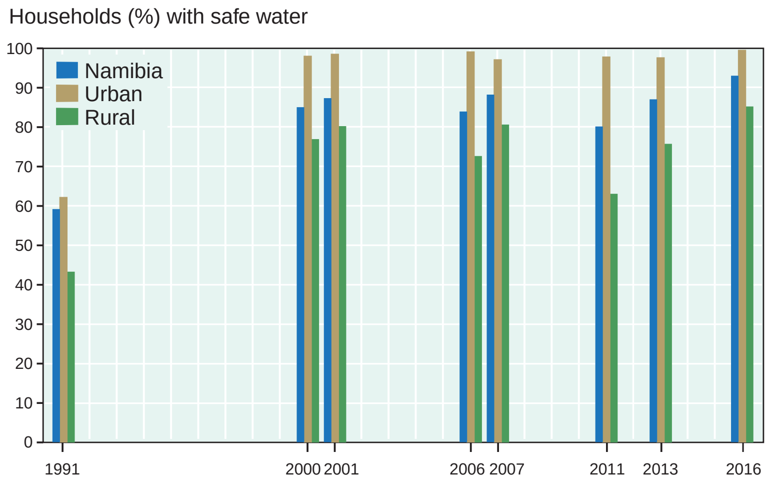
Water access, demand and supply

Two realities make supplying water in Namibia a challenge. First is the general scarcity of water due to high evaporation (page 102) and low rainfall (page 88). Second is because many people are concentrated in areas (page 300) far from where sufficient water is naturally available. Water is thus often transferred over considerable distances, making its supply an expensive undertaking.

To meet the challenges of supplying water in Namibia a range of unconventional sources are used, such as desalinated seawater, and wastewater that is treated for irrigation and purified for drinking, and the artificial recharge of Windhoek's aquifer by injecting treated water from Von Bach Dam. As far back as 1968 Windhoek became the first major urban centre in the world to introduce direct potable reclamation whereby treated wastewater is sufficiently purified to be reintroduced directly into the pipes supplying drinking water. Treated wastewater is also used for irrigation and landscaping in Windhoek, Otjiwarongo, Swakopmund, Walvis Bay and in other smaller centres. Desalinated seawater produced near Wlotzkasbaken is supplied to Swakopmund, Walvis Bay, Arandis and some of the larger uranium mines in Erongo.

Groundwater is the most widely used water source in Namibia, and is the only water used by many farms, villages and smaller towns. It is also used to supply all the water used by some larger towns such as Grootfontein, Tsumeb, Otjiwarongo, Lüderitz and Henties Bay, and groundwater contributes substantially to the overall supplies to Swakopmund, Walvis Bay, Arandis and Windhoek. However, most of the 55,000 boreholes that have been drilled across the country to explore for underground water and better understand this resource are either dry or only adequate for farm use or small villages. All of these boreholes, windmills and other pumps are testimony to the hard work of geohydrologists, drillers and farmers to bring groundwater to places which would otherwise be hard to occupy.

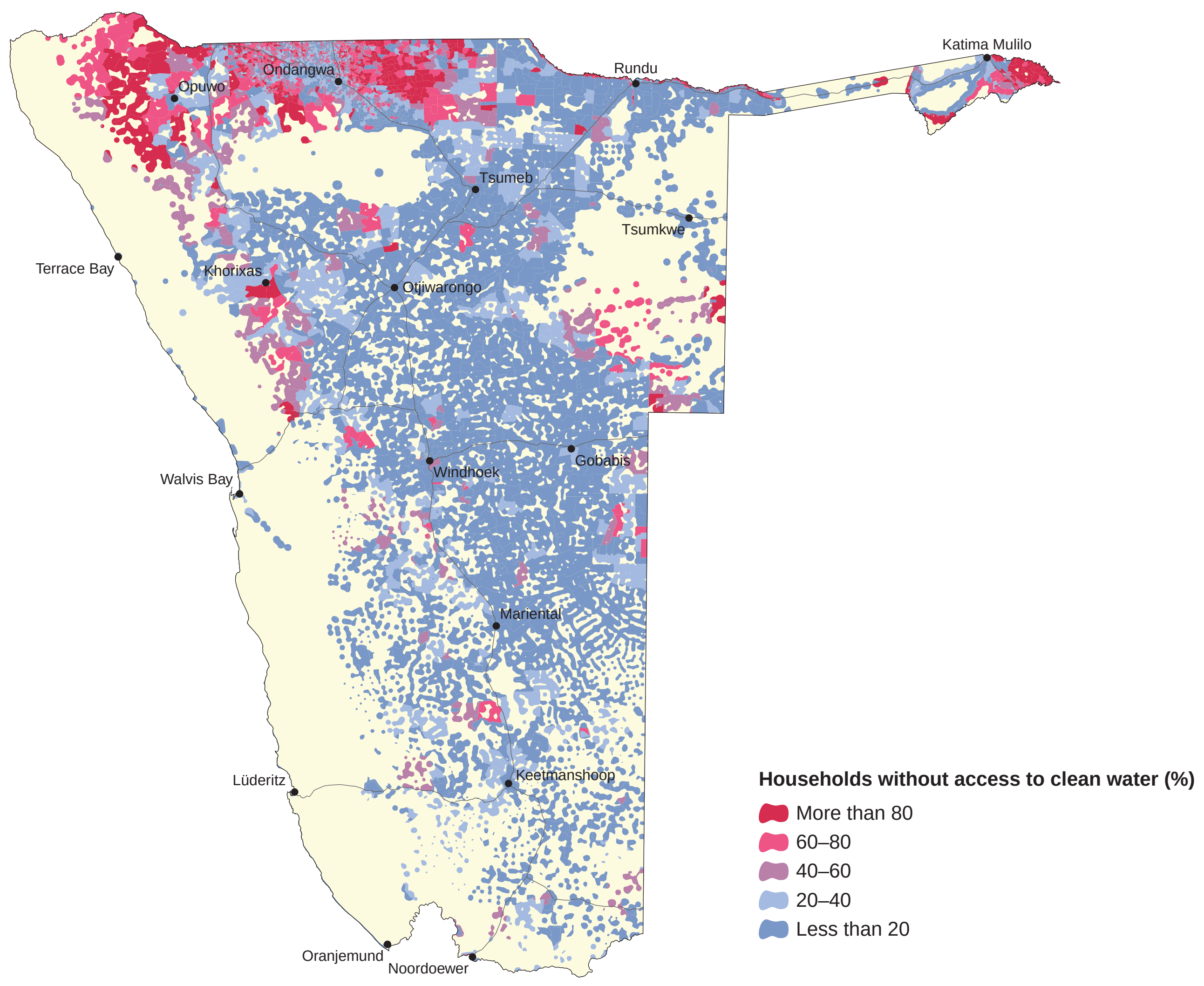
Access to water



4.17 Access to clean water since 1991[19]

The supply of clean (i.e. potable) drinking water has increased significantly in recent decades. In 2011, 80 per cent of households were estimated to have access to safe drinking water, up from 60 per cent at independence in 1991. By 2016, 94 per cent of Namibian households were estimated to have access to potable water.

