A profile and atlas of the CUVELAI - ETOSHA Basin

THE CUVELAI - ETOSHA BASIN

A profile and atlas of the

Cuvelai - Etosha Basin

First published: 2013

Printer: John Meinert Printing Windhoek

Design and layout: RAISON (Research & Information Services of Namibia)

Published by: RAISON www.raison.com.na
& Gondwana Collection www.gondwana-collection.com

ISBN: 978-99916-780-7-8

Production of this publication formed part of the project *Sustainable Integrated Water Resources Management in the Cuvelai-Etosha Basin in northern Namibia*. The project was funded by the European Union, Ministry of Agriculture, Water & Forestry (MAWF) and German government through *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH* and *Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)*. The Desert Research Foundation of Namibia (DRFN) is an implementing partner.

A profile and atlas of

THE CUVELAI - ETOSHA Basin

by

John Mendelsohn
Alice Jarvis
Tony Robertson

Published for the Sustainable Integrated Water
Resources Management Project in the
Cuvelai-Etosha Basin of the
Ministry of Agriculture, Water & Forestry

by

RAISON and Gondwana collection

2013

Contents

Preface

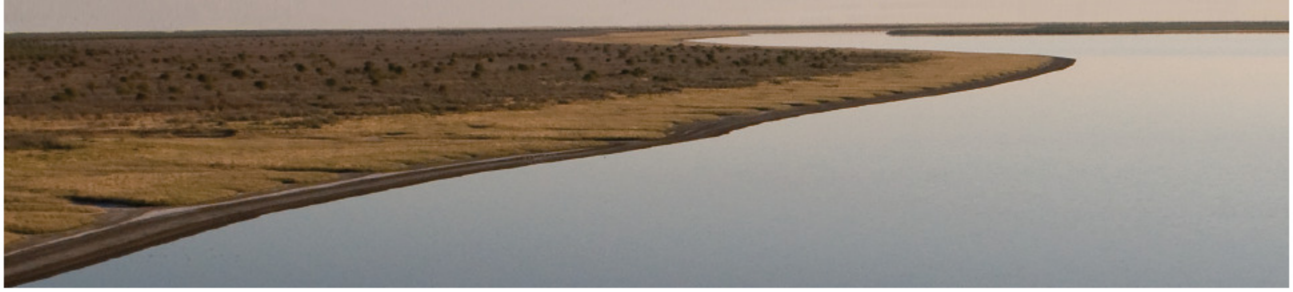
Without exception, water flows from high to low ground, and so rivers and streams make their way from highlands downwards, usually to the ocean. The moving waters etch and scar the surface of the earth, carving great valleys in places, levelling mountains in others.

This is true throughout the world, or almost everywhere. Imagine now an area where there is not one river, but hundreds of channels. They too flow from highlands, but often merge or separate to take divergent paths as they descend. This area is the Cuvelai and its rivers, called *iishana*.

The land surface here is extremely flat, causing the waters to move slowly, some seeping away into the ground and some lost to evaporation. Where the waters begin to flow, they are fresh from falls of rain. What was fresh water becomes salty with the progressive loss of water molecules downstream to the atmosphere. And none of the river channels ever reach the sea, but rather end in lakes and pans baked by the sun and caked in salt. This is the area of Etosha.

Few people live in Etosha, not only because it is a national park, but also because the parched, saline environment that surrounds the pan can't support many farmers. But Etosha is famous internationally, known to millions of people who have visited as tourists or who have been enthralled by the many documentary films that have showcased Etosha.

By contrast, the Cuvelai is largely unknown to the rest of the world. But it supports hundreds



of thousands of people who live in an often magical, watery landscape crisscrossed by countless *iishana* channels. About 40% of all Namibians live there.

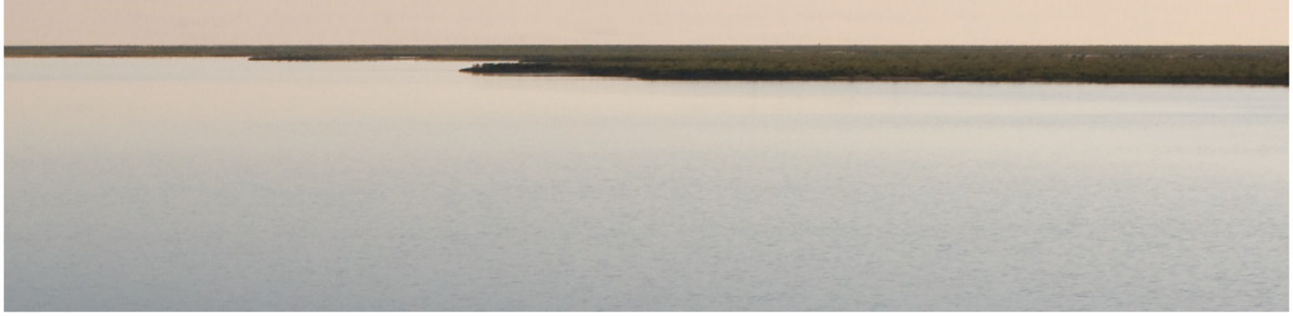
Here begins the story of the Cuvelai-Etosha Basin, a part of the world with many extraordinary facets. As a trans-boundary landscape or wetland system, the Basin is more correctly called the Cuvelai Basin, since Etosha is just the lowland culmination of its drainage. Geologists call it the Owambo Basin. About half the Cuvelai or Owambo Basin lies in Namibia, the remaining northern half in Angola. Resources in the Cuvelai are thus shared between Namibia and Angola, as should be its management. Within Namibia, the Basin covers some 97,620 square kilometres, equivalent to 12% of Namibia's surface area.

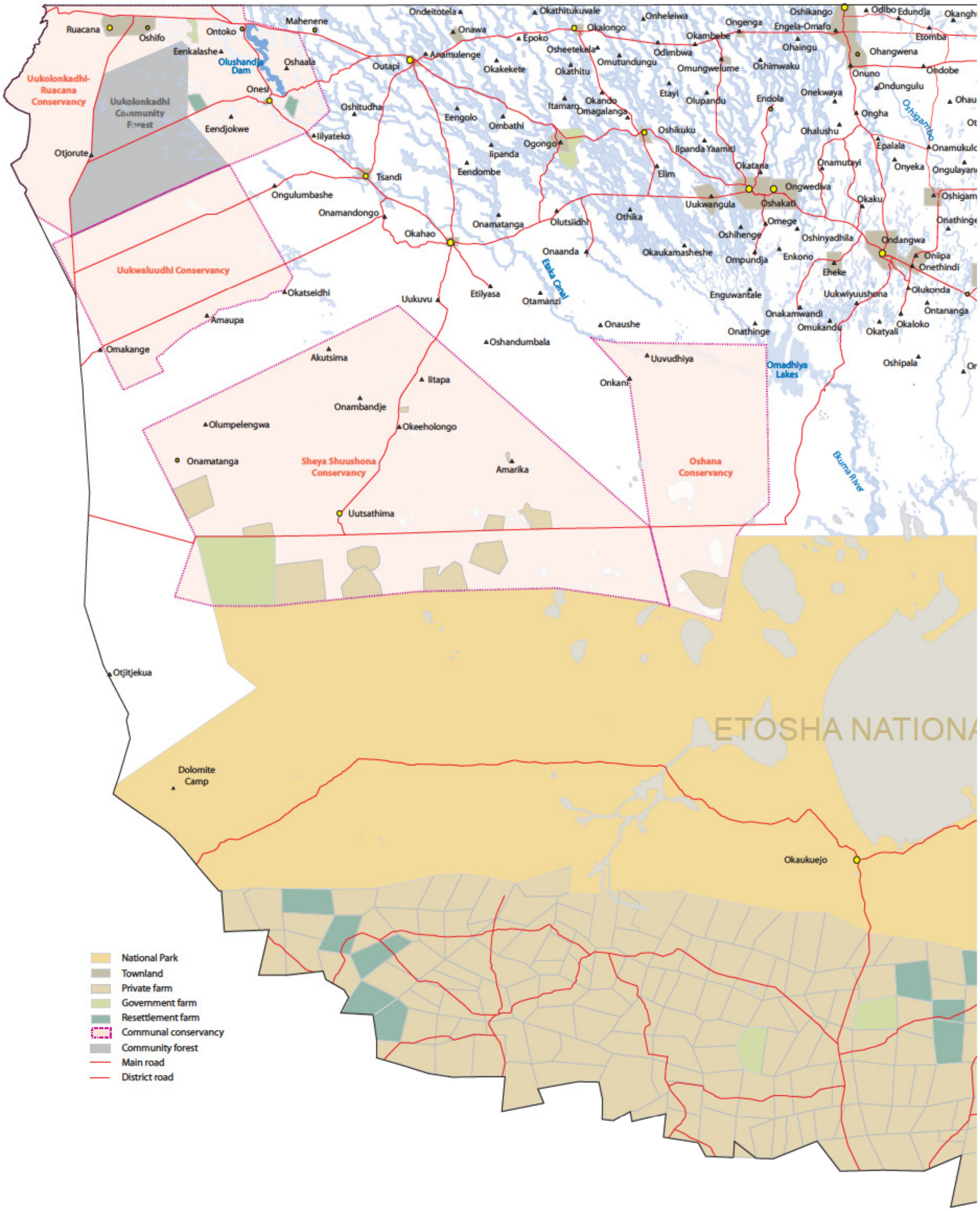
This book focuses mainly on the Namibian part of the Basin, hence the wording Cuvelai-Etosha, while the word Cuvelai on its own reflects reference to the broader shallow bowl and its internal drainage in both countries.

While there is often an abundance of water in the Cuvelai, droughts occur and people require supplies of potable water. Water management is therefore a challenge, and this book owes is its origins to the project *Sustainable Integrated Water Resources Management in the Cuvelai-Etosha Basin in northern Namibia*. Funding for the project was generously provided by the European Union, German government and Namibian Ministry of Agriculture, Water & Forestry.

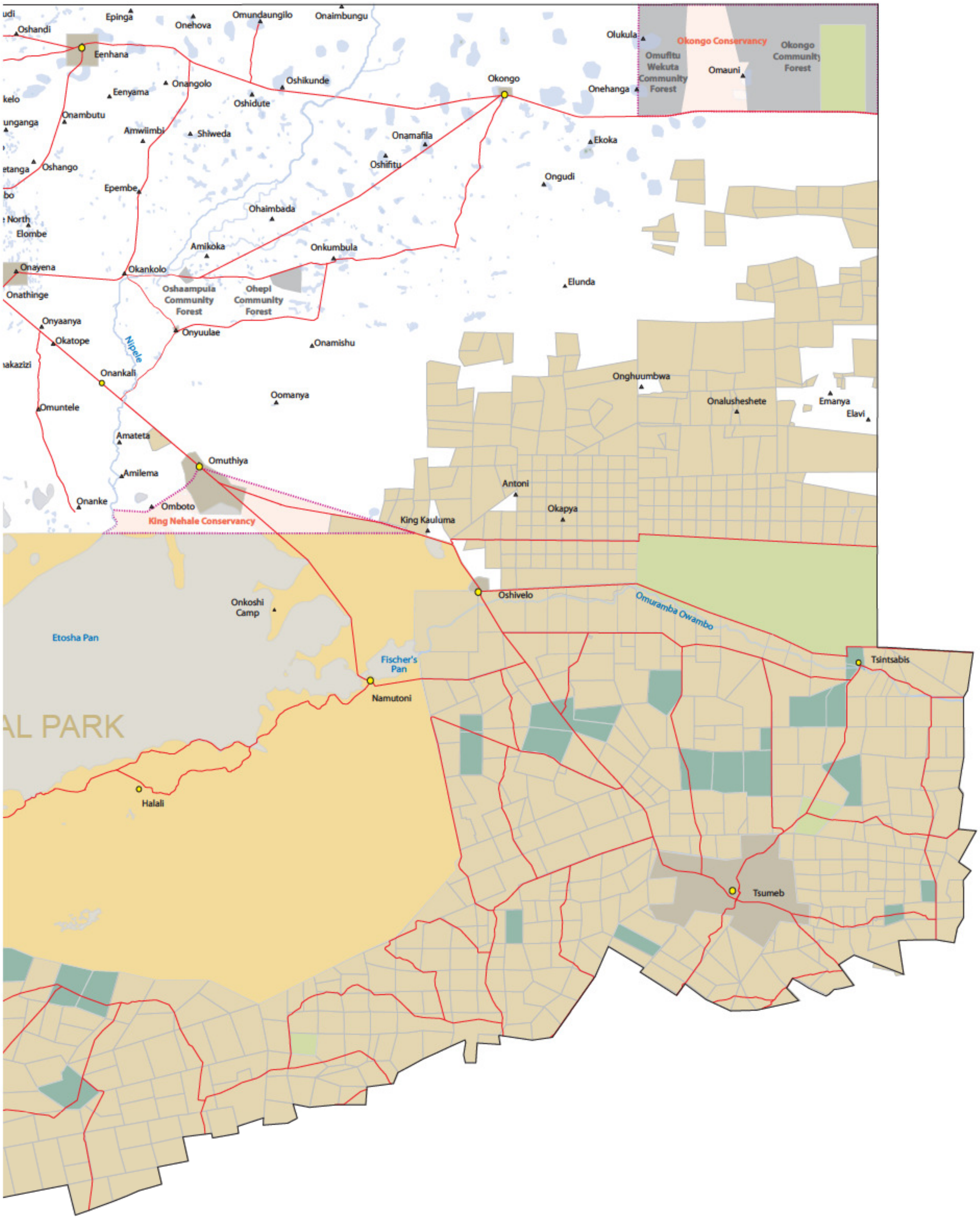
In addition to this financial support, compilation of the book has been helped by many people and organisations. Acknowledgments are due to Maria Amakali, Modestus Amutse, Sonja Berdau, Henry Beukes, Alec Bishi, Arnold Bittner, Nad Brain, Greg Christelis, Roger Collinson, Rod Davis, Helge Denker, Katharina Dierkes, Manni Goldbeck, Connie Haak, Tuwilika Haludilu, Phillip Hendjala, Leonard Hango, Martin Hipondoka, Gereon Hunger, Indongo Indongo, Uahoo Isakor, Donata Kapitango, Werner Kilian, Witta Kroll, Keith Leggett, Christophe Lowe, Katjizeu Mc-cloud, Celia, Martin and Stephie Mendelsohn, Roy Miller, Mally Mott-Adams, Pauline Mufeti, Sepiso Mwangala, Moises Mwanlange, Ndapewa Nakanyete, Namibia Meteorological Services, Namibia Statistics Agency, Lovisa Nangombe, Ben Nathanael, Ndapandula Ndikwetepo, Abraham Nehemia, Martin Neumann, Toinii Niilonga, John Nkolo, Martin Quinger, Carole Roberts, Kevin Roberts, Ann Scott, Victoria Shifidi, Louise Shixwameni, Mark Stehle, Roger Swart, the late Guido Van Langenhove, Elmarie van Rensburg, Wilferd Versfeld and Beata Xulu.

Many people kindly offered the use of photographs. Their names and the page numbers on which their images appear are listed on page 170. The value of satellite images made available for general and free use by Google Earth and the National Aeronautics and Space Administration (NASA) deserves particular acknowledgement.





Ruacana
Oshifo
Ontoko
Mahenene
Ondeitotela
Onawa
Okathitukuvale
Epoko
Okalongo
Onheleiwa
Ongenga
Oshikango
Odibo
Edundja
Okambebe
Engela-Omafo
Etomba
Eenkalashe
Olushandja Dam
Oshaala
Outapi
Anamulenge
Okakekete
Osheetekela
Okathitu
Omutundungu
Odimbwa
Omungwelume
Oshimwaku
Ohaingu
Ohangwena
Onuno
Ondobe
Ondungulu
Uukolonkadhi-Ruacana Conservancy
Uukolonkadhi Community Forest
Onesi
Eendjokwe
Oshitudha
Eengolo
Ombathi
Itamaro
Okando
Omagalanga
Etayi
Olupandu
Endola
Onekwaya
Ongha
Oshigambo
Otjorute
Iilyateko
Ogongo
Iipanda
Oshikuku
Iipanda Yaamiti
Ohalushu
Epalala
Eendombe
Elim
Okatana
Onamutayi
Onyeka
Tsandi
Ongulumbashe
Ongwediva
Uukwangula
Oshakati
Okaku
Onamandongo
Onamatanga
Olutsiidhi
Othika
Omege
Oshihenge
Oshinyadhila
Okahao
Onaanda
Okaukamasheshe
Ompundja
Enkono
Ondangwa
Onilpa
Onethindi
Eheke
Uukwaludhi Conservancy
Okatseidhi
Etilyasa
Otamanzi
Etaka Canal
Enguwantale
Uukwiyuushona
Olukonda
Ontananga
Uukuvu
Amaupa
Onaushe
Onakamwandi
Omukandu
Onathinge
Okatyali
Okaloko
Omakange
Oshandumbala
Akutsima
Uuvudhiya
Omadhiya Lakes
Oshipala
Iitapa
Onkani
Onambandje
Olumpelengwa
Okeeholongo
Onamatanga
Sheya Shuushona Conservancy
Amarika
Oshana Conservancy
Ekuma River
Uutsathima
Otjitjekua
ETOSHA NATIONA
Dolomite Camp
Okaukuejo
National Park
Townland
Private farm
Government farm
Resettlement farm
Communal conservancy
Community forest
Main road
District road



Epinga
Onehova
Omundaungilo
Onaimbungu
Oshandi
Eenhana
Olukula
Okongo Conservancy
Omufitu Wekuta Community Forest
Omauni
Okongo Community Forest
Eenyama
Onangolo
Oshikunde
Oshidute
Okongo
Onehanga
Onambutu
Amwiimbi
Shiweda
Onamafila
Oshifitu
Ekoka
Oshango
Ongudi
Epembe
Ohaimbada
Amikoka
Onkumbula
Onayena
Okankolo
Oshaampula Community Forest
Ohepi Community Forest
Elunda
Onathinge
Onyaanya
Okatope
Onyuulae
Onamishu
Nipele
Onankali
Onghuumbwa
Oomanya
Onalusheshete
Emanya
Elavi
Omuntele
Amateta
Omuthiya
Amilema
Antoni
Onanke
Omboto
Okapya
King Nehale Conservancy
King Kauluma
Oshivelo
Omuramba Owambo
Onkoshi Camp
Etosha Pan
Fischer's Pan
Namutoni
Tsintsabis
Halali
Tsumeb

1 - The Cuvelai: an introduction

In combination, several features set the Cuvelai Basin apart from all other drainage basins in the world, making the Cuvelai unique in the correct sense of the word. Its core drainage area consists of hundreds of channels (called *iishana*, singular *oshana*) that merge and diverge hundreds of times. Some water comes from narrow tributaries that drain the southern slopes of the Angolan *planalto* highlands, but most channels start and remain as broad courses from their headwaters all the way until they end in the Omadhiya Lakes north of the famous Etosha Pan.

Most *iishana* are dry for much of the year. When flows do occur, they range between tiny trickles to broad fronts of floodwater. All the water gradually disappears: evaporating, being transpired by plants or seeping away into the ground. The Cuvelai has no outlet to the sea but when flows are strong some water may continue and fill Etosha Pan.

Another special feature is the Cuvelai's position as a trans-boundary wetland shared almost equally in extent between Angola and Namibia. Compared to surrounding areas and much of southern Africa, the Cuvelai is home to a very large number of people, mainly because of the presence of shallow groundwater and relatively fertile soils in many areas. That has allowed the cultivation of crops as well as year-round access to fresh water for people and livestock for hundreds of years.

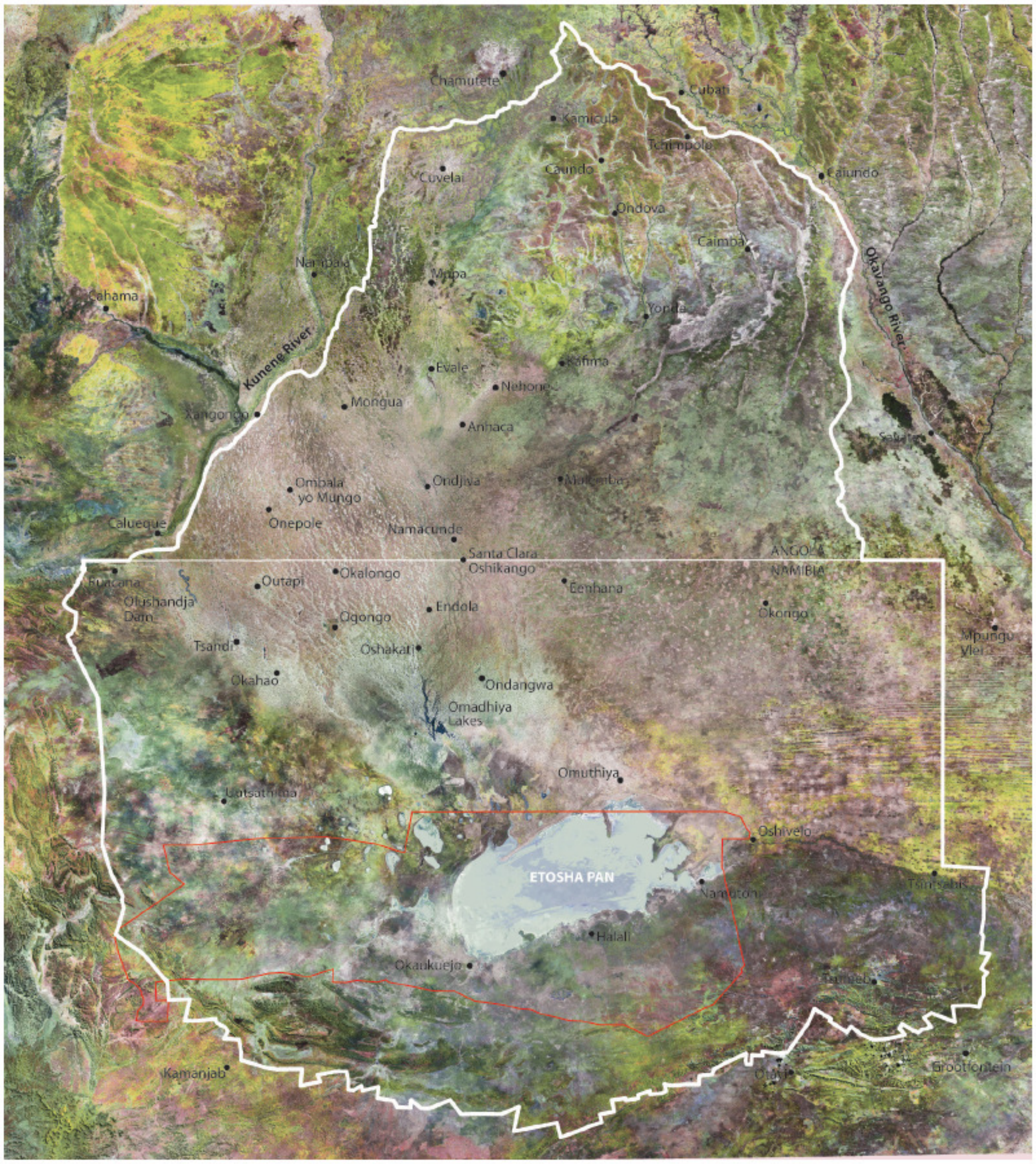
There is also an extraordinary link between the Cuvelai and the Owambo (in Angola known as Ambó) people. The great majority of people in the Cuvelai are Owambo, and prior to recent migrations all Owambo people lived in the Cuvelai. Few other drainage basins are as intimately associated with a single group of people.

The Cuvelai Basin is indeed a special place! While the book describes its main features within Namibia, this first chapter provides an overview of the entire Basin, sometimes also called the Owambo or Cuvelai-Etosha Basin.

The furthest south that the Cuvelai can flow is the salty Etosha Pan, which is conspicuous from space and the centrepiece of the world-renowned national park that bears its name: Etosha National Park.

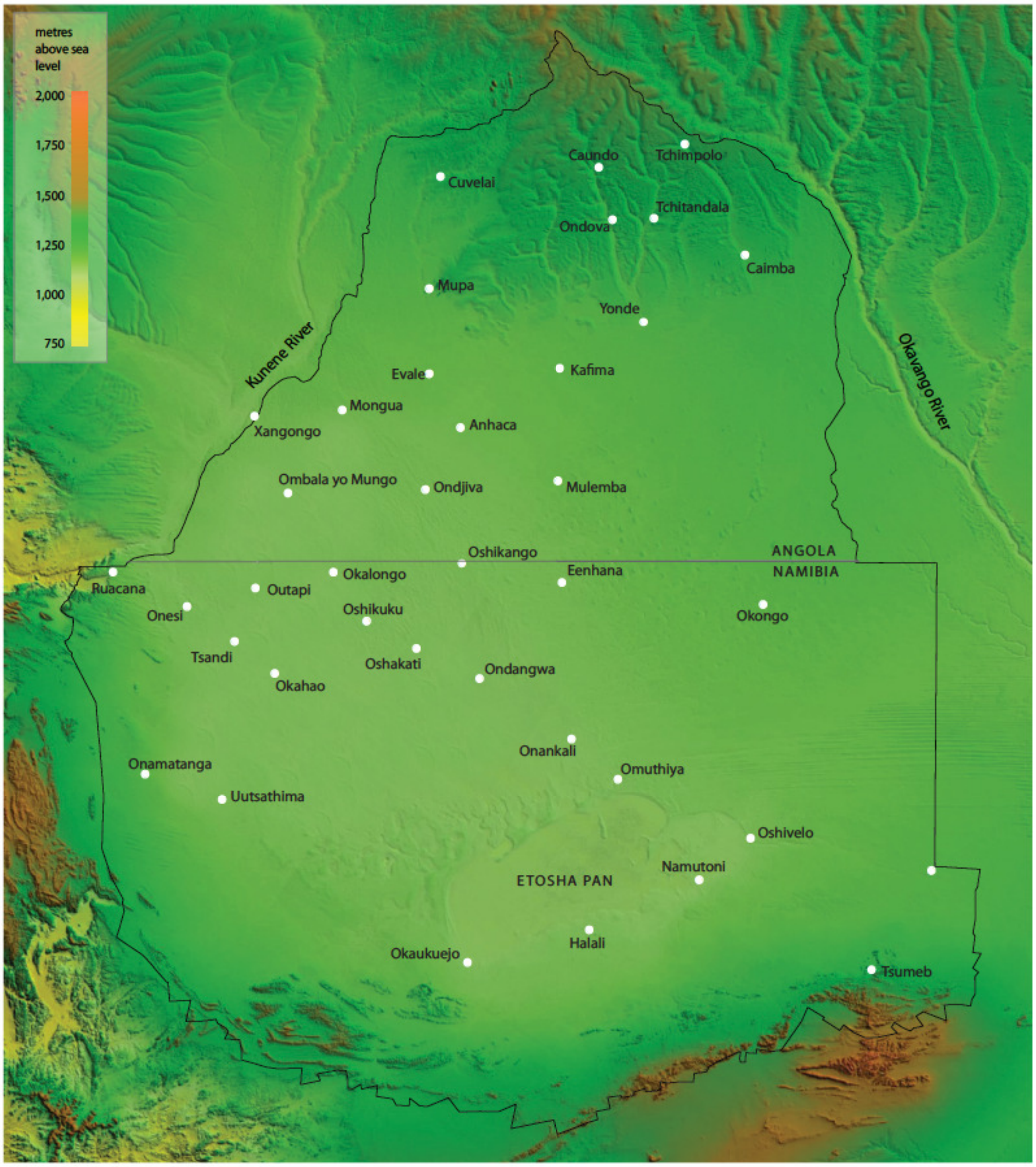
The straight borderline between Angola and Namibia is also clearly visible from space, one of only a few man-made international borders to be so conspicuous. This is largely due to fact that many more trees have been cut down for building and fencing by the larger population in Namibia. As a result, the Namibian side of the boundary is much paler than the more forested, darker Angolan side.

This photograph was taken from a space shuttle on 28 May 2000. The Atlantic Ocean stretches westwards to the horizon.



The principal features of the Cuvelai Basin lying between the Kunene and Okavango Rivers in Angola. The convergence of *iishana* channels into the Omadhiya Lakes and then into Etosha Pan is clearly visible in this image, which also shows the Olushandja Dam, which was built to store water from the Kunene River. The grounds of the Ogongo Agricultural College protect a remnant patch of woodland that appears darker than the surrounding areas that have been deforested.

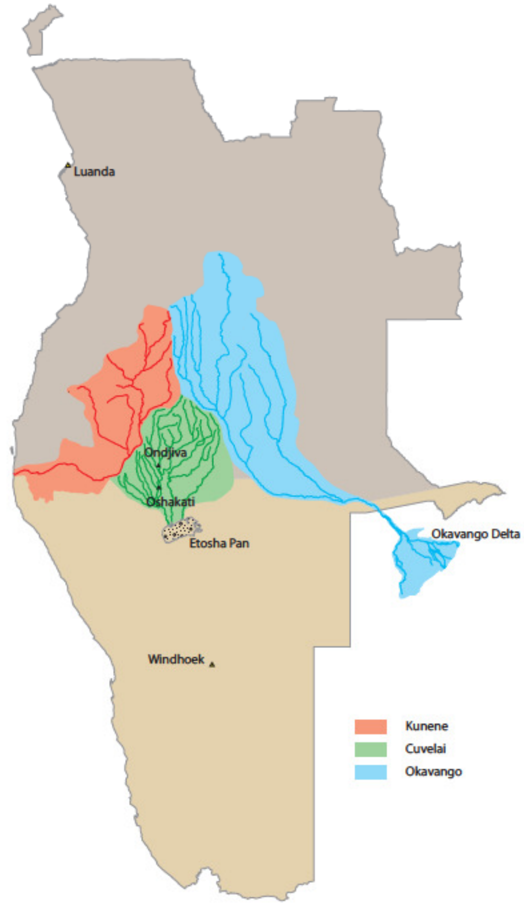
A large expanse of sand dunes, visible as horizontal lines north of Oshivelo and Tsintsabis, was formed during much drier times tens of thousands of years ago. The dunes are now covered in trees.



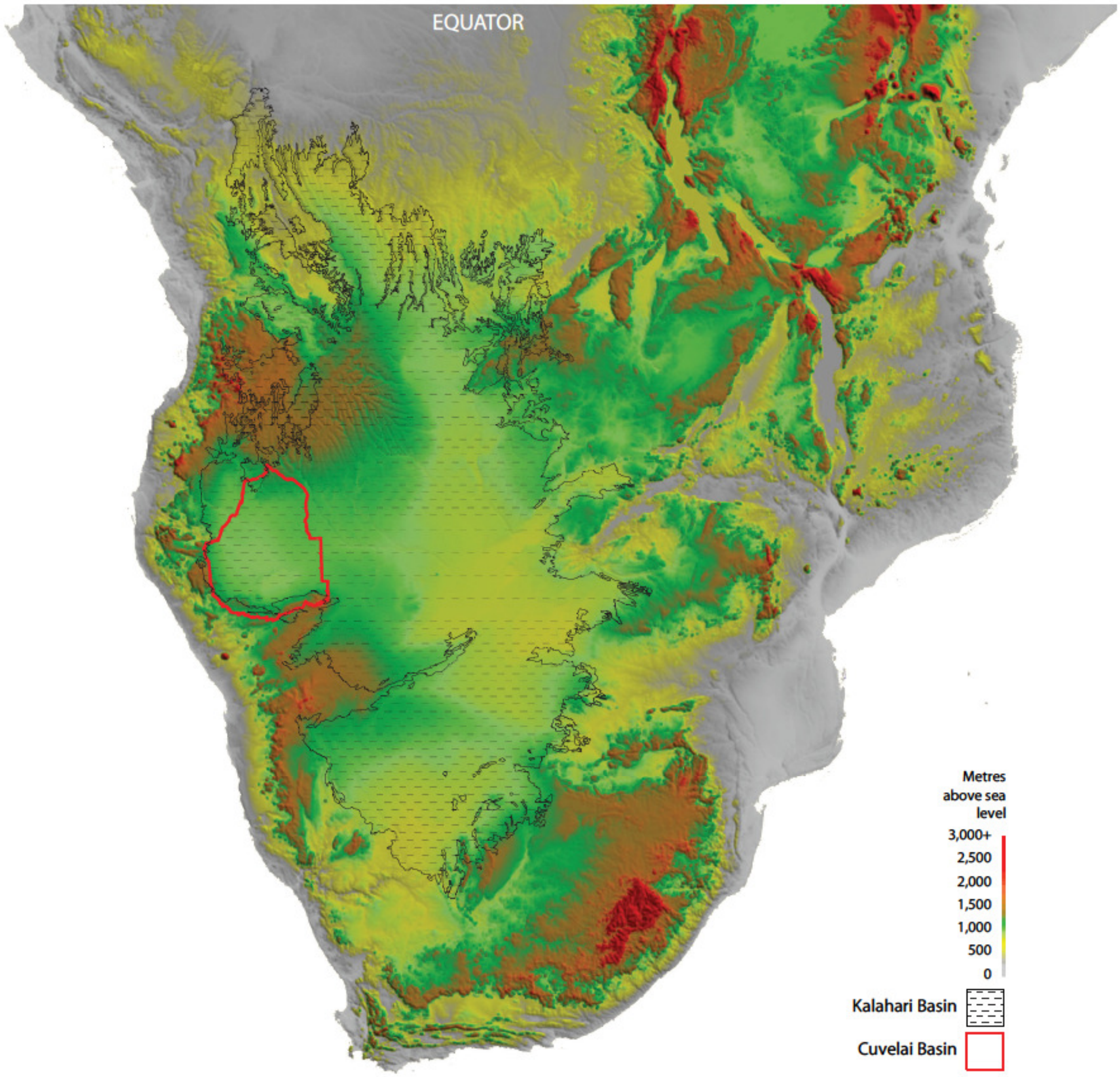
Elevations in the Cuvelai Basin between the Angolan *planalto* highlands in the north and an encircling margin of rocky hills to the south and west.[1] Most of the Basin lies between 1,100 and 1,200 metres above sea level. It is also extremely flat, with little change in altitude or relief. For example, there is a drop of only 110 metres from the town of Cuvelai to Oshakati, 230 kilometres to the south. That is a change of less than one metre per kilometre. At about 1,085 metres above sea level, Etosha Pan is the lowest point in the Basin.