In 2011, a much higher proportion of households in urban areas (98 per cent) had access to safe drinking water than those in rural areas (63 per cent). Access improved further by 2016, at which time 99 per cent of urban households and 85 per cent of those in rural areas had access to safe drinking water.



4.18 Access to clean water, 2011[20]

While the graph in figure 4.17 gives absolute values, this map shows that households in some areas were not as well served as others. In certain areas of Namibia more than 80 per cent of households did not have access to safe drinking water in 2011. These were largely in rural areas in northern Namibia, especially in the northwest and far northeast of the country. There are also isolated areas in the central east and the south where 40 per cent of households or more did not have access to clean water. Population densities in these areas are relatively low and households are reliant solely on groundwater. This is also the case in the southern portions of Omusati and Oshana, and in eastern Ohangwena.

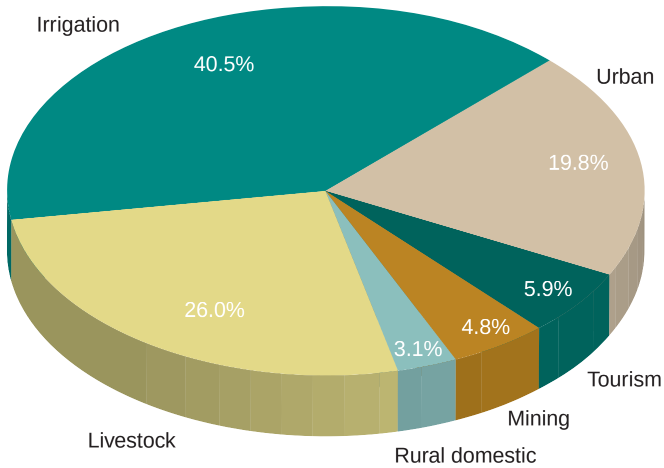
Water demand

Demands on water steadily increase as Namibia's population and industrial, agricultural and service sectors grow. Meeting these needs in a country as dry as Namibia requires the development and use of a range of different sources, management strategies and innovative methods to harvest, conserve, treat and reuse water. An additional challenge comes from the substantial recent increase in urbanisation (page 299), to which Namibia has yet to become accustomed. However, water supplies focused on these centres of growth and development can be provided more economically and effectively than those in rural areas, and urban-based economic activities usually give a higher return per cubic metre of water than those in rural areas.

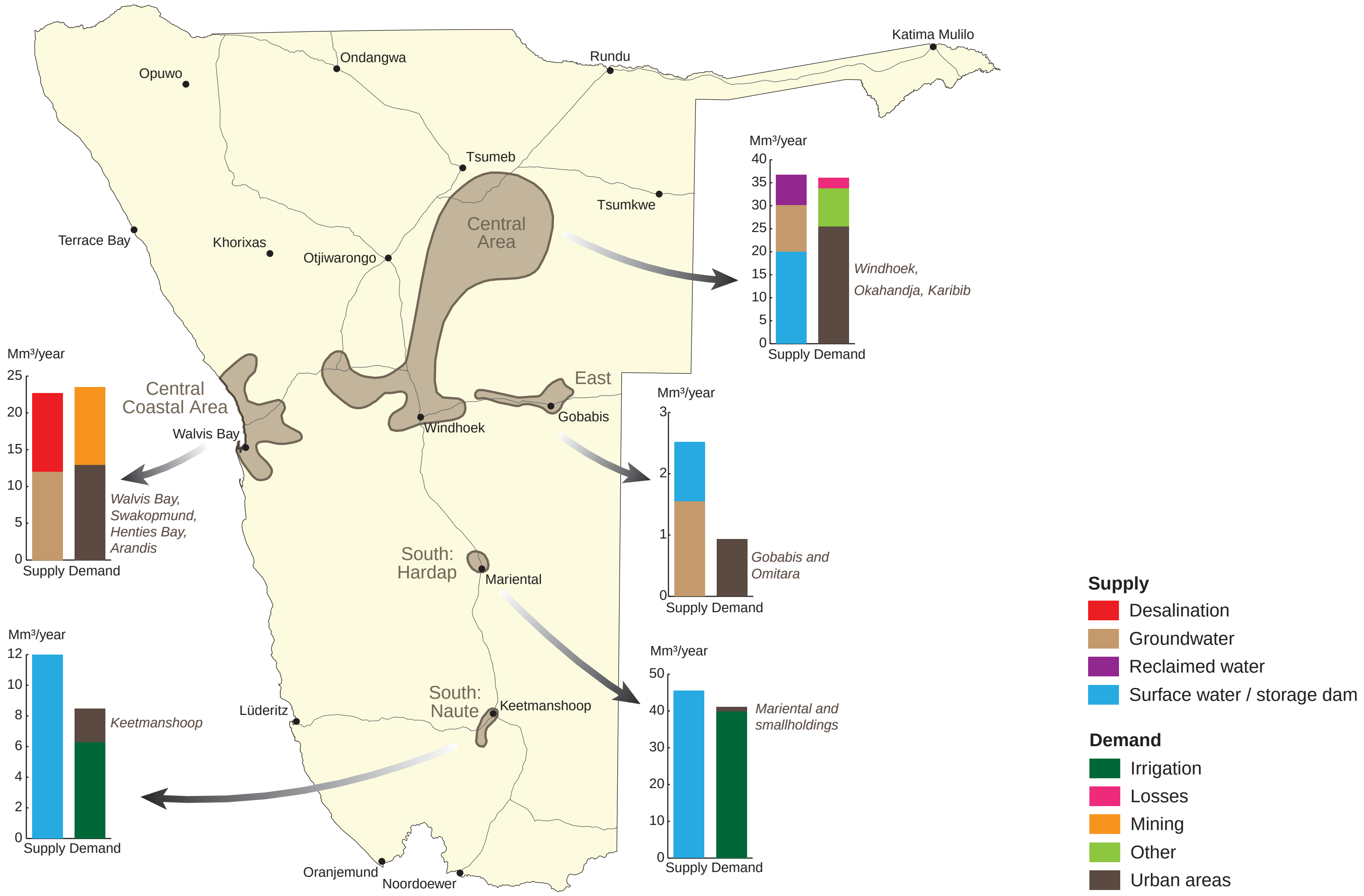
4.19 Water demand by sector, 2008[21]

From an estimated 334 million cubic metres in 2008, Namibia's total water consumption is expected to more than double to 772 million cubic metres by 2030. Irrigation is by far the largest water user, accounting for more than 40 per cent of use in 2008, followed by livestock farming (26 per cent) and urban use (domestic, industrial and other use) at 20 per cent, whilst mining accounted for less than 5 per cent of total use.