The Cuvelai Basin extends over 450 kilometres from north to south. The Basin's widest point is along the Angola-Namibia border from the Kunene River east to the Okavango River.

Three neighbouring river systems. The Cuvelai is bordered by the Kunene and Okavango Rivers which drain large areas of the Angola *planalto*. Although the Kunene now flows west to the Atlantic Ocean, it is generally accepted that the Kunene once flowed into the Cuvelai Basin (see page 30), and it has been suggested that in earlier times the Okavango also made its way due south into the Cuvelai.[2] Water flows and volumes of sediments would then have been orders of magnitude greater than we ever see these days. Etosha Pan would have covered an area several times greater than today and been many metres deep.



There are similarities between the Cuvelai and Okavango Basins. Both have extremely gentle slopes and thus slow rates of flow, for example. However, the Okavango is perennial while the Cuvelai is ephemeral. Fresh, extremely clear waters flowing over permeable sand characterise the Okavango, as in the photograph below. By contrast, water in the Cuvelai (below right) carries much more mud which is deposited as clay. The clayey soils in the drainage lines of the Cuvelai limit infiltration which leads to more evaporation. As a result, Etosha is a salt pan while the Okavango Delta is a freshwater wetland.



The Kalahari Basin. The Cuvelai lies in a relatively small bowl along the western margins of the vast Kalahari Basin that covers much of south-central Africa. Much of the Kalahari and Cuvelai are now filled with hundreds of metres of sediments, most deposited by rivers over tens of millions of years. As an outlying part of the Kalahari, geologists call the bowl the Owambo Basin, and so the Cuvelai, Cuvelai-Etosha and Owambo Basins are largely the same.

Soils of the Cuvelai.[3] The nature of soils depends on the degree to which they have been deposited, reworked or influenced by wind, water or evaporation. Thus, most soils in the east are wind-driven arenosols, those in the centre and west have been formed largely from fine sediments carried in water, while evaporation has led to soils in the south being very saline.

The wind-blown sands are particularly infertile and hold little water as a result of the porous structure of the soil. The relatively few people who live in these areas (see page 18) have their homes on old pans and drainage lines where the soils have higher clay content and thus hold more nutrients and water.

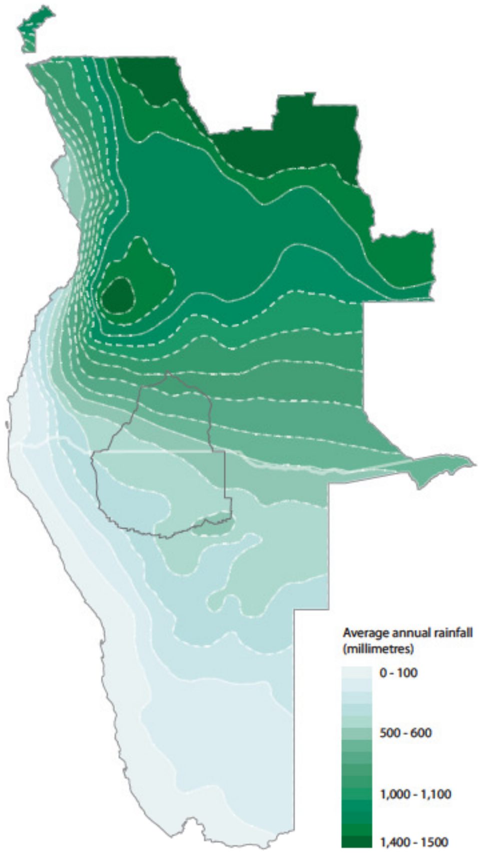
While water-borne sediments make up substantial areas of the central zones, they are concentrated within the *iishana* channels where the soils are too clayey for domestic crops. However, between the channels on higher ground (*omitunda*) are cambisols and calcisols that formed as a mix of water-borne and wind-blown sediments. This combination results in soils that are not too dense or clayey; and neither are they too sandy, infertile and porous. Together with access to fresh water in shallow wells, it is these fertile soils that allowed people to settle and farm here 500 to 600 years ago.[4] Most people continue to live in the areas of calcisols and cambisols.

The composition and structure of plant life in the Basin is closely related to the underlying soils. In most places, no plants grow on the most concentrated pan salts.

Clayey soils that are flooded less often are characterised by mopane trees, which are probably the most abundant trees in the Cuvelai.

On less saline soils, plant life consists largely of spiky, hardy grasses and short shrubs.

On sandy substrates, the typical trees are Zambezi teak, Angolan teak, burkea and mangetti. These trees are replaced in areas of higher rainfall (roughly half-way between Mupa and the town of Cuvelai) by miombo woodland dominated by various species of *Brachystegia*, *Julbernadia* and *Isoberlinia*.



Average annual rainfall in Angola and Namibia.[5] Climatically, the Cuvelai spans an area between what may be called sub-tropical in the north and semi-arid in the south-west. Rainfall in the northern-most parts of the Basin averages about 900 millimetres per year, or three times more than the average of 300 millimeters in the extreme south-west.

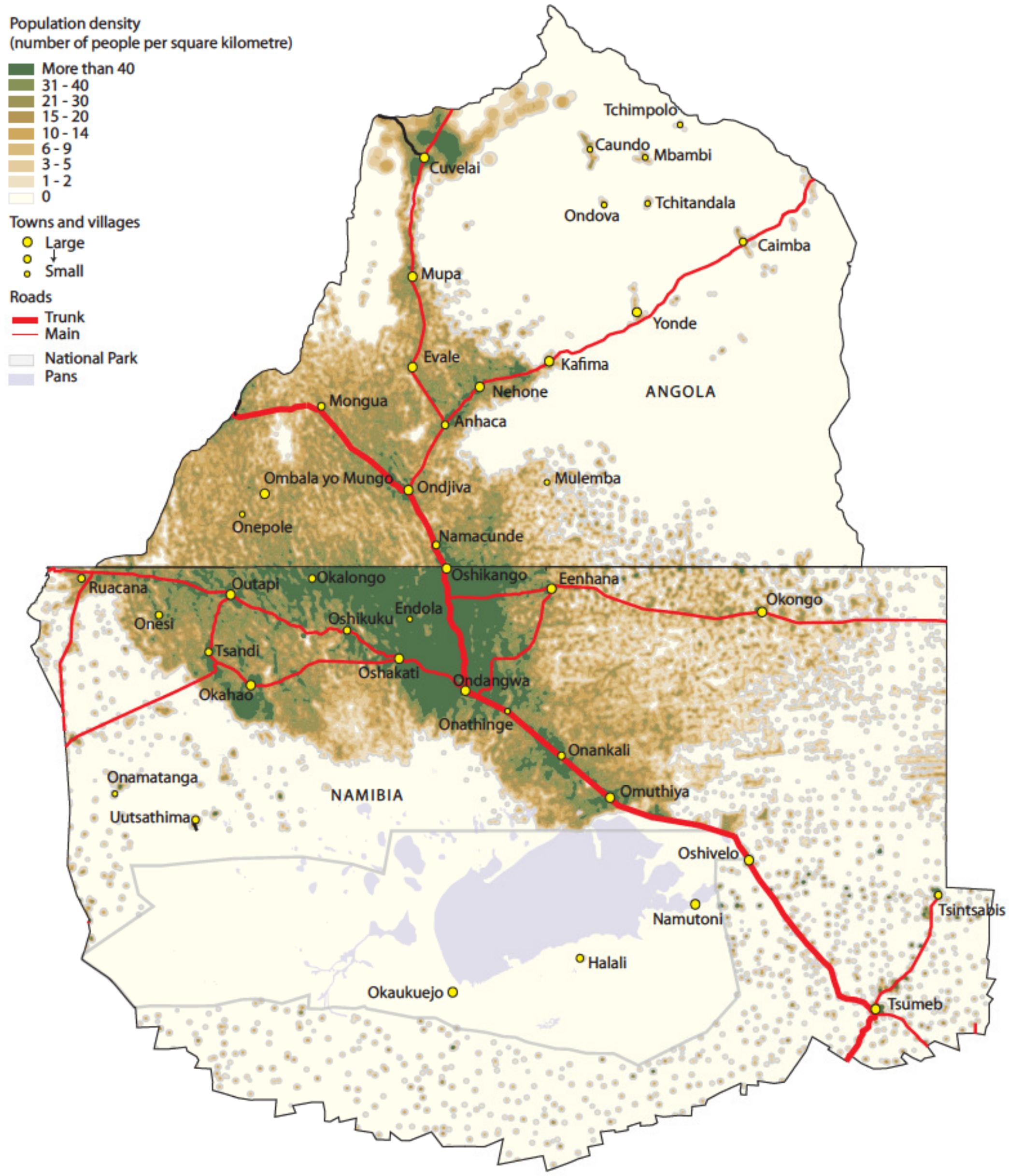
In the southern, Namibian half of the Basin, rainfall is higher in the east than the west, a consequence of the prevailing winds that bear moist air from the north-east. Rainfall is also more variable in the south than the north of the Basin.[6]

Administration of the Basin is shared by Angola and Namibia. Angola is divided into 18 provinces, and most of the northern Cuvelai is in Kunene province. Ondjiva is the capital of Kunene. Small areas of the Cuvelai Basin also fall within the provinces of Cuando Cubango and Huila. Their capitals are Lubango and Menongue, respectively.

In Namibia, much of the Basin lies in four administrative regions: Oshikoto, Omusati, Ohangwena and Oshana, their respective capitals being Omuthiya, Outapi, Eenhana and Oshakati. Additionally, small areas in the southern areas of the Basin fall in the Kunene and Otjozondjupa regions.

Infrastructure and land. There are two national parks in the Cuvelai. Mupa was proclaimed in December 1964 but has not been managed for conservation in recent decades, and several thousand families now live there. Etosha was proclaimed in 1907, although its extent then was far greater than today. Much of the southern area of the Basin consists of large, exclusively owned farms, most of which are several thousand hectares in extent. Apart from small town-lands (which are not shown here), all other land is communal and owned by the state and traditional authorities.

A great deal of trade in the Cuvelai is concentrated in towns along the major trunk route running from the south to Tsumeb, then north to Ondangwa, Oshikango and Santa Clara, Ondjiva, Xangongo and onto the rest of Angola to the north. Every day, hundreds of big trucks ply this route and millions of US dollars are exchanged at the Santa Clara/Oshikango frontier.



The distribution of people.[7] In 2012, approximately 1.3 million people were living in the Basin. About 70% of this population was in Namibia and 30% in Angola. The greater densities in Namibia are a consequence of migration from Angola over many decades as a result of political and economic factors.

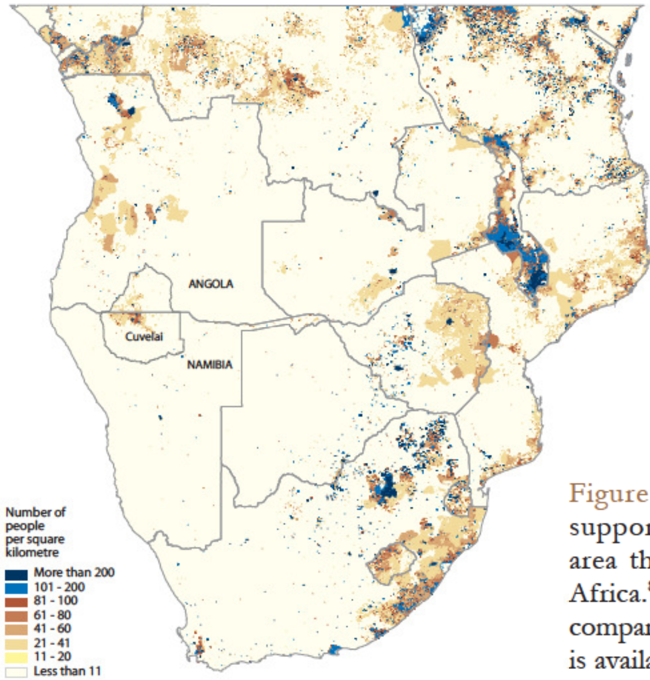


Figure 10. The Cuvelai-Etosha Basin supports many more people per unit area than most rural places in southern Africa.[8] This is a product of soils that are comparatively fertile and the fresh water that is available in shallow wells.

The leaf of a mopane or *omusati* tree commands the grave of Mandume Ya Ndemufayo, the last king of the Kwanyama people who reigned between 1911 and 1917. The monument lies south-east of Namacunde in Angola, as seen in Google Earth at 17.332 South, 15.959 East (bottom left).

The leaf and Mandume symbolise much of what constitutes the Cuvelai Basin since both the Kwanyama people and mopane are so widespread.

Traditionally, all rural households in the Cuvelai had small fields of crops and vegetables. Many homes also kept chickens, pigs, goats, donkeys and cattle. Home produce from fields and livestock supplemented by fish, frogs, other wildlife and wild fruits then provided all domestic food. This is still the case for the majority of families in Angola whose livelihoods are of a subsistence nature.

The same is still true for some homes in the Namibian Cuvelai, particularly those in remote and less densely populated areas. But most Namibian rural households now live on cash incomes derived from wages, business profits, pensions and remittances. Many of the incomes are supplied by family members who live and work for salaries elsewhere (see page 125). These cash-based households in rural areas nevertheless continue to cultivate fields and keep livestock, even though most of their sustenance is bought in local shops.

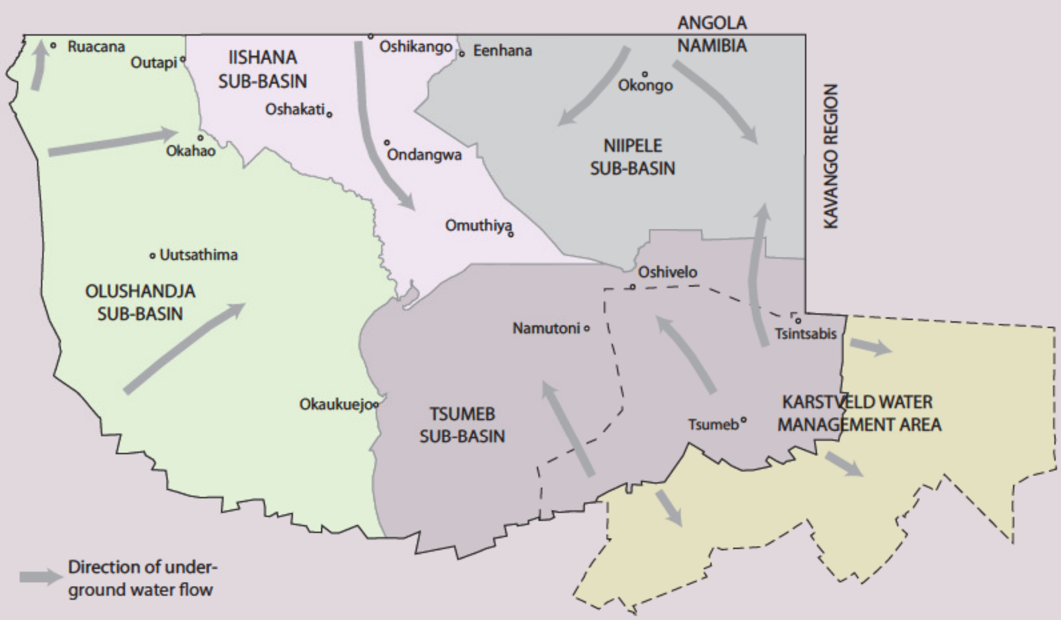
The effect of access to cash is clearly visible in the materials used for building. The very poorest homes are built with labour from locally harvested materials, as in the photographs at the bottom. Such poor homes are usually small, often headed by women with few or no household members of working ages. Their fields are generally small and often in areas of poor soil quality. Wealthy homes are much larger, as seen from the many rooms in the homestead at the top, where many of the rooms were built with cash. Local resources contribute little or nothing to livelihoods in those wealthy households.

Basin water management. In Namibia, the Cuvelai-Etosha Basin has been designated by the government as an integrated water resources management area. Its borders have been defined on the basis of the nature of bodies of water underground and the directions of water flow beneath the surface. Political borders have also been taken into account.[9]

Just as the Basin has been filled by sediments blown by wind and carried by water over tens of millions of years, water continues to flow underground into the Basin. Of course, the rate of flow is extremely slow. The arrows in the map show the direction of water flow.

The landscape in the east is very flat with no discernible drainage channels or watershed, and so defining the eastern boundary of the Basin is difficult. For this reason, the political boundary between Kavango and Oshikoto and Ohangwena Regions has been adopted as the eastern margin of the Cuvelai Basin.

Within the Cuvelai-Etosha Basin, four sub-basins have been demarcated as local areas where water resources can be managed by people living within each sub-basin. The Karstveld Water Management Area straddles the south-eastern boundary of the Basin because it contains water resources that flow to the north-west and south-east.



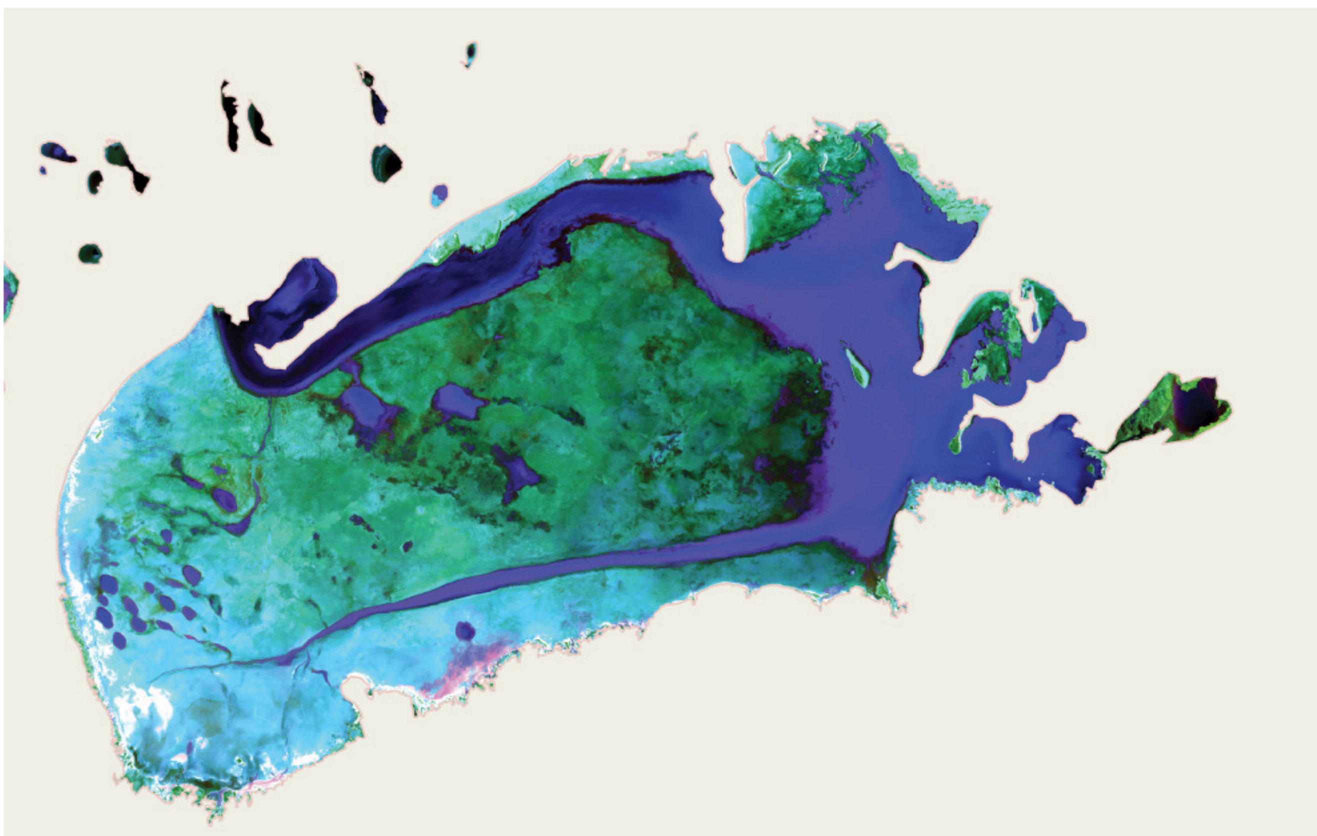
2 - Landscapes: foundations of Cuvelai-Etosha

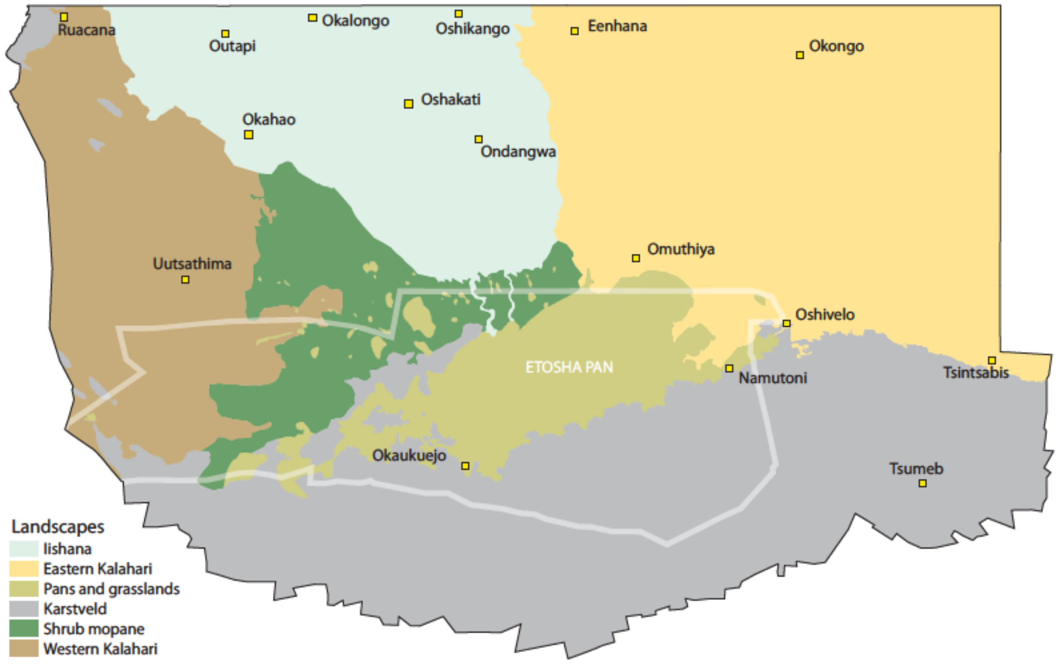
Much of the Cuvelai Basin is an extremely shallow or flat depression, surrounded by a rim of rocky, raised ground in the west and south. However, beneath the Basin is a deep bowl which developed during the formation of the continent of Gondwana some 570 million years ago. Geologically, the bowl is known as the Owambo Basin. The southern and western rims of hills were also raised during Gondwana's formation.

Between the surface and the bed rock of the Owambo Basin lie hundreds of metres of sediments that accumulated over the past 570 million years. Most sediments were deposited in the bowl by large rivers that drained the higher ground in Angola and the southern and western highland rims.

More arid conditions have prevailed during the last two million years and so the upper layers of sediments consist mainly of windblown sands. However, rivers and drainage lines, such as the present *iishana*, have also deposited alluvial sediments in the Basin during this more recent period, particularly during short, wetter cycles when the rainfall was two or three times what we measure today. Etosha Pan was then much larger and huge areas of the Basin were under water. Conversely, there were also much drier times during the last two million years when the Basin was covered largely by sand dunes, rather like the present southern Kalahari Desert in southern Namibia and Botswana.

In essence, the Basin has had a history of alternating dry and wet periods during which sands and alluvial clays, respectively, were laid down, each layer steadily filling the deep Owambo Basin to form the flat surface of the current Cuvelai Basin.





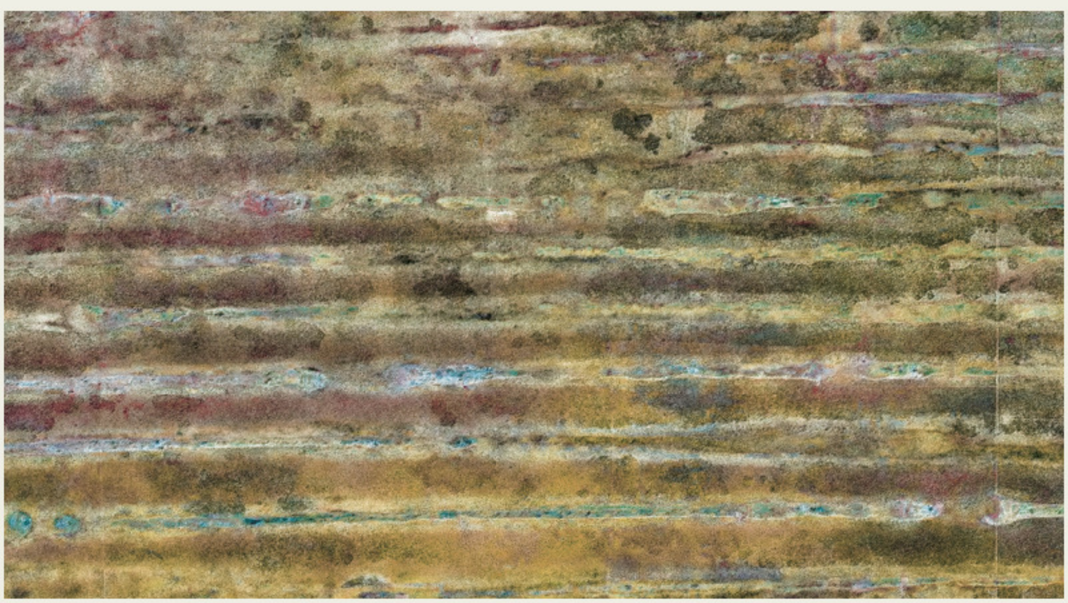
Each of the six major landscapes[1] in the Basin formed from different processes of erosion and deposition that have prevailed. In many areas, such as the pans and *iishana*, the soils and vegetation are characteristic of alluvial sediments. Elsewhere, particularly in the east and southwest, aeolian wind-borne sands predominate and support plants and animals that characteristically prefer sandy substrates.

Within any one small area, there is often a mix of water- and wind-borne sediments. This is most obvious where expanses of aeolian sand surround pans and *iishana*. Here, the lowest levels are clayey and often wet from local rain or from flows of water from the north. Just above the banks of the *iishana*, the soils are typically a composite of sediments, while the highest ridges (*omitunda*) between the iishana often consist entirely of wind-borne sands. The most fertile and productive soils have formed where the sediments have been heavily mixed, and it is here that the majority of people live. Much of the mixing of sediments has been caused by prevailing easterly winds which have carried fine sediments out of the low-lying drainage lines and pans and onto the surrounding sands.

On the surface the **Karstveld** consists largely of sediments derived from limestone and dolomite rocks, many of which remain as hills along the southern edges of the Basin. Water has dissolved these rocks to form large underground aquifer hollows from which water is now pumped to irrigate crops. Rocks above these hollows have collapsed in some places, such as at Lake Guinas (shown on the right) and Lake Oshikoto.

Much of the Eastern Kalahari consists of deep, infertile sands which hold little water. Tall woodlands grow on these sands which are not suited to crop production. However, there are many small pans which formed during much wetter times. The soils around the pans contain more clay, and therefore hold more water and have greater concentrations of nutrients. It is on these soils that crops are grown and this is where most people live in homes clustered as villages around the pans. Some pans, such as the one shown to the left, straddle the border and have fewer residents on the Angolan side. This pan is clear in Google Earth at 17.391 South, 17.387 East.

Old sand dunes remain visible in certain areas (below), showing how this area has also been extremely arid in times past. The most extensive zone of dunes is north of Tsintsabis and Oshivelo in the Mangetti area. South of Ruacana there is a smaller area of less conspicuous dunes. This area is broadly around 18.11 South, 17.88 East.



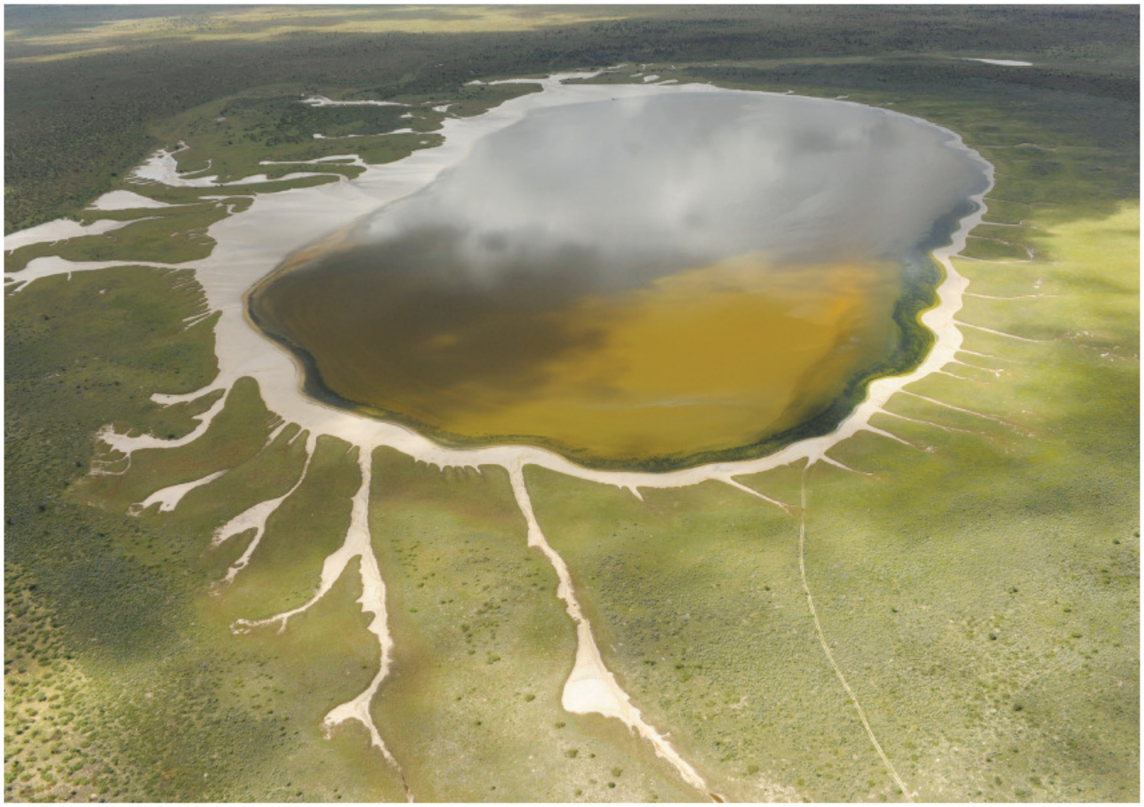
The **Western Kalahari** is a drier version of the Eastern Kalahari, both having been formed from wind-blown sands. As a result of lower rainfall, there are fewer pans and arable soils and less water close to the surface. The woodland is poorly developed and the trees smaller than in the Eastern Kalahari. There are also fewer people, and they concentrate their efforts largely on cattle and goat farming.