Different uses of water deliver quite different benefits, however. For example, each cubic metre of water used to irrigate commercial crops is estimated to return N$0.55, but a cubic metre of water used for commercial livestock farming returns N$18. Other uses of water are estimated to produce average returns of N$261 for manufacturing, N$127 for mining and N$552 for services per cubic metre of water.[22]



This canal carries water across central-northern Namibia from the Calueque and the Olushandja dams to Oshakati. Water from this canal is treated and then piped across the region to supply about 35 per cent of Namibia's population, as well as enterprises and services in several major towns (figure 4.21).



4.20 Matching supply and demand[23]

Namibia's aridity and its battle to supply water to its widely distributed population is well known. However, the struggle is most difficult in certain areas, especially in and around urban centres where the demands for water increase rapidly and supplies may fluctuate or be inadequate. This map focuses on five areas where supply and demand is hardest to match in the long term.

Surface and groundwater sources cannot sustainably satisfy demands in the Central Area indicated on this map due to years of drought and increasing needs for water. Such circumstances require the reuse of water, the acquisition of water from elsewhere, reductions in demand, and/or water-saving measures.

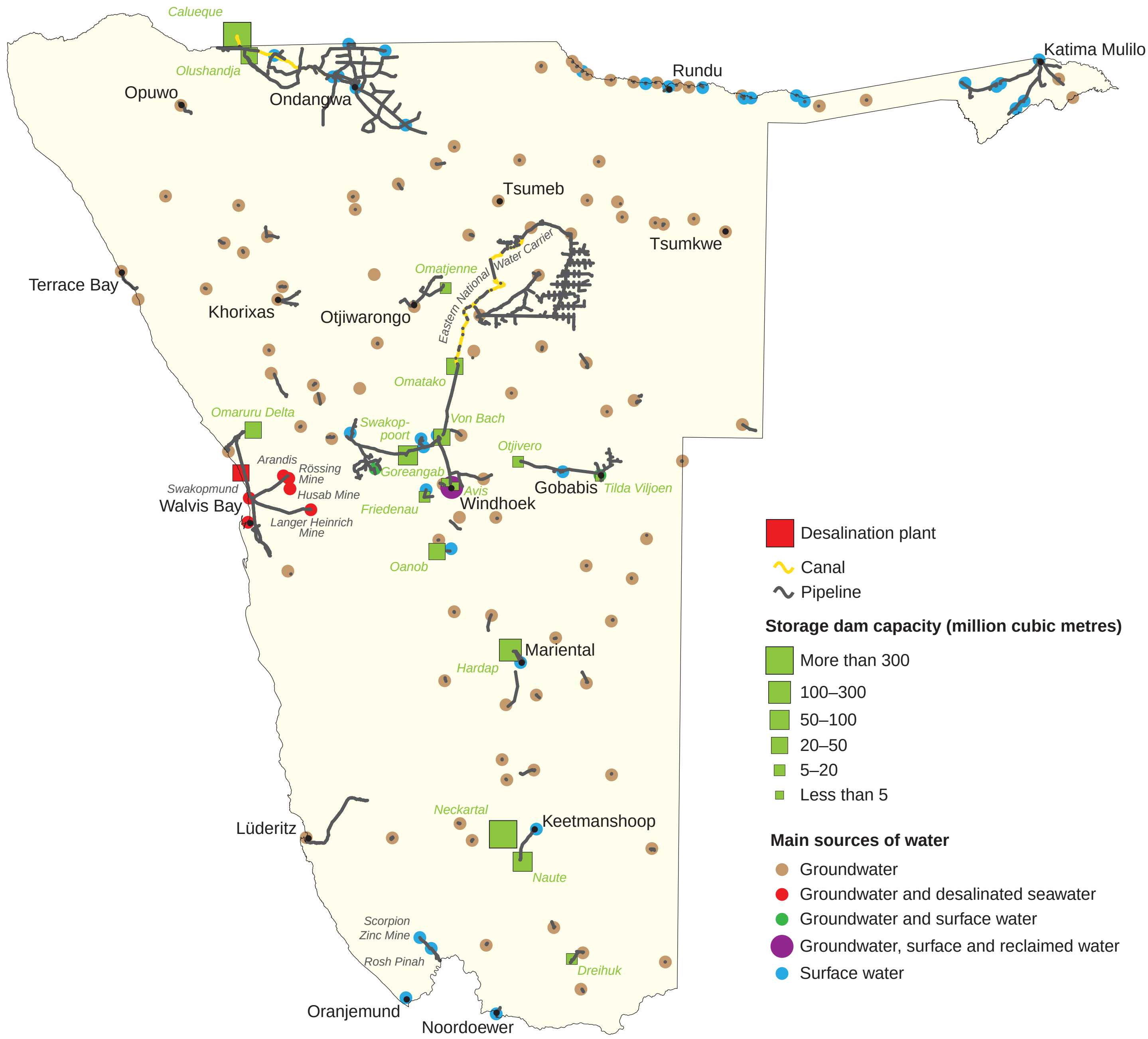
At the time of publishing this atlas, urban demands in the Central Coastal Area slightly exceeded yields from the Omdel and Kuiseb aquifers. Desalinated seawater makes up the deficit, and also supplies all the water used by the uranium mines in the area. In the longer term, it is expected that water reuse and additional desalination of seawater will dominate supply in this area.

Whilst groundwater sources could meet the East's urban demands in Gobabis, dammed surface water is supplied first when it is available to maximise its use before it is lost to evaporation. Groundwater is thus conserved for later use and for local farmers reliant on it. Demands can therefore be met from different supplies at different times, but only if rainfall provides adequate amounts of surface water.

Water consumption for irrigation is considerably higher than other uses in the South in both the Hardap (Mariental) and Naute (Keetmanshoop) supply areas. While these areas may not appear to be water stressed, water shortages do occur when rainfall and runoff is low in the catchment areas of the two dams. How supply and demand will change when Neckartal Dam (figure 4.22) and its associated irrigation scheme become fully operational remains to be seen.

A relatively unlimited, but expensive, supply of desalinated water is available on the coast. This is the Erongo Desalination Plant 35 kilometres north of Swakopmund, and the first of its kind in Namibia.

Water supply

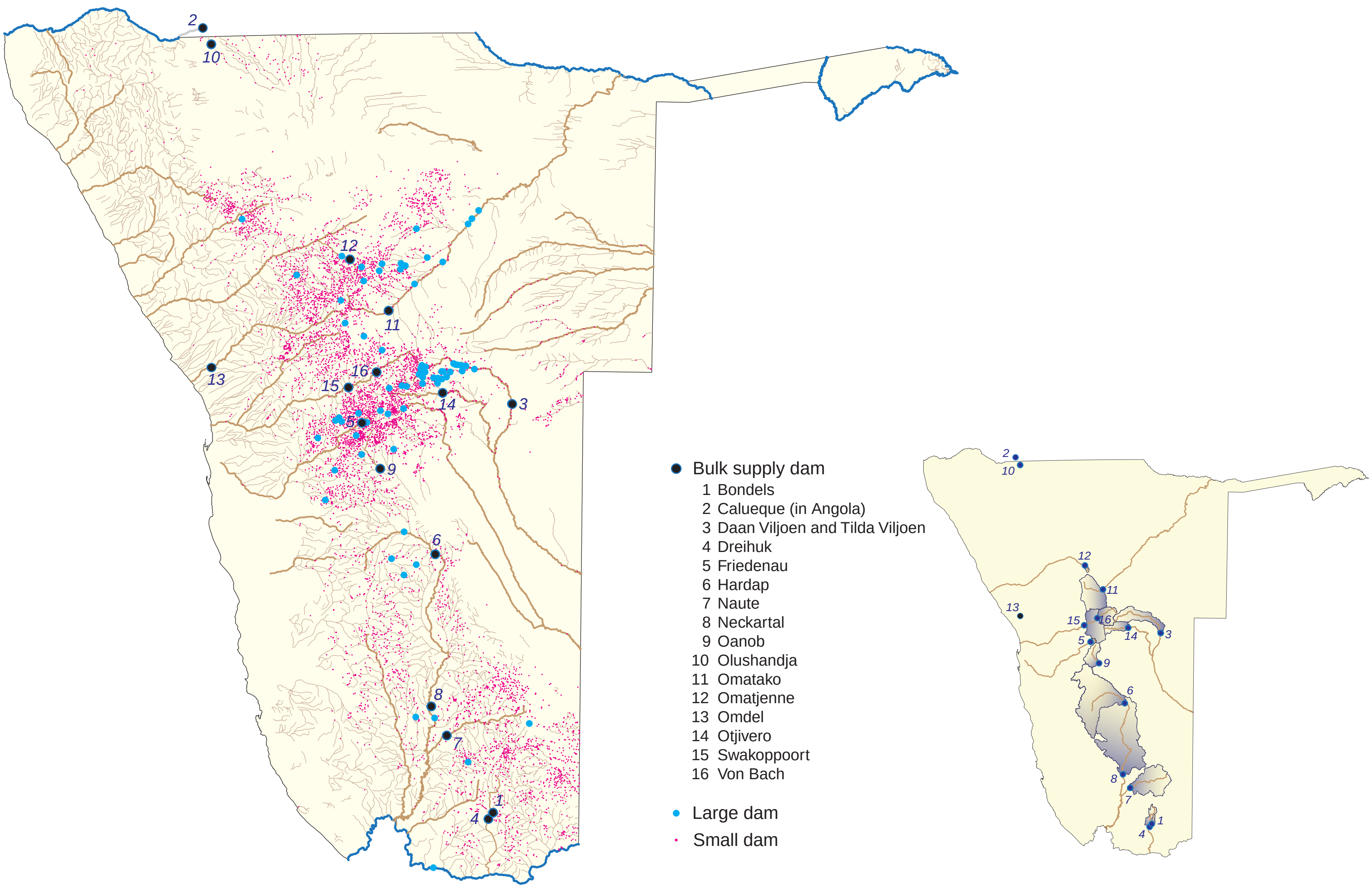


4.21 Bulk water supply sources and schemes[24]

Namibia Water Corporation Ltd (NamWater), the publicly owned national bulk water supplier, is responsible for supplying most Namibians with potable water. NamWater establishes schemes drawing on dams, rivers, groundwater and desalinated water to supply water in bulk via pipelines and canals to where it is required. It sells the water to local authorities, which in turn sell water to residents and commercial users in urban areas, and to the Ministry of Agriculture, Water and Land Reform, which in turn sells water to residents in rural areas, and directly to some large-scale commercial enterprises. Municipalities and the Ministry of Agriculture, Water and Land Reform often establish and run smaller schemes to complement NamWater's bulk schemes. Many farmers supply their own water from small dams, springs and boreholes. Ultimately, a considerable variety of conduits are used to distribute water to where it is needed: pumps in boreholes and rivers, desalination plants, dams, canals, pipelines, and mobile and stationary water tanks.

Dams

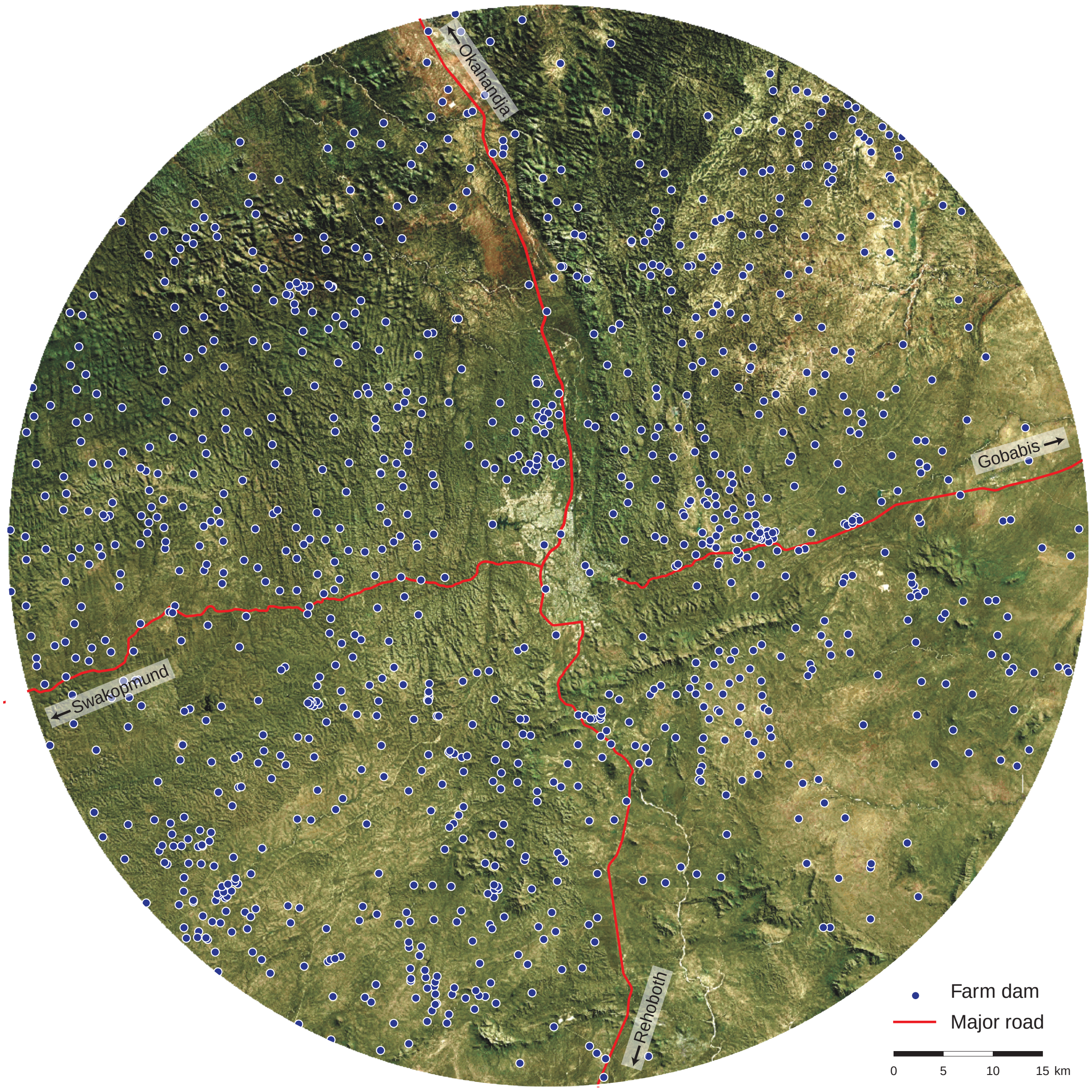
Namibia has thousands of dams, indeed almost 7,900 of them. All of them are on ephemeral watercourses. Most are small earth dams that store surface water for livestock and game on farms in a northwest–southeast swathe across the country. The deep sands in the Kalahari basin to the east and northeast are too flat and porous to collect and store much water, while low rainfall along the coast also makes building dams anywhere but along major rivers impractical. As a result, most of the dams are found in areas that have sufficient runoff and appropriate topography to store water in dammed impoundments.