The **Shrub Mopane** landscape is a mix of alluvial clays and aeolian sands which are generally salty as a consequence of high rates of evaporation. The surface soils are probably underlain by impermeable layers of rock formed from mineral precipitation, such as calcrete. Roots are thus unable to reach nutrients and water beneath these layers and many of the plants therefore remain stunted.

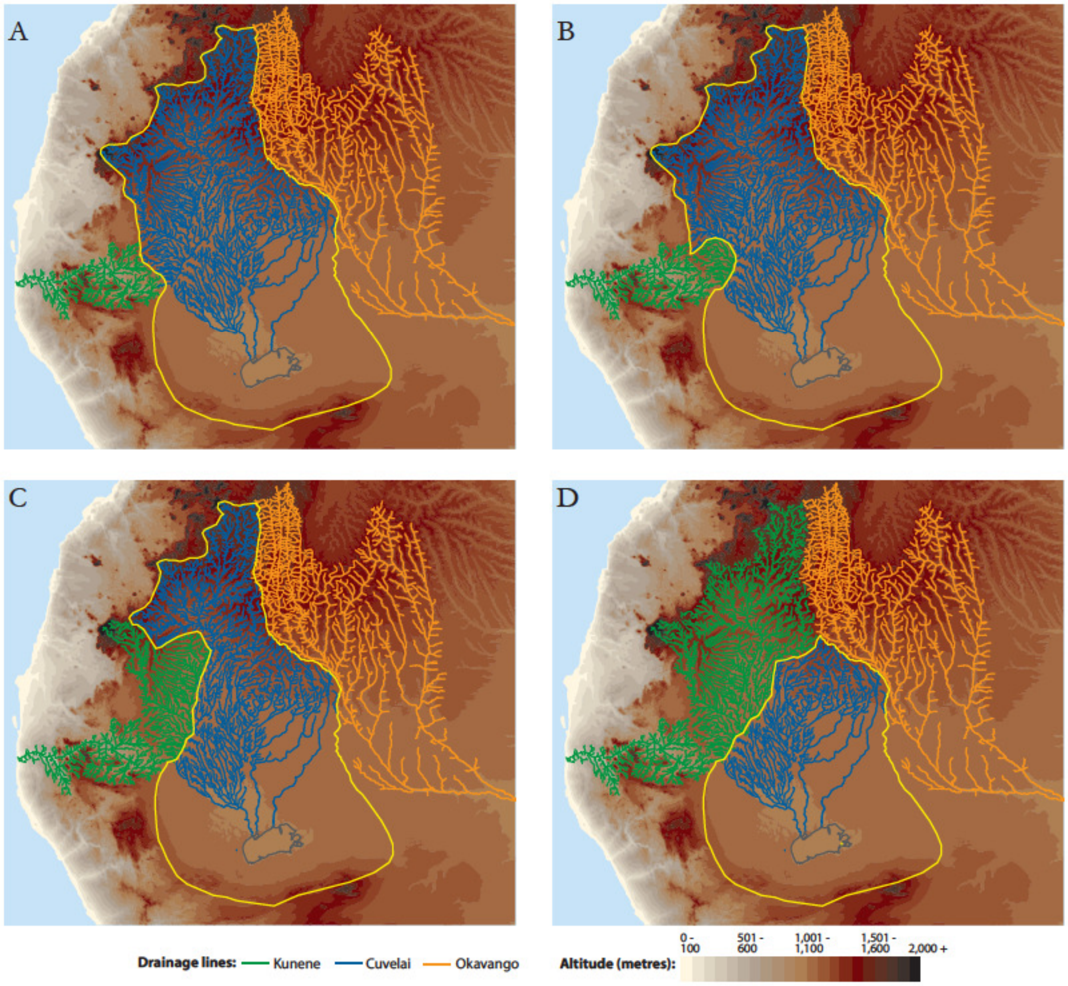
Iishana. The great majority of people live in this landscape where there is a combination of wind-blown sands on higher ground and water-borne clays in the low-lying channels and pans. Particularly in the eastern areas, the clays and sands have been mixed and moulded to form the most fertile soils in the Basin.

The *iishana* are narrow in the east where water flows are relatively rapid. By contrast, channels in the west are broad, slow-flowing and saline because water easily evaporates from their large surface areas.

Most of the channels converge in the south, where they fill the Omadhiya Lakes. Other channels have been covered over by wind-blown sands in the drier southern areas. As a result, these southern *iishana* areas are characterised by tens of thousands of small pans which are only filled by local rain and are generally never connected to each other.



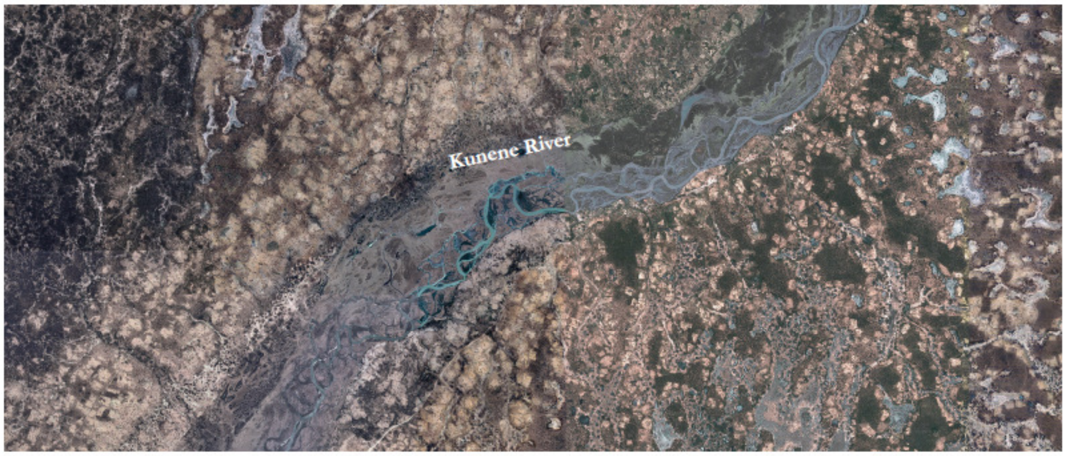
Pans and grasslands. High concentrations of salt in Etosha and the many surrounding pans and grasslands are due to the evaporation of water that has flowed into these southern, dry areas of the Basin. The margins of most of the smaller pans are decorated by intricately shaped narrow drainage lines along which water may flow after the heaviest rain storms. The small pan shown here is Ngandjela Pan which has provided people in the Basin with salt for domestic use and trade for hundreds of years. This pan is visible in Google Earth at 18.57 South, 15.26 East.



The Kunene and the Cuvelai. Most sediments that fill the Cuvelai Basin were deposited by rivers that drained surrounding highlands. The Okavango (known as *Rio Cubango* in Angola) was probably one of these rivers when it flowed south into the Basin. Since then, the river has been diverted east towards Botswana and the Okavango Delta.

The Kunene River also drained into the Basin before being captured by the western river that now flows to the coast. Map A shows what that western or coastal drainage system may have looked like – as a river flowing from about Ruacana to the Atlantic – before the river capture began. The headwaters of that western, coastal river then probably nibbled or eroded their way upstream, their nick-points progressively capturing tributaries that had flowed north-west to south-east into the Basin (maps B and C). With the capture of each tributary, the volume of water reaching the Basin would have decreased.

Eventually, the river's headwaters cut back all the way up until it had captured the entire Kunene River system (map D), thus leaving the Cuvelai Basin with almost no sources of perennial inflow. Nowadays, only the small Mui and Cuvelai Rivers continue to provide some water year-round to the northern areas of the Basin in Angola (see page 63).



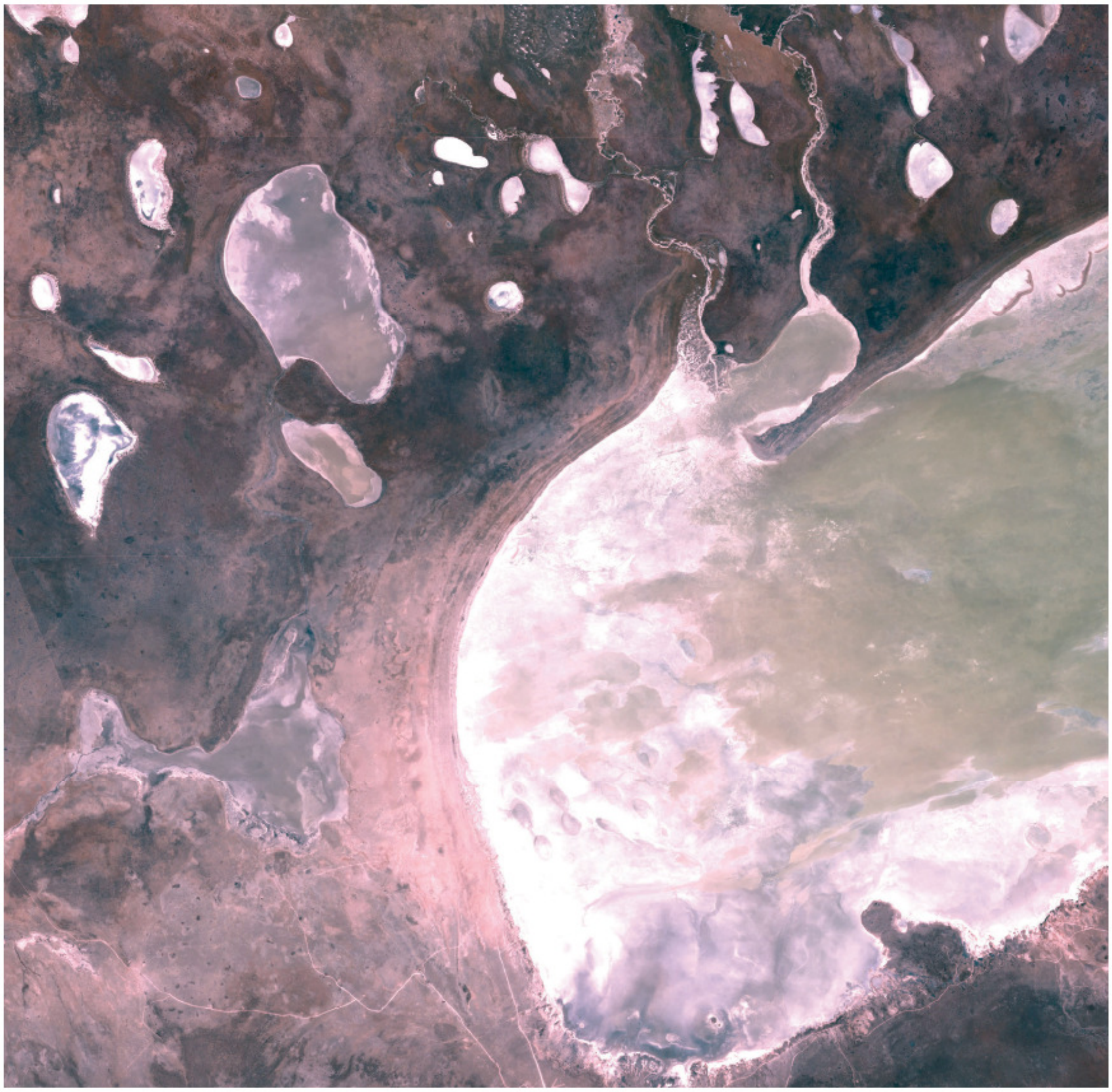
Throughout the world, rivers begin as narrow tributaries, widening and gaining stature as they flow downstream. However, the present headwaters of *iishana* drainage lines just east of the Kunene River are wide and not much narrower than they are downstream. The *iishana* thus start as broad channels and remain like that all along their courses.

The shape and size of the *iishana* close to the Kunene River also resemble drainage lines to the west of this river, again suggesting that the *iishana* once flowed across the area now bisected by the Kunene. This image shows the Kunene just north of Xangongo in Angola, where many *iishana* are clearly visible immediately east of the river.

The progressive north-eastward capture of *iishana* means that the channels in the west of the Basin have been cut-off for longer. One interesting consequence of this is that the western *iishana* should have the most saline soils, since they have probably been deprived of substantial flows of fresh water for longest. *Iishana* to the east, by contrast, were probably cut-off more recently.



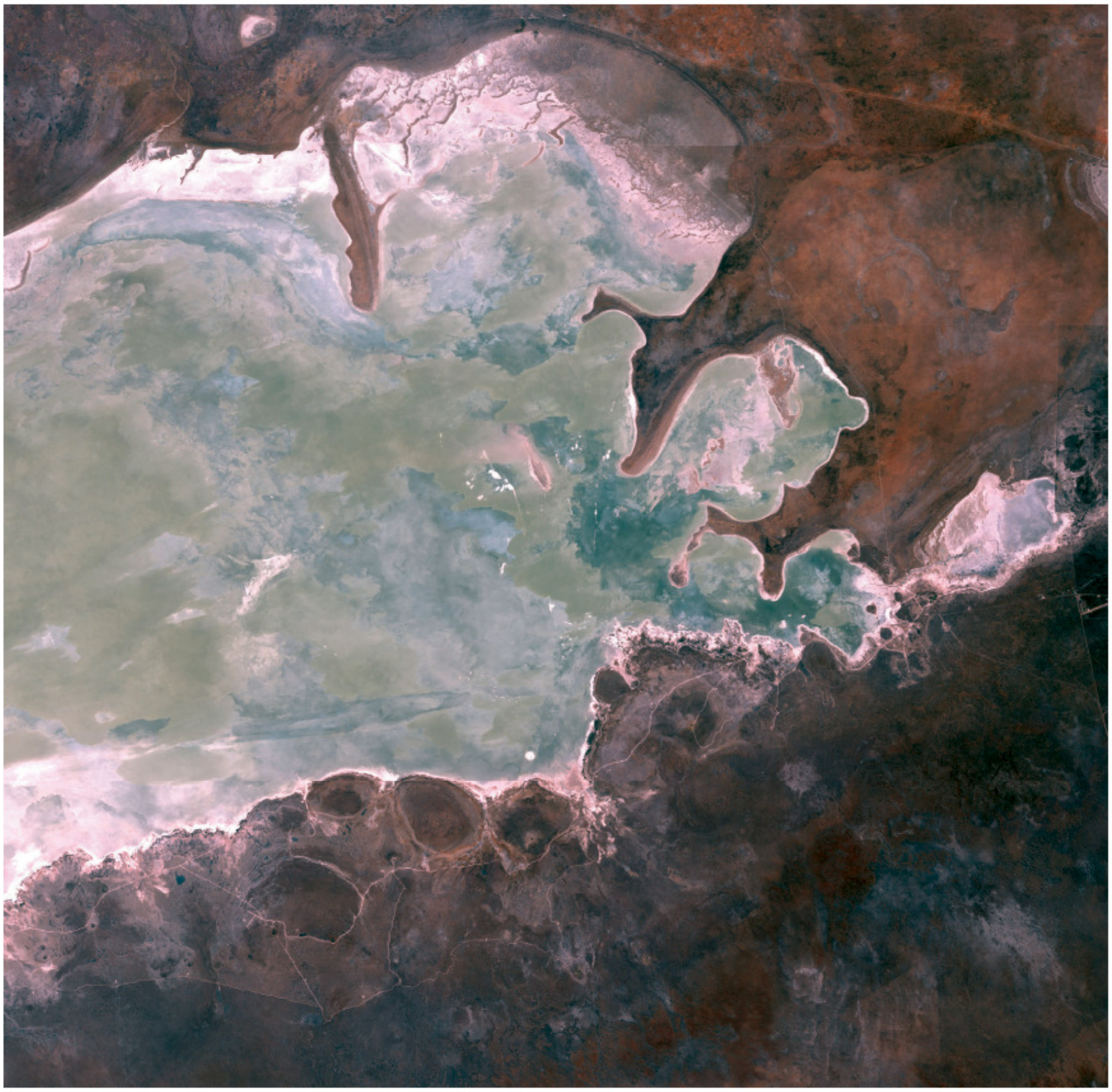
A variety of fossils have been found in Etosha Pan, many the bones of animals that would have only been there when conditions were much wetter than now, and when fresh water filled the Pan.[2] Some of the fossils belong to species that were last alive several million years ago, while others have been dated to periods going back thousands of years. Shown here is the trunk and roots of a tree that grew in what is now the Ekuma River (left), the remains of hundreds of stromatolites (which are bacterial growths called blue-green algae, centre) on the edge of the Pan, and the horn of a reedbuck-like antelope (right).

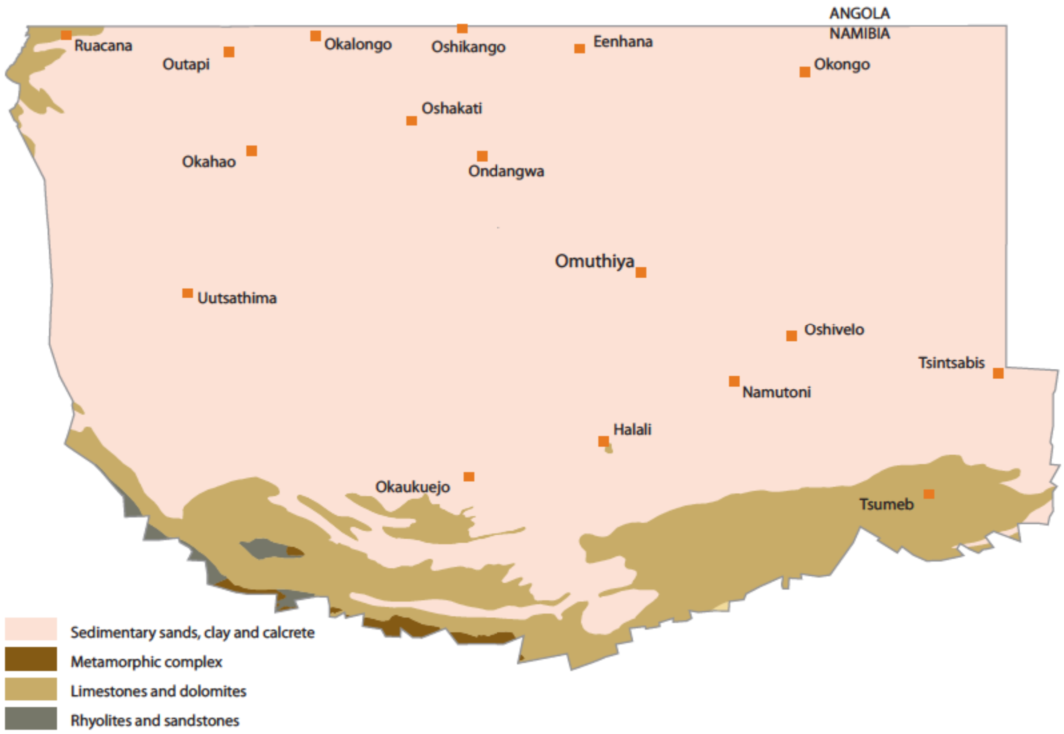


Etosha Pan is now usually a vast accumulation of white salty sediment, but in much wetter times past it was a huge permanent freshwater lake which might have covered much of the area up to the present Angola border, perhaps beyond. And during drier times, the lake area shrank to a tiny remnant, or disappeared altogether under a blanket of sand dunes.[3]

The elevation of the pan varies little, from 1,080 to 1,100 metres above sea level. Most of the present day inflow is from the Ekuma River in the north and, to a much lesser degree, from the Omuramba Owambo into Fischer's Pan in the east.

The main pan covers an area of 4,850 square kilometres, and stretches some 100 kilometres from east to west, and 50 kilometres from north to south. The delta of the Ekuma River is shown to the right.

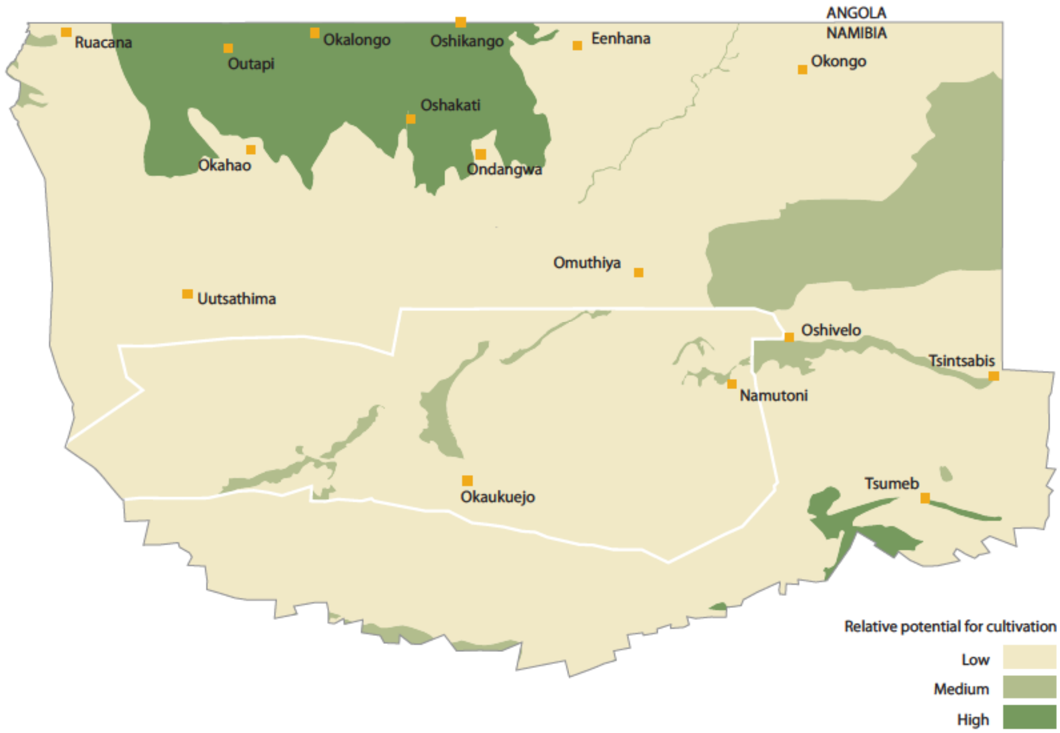




The geology of the Basin.[4] Prior to about 1,000 million years ago, southern Africa was part of the continent of Rodinia. A few rock formations that were part of Rodinia remain on the southern margin of the Basin – shown here as Metamorphic complex. Then the continent broke apart and by 750 million years ago the area that was to become the Basin was submerged in an ocean. About 650 million years ago the land masses on either side of the ocean began to drift towards each other, eventually colliding and amalgamating to form the super-continent of Gondwana. Various mountain ranges were lifted up by the force of the collision, one of which remains as the ridge of hills that encircles the south of the Basin.

The depression that became the foundation to the Cuvelai Basin then formed when the earth slumped down to the north of that highland ridge. This was 570 million years ago. Since then, successive periods of deposition have filled the Basin. One major period started about 300 million years ago during an almost worldwide period of glaciation. Its deposits are called the Karoo Sequence, which lie in the Basin as shales, sandstones and beds of organic material derived from plants. Some of that plant material was later transformed into seams of coal and perhaps oil-bearing rock.

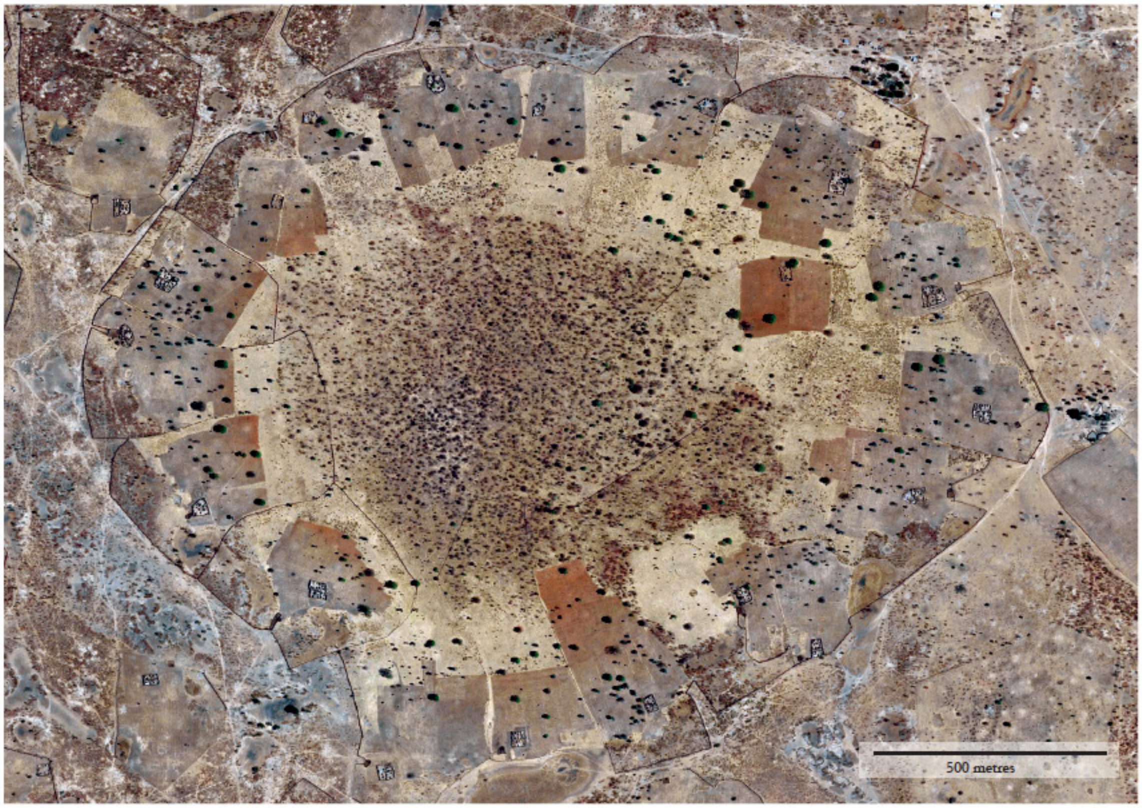
These seams are concealed below hundreds of metres of sediments laid down subsequently by various rivers during wet periods and by wind during periods of aridity.



Potential for cultivation.[5] The great majority of areas in the Cuvelai Basin are covered in wind-borne (aeolian) sands or water-borne (alluvial) clays, respectively, as shown in the map of soil distribution on page 14. As pure sands and clays, both soils are not well-suited for crops. The very sandy Western and Eastern Kalahari landscapes are nutrient-poor and have low water-holding capacity. Elsewhere, the fine alluvial clays are too dense, saline or water logged for crops, while soils in the south are too rocky or shallow in most places.

However, the mixing of sands and clays in the central-western area south of the Angolan border produced some of the most fertile soils in Namibia. These composite soils are known as cambisols and calcisols, and it is their presence that led to these being the most densely populated areas in the Basin, indeed in much of southern Africa (see page 19).

Even in these fertile areas, however, local variations in the organic content, salinity, water-holding capacity, chemical composition and depth of soil may limit crop production. Low and erratic rainfall and pests are additional factors which affect yields.



The maps on pages 14 and 35 provide perspectives on the broad distribution of soils and their potential for cultivation, respectively. Within any one area, however, there is a great deal of local variation. In places where soils are suited to cultivation, farmers select patches of soils that have the highest fertility, and it is here that most homes and fields are located.

This image shows about 20 homesteads surrounding a central area of wind-borne sands. The sands and many remaining trees are on the highest elevations or ridges (locally called *omitunda*), while the fields have been cleared on the slopes between the sands and the clayey, saline soils in the *iishana*. Soils on the highest areas of the slopes are darkest, while others are progressively lighter at lower elevations. This area can be seen in Google Earth at 17.414 South and 14.784 East.

The areas used for crops shown on the facing image are composites of sand and clay. These soils have largely been mixed by wind which has blown fine clayey sediments out of low-lying areas onto surrounding higher zones of sand. Since the prevailing winds in the Cuvelai are from the east (and have obviously been blowing from the east for a very long time), the best mixes around pans in the eastern Kalahari have been created on their western, downwind margins. Gentle lunette dunes have also formed to the west of some pans.

Similar effects of wind erosion are to be seen along *iishana* drainage lines where the most mixed soils lie on the western slopes of each *oshana*. These pans are visible in Google Earth at 17.442 South and 16.595 East.

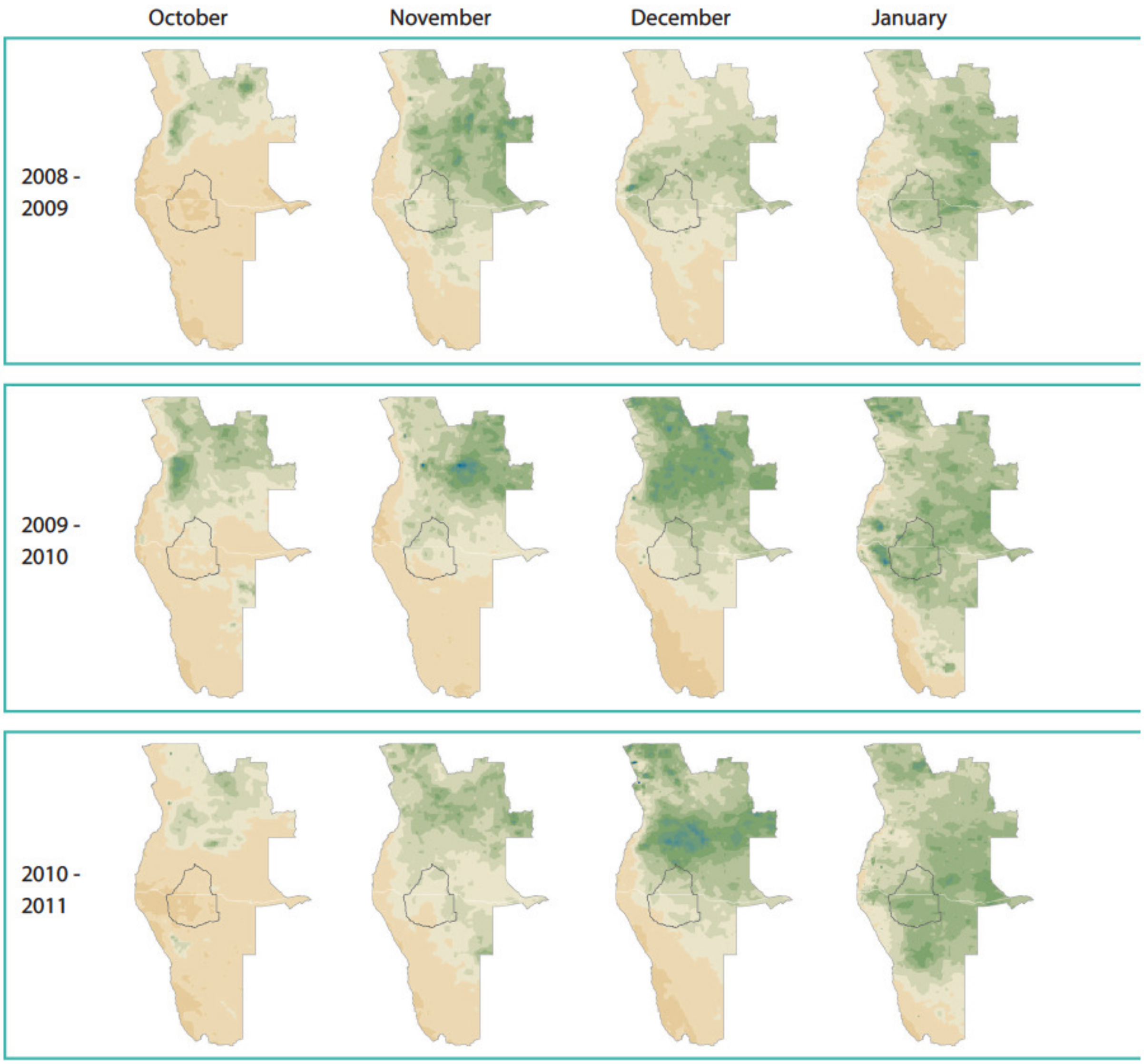
3 - Climate: rain, wind and heat

The Cuvelai Basin's climate is dominated by the movement of air controlled largely by high pressure systems: the South Atlantic Anticyclone situated over the Atlantic Ocean, and the Botswana Anticyclone positioned inland over southern Africa. The positions of these high pressure zones shift seasonally in tandem with the seasonal north-south movement of the inter-tropical convergence zone (ITCZ). In winter the anticyclones are in their most northerly position and prevent the southward and eastward movement of tropical warm moist air in the ITCZ. It is only when the high pressure cells have shifted south during the summer months (November to April) that conditions are suitable for cloud development and rain.

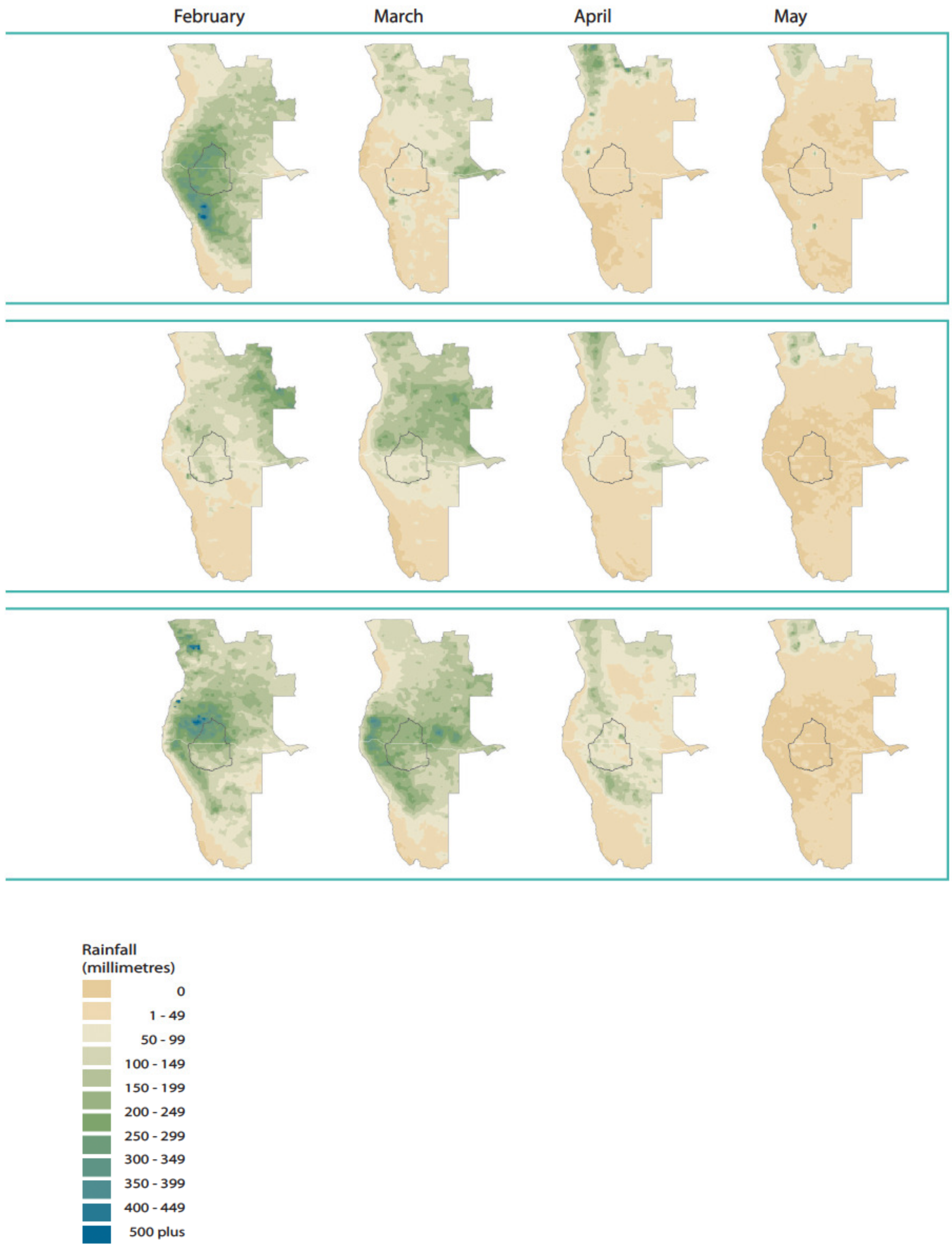
These seasonal changes have marked effects on all forms of life in the Basin. During the dry, cold winter months and hot early summer months little vegetation grows and most surface water evaporates. The countryside is then parched and seemingly bleak.

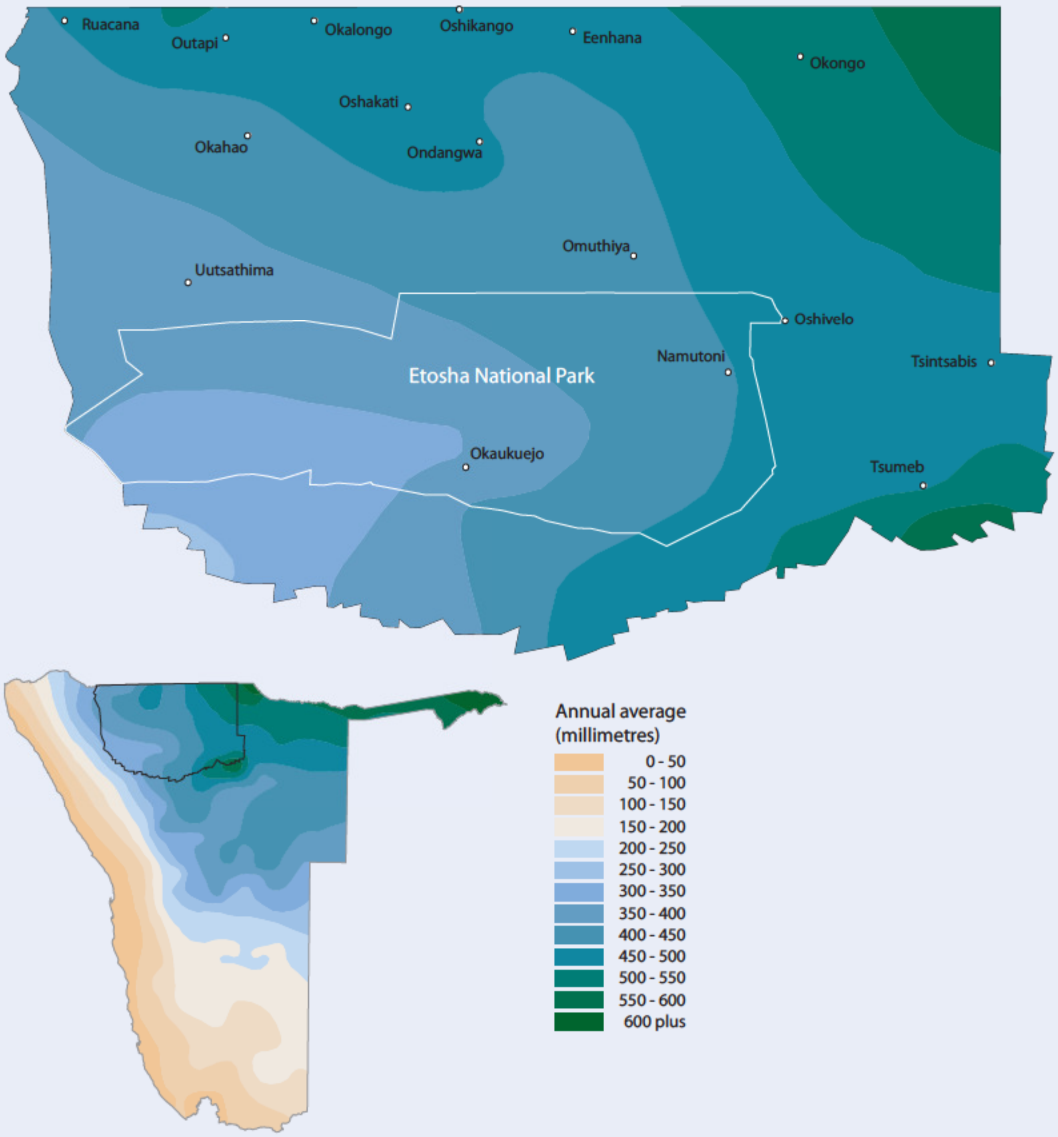
All this changes with the arrival of rain which stimulates the germination and growth of natural vegetation and allows people to begin cultivating crops. When heavy rains fall, which is normally in the second half of summer, thousands of pans may fill with water and the *iishana* may flow from north to south, bringing rich harvests of fish. The Basin then becomes vibrant, brimming with life.

Most rain falls during afternoon thunderstorms which typically last less than an hour. The downpours are often heavy, sometimes causing local run-off and erosion even though the landscape is so flat. The removal of soil from the surface of fields by erosion may cause *iishana* to fill with sediments, thus contributing to flooding (see page 76).

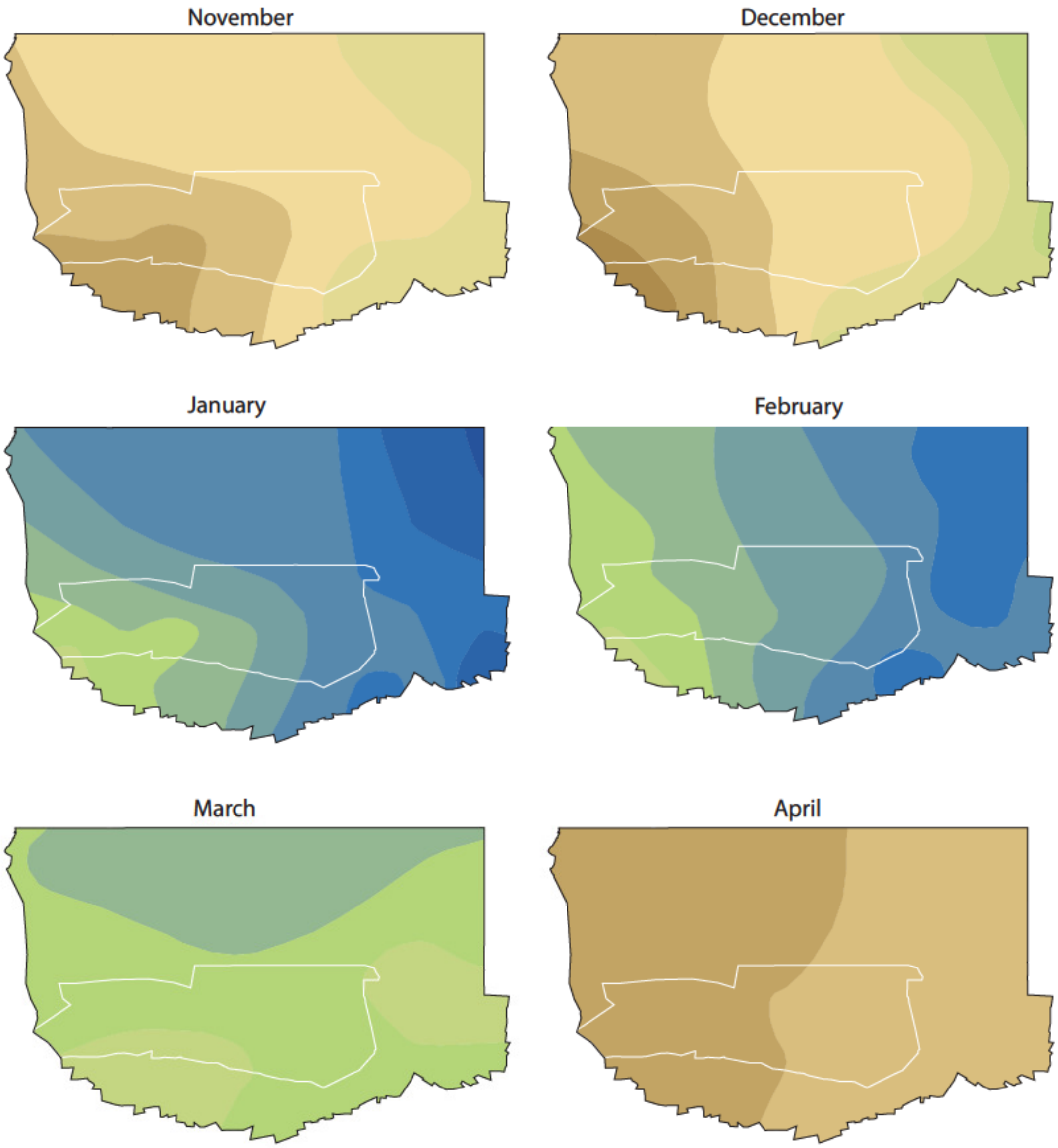


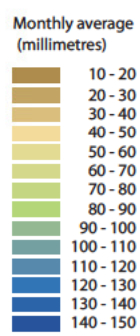
Rainfall over Namibia and Angola during successive seasons.[1] This series of maps shows the amounts of rain that fell each month during three rainy seasons (October-May): 2008-2009, 2009-2010 and 2010-2011. They demonstrate several aspects of rainfall in the Basin. Firstly, the progressive movement between October and December of moisture carried by the ITCZ is visible, followed by its later retreat north, particularly from March onwards. Secondly, the maps demonstrate how rainfall varies from month to month and year to year. Compare, for example, rainfall in March 2009 and March 2011, or in February and March 2009. In the 2008-2009 season most rain fell in only one month (February) while January to March were all wet months in the 2010-2011 season, which is when the Basin experienced very severe flooding. Third, many of the maps show higher falls of rain in the north of the Basin than the south.


February
March
April
May
Rainfall
(millimetres)
0
1 - 49
50 - 99
100 - 149
150 - 199
200 - 249
250 - 299
300 - 349
350 - 399
400 - 449
500 plus



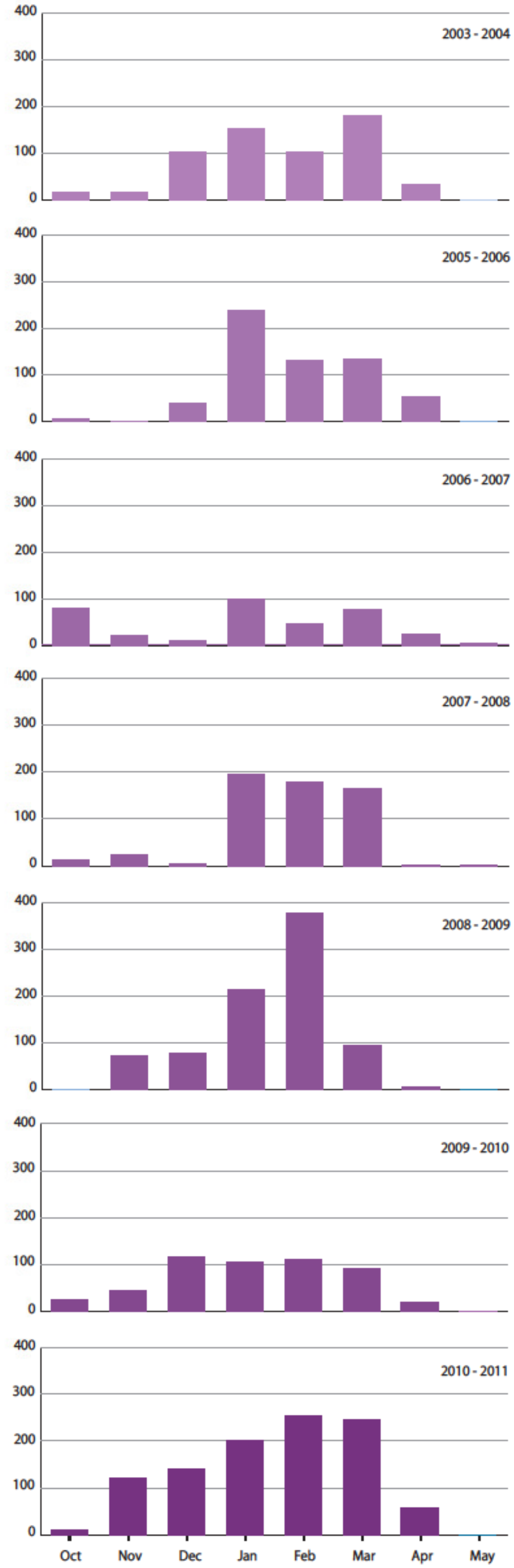
Annual average rainfall.[2] As in Namibia as a whole, there is a east to west rainfall gradient across the Cuvelai Basin as a result of moist air being fed in from the north and north-east during the rainy season. The extreme south western parts of the basin consequently receive on average only around 250 millimetres per annum while the north-east receives about 600 millimetres. The extreme south-eastern parts near Tsumeb receive higher rainfall than the surrounding area as a result of orographic rainfall which occurs when moist air, which is forced up over the surrounding hills, cools and condenses to produce rain.



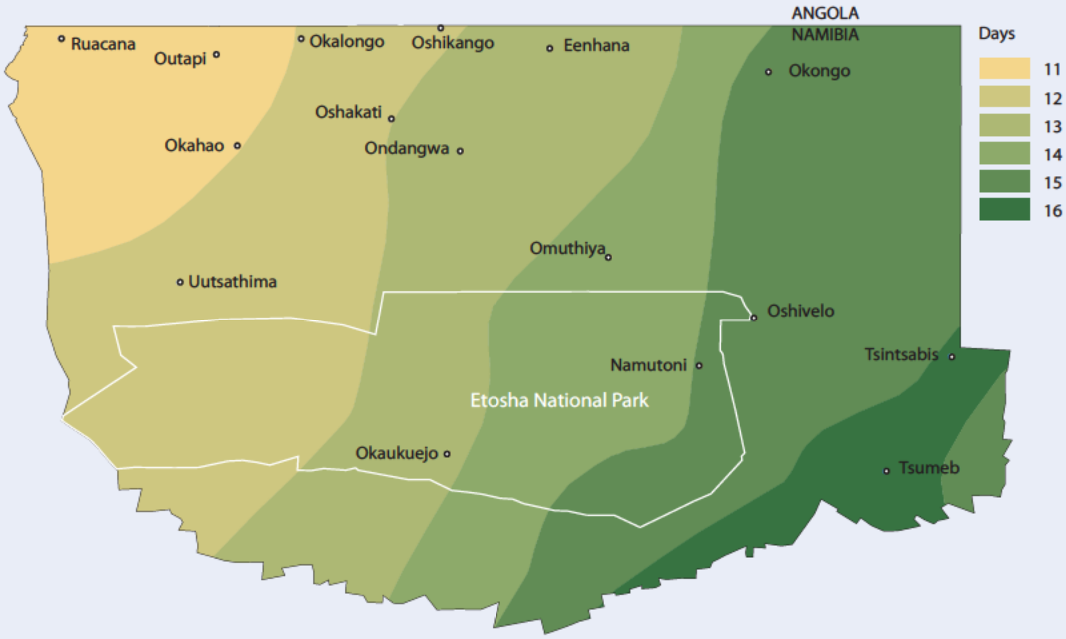


Average monthly rainfall between November and April.[3] The rain season is limited to the months between November and April with over two-thirds of all rain falling in the three months of January, February and March. January is the wettest month, on average.

Variation in rainfall from month to month, and year to year.[4] Both the amount of rainfall received and its timing during the summer show a remarkable degree of variation, as shown by these graphs of monthly rainfall over seven years at Ondangwa. For example, the highest total over these seven seasons in Ondangwa was in the 2010-2011 season when 1,027 millimetres fell. The majority of the Cuvelai received twice its normal precipitation during this season. By contrast, four years earlier, only 372 millimetres fell at Ondangwa. There is also little consistency between years in the timing of the rainfall. In some years,



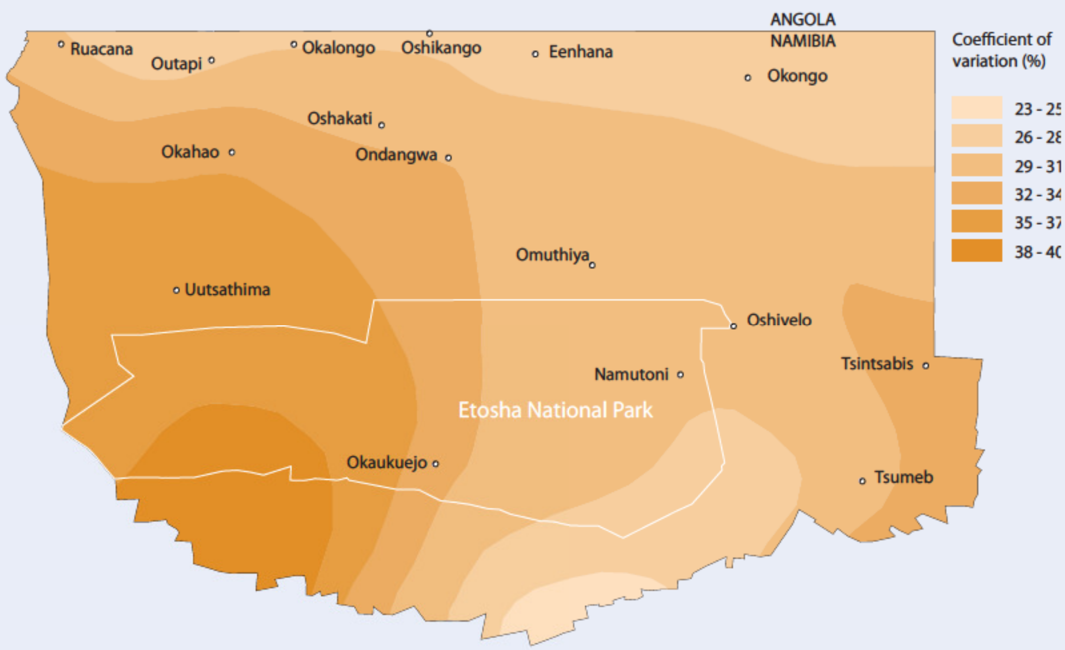
peaks occur in January and February while in other years rain may be spread more evenly between December and March, or skewed towards the earlier or later months of the season. This variation strongly influences the planting, growth, harvesting and yields of crops in the Basin.



The average number of days on which productive rainfall is expected.[5] These are days when 10 or more millimetres are recorded. Both the number of productive rain days and their spread throughout the season are important for plant growth. For example, many days of productive rain in one month would be good for crops, but the crops would fail if little or no productive rain fell thereafter. From the map it is evident that the risks of farming are greatest in the west where there are fewer productive rainfall days than in the east, on average.

Heavy rains caused substantial flooding in 2007-2008, 2008-2009 and again in 2010-2011. There was also some flooding in 2009-2010. This succession of flooding has led some people to suggest or claim that the high rainfall and flooding are due to climate change.

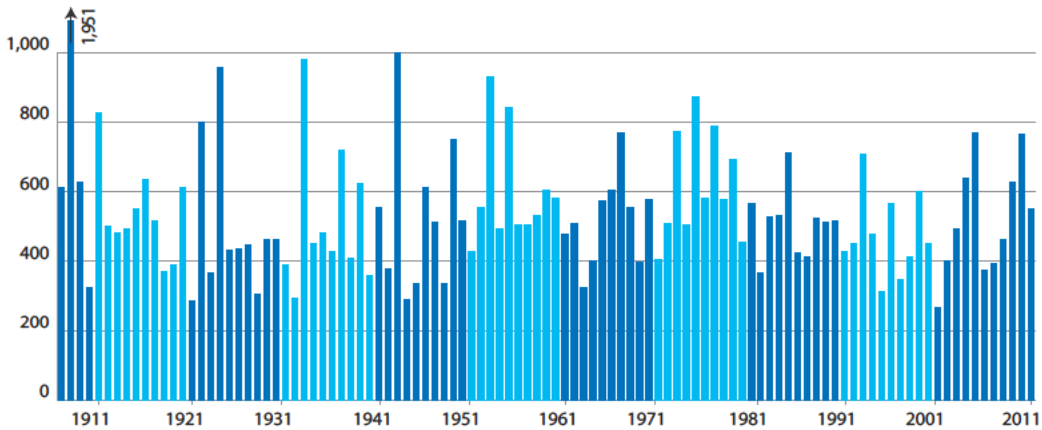
While the climate is indeed changing, there is no conclusive evidence that the floods were necessarily caused by climate change. And as this book was being finalised, the Basin was experiencing very low rainfall in 2012-2013.

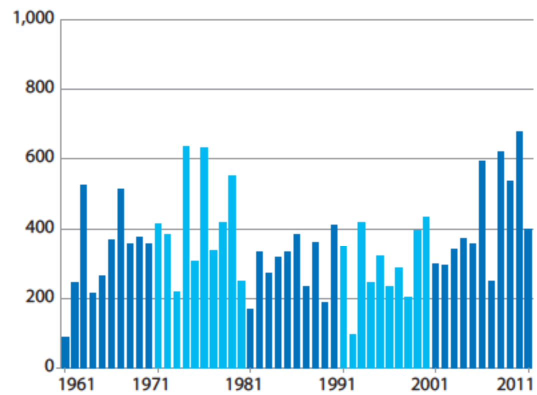


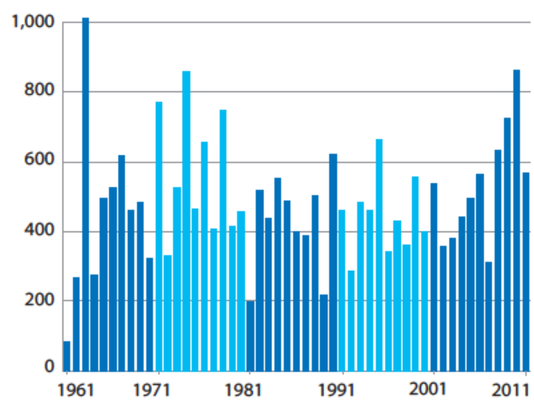
Variation in rainfall.[6] The map shows the coefficient of variation of annual rainfall, which provides another measure of how reliable rainfall is across the Basin. A high value indicates a higher degree of variability between rainfall seasons. By comparing the maps of average annual rainfall (page 42) and this one of the coefficient of variation, we can see that the western parts of the Basin not only receive less rainfall than the eastern areas but that rain is also less predictable in the west.

Rainfall has been generous in the Basin and in Namibia as a whole in recent years, and memories of drought are fading. However, severe shortages of rain are certain to occur again, when large numbers of livestock and wildlife will die, as happened in the 1994-1995 drought and during the early 1980s.

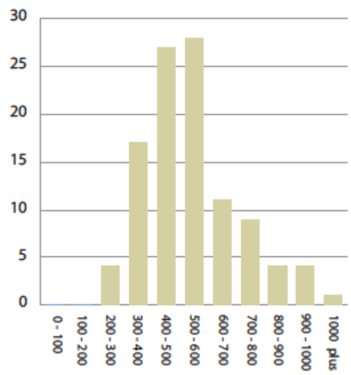
Well before this time, severe droughts took even greater tolls when perhaps as much as 30 to 40% of the human population died as a result of famines (see page 141).


1,951
1,000
800
600
400
200
0
1911
1921
1931
1941
1951
1961
1971
1981
1991
2001
2011

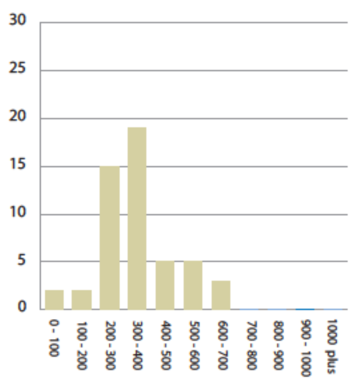

1,000
800
600
400
200
0
1961
1971
1981
1991
2001
2011


1,000
800
600
400
200
0
1961
1971
1981
1991
2001
2011

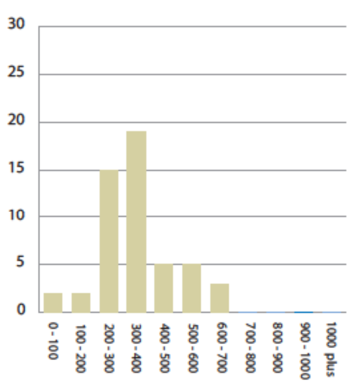
Tsumeb



Okaukuejo

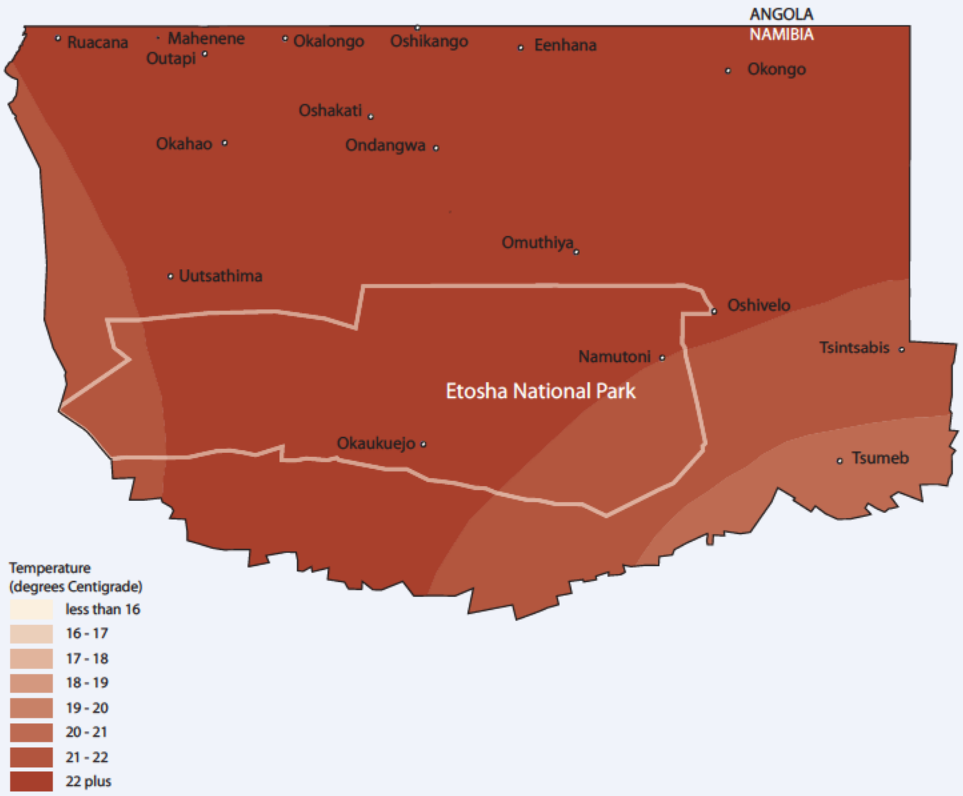


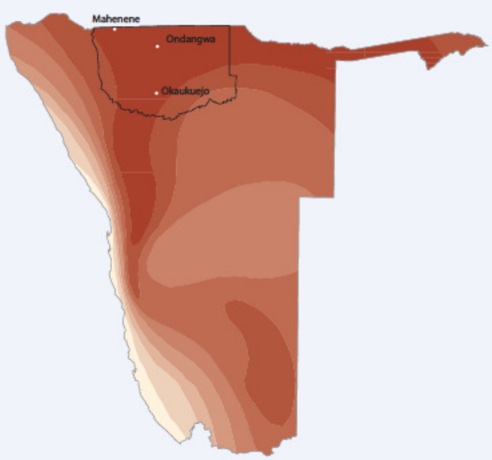
Okatana



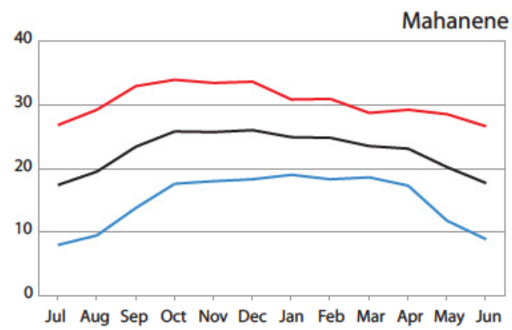
Annual rainfall over several decades at Tsumeb, Okaukuejo and Okatana.[7] These long-term records illustrate not only the degree of variability in rainfall between seasons, but also longer term cycles of drier and wetter periods. At all three places, rainfall increased during the 1970s and dropped again in the 1980s and 1990s. While Okaukuejo and Okatana again received increased rainfall totals over the past decade, rainfall at Tsumeb has shown a continued decline since the previous peak in the mid 1970s. The graph for the past 100 years at Tsumeb suggests that extremes in rainfall between seasons were more frequent up to the 1950s than during the second half of the 20th century. That trend is contrary to current wisdom on climate change which predicts that weather is becoming more variable.

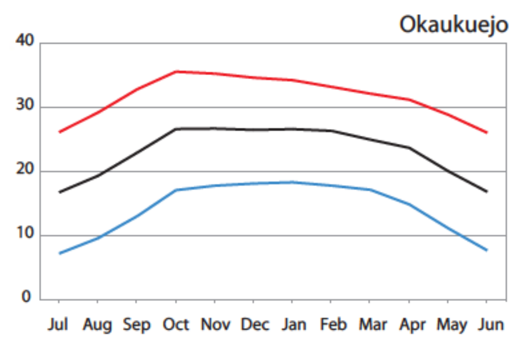
The small charts immediately to the left show the number of years in which different totals were recorded, and provide more insight into rainfall variability. For example, while 70% of the seasonal totals at Tsumeb ranged between 300 and 600 millimetres most other seasons received higher rainfall. By contrast, two-thirds of all seasonal totals at Okaukuejo were between 200 and 400 millimetres.