4.22 Distribution of dams across Namibia[25]

Only a handful of dams are used to provide the public with potable water and water for industry and agriculture. Most other dams, especially the small ones, supply water for livestock and for some irrigation on private farms and in communal areas in the Cuvelai drainage system.

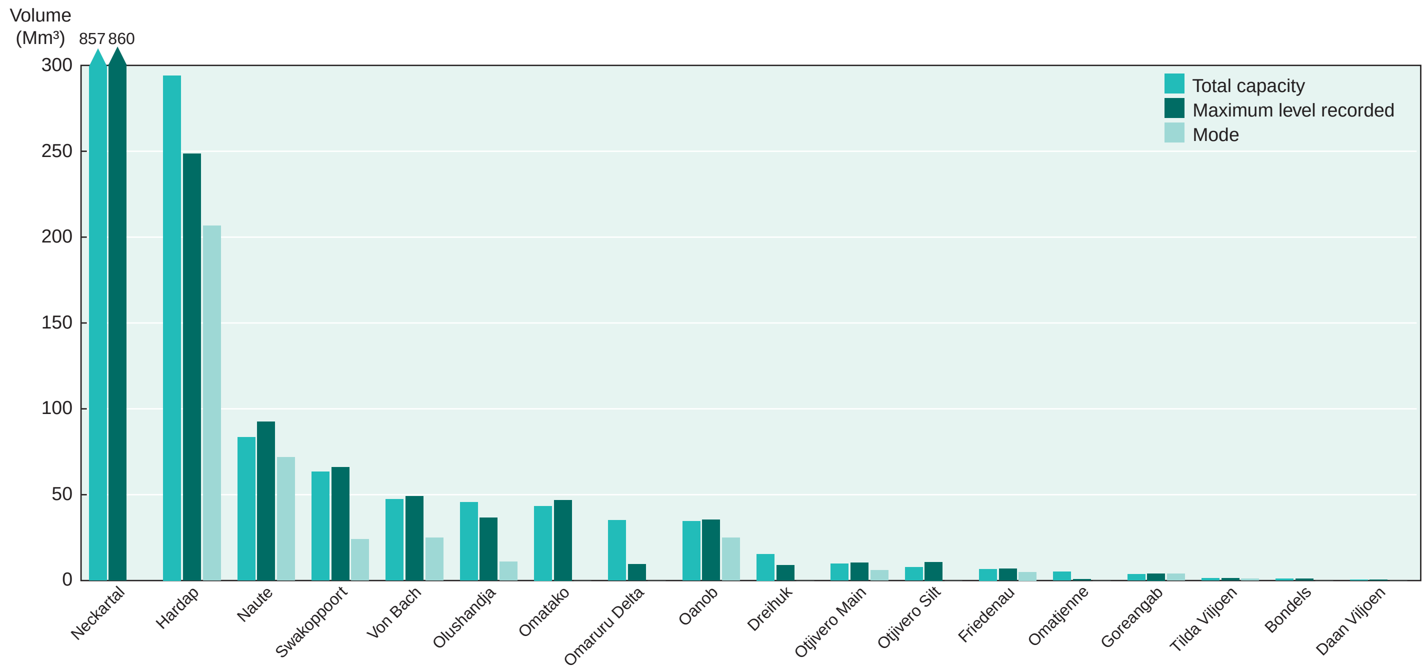
Water from the Omatako, Swakoppoort and Von Bach dams forms a vital component of supply to the central area of Namibia, whilst the Hardap and Naute dams supply irrigation schemes adjacent to them and the towns of Mariental and Keetmanshoop, respectively. The Otjivero silt and main dams, and the Tilda Viljoen and Daan Viljoen dams form part of the supply to Gobabis. The use of Neckartal, Namibia's largest and newest dam, is not yet clear.



4.23 Farm dams around Windhoek[26]

The greatest density of dams is around Windhoek, where 1,046 dams are within a 50-kilometre radius of the city, equivalent to an average density of one dam every 750 hectares. Most of these are used to provide water for livestock. Some are used to help recharge groundwater. The dams vary in surface area, and silting has reduced the storage capacity of many. The shallowest dams lose water most rapidly to evaporation.