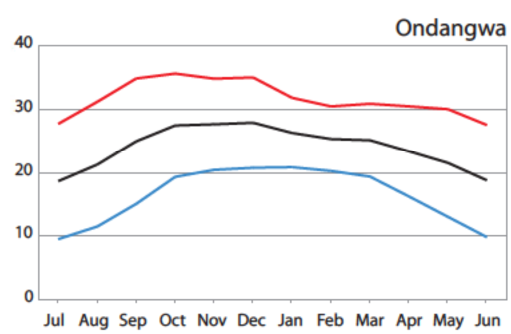




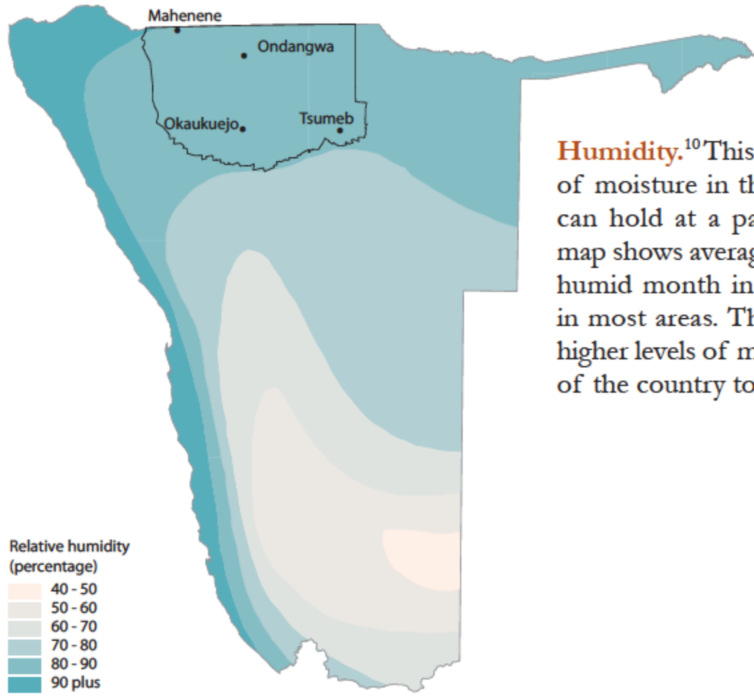
Average temperature during the year.[8] Temperatures vary little across the Basin where the average is greater than 22 °C in most areas. The south-eastern and south-western parts are slightly cooler. Temperatures experienced in the Basin during the early summer months are some of the highest in the country.





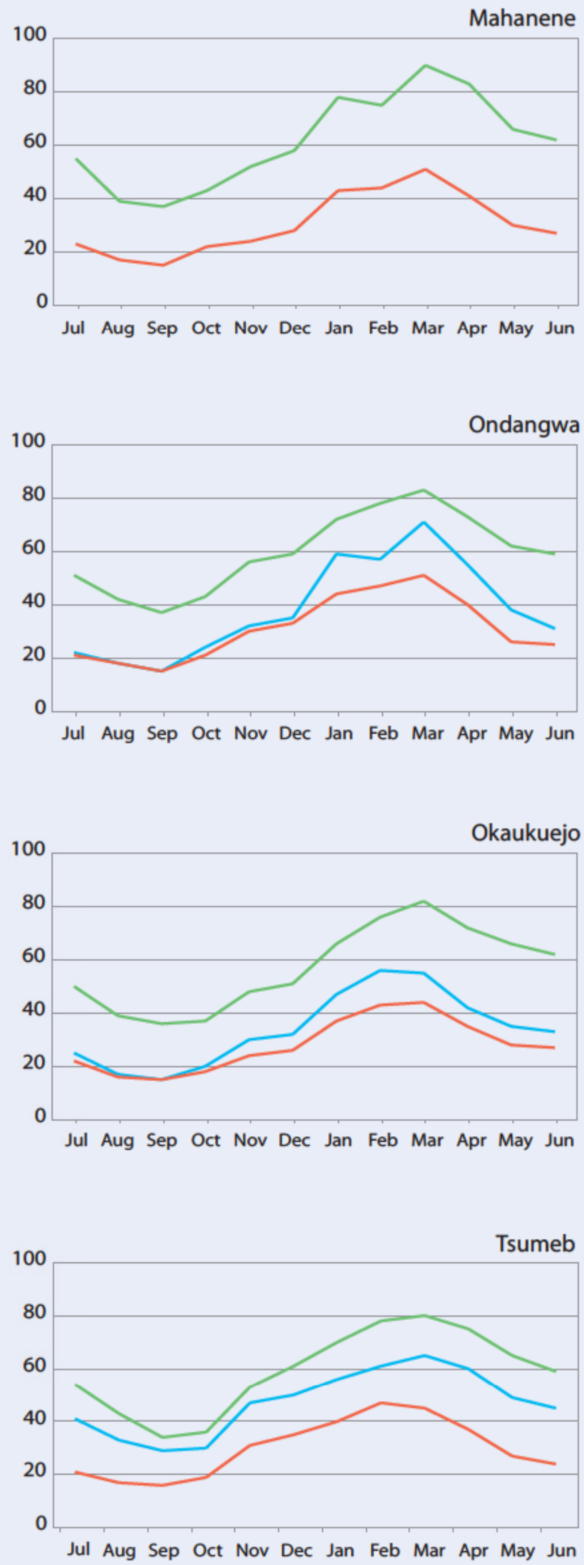


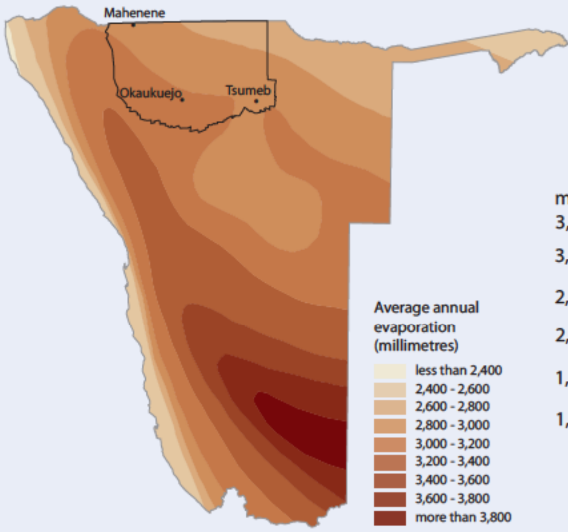
Maximum and minimum temperatures.[9] The graphs show the average minimum (blue) and maximum (red) temperatures recorded each month, as well as the overall average (black) which is mid-way between the minimum and maximum. Maximum temperatures range between 24°C in June and July and 36°C in October to January. Minimum temperatures range between 7°C in June and July and 21°C in mid-summer. During the summer temperatures seldom drop to much below 20°C. October is the hottest month, although September, November and December are usually very warm as well. Many animals then spend much of the day in shade.

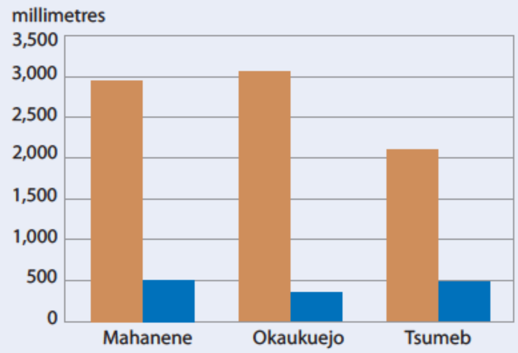


Humidity.[10] This is a measure of the amount of moisture in the air in relation to what it can hold at a particular temperature. The map shows average humidity during the most humid month in Namibia, which is March in most areas. The Basin then has relatively higher levels of moisture in the air than much of the country to the south.

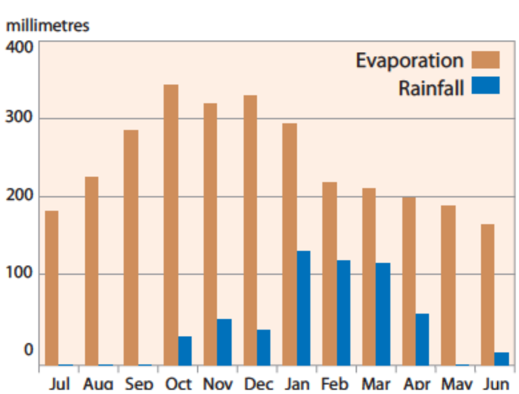
Relative humidity at three times of day during the year at Mahanene, Ondangwa, Okuakuejo and Tsumeb.[11] March is the most humid month in the Basin when humidity levels rise on average to over 80%. September is the least humid and therefore the driest month with humidity levels usually less than 20%. Cool air holds relatively more moisture than warm air and consequently percentage humidity in the early morning is higher than later in the day.



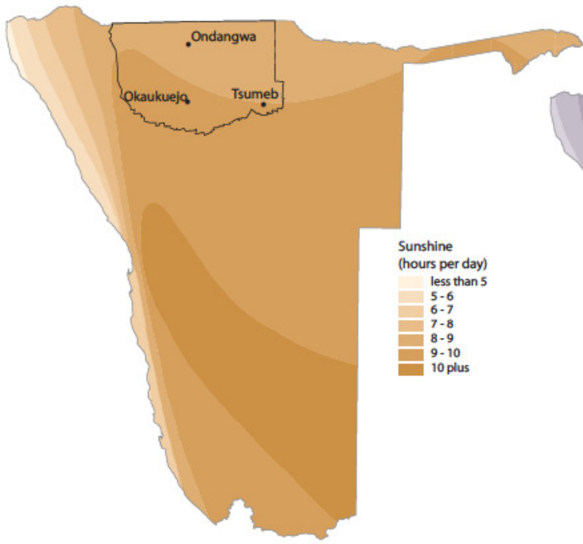


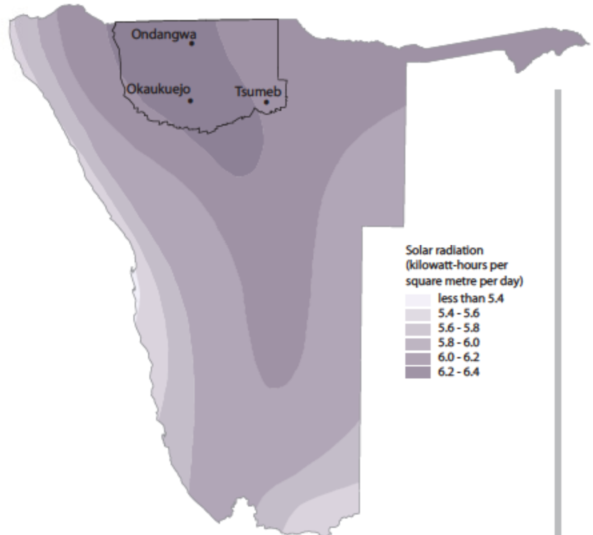


Annual evaporation across Namibia and at three places in the Basin.[12] Several factors contribute to the amount of water lost through evaporation. These include temperature, humidity and cloud cover, wind and solar radiation. Although temperatures and levels of solar radiation are high in the Basin (see pages 50 and 55) their impacts are offset to some extent by the relatively higher levels of humidity and cloud cover which occur in the rainy season. Most parts of the Basin experience similar levels of evaporation with the exception of the south-eastern section which has greater cloud cover as a consequence of the hilly terrain, and thus lower evaporation rates. For example, evaporation rates are four times greater than annual rainfall at Tsumeb, compared to about six times more at Okaukuejo and Mahanene.



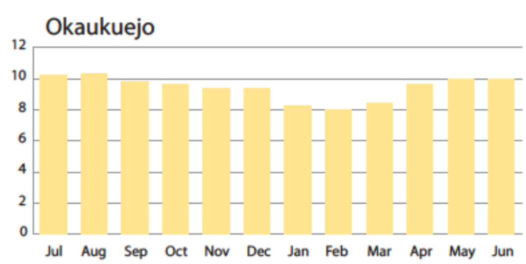
Average evaporation rates and rainfall each month at Mahenene.[13] Water loss is greatest in the early summer months of October, November and December when sunshine is intense and there is little cloud to reflect the heat. Evaporation levels then drop to around 200 millimetres during the peak rainfall period when there is much more cloud cover.

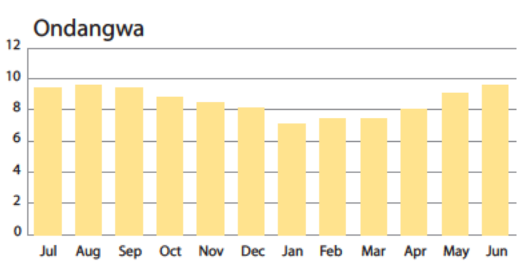


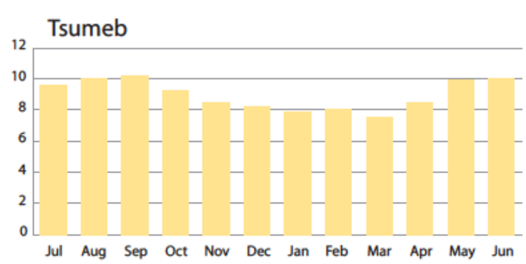


Average sunshine hours (above) and levels of solar radiation (right) across Namibia.[14] The Cuvelai-Etosha Basin receives some of the highest levels of solar radiation in the country. Incidentally, this means that solar power could be more effective here than elsewhere. This is true even though the Basin has slightly fewer sunshine hours due to more frequent cloud cover than in many other parts of Namibia.

Average sunshine hours per day at Okaukuejo, Ondangwa and Tsumeb.[15] During the winter months the Basin experiences about 10 hours of sunshine per day. This declines steadily during the rainy season to 8 hours or less when large cloud masses obscure the sun.

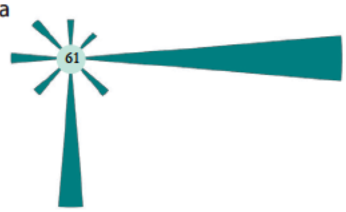




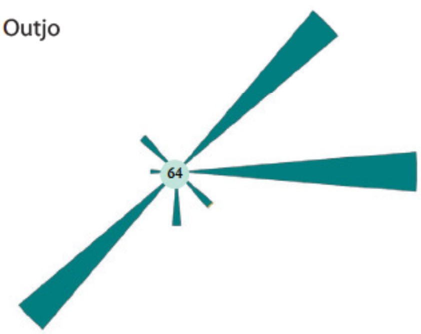


Average wind directions at Grootfontein, Ondangwa and Outjo throughout the year.[16] While there is variability, for much of the year winds blowing across the Basin come largely from the north-east and east. Most of the moisture, and therefore rain, that comes into the Basin also comes from these directions. The length of the 'arms' of the wind roses indicates the proportion of time that wind blows from each direction Figures in the centres of the wind roses are the percentages of the time that it is calm.

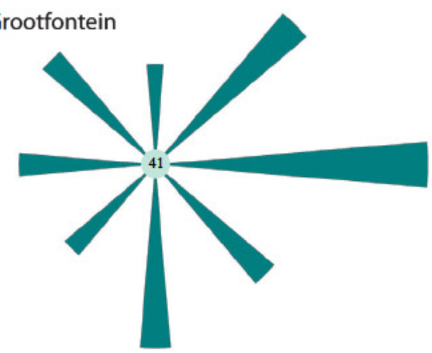
Ondangwa



Outjo



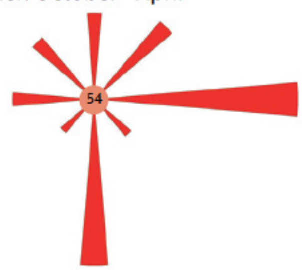
Grootfontein



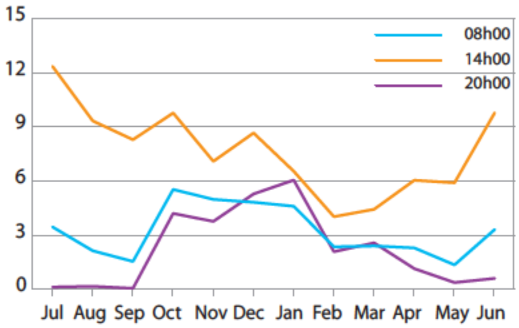
Wind directions in summer and winter. During the winter at Ondangwa almost all wind is fed in from the east by the strong anti-cyclonic conditions over southern Africa. By contrast, wind directions are more variable in summer.

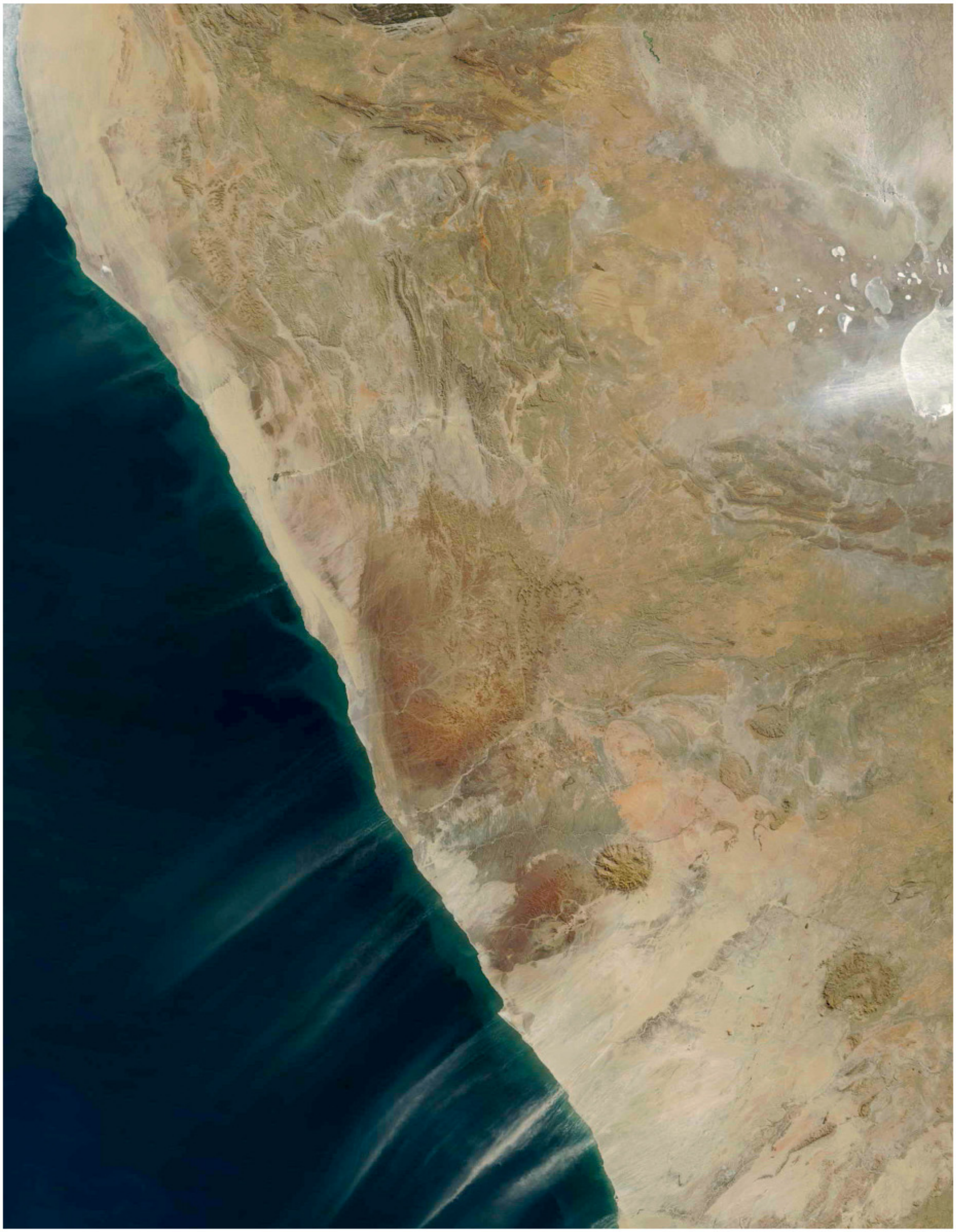
Winter: May - September

Summer: October - April



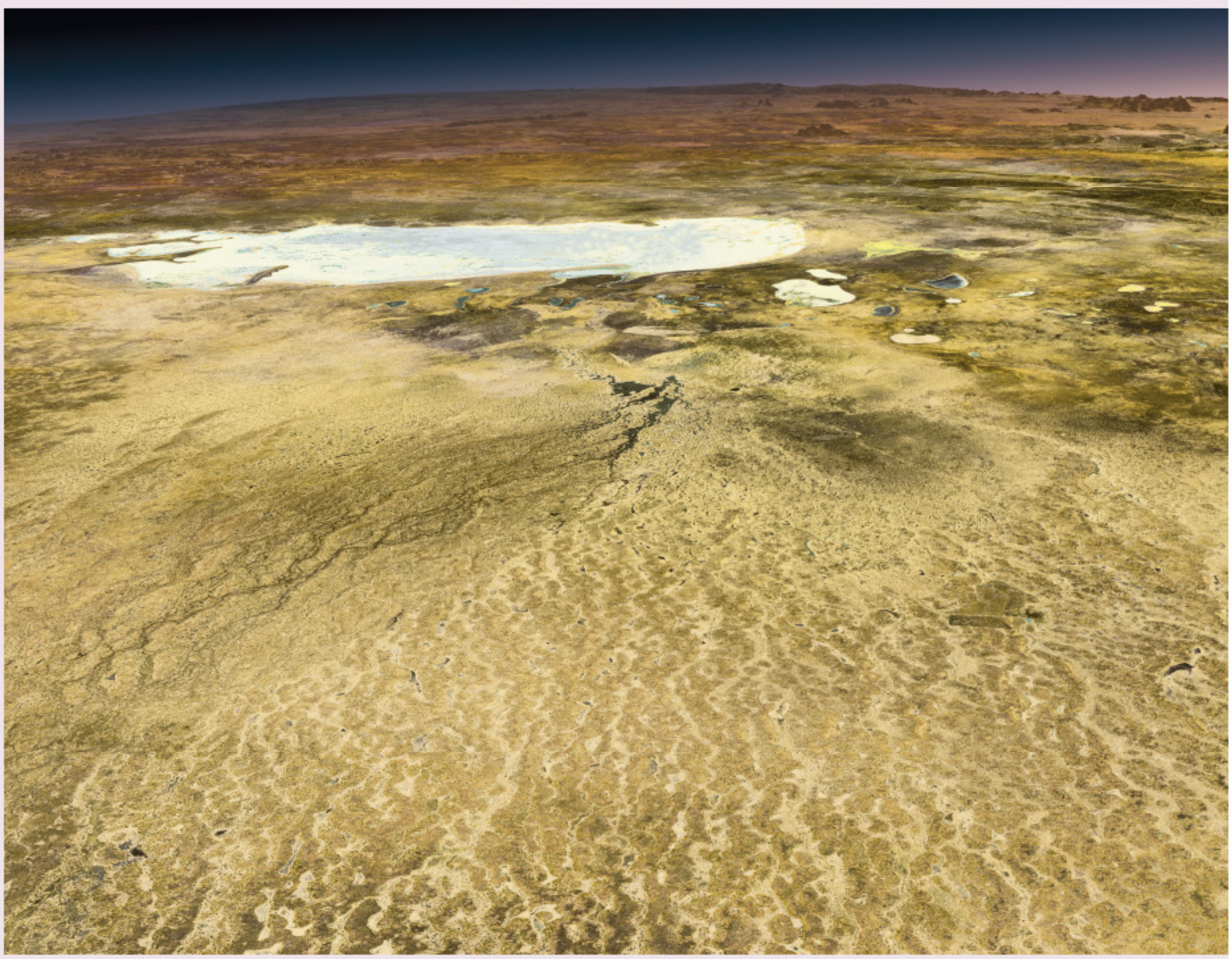
Wind speeds during the day.[17] The graph shows speeds in the morning (08h00), afternoon (14h00) and evening (20h00) at Ondangwa. The units are kilometres per hour. Wind speeds are fairly low in general, and for much of the time it is actually calm. The strongest winds are often the easterly anti-cyclonic winds, as reflected by the highest wind speeds during the middle of the day (14h00) in June and July.





Strong winds from the east are generated by the Botswana Anticyclone situated over the centre of southern Africa. The winds scour dust from the surface of Etosha Pan which has been maintained as a local depression by scouring over thousands of years. Some sediments have been deposited in lunette dunes on the western margin of the Pan. For similar reasons, ridges or highland *omitunda* on the western sides of *iishana* are often slightly higher than those on the eastern sides. On some days, dust from Etosha Pan is blown all the way to the Atlantic Ocean. On the day that this photograph was taken sand from the coastal plain was also being blown out to sea.

4 - Surface waters: their coming and going

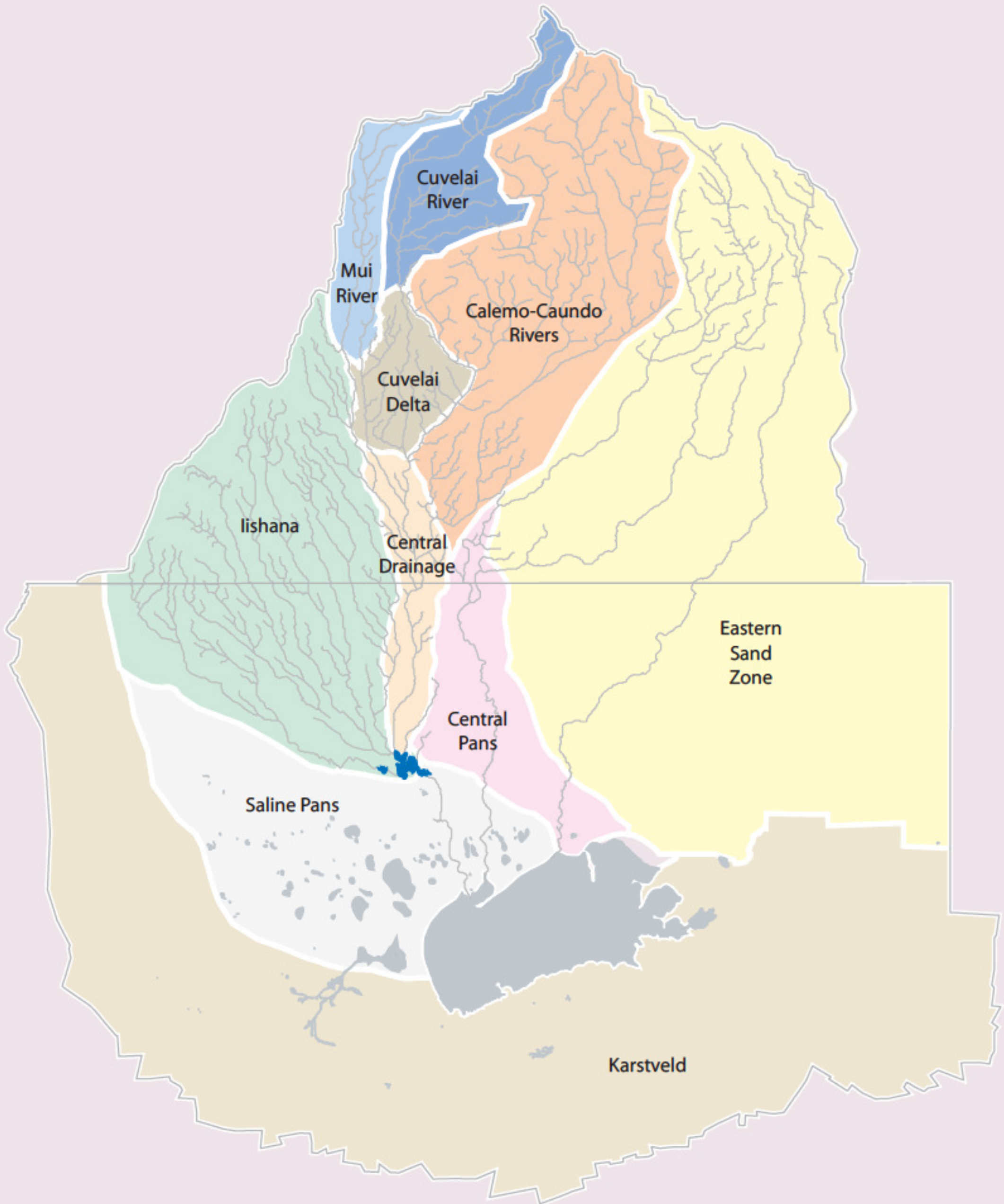


Cuvelai and Etosha are names that characterise two important expanses of surface water: the network of Cuvelai Drainage *iishana* and the massive Etosha Pan. Most parts of the Cuvelai and the Pan are ephemeral, thus only holding water sporadically. The occurrence, distribution and expanse of surface water is seasonal, depending on where rain has fallen. Local heavy rains in the Namibian part of the Cuvelai generally cause localised flooding, while widespread flooding is usually due to extensive heavy rain in higher altitude and higher rainfall areas upstream in Angola. Normally the surface waters are short-lived, evaporating or seeping away over weeks or months, depending on the depth of the water and permeability of the soils.

Although most surface waters are in the *iishana* channels these days, over millennia the whole Basin has been moulded at times by much greater flows and flooding. Water erosion was also more forceful then, for example when the Cuvelai received water from much of the present Kunene River's catchment and rainfall was several times greater than it is nowadays. Under those circumstances, Etosha was a massive lake that perhaps covered the whole *iishana* area.

By contrast, conditions were so dry during other periods that wind-blown sand dunes covered the Basin, and there were probably no flows of water anywhere. The Basin may have then looked like much of the present southern Kalahari semi-desert, probably covered in dunes like the area east of Mariental and Keetmanshoop is today.

In recent years, the Basin has experienced serious flooding which caused the loss of human life, homesteads, crops, livestock and infrastructure, such as roads and canals. These events have heightened the need for preparedness and mitigation, especially since it is the most economically vulnerable people who are generally hit hardest by flooding.


Cuvelai River
Mui River
Calemo-Caundo Rivers
Cuvelai Delta
Iishana
Central Drainage
Eastern Sand Zone
Central Pans
Saline Pans
Karstveld

The major drainage zones in the Cuvelai Basin. All the drainage lines flow south from areas of higher elevation and rainfall and then converge on the Omadhiya Lakes and Etosha Pan which is the lowest part of the Basin. The drainage lines function and flow in ways that differ from one zone to another, each with its own characteristics and patterns of water flow.

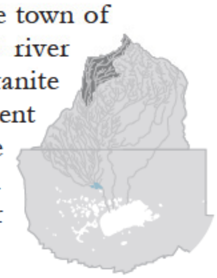
Water flows occur regularly in the northern zones of Iishana, Mui River, Cuvelai River, Cuvelai Delta and Central Drainage, but only rarely and over short distances in the eastern zones. Except for Etosha Pan itself, all surface water in the Saline Pans and Central Pans zones is from local rainfall. Soils in channels of the Iishana Zone are very saline, reflecting the high rates of evaporation of water from these broad waterways. Once the main flows drop and later stop, large areas of water remain standing in the channels and then gradually disappear through seepage and evaporation, leaving behind salts in the surface soil.

Water in the Cuvelai River, Mui River, Cuvelai Delta and Central Drainage Zones is largely fresh, since the flows are relatively rapid. Compared to the Iishana Zone, the channels are also much narrower and are lined with tall trees in many places.

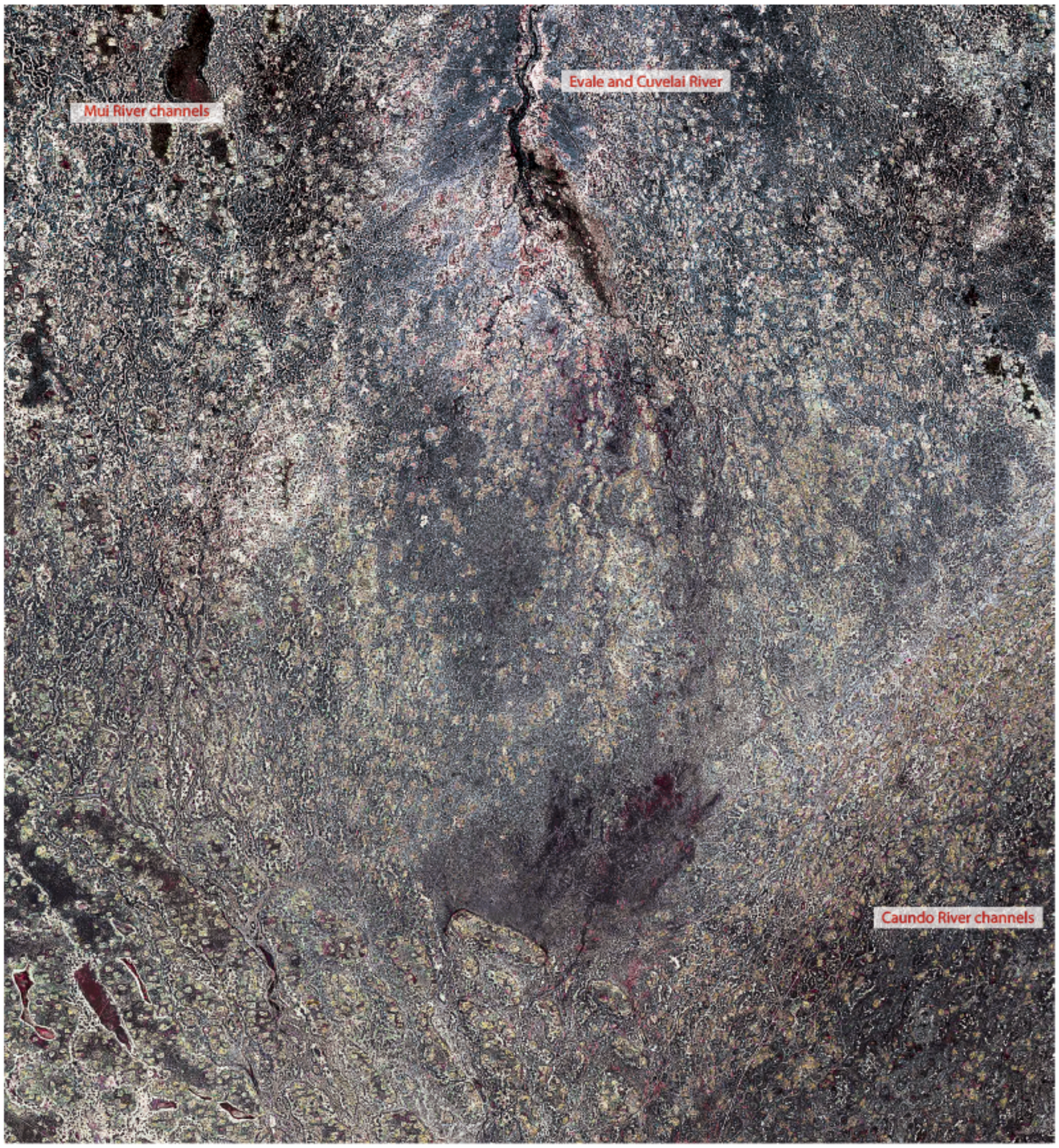
Mui and Cuvelai Rivers

The Cuvelai and Mui Rivers provide the only perennial sources of water to the Basin since they originate in areas that receive an average of about 900 millimetres each year. However, the distance each river carries water down and into the network of *iishana* depends on how much rain has fallen.

This photograph is of the Cuvelai River some 30 kilometres east of the town of Cuvelai. Note that the river banks are lined with granite rocks. This is quite different from most other drainage lines in the Basin which flow across alluvial or wind-blown sediments.



The Cuvelai Delta

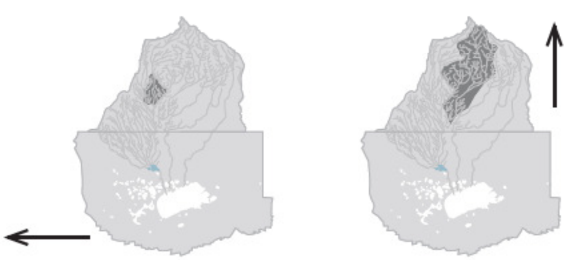


The Mui and Cuvelai Rivers cease being single streams of flow in the Cuvelai Delta where they fan out into a myriad of very narrow branching and inter-connected channels.[1] The Mui fans out along the western edge of the Delta, while the Cuvelai fans out at the town of Evale. However, in earlier years the Cuvelai Delta perhaps started fanning some 60 kilometres upstream, and has since shifted progressively south, gradually building on top of the river-borne sediments previously laid at its apex. This would have happened over a very long period. Flows of water eventually converge again along the Delta's southern margins where they merge with water in the *iishana* from the north-west. In years with exceptional rain, the Caundo River may flow down to Nehone and beyond, and its waters too then combine with those emerging from the channels of the Cuvelai Delta.

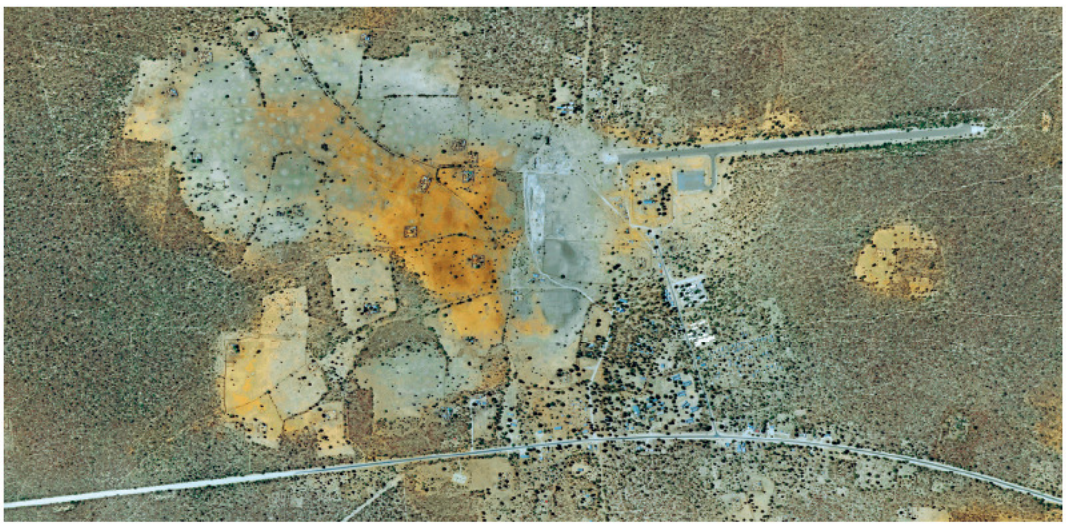
Calemo-Caundo Rivers

While parts of the catchment of the Calemo and Caundo rivers (and of the rivers in the Eastern Sand Zone) drain areas of high rainfall, all these rivers and their tributaries overlie extremely permeable Kalahari Sand. This is especially true in areas furthest to the east. Following heavy rain these rivers may flow for some distance, but the water soon sinks into the ground. The remnant, fossil river courses in the east and south-east, such as the Niipele River, were formed during much wetter periods when water flowed much further than nowadays.

This photograph of the Caundo River was taken in 2010 after exceptional rain near the tiny village of Yonde. Residents reported that it was 40 years ago since they has last seen water like that.



Eastern Sand Zone

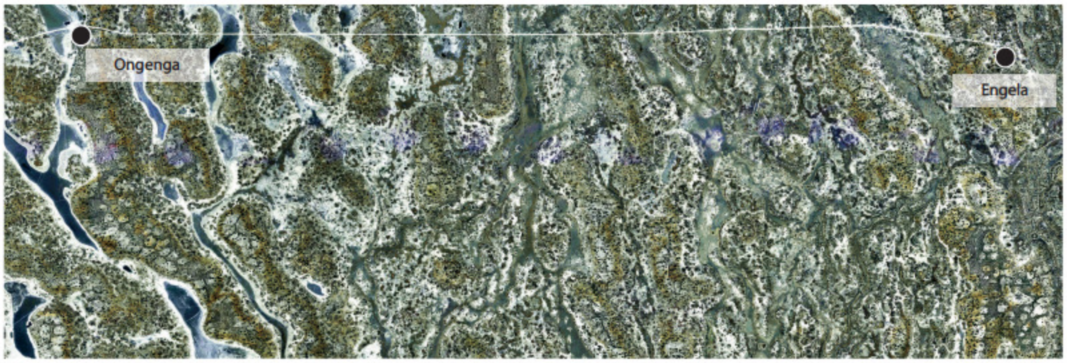


Unlike the ephemeral rivers in the Calemo-Caundo Zone, the few remaining drainage lines in the northern Angolan part of the Eastern Sand Zone have extremely wide margins of grassland. These grasslands - in the photograph at the top - are the most important resource in the traditional Oshimolo dry season grazing area for cattle belonging to Kwanyama farmers.

Away from these drainage lines and the many isolated pans found in a broad swathe north and south of the Angola-Namibia border, the entire landscape of the Eastern Sand Zone is dominated by tall Kalahari sand woodland. The hundreds, perhaps thousands, of pans were formed during wetter periods. Some of them now fill with water after heavy local rain, but the water usually disappears within a few weeks or months. The pans provide the only soils suited to crop growth in this Zone, and therefore all resident farmers live close to the pans.

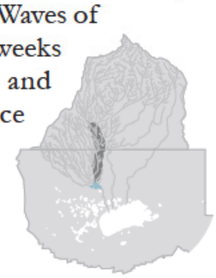
The centres of the pans are usually only 10-15 metres lower than the surrounding woodlands. The town of Okongo shown here is situated around one of the larger pans in the area.

Central Drainage

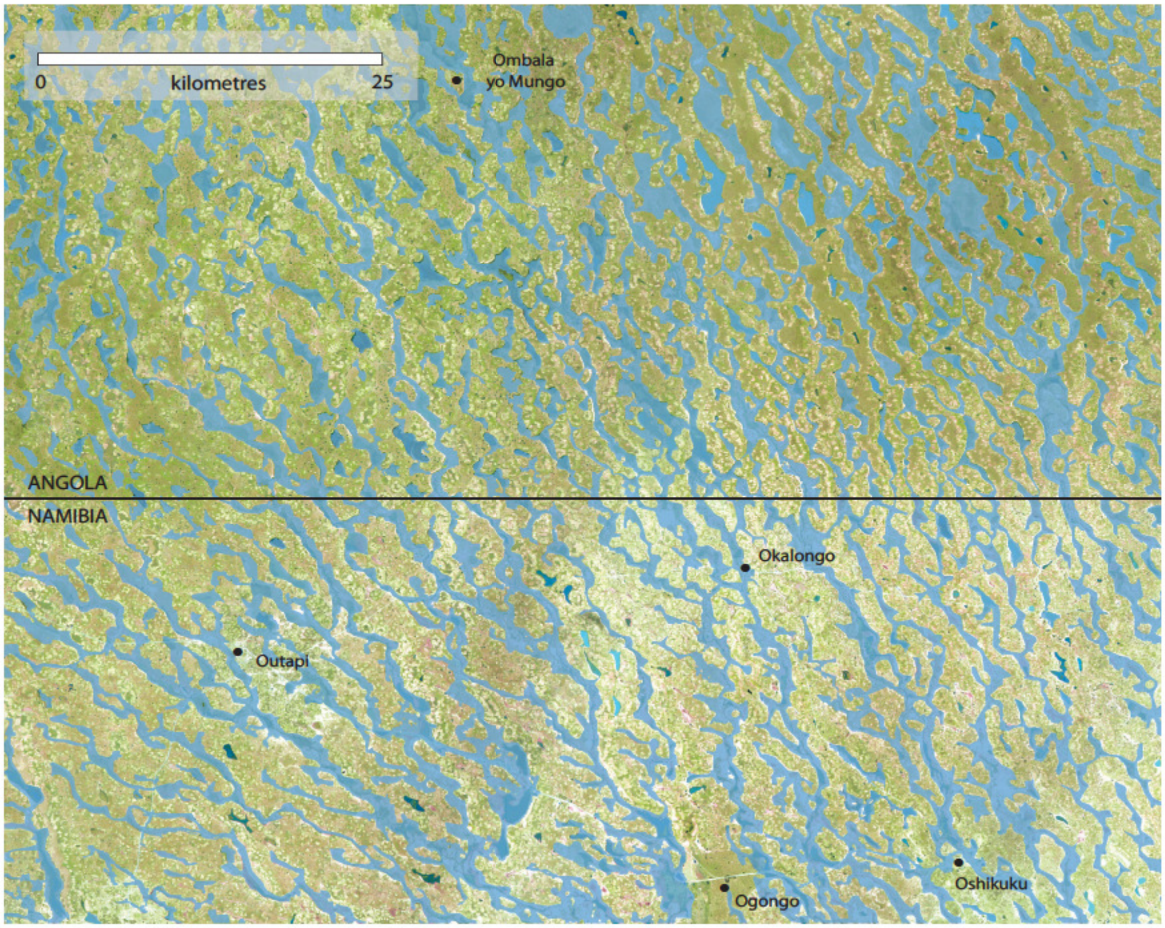


South of the converging flows from the hundreds of channels in the Cuvelai Delta, several larger channels carry water due south down the Central Drainage to Ondjiva, Namacunde, Engela, Endola, Oshakati, Ompundja and finally to the Omadhiya Lakes. Compared to channels in the Iishana Zone, those of the Central Drainage are narrower, generally lined with tall trees and the soils are much less saline. Flows are also much more rapid than those in the shallower Iishana Zone channels, which is why there is less evaporation and salt accumulation in the Central Drainage. The satellite image at the top shows an area between Ongenga and Engela where broad channels from the Iishana Zone merge with the narrow ones of the Central Drainage Zone. The margins of riparian trees along channels of the Central Drainage are clearly visible in the photograph below.

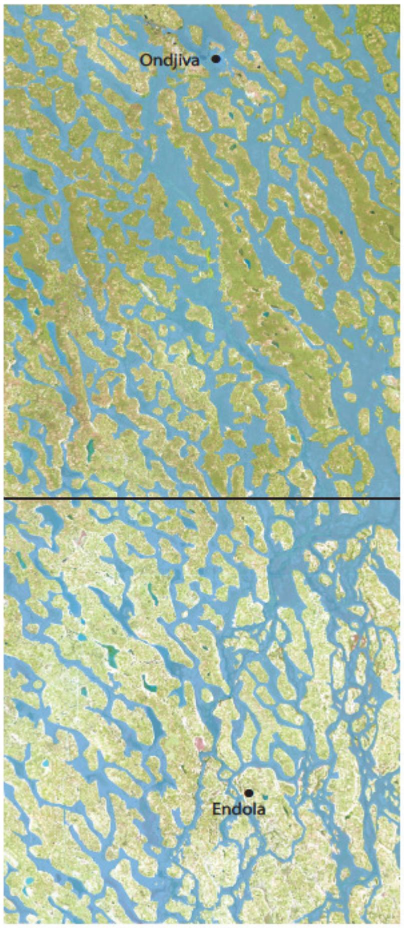
In years of abundant rain, the cumulative and convergent flows may cause significant flood damage to large areas between Ondjiva and the Omadhiya Lakes. Waves of flood water take several weeks to flow between Evale and Oshakati, a direct distance of nearly 200 kilometres (see page 78).

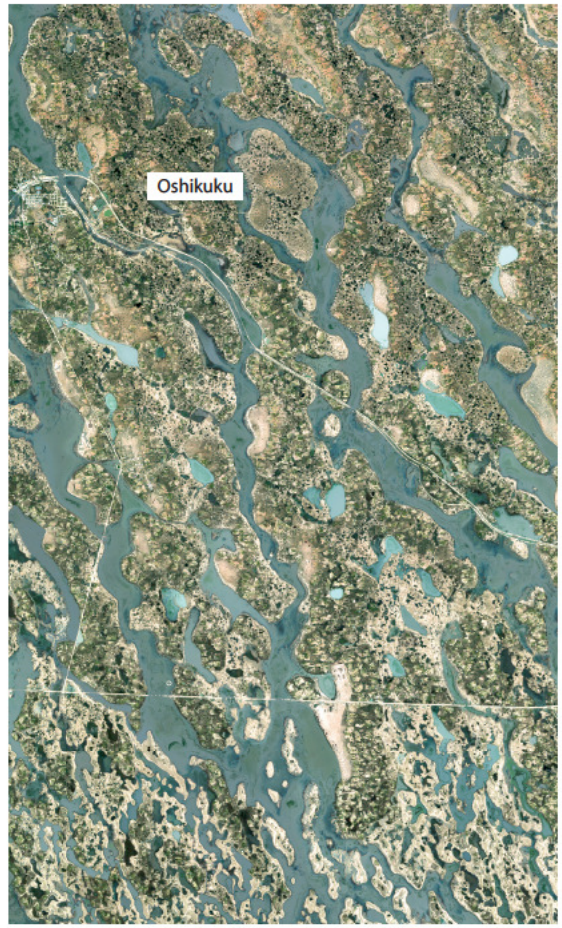


Iishana Zone



Part of the main belt of broad channels in the Iishana Zone as they flow across the Namibian border. The entire Iishana Zone is about 140 kilometres wide and 180 kilometres from north to south. Flows down the *iishana* are often erratic, starting and then stopping, only to start again when rain falls locally or upstream. Widespread or substantial flood damage in the Iishana Zone is rare, at least compared to the Central Drainage Zone.





While the *iishana* generally flow from north-west to south-east, interconnecting channels often cut southwards. The channels are broader in the north than those in the south, which are more interconnected. The photograph was taken during the height of the floods in 2009. During drier periods small pools of water remain for some time in the lowest areas of the *iishana*.

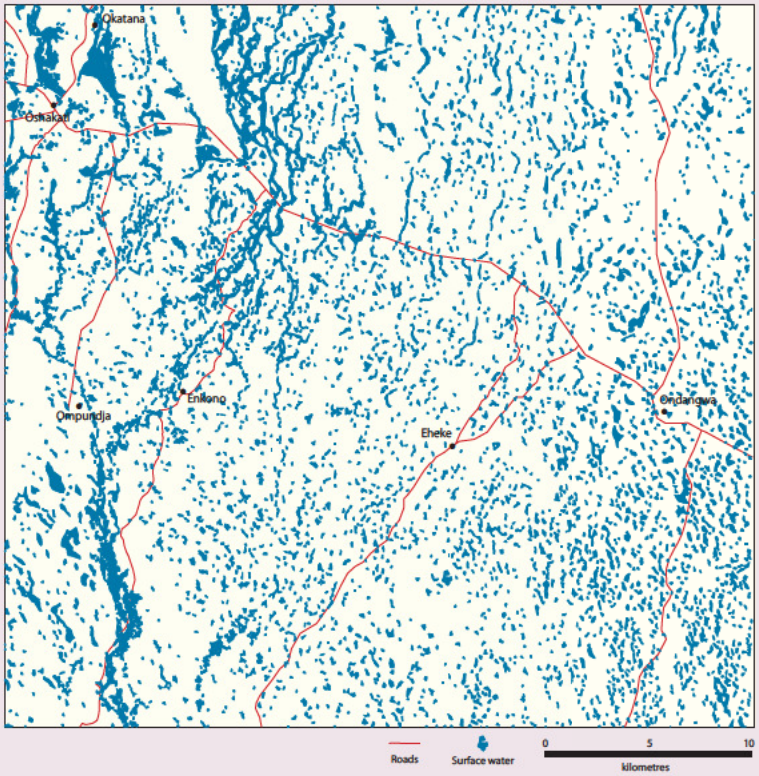
Darker, higher areas between the *iishana* are densely populated since the soils are better suited to crops. But few people live and farm in the paler areas in the southern half of the image because the soils are much more saline than those to the north.

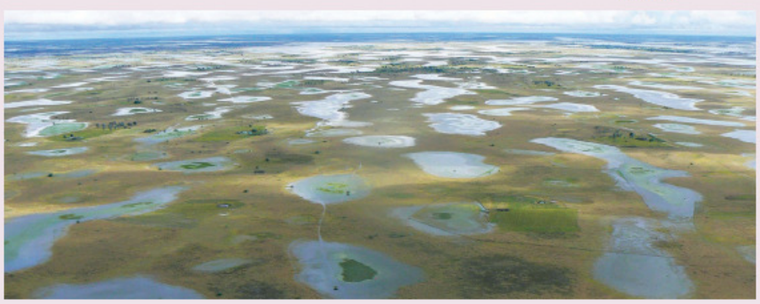
Unlike the narrow rivers and tributaries of the Mui and Cuvelai Rivers and channels in the Central Drainage, the *iishana* are generally broad, many of them extending over several hundred metres from one margin to the other. Moreover, the channels are just as broad near their headwaters alongside the Kunene River as they are much further downstream (see page 30). The channels are also extremely shallow and flat so that elevations between the *iishana* bottoms and surrounding higher ground (called *omitunda*) generally differ by less than 10 metres. The *omitunda* ridges are usually higher on the western than the eastern sides of the *iishana* as a result of prevailing winds from the east blowing sediments from the channels up on to the higher ground. Soils on the *omitunda* are finer on their eastern than western flanks, where there are often extensive patches of Kalahari Sand (as between the road and water in the photograph above), again probably due to the effects of deposition of fine sediments by easterly winds. The same effects are seen around pans in the Eastern Sand Zone (see page 37).

The most southerly *oshana* – the Etaka Canal – is more like a confined river with a single channel. Its origin is near Calueque and just after entering Namibia the Etaka is impounded in the Olushandja Dam, which is a reservoir of water used for the network of piped water (see page 144). A separate canal (visible on the right of the main waterway) was excavated along the Etaka between Olushandja Dam and Uuvadhiya but has since fallen into disrepair.

It is often stated that the Etaka Canal follows an ancient course of the Kunene River before the course of the river diverted to its present mouth on the Atlantic Ocean at Foz du Cunene. However, it seems more likely that the Etaka formed during exceptionally high flows of the Kunene River which overflowed its banks near Calueque.

Central Pans Zone

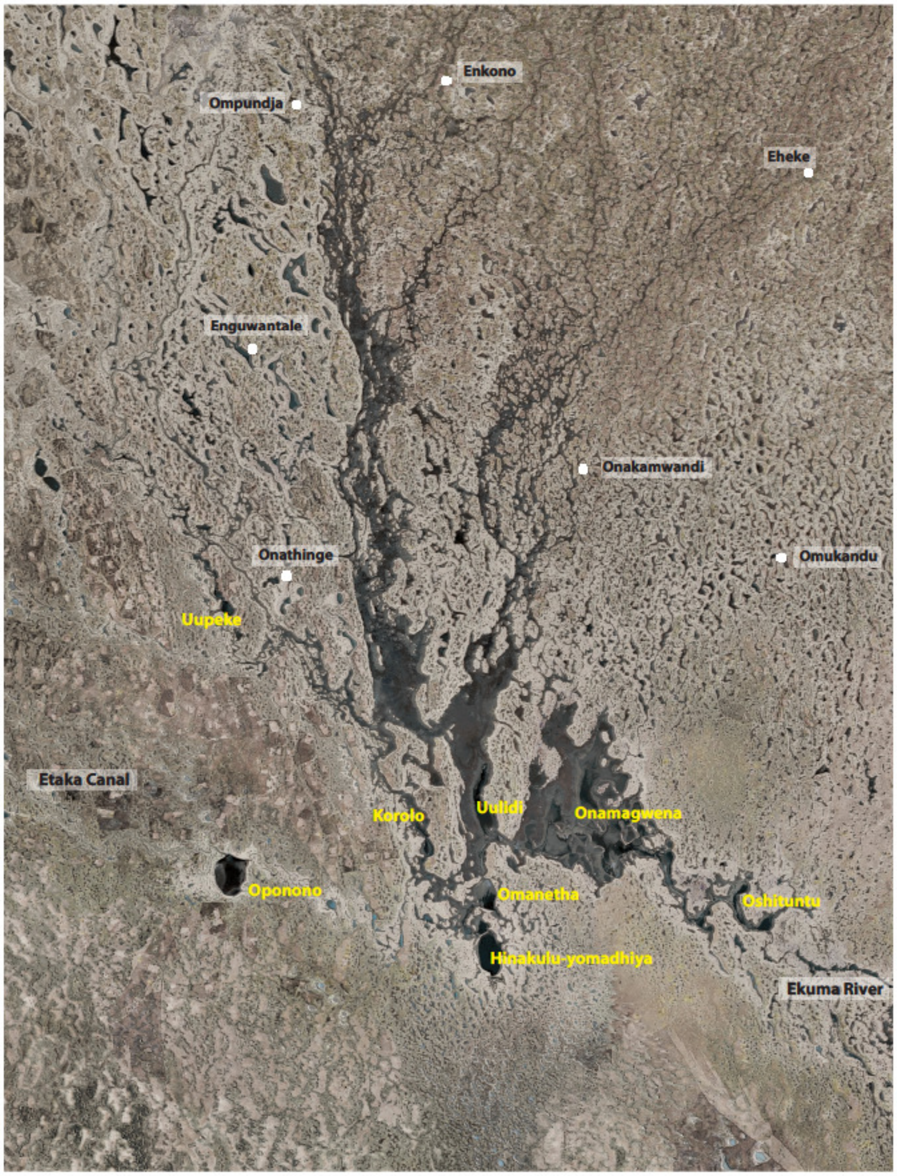




The map and photograph show some of the many small pans that fill after local rain in the Central Pans Zone. To the east of the network of narrow channels in the Central Drainage Zone is a large area where surface waters only collect as a result of local rain. After heavy local rain, tens of thousands of small pans form, many smaller than one hectare.

Most of the pans are totally isolated from adjacent ones, while some pans form along ancient, narrow drainage lines established during wetter periods. A similar landscape of very many small pans sometimes develops after good rain in the northern part of the Saline Pans Zone.

As the large map shows, channels of the Central Drainage do not reach Ondangwa, which therefore does not suffer from the kind of flood damage that has troubled Oshakati.

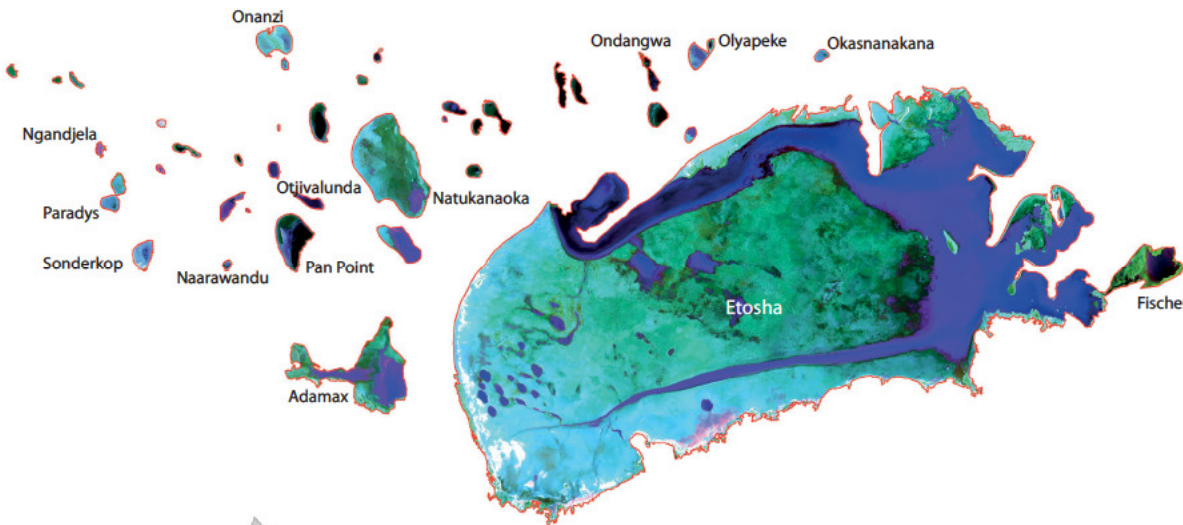

Enkono
Ompundja
Eheke
Enguwantale
Onakamwandi
Onathinge
Omukandu
Uupeke
Etaka Canal
Korolo
Uulidi
Onamagwena
Oponono
Omanetha
Oshituntu
Hinakulu-yomadhiya
Ekuma River

The Omadhiya Lakes are a series of extensive, shallow grassy pans that merge into large bodies of water during periods of flooding.[2] At these times, water from the lakes feeds into the Ekuma River and southwards into Etosha Pan. The lakes are mainly filled by local rain and by inflows from the channels of the Iishana and Central Drainage Zones. In addition, the Etaka Canal provides a separate source of water which first fills Lake Oponono before spilling eastwards into the main complex of lakes.

The biggest lakes are Onamagwena, Uulidi, Oponono and Oshituntu. Water levels are highest in March and April at the end of the summer rains, and the levels then drop rapidly as a result of evaporation. In most years, the lake areas are largely dry by November and December, particularly after the hot windy months of September and October. As the waters drop, salinity increases and may reach 10 times the concentration of sea water. Thick layers of soft mud develop beneath the surface.

The area of inundation in the Omadhiya Lakes varies from year to year. The maximum extent of flooding is about 7,500 hectares, which is five times greater than the 1,500 hectares which is flooded almost annually. The lakes provide water and grazing for cattle as well as substantial numbers of fish which are harvested, dried and then sold in the Basin's major towns.

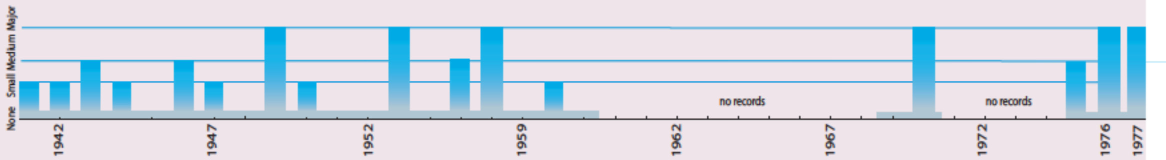
Saline Pans Zone



For at least several million years, salts dissolved and carried in the water from the northern Basin to the south have been deposited after evaporation. The southern reaches of the *iishana* drainage lines therefore consist of extremely saline soils and salt pans where the soils have been scoured out by wind. Cattle farming is the only viable agriculture in this zone, many of the animals only being brought there for seasonal grazing in winter. Few people are therefore resident in the Saline Pans Zone.

The most prominent and famous of the pans is Etosha, which covers some 4,812 square kilometres. During years with strong flows down the Ekuma River from the Omadhiya Lakes, Etosha Pan becomes a lake with water up to 10 metres deep in places. The Pan also receives occasional inflow from the Omuramba Owambo which enters Fischer's Pan at Namutoni. As an indication of how variable conditions can be in the Basin, a major inflow along the Omuramba Owambo occurred in the season of 1907-1908 when over 1,900 millimetres of rain was recorded in Tsumeb (see page 48). Soils in the Karstveld were so waterlogged that the Omuramba Owambo flowed for a whole year. Crocodiles and hippos were found in the Owambo, perhaps having come from Angola or the Okavango River.[3] All the water that enters Etosha evaporates since there is no outlet and the pan floor has an impermeable layer of clay which prevents water from seeping downwards into the ground. Strong easterly winds steadily remove fine sediments from the surface of the Pan during the dry season, thus maintaining it as a local depression (see page 59).

None of the smaller salt pans receive inflows from the Cuvelai, even though some of them cover thousands of hectares. These small pans thus only hold water after heavy rains have fallen locally. The margins of thin, delicate drainage lines add beauty to the extraordinary shapes of many of the pans. Salt has been harvested over centuries from some of the pans, the most famous and important being Ngandjela (see page 29). Salt was one of the commodities exported by Owambo traders from the 18th century onwards.



Flood levels from year-to-year.[4] Perhaps the only thing that can be stated with certainty about water levels in the Cuvelai is that they vary greatly and unpredictably. This has been true over time scales of months, decades, centuries and millennia. Cycles of high and low rainfall and water flow have done much to shape the topography and drainage patterns of the Cuvelai, as well as the characteristics of the soils, the availability of shallow, fresh ground water and density of people.

Floods

It is widely agreed that the extent and severity of flooding may be greater now than several decades ago. This is perhaps due to soil being washed into and accumulating in *iishana* and isolated pools. The beds of the *iishana* and pools are consequently raised which leads to flooding over greater areas, and to flood waters flowing and thus subsiding more slowly.