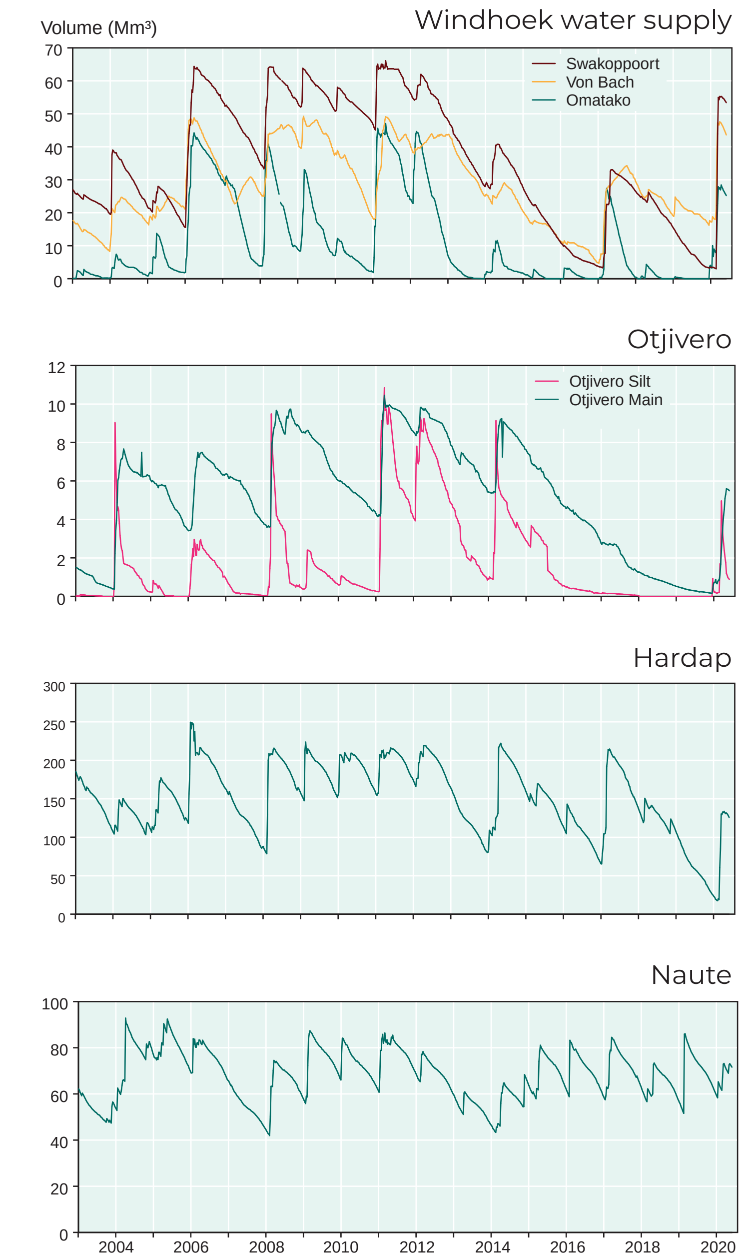
Small farm dams may overflow after good rains allowing other dams downstream to fill.



4.24 Key statistics of bulk water dams, 2003–2020[27]

Namibia's major dams differ significantly in terms of their size, how often they fill, and how long they hold water. The mode is the volume of water held and recorded most frequently, which may be zero in the case of dams that are empty much of the time, such as Omatako. Most of the dams have at some point or another exceeded their maximum capacity during recent years, and Mariental has been flooded in 1972, 1989, 2000 and 2006. However, Hardap is now managed so that it is never fuller than 70 per cent of its capacity to ensure dam safety and avert flooding of Mariental should there be a sudden inflow of water. Neckartal Dam was designed to provide water for 5,000 hectares of irrigation farming.

Dam	Year completed	Purpose	River	Catchment size (km²)	Surface area (km²)	Volume (Mm³)			
						Capacity	Maximum	Mode	Minimum
Neckartal	2019	Not yet in use; designed to supply an irrigation scheme	Fish	43,270	39.8	857.0	860.0	–	0.0
Hardap	1962	Water supply: Mariental and Hardap Irrigation Scheme	Fish	17,763	28.7	294.6	249.0	207	17.5
Naute	1972	Water supply: Keetmanshoop and Naute Irrigation Scheme	Löwen	8,675	1.5	83.6	92.7	72	41.9
Swakoppoort	1978	Water supply: Central area	Swakop	7,804	7.8	63.5	66.0	24	3.0
Von Bach	1970	Water supply: Central area	Swakop	2,958	4.9	47.5	49.1	25	4.7
Olushandja	1990	Storage of reserve water from Calueque in Angola	Kunene transfers from Calueque	–	29.0	45.6	36.7	11	1.8
Omatako	1981	Water supply: Central area	Omatako	6,845	12.5	43.5	46.9	0	0.0
Omaruru Delta (Omdel)	1984	Aquifer recharge: Coastal area	Omaruru	11,313	4.4	35.2	9.6	0	0.0
Oanob	1990	Water supply: Rehoboth and irrigation	Oanob	2,631	3.6	34.5	35.4	25	8.6
Dreihuk	1978	Water supply: Karasburg	Hom	1,594	3.5	15.5	8.8	0	0.0
Otjivero Main	1984	Water supply: Gobabis	White Nossob	2,023	1.5	9.8	10.4	6	0.2
Otjivero Silt	1984	Silt trap for Otjivero Main	White Nossob	2,023	3.6	7.8	10.8	0	0.0
Friedenau	1972	Water supply: Matchless Mine	Kuiseb	215	8.3	6.7	6.8	5	1.4
Omatjenne	1933	Aquifer recharge	Omatjenne	213	1.3	5.1	0.8	0	0.0
Goreangab	1958	Water supply for Windhoek when built; currently stores surplus from Gammams Wastewater Treatment Plant	Gammams	148	0.8	3.6	4.1	4	1.2
Tilda Viljoen	1958	Water supply: Gobabis	Black Nossob	5,391	0.2	1.2	1.23	1	0.0
Bondels	1959	Aquifer recharge: Karasburg	Satco	278	0.8	1.1	1.13	0	0.0
Daan Viljoen	1958	Augmentation for Tilda Viljoen	Black Nossob	5,390	0.2	0.4	0.45	0	0.0