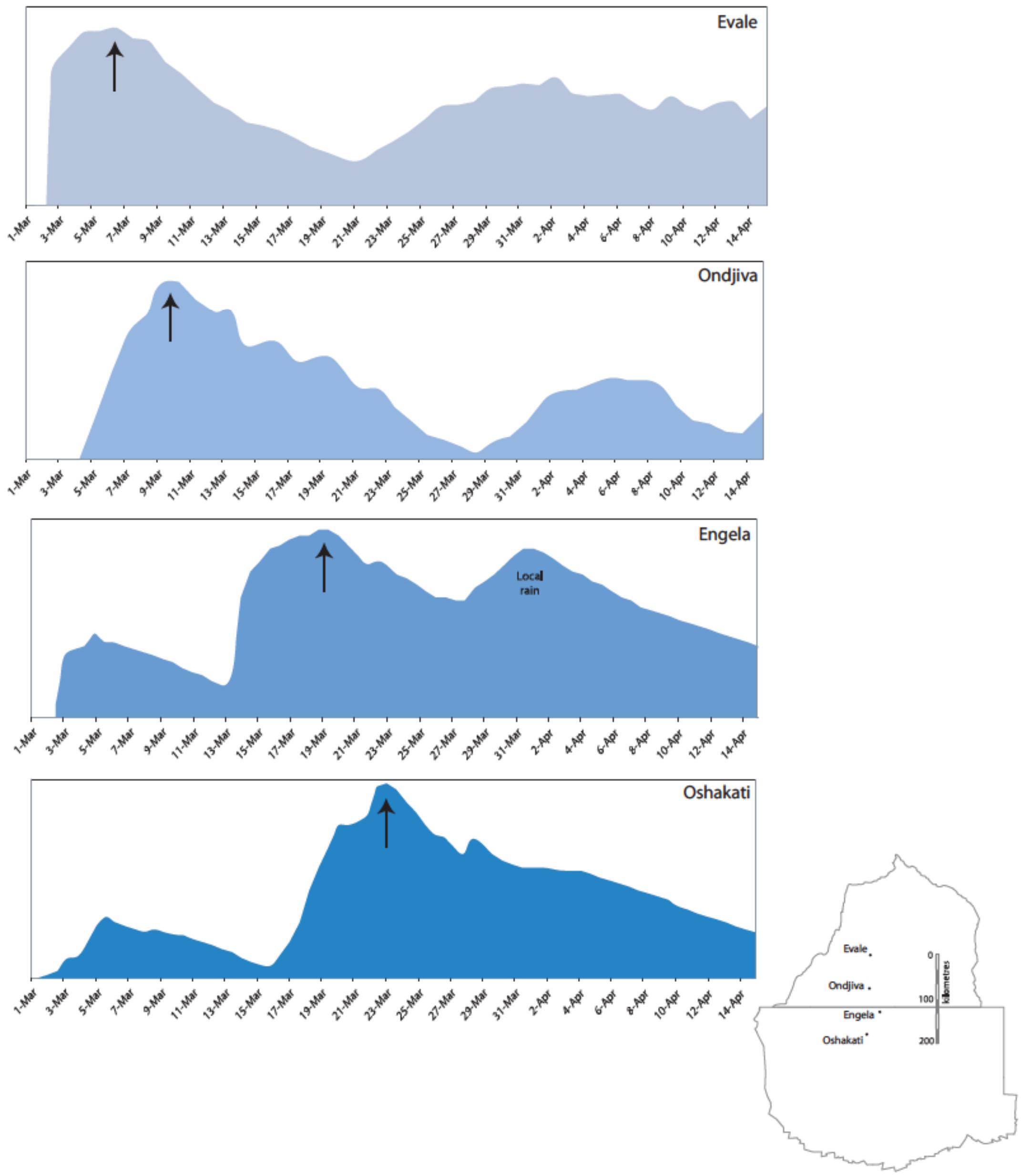
Excessive soil erosion is mainly due to inappropriate ploughing methods which promote the development of layers of hard soil beneath the surface. These layers prevent rainwater from seeping into the soil. Sheet erosion and the loss of soil (as shown in the field above left) follows as a result of the surface soils becoming water-logged (as in the field bottom left). Soil fertility declines as well. In addition, soil erosion is increased by the removal of vegetation through over-grazing, since plant cover impedes the flow of water down to the channels and pools.

The long-term consequences for the Basin are enormous if soil erosion and the gradual filling of drainage channels is as extensive as many believe. Flood damage may become more frequent and severe, and it would be extremely hard to restore the channels to their former levels and flows.

Strong flows of water also lead to flooding for which people are often unprepared. This graph shows the approximate extent or levels of flow and flooding from 1941 onwards. During these 73 years (which includes 13 years for which no information is available), exceptionally high flows, locally called *efundjas*, occurred 11 times: in 1949, 1953, 1956, 1970, 1976, 1977, 1995, 2004, 2008, 2009 and 2011. By contrast, in 19 years there were no or only negligible flows, in 12 years the flows were small and in 18 years the flows were medium.

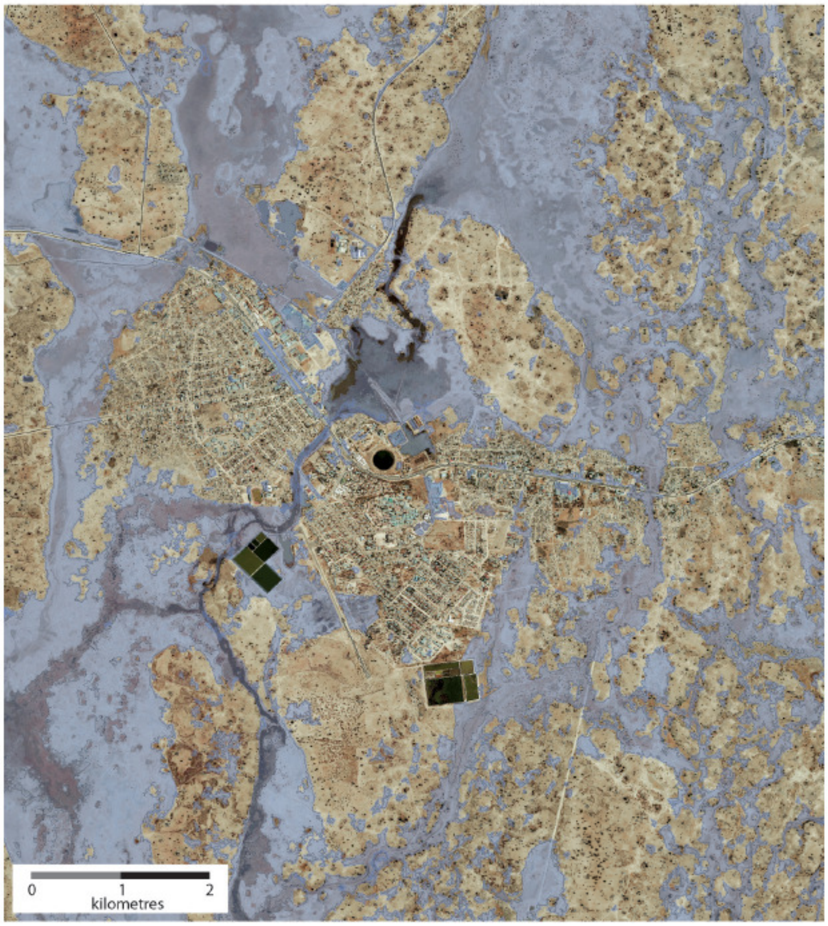
Given the recent floods in 2008, 2009 and 2011, there is now a special and renewed interest in whether such events can be predicted, how their likely effects can be anticipated, and what mitigation measures would be most effective. Three components seem most appropriate in response to these questions:

- Understanding the hydrology of the *iishana* so that flow patterns and directions can be understood and predicted more effectively.
- Having early warning systems in place, especially based on information upstream in Angola to alert people downstream in Namibia.
- Determining which areas and people are most vulnerable to flooding.



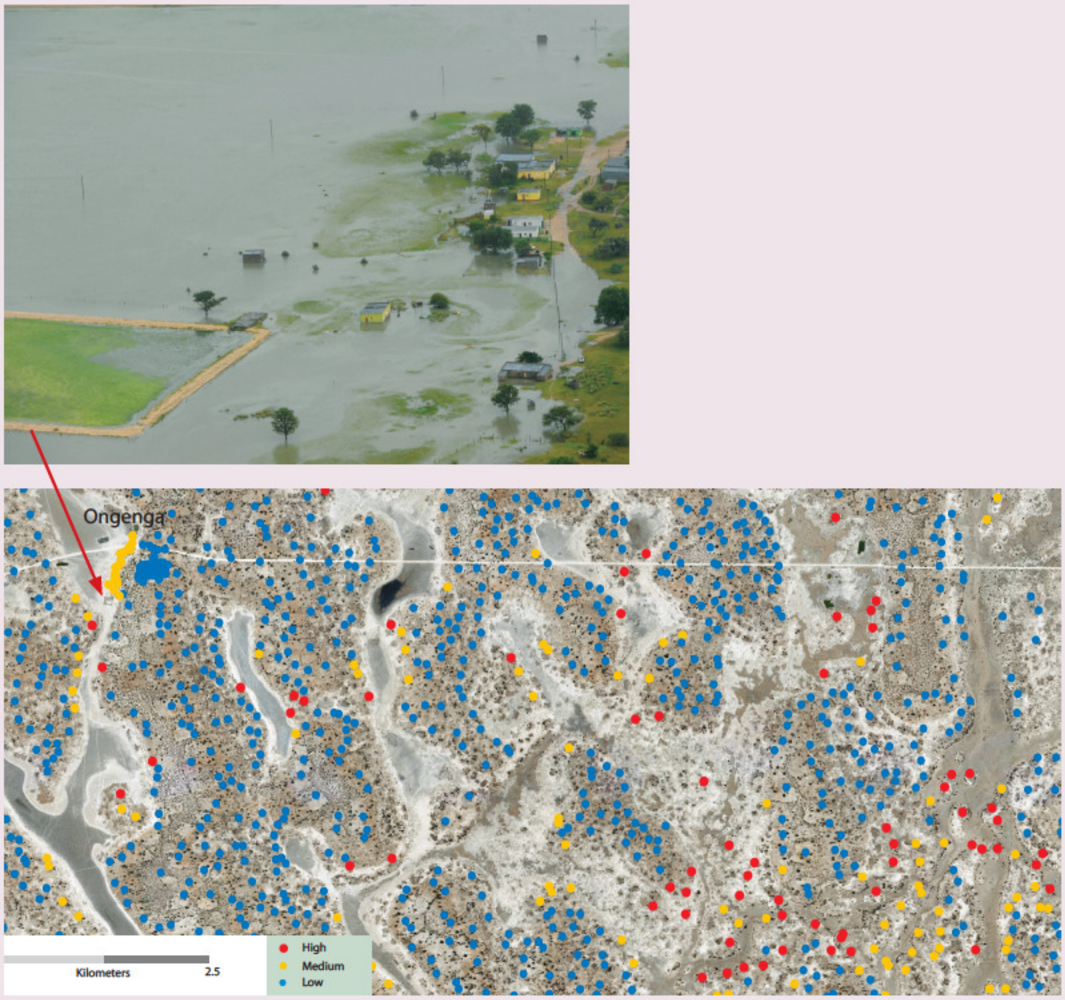
The charts show an example of a wave of flood water moving from Evale to Oshakati in March 2010.[5] Flows in the Cuvelai River peaked between the 4th and 6th of March at Evale, and then reached Ondjiva about 5 days later on the 9th and 10th. The wave of water arrived 8 to 9 days later at Engela just south of the Namibian border between the 17th and 19th and went on to reach Oshakati on the 23rd of March, 6 days later.

Flows down the Central Drainage Zone travel at about 5 to 7 kilometres per day. Some of the changes in this succession of flow in 2010 were affected by local falls of rain, as indicated by the much longer period of high water at Engela than at the other places. A second peak at the end of March was almost certainly due to heavy rains around and just upstream of Engela.



The need to better understand patterns of flow is of critical importance, both to predict the movement of water and to ensure that flooding patterns are taken into account in the design of new housing, transport, water supply and other infrastructure projects. For example, this image of Oshakati was taken at the height of the floods in 2009. All the areas in blue were under water, and much of the flood damage was caused by inadequate and blocked drainage, particularly beneath major bridges that span the *iishana*.[6] As a result of recent studies, flows around Oshakati are now better understood and measures are eventually being implemented to reduce the impacts of *efundjas*.

The need for early warning of floodwaters from the Angolan catchment and also from upstream areas within Namibia is self-evident. Various sophisticated telemetry and satellite surveillance systems can be employed to obtain information in advance of floodwaters, but this is only useful if people are available to collect, process and disseminate this information.



Although it is clear that certain areas are more prone to flood damage than others, almost nothing has been done to identify the most vulnerable places. The map above provides an example of how households liable to different levels of risk from flooding can be identified from high resolution images. Red dots indicate households at most risk from flooding, typically those which are in the lowest-lying areas. Blue dots are households in higher areas where the risk of flooding is lowest.

The mapping and assessment east and south of Ongenga was done on an experimental basis in 2010, and so it was of interest to see that many buildings rated as being at moderate risk were badly flooded in March 2011, as shown in the photograph at the top. These are shops built between the town of Ongenga and the *oshana* immediately to its west. The photograph also shows how floodwaters were flowing in and out of the town's sewage treatment ponds, causing obvious health risks to people living downstream of Ongenga. Similar problems are caused by the poor planning and construction of sewage treatment ponds around many other towns in the Basin.

One aspect to assessing vulnerability is to identify areas most prone to flooding. This is spatial risk. Another is to consider socio-economic factors to identify households that are likely to suffer particular hardship when flooded. The most obvious concentrations of vulnerable people are those living in informal, squatter settlements, such as the ones shown here in Oshakati. The local government has not made available higher, safer ground to informal settlers who have thus been forced to build their shacks in places that are certain to be flooded. Informal settlements in Oshakati were badly flooded and evacuated in 2008, and in 2009, and then again in 2011. The social and economic costs incurred by poor people during these floods were substantial.

Flooding has caused extensive damage to roads, bridges and causeways that were washed away. The water canal from Olushandja Dam to Oshakati has also been damaged by floods.

A substantial number of people have drowned in the floodwaters, generally as a result of people attempting to cross swollen *iishana*. In 2009, 100 people died from drowning and other effects of flooding. This was followed by 102 deaths in 2009 and 110 more deaths in 2011. In each of these years, an estimated 65,000, 50,000 and 37,000 people were displaced from their homes, respectively.[7]

This image provides perspectives on various aspects of flooding, and is indeed a picture worth many words. The distinction between impacts on higher and lower ground is clear, as are the massive expanses of water that cover large areas, especially of commonage in the *iishana*. Most homes on higher ground belong to comparatively well-off families, whereas those of poorer people are often located in low-lying vulnerable areas. There is also much variation between homes that do get flooded. Compare the homesteads surrounded by water. The one on the right (A) consists of many separate buildings, some of which have roofs of corrugated iron. The family living here must be relatively large, with several members available to work at home, to have jobs or to run small businesses. Their cash incomes have enabled the family to buy modern building materials, such as the roofing. They also have comparatively large crop fields, most of which have not been inundated.

The home in the centre (B) is built entirely of locally-harvested materials, such as mud and wood. It is small with few people to

provide labour, and households like this are most likely run by a single woman, often a widow who cares for several grandchildren. Most of the small fields are under water, and being so close to this *oshana* means that the soils are clayey, saline and poorly suited to crop production. The home on the left (C) is somewhat larger with bigger fields, but also shows little indication of having incomes that might shield it from the devastating effects of flooding.

While floodwaters cause widespread damage, they also carry down large numbers of fish,[8] here being harvested at a culvert where the fish leap out of the gushing water into buckets. Good rainfall creates ponds in which huge bullfrogs congregate to breed. The large animals are easy pickings and a welcome source of protein.

5 - Groundwater: a hidden resource

Groundwater is rain or floodwater that has seeped into the ground where it is stored in water-bearing layers known as aquifers. Depending on the type of aquifer, the water will have accumulated over periods ranging between years and thousands of years. The water is especially valuable in places where no other water is available. People and their livestock in those places then rely on groundwater, which is the case over large areas south of Etosha Pan and in eastern Oshikoto and western Omusati.

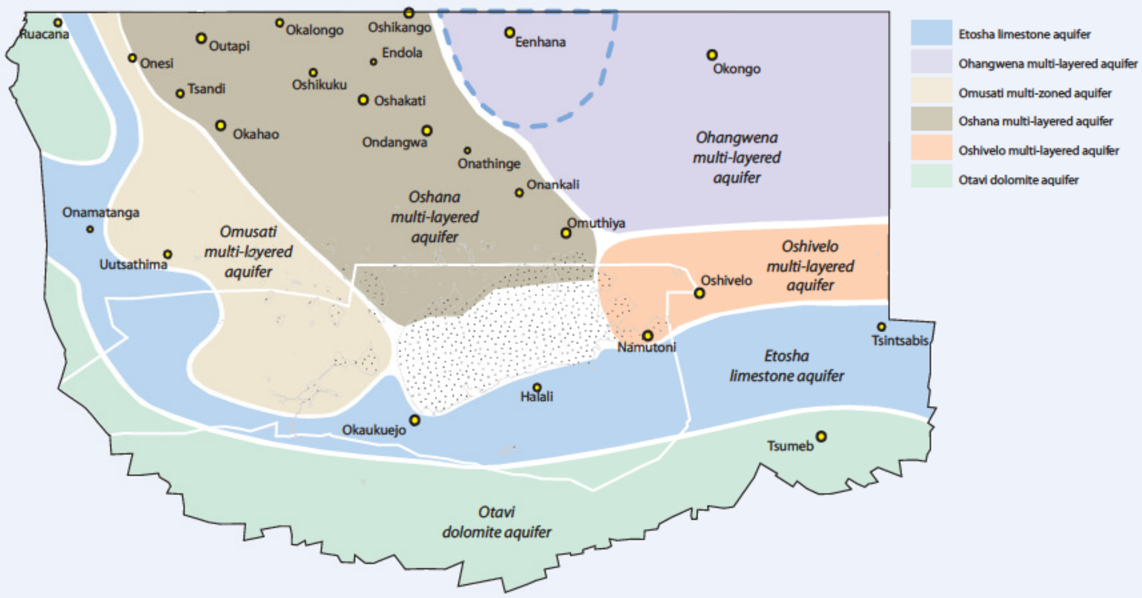
Elsewhere, groundwater is used to supplement supplies obtained from other sources, notably water pumped from the Kunene River into a vast network of pipelines across much of the northern half of the Basin (see page 144). Other surface water in this area is available from *iishana* and pans after good rains have fallen, and from small freshwater ponds known as *eendobe*. This surface water is often contaminated by livestock, however, and not well-suited for human use. Cleaner water is also widely available in small quantities from shallow hand-dug wells called *omifima*.

Given the high value of groundwater, many boreholes have been drilled to find and pump groundwater to the surface. Of about 6,000 boreholes drilled in the Cuvelai-Etosha Basin, many were dry or could produce too little to be used economically. However, data from these and other, more productive boreholes, have been useful in providing information on where groundwater occurs, how it flows in the Basin, and its depth and quality. This chapter provides a synthesis of information and current understanding of groundwater resources.[1]

Much of this chapter is about deep groundwater, but it is useful to remember that access to shallow groundwater in *eendobe* pools and especially *omifima* wells was the crucial factor enabling people to live in the Basin for hundreds of years before piped or pumped water became available. Without that water, people would simply have been unable to settle here permanently.

While *iishana* channels and pans are often filled seasonally, these are only temporary water sources. This water becomes brackish towards the end of the dry season and it is extremely vulnerable to pollution because it is shallow and exposed.

It is noteworthy that water in *eendobe* and *omifima* is actually trapped in a very shallow and discontinuous aquifer, and is therefore also groundwater. Layers of impermeable ferrocrete rock close to the surface trap rainwater in a lens by preventing it from percolating further. In most areas, this shallow water can only be reached by digging wells which are often a few metres deep. These are the *omifima* wells (top), the ones clustered in the second photograph being visible in Google Earth at 17.23 South and 16.03 East. Some wells that go down 10 or 20 metres (centre) are mainly found north of Etosha in southern Oshana and Omusati where they provide water for dozens of cattle posts. The water in these deeper wells is often rather saline. Fresh water which has been trapped in the same shallow aquifers collects in small *eendobe* pools (bottom) which are often surrounded by jackal-berry trees.



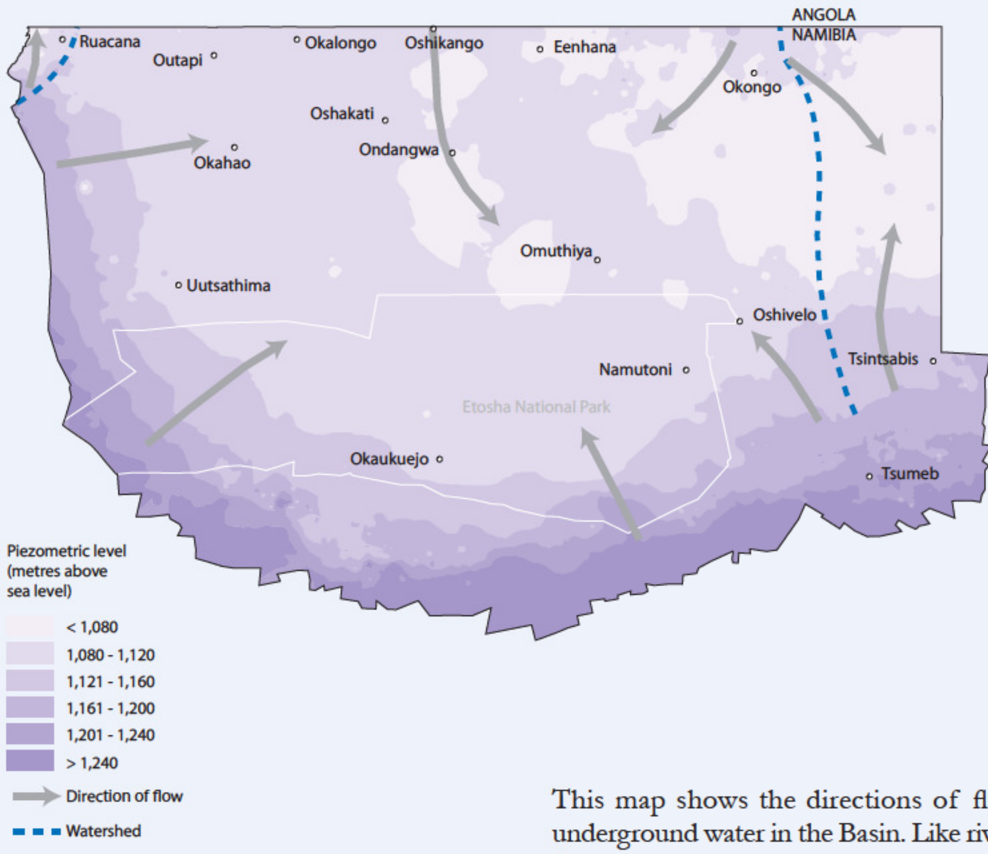
Type of aquifers. In broad terms, aquifers are divided into those that are confined and those that are unconfined. The former describes bodies of water that have an impermeable layer of clay or rock both above and below them. They are thus confined, and usually fully filled with water which is under pressure. Unconfined aquifers are underlain by impervious layers, but the soil layers above are permeable and thus allow water to seep down into the aquifers.

There are six main aquifer systems in the Basin that are characterised by differences in geology, chemistry, patterns of flow, types of confinement and depths. Most of the systems contain different aquifers or layers of water that are separated by impermeable layers and thus overlay one another. From the table of information for each aquifer system (page 88) it is clear that there is considerable variation within each system. Some of this variation is due to the presence of separate aquifers at different depths in the same area. Thus, one borehole may pass through quite different layers of water in a multi-level system. The chemical qualities of the layers are often quite different, some being brackish and others fresh, for example. Other variation from place to place is due to water being held in cavities of different capacities, or in different rock formations at different depths.

Recent investigations have led to the discovery of an extremely rich freshwater aquifer in Ohangwena,[2] shown in the map above as a dotted line. The water resource lies several hundred metres below the surface, and is so large that it may be used to supplement the piped Kunene River water that now supplies many of the people in the Basin. Further research may show that water in this deep aquifer may be sufficient to pump to users even further afield.

Aquifer system	Main rock type	Depth below surface in metres	Quality of water	Yield in cubic metres per hour
Ohangwena Multi-layered Aquifer	Sand, sandstone	60-300	Fresh to brackish	1-50
Oshivelo Multi-layered Aquifer	Conglomerate, sandstone, sand, dolocrete, calcrete	30-150	Fresh to brackish	5-100
Etosha Limestone Aquifer	Dolocrete, calcrete, sand	10-100	Fresh, locally high nitrate concentrations	3-100
Oshana Multi-layered Aquifer	Sand, calcrete/limestone	10-80	Saline to hyper saline	1-30
Omusati Multi-zoned Aquifer	Sand, clay and calcrete, dolocrete	10-50	Brackish, freshwater in places	1-30
Otavi Dolomite Aquifer	Dolomite	20-250	Fresh	More than 50

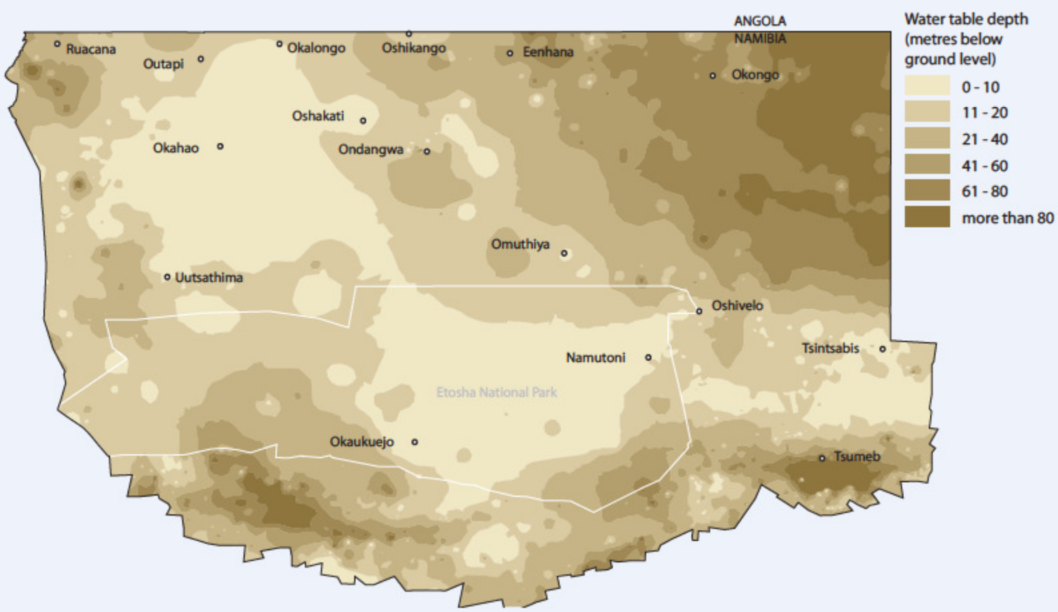
A variety of pumps are used to bring groundwater to the surface. Windmills are the most conspicuous and work well where the water is not too deep. Diesel engines are also commonly used to drive pumps, and solar energy is now being used increasingly for pumping.



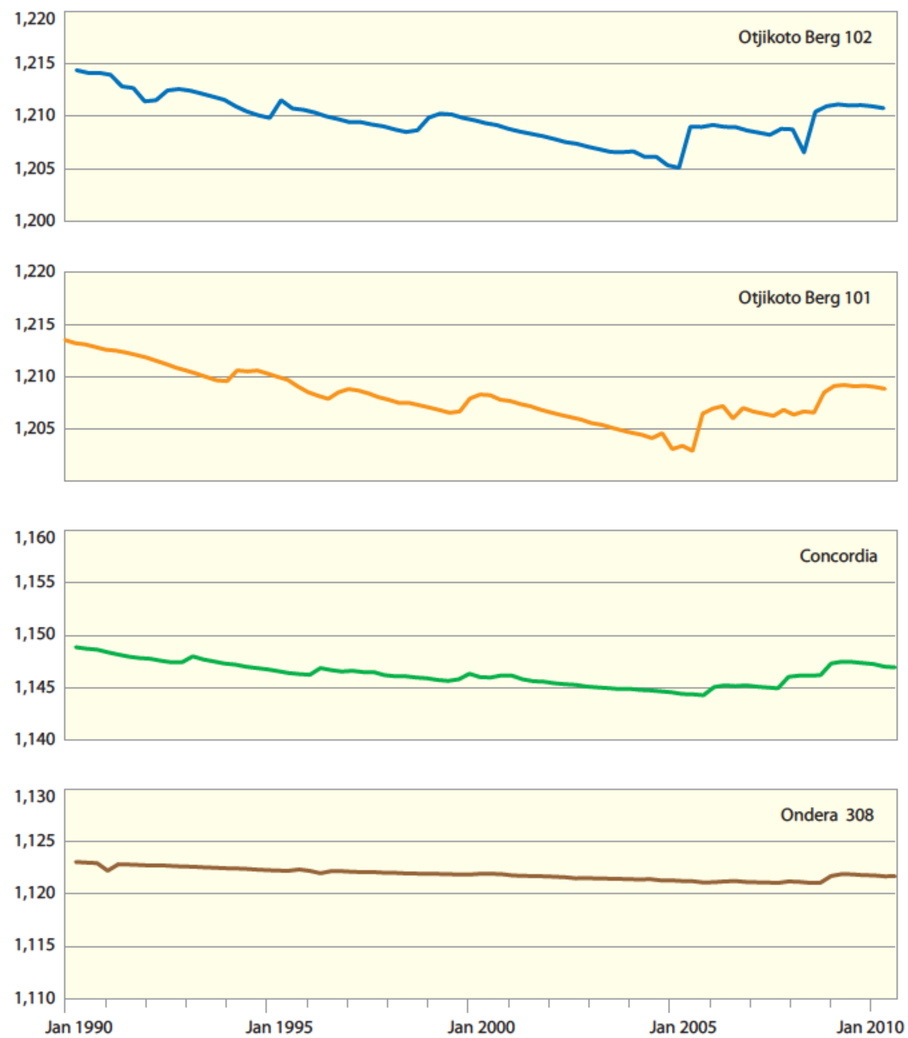
This map shows the directions of flow of underground water in the Basin. Like rivers on the earth's surface, water beneath the ground also moves from high elevations to lower altitudes. All groundwater within the Basin flows towards Etosha Pan (which happens to be the lowest area to which all surface waters also move (see page 11). In the southern parts of the Basin water often comes to the surface through springs along the southern edge of Etosha Pan, where it evaporates rapidly. Groundwater along the northern border of the Basin is recharged by flows from Angola.

The flow of groundwater. An important part of understanding an aquifer system is to know how water flows into and perhaps out of an aquifer. It is hard, for instance, to envisage how aquifer water will be replenished if potential sources of recharge water are not known. Similarly, predictions on where groundwater may be found are improved by knowing directions of flow.

In places where the groundwater is under considerable pressure, the water may rise and flow out onto the surface. Such places are called artesian wells, and one of the biggest and most spectacular of these wells is at Gobaub in Etosha National Park. The well is actually above the surrounding countryside and is centred in a natural clearing with a diameter of over half a kilometre. The clearing is a result of trampling by the many animals that visit the water-hole and the saline soils that have developed from the groundwater evaporating on the surface.



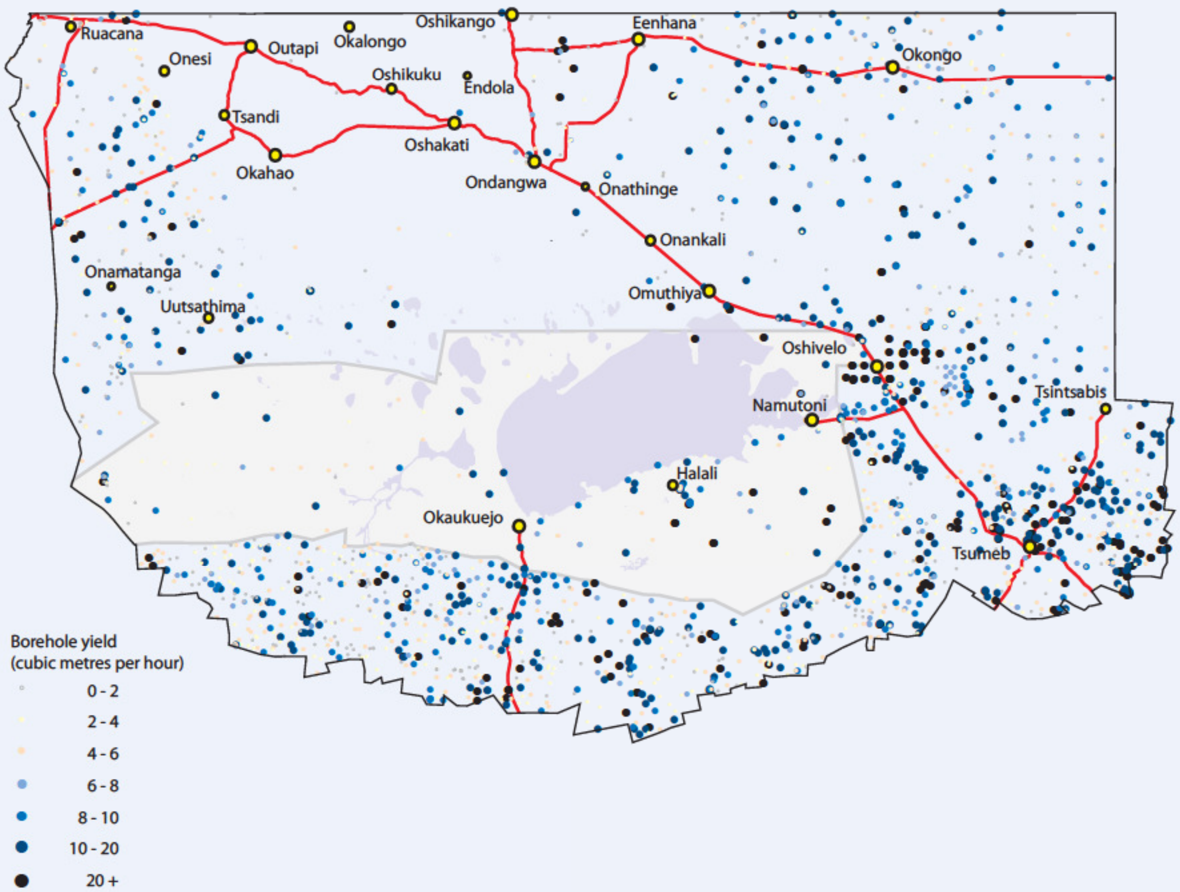
Water table depth. Groundwater can be found at less than 40 metres below the surface in most areas of the Basin, especially so in the central and north-western areas. Around the southern rim of the Basin the depth to groundwater increases to 80 metres or more in many areas. The same is true in eastern Ohangwena and Oshikoto. The newly discovered aquifer in central Ohangwena lies below the shallower aquifers at depths of about 300 metres.[3]



Rates of depletion and recharge.[4] Groundwater at deep levels has often accumulated slowly over long periods, perhaps tens of thousands of years. The rate at which it is used is often greater than the rate at which the water is replenished, which means that the groundwater is being extracted unsustainably.