4.25 Water volumes in four supply dams, 2003–2020[28]

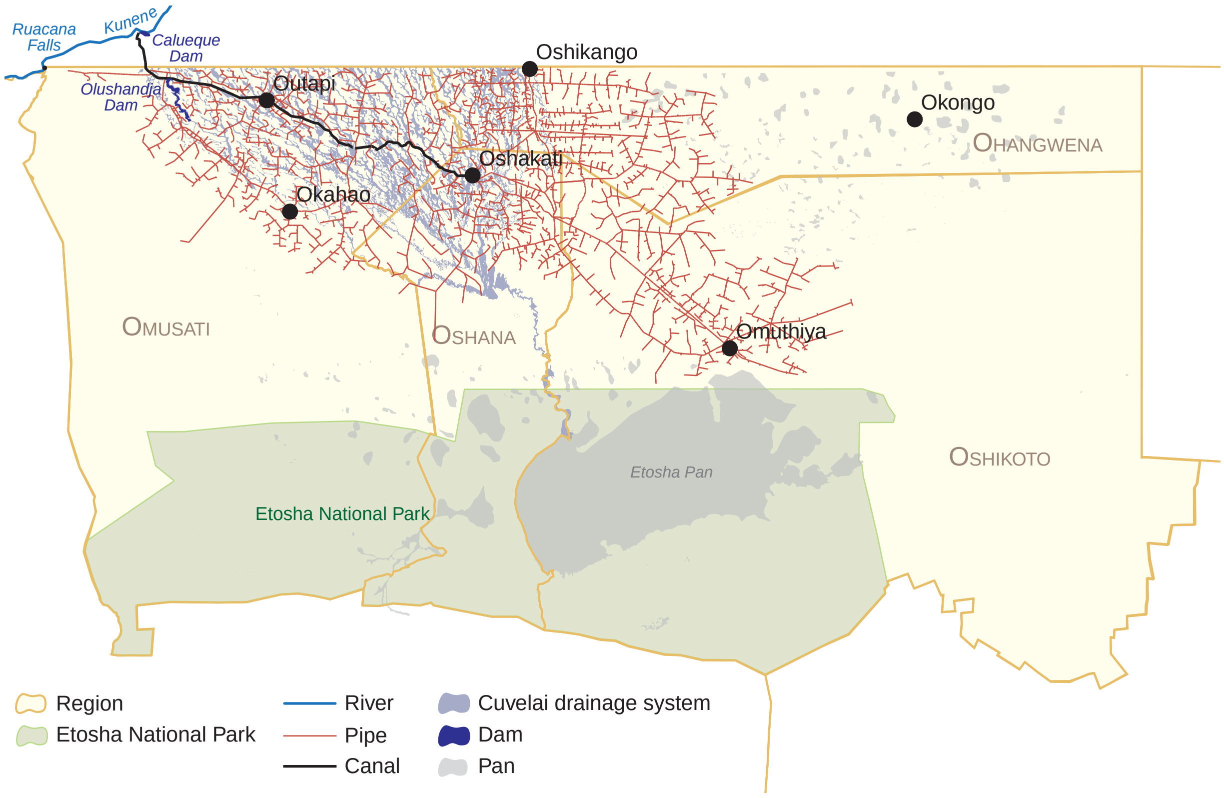
These graphs illustrate how the levels of some major supply dams have changed and varied from one dam to another. Whilst those with large catchments in areas of higher rainfall have filled quite regularly, others have only filled sporadically. Decreases in volume between years have depended on how much of the water was used, and on how much was lost to evaporation or underground seepage into aquifers.

While most dams function to store water for regular supply to consumers, others have been built for somewhat different purposes. Olushandja (above) is used as a long-term reserve supply of water for central-northern Namibia; it receives its water from the Calueque Dam on the Kunene River in Angola. The Omaruru Delta (Omdel) and Bondels dams are used to enhance aquifer recharge by trapping water over an area that allows water to percolate underground into aquifers where it cannot be lost to evaporation. Similarly, in good rain years, some water from Von Bach Dam is used to recharge the Windhoek aquifer. Many farmers have built smaller dams and berms to encourage local aquifer recharge on their farms too.

Most water from dams, if it is not pumped for use elsewhere, is lost to evaporation. For example, once the shallow Omatako Dam is full, up to 80 per cent of its total capacity can be lost in a year to evaporation from its large surface, while the deeper Von Bach Dam (seen above) would only lose around 24 per cent of its water. For this reason, much of the water from the Omatako Dam is pumped to Von Bach for longer-term storage. Transfers also occur from the Swakoppoort Dam to Von Bach, but for a different reason. Concentrations of sodium, chloride, magnesium and sulphide salts in Swakoppoort Dam increased between 2011 and 2017, making its water unsuited to drinking. It is not clear why these high concentrations developed, but one possibility is that the minerals were introduced through polluted water from Windhoek. Another theory is that the minerals were leached out of rocks beneath the Windhoek area during the heavy rains in 2011. Whatever the reason, Swakoppoort water transferred to Von Bach can then be mixed and diluted to an extent so that it can be added to supplies of water for Windhoek and Okahandja.

Pipelines and canals

Namibia's water infrastructure is impressive. To almost 7,900 dams and thousands of operational boreholes can be added hundreds of kilometres of canals and thousands of kilometres of pipelines, all designed to take water from where it is available to where it is needed.



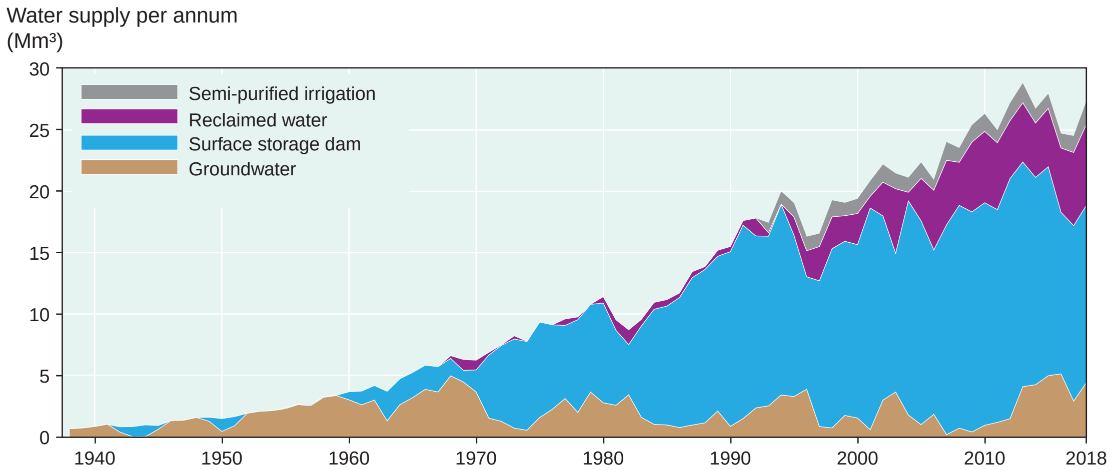
4.26 Supplying central-northern Namibia[29]

The Kunene River – via the Calueque Dam in Angola – is the sole source of water supply to the majority of households and enterprises in the central north of Namibia, including the major towns of Outapi, Oshakati, Okahao, Ondangwa, Eenhana and Oshikango. This supply system is both extensive and integrated, and includes the Olushandja Dam in Namibia and a network of 146 kilometres of canals between Calueque and Oshakati, five purification plants and more than 1,300 kilometres of bulk and 4,800 kilometres of rural distribution pipelines.

Water is pumped from the Zambezi, Okavango, Kunene and Orange rivers and used to supply nearby towns, industry and irrigation schemes. These pipes (left) transport water from the Okavango River to the 850-hectare Sikondo Irrigation Scheme about 20 kilometres west of Rundu. In southern Namibia, this canal (right) takes water from the Orange River to irrigation schemes close to Noordoewer. Towns and settlements supplied with water from perennial rivers include Katima Mulilo (Zambezi River), Rundu and Divundu (Okavango River), Noordoewer, Oranjemund and Rosh Pinah (Orange River) and those in figure 4.26 above (Kunene River).

Supplying Windhoek with water

NamWater supplies most towns and cities with bulk water, but Windhoek supplements this supply with its own groundwater sources and reclaimed water, especially following years of poor rains. Various and alternative sources are then used in greater amounts, and measures are implemented to control or reduce the demand for water.



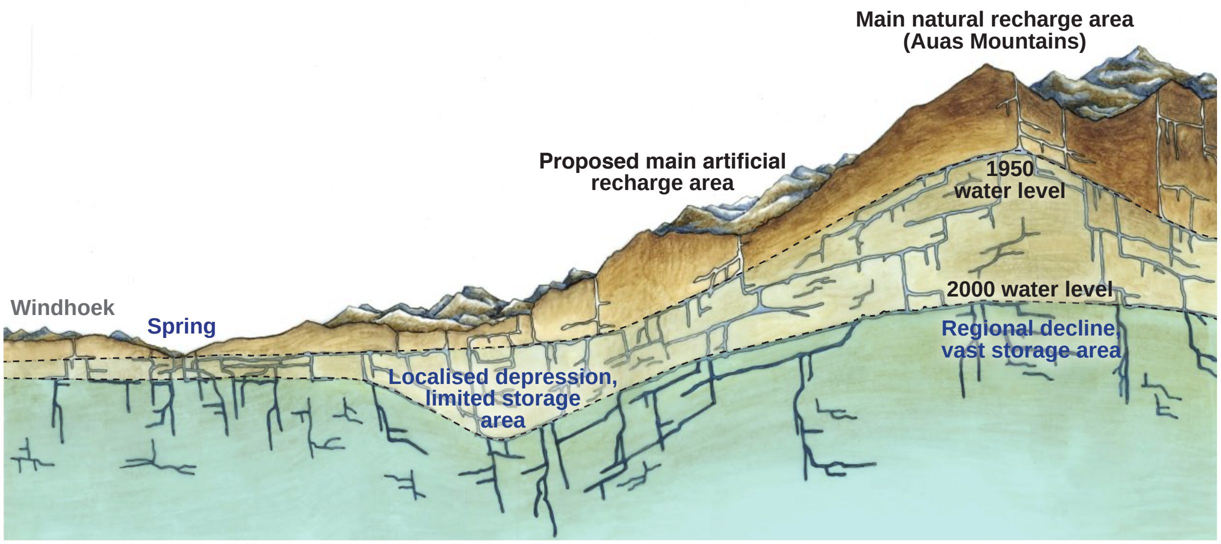
4.27 Volumes of water supplied from different sources to Windhoek, 1938–2018[30]

Windhoek's supply comprises a mix of water from conventional sources (surface water and groundwater) and unconventional sources (reuse of semi-purified and reclaimed water) and interventions (artificially recharging its aquifer). Water restrictions, water-saving campaigns and increasing block tariffs have been used to reduce demand during periodic droughts, including those of 1980–1982, 1994–1996 and 2015–2019. The use of groundwater increased during those drought periods, and reclaimed water has grown in importance, providing 26 per cent of Windhoek's potable supply in 2018.

4.28 Recharging Windhoek's groundwater

About 20 per cent of all Namibians live in Windhoek where they – and the associated concentration of public services and industries – require a substantial supply of water. On average in recent years, this has amounted to about 25.4 million cubic metres per year. Dams such as Von Bach and Swakoppoort have met about two thirds of this water demand, 26 per cent has come from reclaimed water and 7 per cent from Windhoek's aquifer. However, during the severe drought of 2019 groundwater abstraction contributed 39 per cent of Windhoek's needs.

The aquifer is thus of great value as an emergency supply and has the major advantage over surface water in that it does not lose water to evaporation. To secure this supply of groundwater, Windhoek embarked on an innovative programme to supplement its groundwater in years of high rainfall, thereby increasing the aquifer's production capacity in dry years. At the time of compiling this atlas, Windhoek had seven recharge boreholes which can be used to recharge the aquifer with 4.2 million cubic metres of water per year, giving the city a considerable reserve for use in times of drought.



This diagram illustrates the link between the Auas Mountains and Windhoek and how groundwater levels dropped after the 1950s, thus creating a cone of depression which could be recharged by injecting treated water from Von Bach Dam.[31]

Key points

- Namibia has only five perennial rivers. They all flow along or cross Namibia's borders.
- The Orange and Kunene rivers flow very strongly at times, delivering torrential flows because they drop steeply to sea level from elevations of 1,600 metres and more. Both can be very muddy, carrying huge sediment loads eroded off their upland catchments. Both are significant to Namibia's welfare. It is the Orange that sorted and exported the best diamonds from Lesotho, South Africa and perhaps Botswana to Namibia, and it is the Kunene that supplies up to 45 per cent of Namibia's electricity and water to about 35 per cent of its population.
- By contrast, waters of the Okavango, Kwando and Zambezi are clear and placid; their catchments are largely composed of deep infertile sands, their headwaters are only a few hundred metres higher than Namibia's northern borders where they enter the country, and they all flow along a gentle gradient before they leave Namibia.
- Apart from occasional contributions by the Fish River to the Orange River, all perennial river waters originate from catchments outside Namibia.
- Namibia has two lake systems (Liambezi and Omadhiya) and one large swamp (Linyanti). Smaller marshes and floodplains fringe the Okavango, Kwando and Zambezi rivers. Ephemeral freshwater wetlands, such as the Nyae Nyae pans around Tsumkwe, Lake Liambezi and pans in the Cuvelai are often extremely productive of plant and animal life.
- The Cuvelai is a network of about 100 ephemeral channels that flow from Angola into Namibia. They are usually dry, but sporadic floods bring large numbers of fish and water that may eventually flow south into Etosha Pan.
- Pans and springs are mostly complementary in distribution. Pans, porous aquifers and fossil rivers characterise the flat, sandy areas of eastern Namibia, whereas springs, ephemeral rivers and dams typify the water resources of the hilly, rocky central ridge of the country.
- Numerous ephemeral watercourses score Namibia's arid landscape. Short-lived periods of flow recharge groundwater, give new life to seeps and springs and replenish dams. This water supports the trees, shrubs and grasses that delineate these linear oases, which birds and other wildlife in turn make their temporary or permanent habitats.
- All ephemeral rivers that reach the Atlantic Ocean are in the northern half of the coastal plain, with the Kuiseb being the southern-most ephemeral river that occasionally flows to the sea.
- Tens of thousands of boreholes and deep wells have been drilled or dug to access groundwater. Volumes and qualities of water that aquifers provide vary greatly. The most productive aquifers are in the Stampriet area, in and around the Karstveld and in Ohangwena. Many boreholes elsewhere produce lower but useful yields of water that is potable for people and livestock. However, many others were dry or held little water, or the water is of poor quality with high concentrations of salts, sulphates, fluoride or nitrates.
- People in Namibia have used a number of approaches to meet their need for water; some have been used more than others in different parts of the country. Over the years, these have included migrating between water sources; digging wells; storing water in containers, tanks, reservoirs and dams; and channelling, piping, pumping and canalising water from rivers and aquifers. More recently, water is recycled, aquifers are artificially recharged and seawater is desalinated.