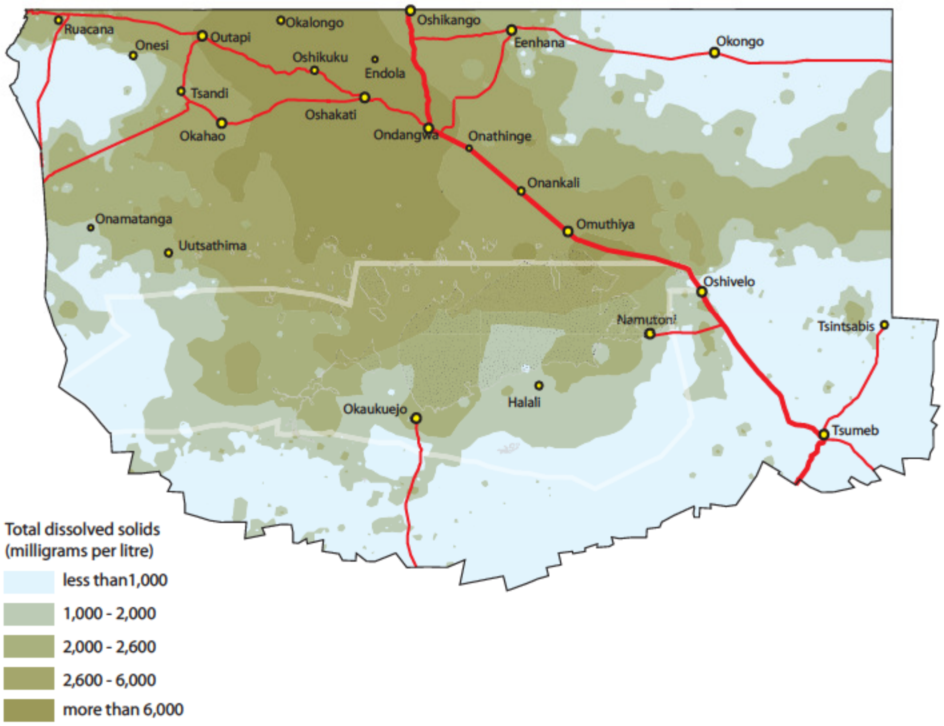
These graphs show water levels (in metres above sea level) in four monitoring boreholes some 70 kilometres apart: Otjikoto Berg about 20 kilometres west of Tsumeb, and Concordia and Ondera some 60-70 kilometres north of Tsumeb. Patterns of water depletion and recharge were similar with water levels dropping steadily over the 20 years. Significant recharges occurred in only six of the 20 years: in 1994, 1997, 2000, 2006, 2008 and 2009.

Thus, rainfall in 14 years did little to restock the aquifers and, in fact, it was only in 2006, 2008 and 2009 that the natural recharges did more than top up what had been harvested the previous year. At the end of 2010 after the recent years of good rain, water levels at both places remained below those when recording began in 1990.



Borehole yields. Nobody knows what will be discovered at the bottom of a borehole when it is being drilled. Often the hole is dry and the drill rig must be moved to try elsewhere. Even when water is found, the yield and chemical quality of the water must first be assessed before deciding whether to install a pump or not.

Borehole yields vary considerably, and even those very close to each other often provide different volumes of water, as this map shows. Modest volumes of between 1 and 5 cubic metres per hour are enough to supply a small village and many boreholes across the Basin produce this much. There are also many places where the majority of boreholes produce much greater quantities, such as around the Oshivelo area, where yields may exceed 100 cubic metres per hour. By contrast, there are also areas where yields are so low that the costs of pumping render the boreholes uneconomic.

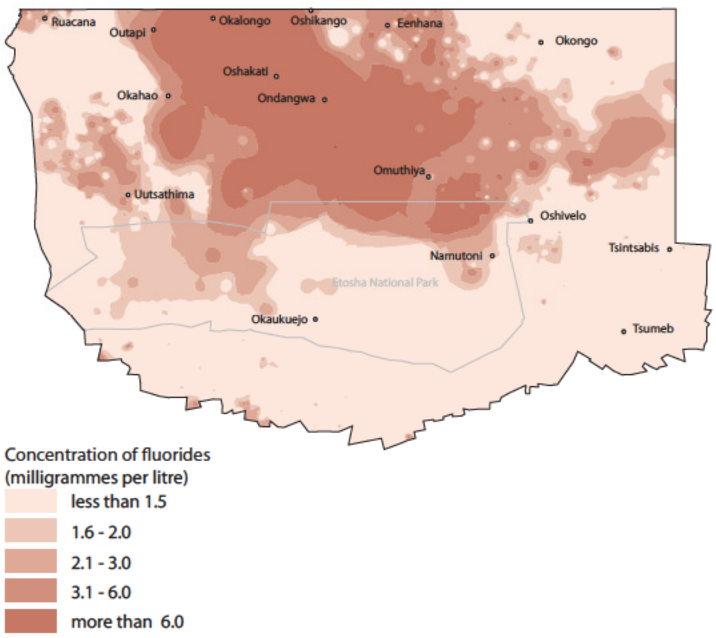


The quality of groundwater. Finding groundwater is one challenge, another is to find water suitable for human or even livestock use. Many boreholes have been drilled and then abandoned because they do not supply potable water. Water quality is the result of a combination of factors, including the geology and chemistry of the rock and soil substrates through which the water has flowed. Water quality can also be negatively influenced by chemical pollution from farming activities and mining.

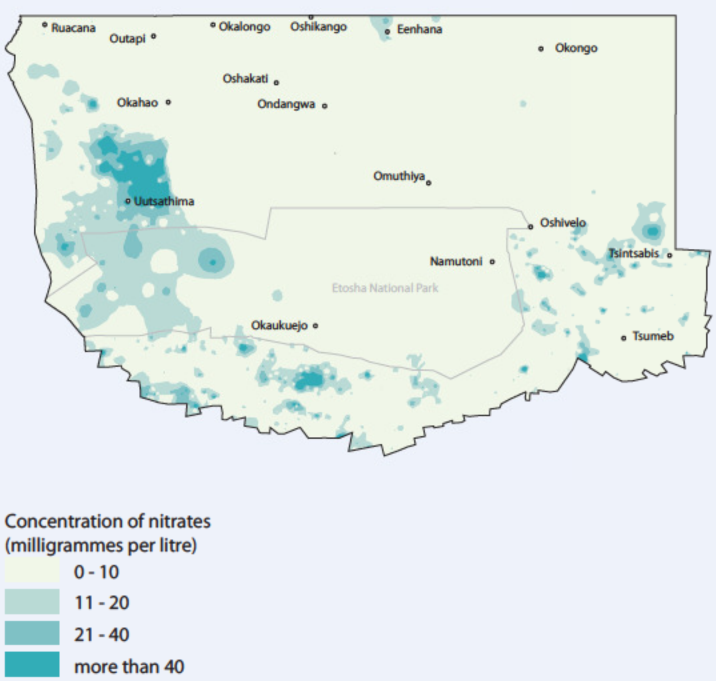
This map provides a measure of the overall chemical quality of water in different parts of the Basin. The measure is of the total amount of dissolved solids (TDS), of which salt makes up much more than any other chemical impurity. The TDS values provide good indications of how groundwater may be used; the lowest values reflect the most potable and pure water, while higher values are associated with increasing salinity. Water with TDS values above 2,600 milligrams per litre is not fit for human use, while water with TDS values above 5,000 is detrimental to livestock.

TDS values generally increase from the south and west towards the centre of the Basin as a result of increasing concentrations of chloride, sodium, fluoride and sulphate, as the maps on the following pages show. Consequently, good quality groundwater is only present in the eastern and far western areas of the Basin and up to, and along the southern rim of Etosha Pan.

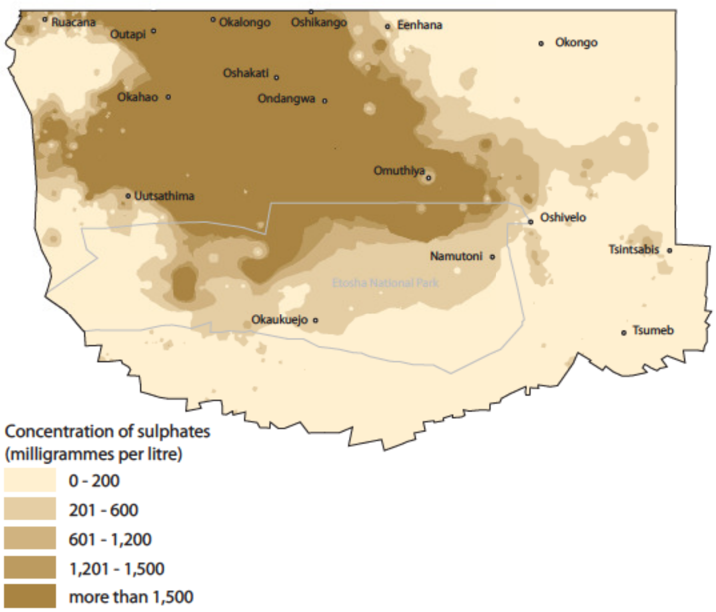
This map provides measures of the quality of water found in boreholes at depths beyond those reached in hand-dug wells. The very high TDS values in the central areas of the Basin reflect the poor quality of its deep water, but it is incorrect to assume that people living there drink that water. Instead, people here use piped water (see page 144) or water in shallow *omifima* wells.



Concentrations of fluorides. Fluoride levels above 3 milligrams per litre may cause the abnormal development of the skeleton in children, and can also cause the mottling and wearing away of teeth of both humans and livestock. Very high fluoride levels are found in a belt running south-eastwards from Outapi towards Omuthiya and Oshivelo. Fortunately, most people in this area do not use deep groundwater, but high fluoride levels in eastern Oshikoto and western Omusati are of concern to people who drink borehole water in those areas.



Concentrations of nitrates. High levels of nitrates can cause birth defects and even death in infants. Levels above 10 milligrams per litre are considered harmful as they affect the availability of oxygen in tissues. Levels far higher than 10 milligrams are found in large parts of Omusati and in localised places in a belt across the south of the Basin. Cattle dung may contribute to unsafe levels of nitrates, and care thus needs to be taken to ensure that water sources are not polluted by livestock.



Concentrations of sulphates. Above 1,200 milligrams per litre, sulphate can act as a laxative. Much of the Basin north of Etosha Pan has levels higher than this, but the high concentrations in the central parts of the Basin are of little concern to people who have access to piped water. However, the many people who depend on deep groundwater in southern and western Omusati may suffer the effects of high sulphates more than others.

As many of the previous maps show, groundwater in central and southern Omusati is extremely saline. Concentrations of sulphates and nitrates are also high, and shallow hand-dug wells in these areas are often contaminated. Recently, two solar-powered desalination plants have been established. The one to the left supplies the village of Amarika with 5,000 litres of fresh, clean water per day. Another system provides water to Akutsima.

There has been considerable concern that chemicals used at the copper smelter at Tsumeb contaminate local groundwater, and sites near the smelter do indeed have elevated levels of sulphates and trace elements that include arsenic, lead and cadmium. However, more research is required to establish the significance of these levels and to provide measures to prevent further pollution.

Groundwater is hard to understand since most of us never get to see the water, let alone to imagine how it is stored, flows or how it is replenished. Lake Otjikoto (right) and Lake Guinas (see page 25), however, are two places where groundwater is visible because the roofs that covered the caverns holding the water have collapsed. Both lakes have communities of animals that are found nowhere else, and both have become popular tourist attractions.

6 - Plants and animals: living resources and treasures

A wide range of habitats occur in the Cuvelai-Etosha Basin, including freshwater and saline pans, seasonally flooded grasslands, palm tree savanna, woodlands, and dry bush savanna. Much of the habitat variation is related to the type of underlying soil which, itself, is a consequence of how much sediment has been deposited in different areas by water and wind. Surface drainage also has an important influence on soils and habitats. In places where the water seeps into the ground the soils remain salt free, whereas high concentrations of salt accumulate in areas where most of the water evaporates.

Much of the Basin's taller woodland and large wildlife has been lost in recent decades, especially in the densely populated areas. To give an idea how much wildlife there was in Owambo, a traveller described the following sights in 1876.[1] "we fell in with immense numbers of animals beyond anything I had yet seen. …. Gnus in herds like the buffalo of the plains (of North America), hundreds of zebra, beautiful in their striped coats, springboks by tens of thousands, ostriches, gemsboks, steenbok, hartebeeste and elands. Water and grass were plentiful and they seemed to be having an easy time of it."

It is not known where these animals were seen, but it is certain that they would have been moving around the Basin, especially in grassland areas. Movements and opportunism remains a key feature of most animal life. Huge numbers of birds, fish, frogs and many other smaller kinds of animals emerge or arrive here to feast and breed when conditions are suitable, usually after good rain has filled the *iishana* and pans and stimulated the growth of fresh grass. The movements of large mammals are now mostly limited to within the fenced boundaries of Etosha National Park, but the Omadhiya lakes, the Cuvelai *iishana* and Etosha Pan are still regarded as wetlands of national and global importance in terms of their ecology and hydrology. That recognition was formalised by the designation of these areas as a Ramsar site in 1995. These wetlands are therefore special and of high value internationally.

Each of the eight major **vegetation types** in the Basin is strongly influenced by underlying soil, geology and rainfall.[2] The Kalahari woodlands in the east and west grow on windblown sand, while the central Cuvelai Drainage, Mopane shrubland, and the pans with their surrounding grassland and dwarf shrubland are all on water-borne soils. Thus, most of the Basin's vegetation grows on sedimentary deposits, and only the Kunene Valley and Karstveld Woodlands are on soils produced by the local erosion of underlying rocks. The vegetation is taller, more luxuriant in the east due to the higher rainfall there.

Kunene Valley. A small part of this extensive valley falls in the north-western corner of the Basin. The valley is characterised by steep slopes which support a varied community of plants. Along the Kunene River, tall ana trees, makalani palms and mopane grow on the deep alluvial soils.

Western Kalahari woodland. Woody vegetation here comprises shrubs and open-tree savanna. The soils are mostly deep Kalahari sands with clayey soils around pans. In the south-west there are many scattered pans interspersed with copses of shrubs and trees, particularly mopane. On the plains in the south, the dominant tree species are camel-thorns, *Acacia reficiens, Philenoptera nelsii* and silver-leaf terminalia. Towards the north-west, the vegetation changes to a savanna of taller trees of mopane, kudu bush and purple-pod terminalia. Although the low rainfall and absence of permanent fresh water makes much of the area unsuitable for habitation, the northern areas have patches of rather fertile loamy soil suitable for cultivation. Grazing value is moderate to good.

Cuvelai Drainage. The *iishana* and other lowlands are mostly covered by a variety of grass species. Mopane shrubs and trees dominate the woodland on higher *omitunda* ground between the drainage channels, but a variety of trees more typical of the Kalahari woodlands are found on patches of sand and on the *omitunda* in the east of the Cuvelai Drainage. Makalani palms are prominent in places where the soil is somewhat saline.

Saline grasses predominate in the south where the almost complete absence of trees and shrubs is due to the shallow and highly saline soils. Over 150 plant species have been recorded in the *iishana* system, but this vegetation type is much more degraded than any other in the Basin because this is where the majority of the human population lives.

Etosha grass and dwarf shrubland is the most important grazing resource for most large herbivorous mammals in Etosha. The plant community here is dominated by grasses and small shrubs which have a high nutrient content and forage value due to the nitrogen-rich soils. The shallow saline soils inhibit the growth of trees and the most common large woody species are shrubs of *Acacia nebrownii* and *Catophractes alexandri*.

As the name suggests, **Mopane shrubland** is dominated by mopane, and there are few other woody species. The shrubs or small trees vary between about 1 and 3 metres in height, depending on the structure of soils. In any one area, however, the plants tend to be similar in height. Grass production can be high in years with good rain. Adding colour to this scene, where the mopane have been recently burnt, is a Bushman poison or *ouzuwo* flower. The sap is used to coat arrows with poison.

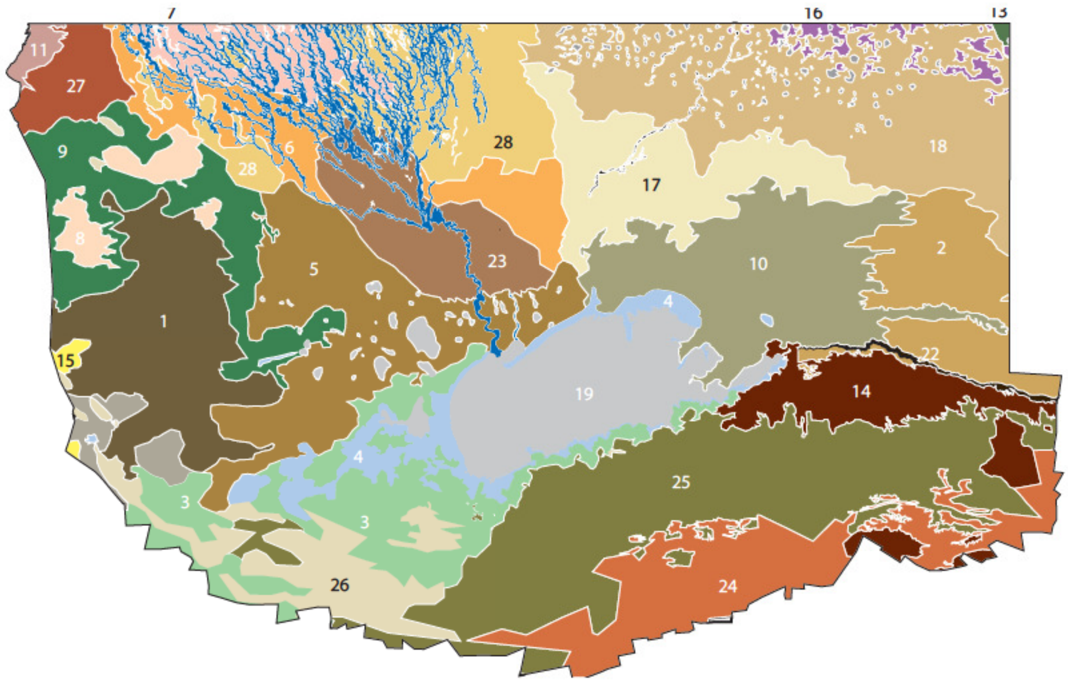
Pans. Very few plants grow on the pans which consist of very saline clays, generally called solonetz and solonchak soils (see page 14). After good rains or flooding, the annual grass *Sporobolus salsus* grows on the pans. Pan margins support perennial grasses and sedges such as *Odyssea paucinervis*, three salt-loving species of *Sporobolus*, and *Cyperus marginatus*. Two woody dwarf shrubs - *Suaeda articulata* and *Salsola tuberculata* - also occur on the pan margins.

North-eastern Kalahari woodland is a diverse community of trees where most species are typical of the deep sandy soils which are not suited to crop production. There is also a range of species which prefer clayey soils, thriving in these soils around the old pans, drainage lines and inter-dune valleys. The clayey soils are better for crops and so most households are clustered in these areas. Burkea, Angola teak, camel-thorn and various combretum species dominate the large trees. Valuable stands of Zambezi teak occur in some areas.

The dominant woody plants in the **Karstveld woodland** are mopane trees and shrubs, acacia species and *Catophractes alexandri*. In the south-east, an area that suffers from considerable bush-encroachment, purple-pod terminalia, sickle-bush, kudu bush and tamboti woodland are more common. In the west, isolated hills of granite, quartzite, calcrete and dolomite occur. Here the soils are shallow and sandy to loamy, and the vegetation is dominated by open shrubs and low trees of acacia species, mopane, purple-pod terminalia and kudu bush.

Icons of the Cuvelai: more than any others, these four trees characterise the Basin:

Makalani palm (top left), mopane (bottom left), baobab (above) and marula (below)

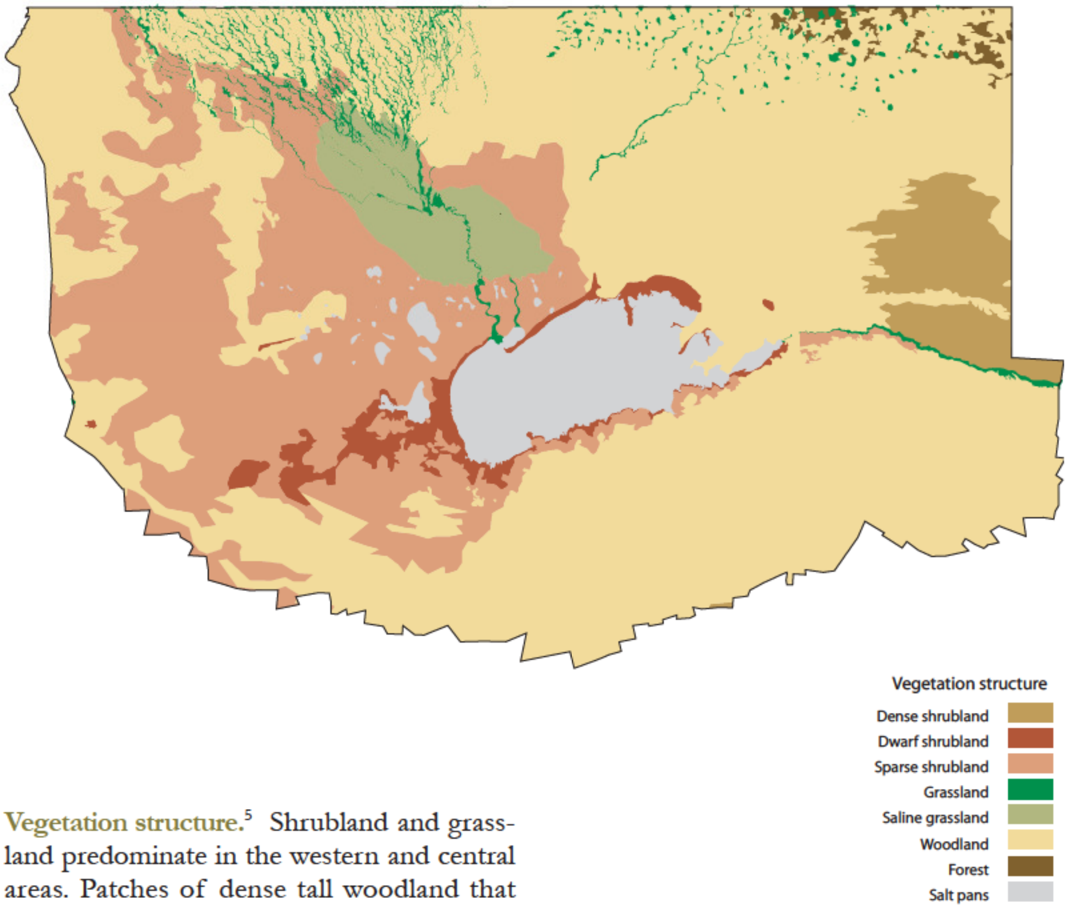


Vegetation units

- 1 Shrubland on sand plains
- 2 Camelthorn - Silver Terminalia shrubland mosaic
- 3 Etosha mixed shrubland on calcrete
- 4 Etosha grass and dwarf shrubland
- 5 Mopane shrubland of Etosha
- 6 Mopane shrubland in Cuvelai oshana
- 7 Mopane woodland in Cuvelai oshana
- 8 Mopane panveld
- 9 Mixed woodland on sand
- 10 Eastern mixed woodland on sand
- 11 Mixed woodland of the Ruacana escarpment
- 12 Mixed broadleafed woodland on dolomite sand
- 13 Woodlands of northern sand plain
- 14 Tamboti woodlands
- 15 Broadleafed hilly woodland of north-central drainage
- 16 Baikiaea forest
- 17 Burkea woodland on sand
- 18 Burkea - Baikiaea woodlands
- 19 Etosha salt pans
- 20 Small pans in sandy woodland
- 21 Oshanas
- 22 Owambo omurambas
- 23 Ombuga-Oponono saline grasslands
- 24 Dolomite Karstveld
- 25 Loam and turf Karstveld
- 26 Etosha dolomite hills
- 27 Ruacana sand plateau
- 28 Oshana Kalahari mosaic

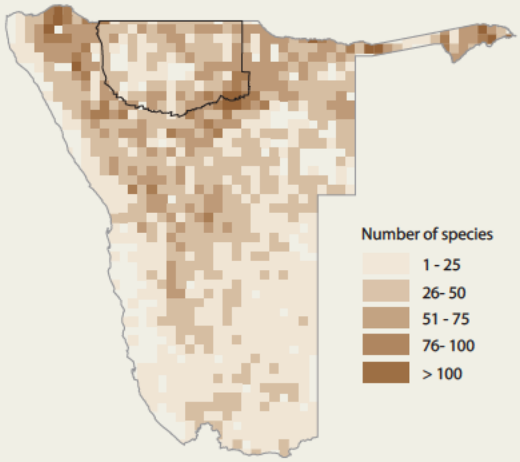
Vegetation units.[3] The major vegetation types shown on page 100 are not homogenous but rather mosaics of many smaller units and can be subdivided further on the basis of differences in the structure of woody plant growth, species composition and soil type, as shown here. Most of those differences are the consequence of flooding and the deposition of sand by wind. Grasses and shrubs dominate in areas where the soils are flooded more often since these soils tend to be relatively shallow, clayey and saline. Taller woodlands grow on deeper, wind-blown sands.

In turn, there are many more micro-units within the 28 vegetation types shown in this map. Most of the landscape and habitat photographs in this book show just how much local variation there can be. Farmers have keen eyes for that kind of local variation since subtle differences in vegetation reveal features of soil quality that are important in choosing where to plant crops.[4]



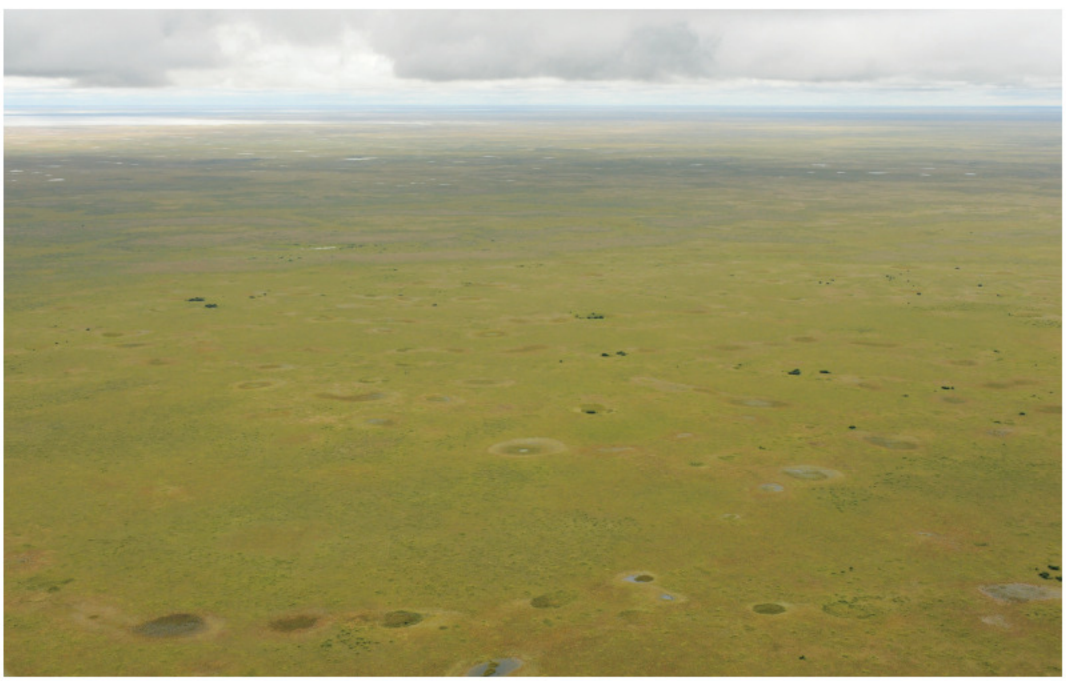
Vegetation structure.[5] Shrubland and grassland predominate in the western and central areas. Patches of dense tall woodland that qualify as forest occur in the north-east, where the dominant tree is Zambezi teak. Curiously, and reflecting drier times when deep Kalahari Sands covered the whole Basin, there is also a substantial area of Zambezi teak south and east of Ruacana where the sands are deep.

Although much of the Basin is classified as woodland, there has been substantial deforestation, particularly in the densely populated areas (see page 112). Overall, the vegetation is taller and more luxuriant in the north-east and south-east as a result of the higher rainfall in these areas. Plants are also limited in stature by the saline soils in the central and western areas of the Basin.



Tree diversity.[6] Shrubland and grassland areas typically support fewer than 40 species of trees, considerably less than the woodlands in the Basin. The diversity of trees is greatest in the Tsumeb area in the south-east where local habitat diversity and rainfall is highest. Here, quite different trees grow on the lowlands among the hills which, in turn, support different communities of trees and other plants.

The *ombuga* area is a vast expanse of saline grasslands grazed by tens of thousands of cattle. The animals are herded by young men who live at dozens of cattle posts scattered across the open landscape where there are very few woody plants. Water is plentiful in small pans following rain, but at other times the cattle concentrate around a few wells and deeper pans. Severe over grazing occurs around these water sources.[7]

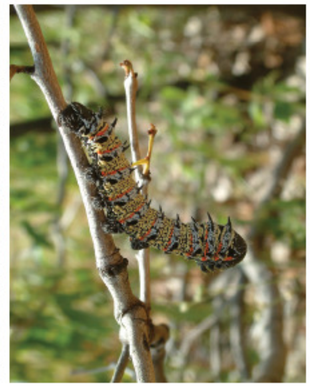


The use of vegetation resources. Households in the Basin traditionally depended directly on plant resources for most of their needs. These include grazing for livestock, poles from trees for fencing and home construction, fruits for consumption and production of beverages, grass for thatching and production of baskets, wood for fuel, fish traps, storage containers and many more. Poorer households are still more dependent on natural resources than those which can afford to pay for alternatives, and they are therefore at a severe disadvantage in areas where the commonage resources have been diminished. The differences between households are most easily seen in the materials used for the construction of homes, such as the one below which is partly built with purchased corrugated iron and partly with locally collected grass and poles.

Marula fruits provide food, drinks and oil which is extracted from the seed kernels. In addition to its domestic use, marula has considerable commercial value. Skin and hair care products containing marula oil are now sold in Namibian supermarkets and herbal shops. The oil is also exported: total export volumes increased from 3,419 kg of oil in 2009 to about 7,000 kilograms in 2011, generating total earnings of approximately N$1 million.[8] Typically, one family can collect and sell about 100 kilograms of marula kernels per season.

The fruits of bird plum trees, known locally as *ombe,* are dried and sold for food, and also used to make a tasty liqueur. The commercialisation of these and other indigenous plant products has provided additional opportunities to earn cash incomes. Several co-operatives and harvesting groups have been established, such as Eudafano Women's Cooperative in Ondangwa. The groups increase the value of products by buying directly from harvesters, making bulk sales to buyers and negotiating fair prices on behalf of the producers.






Perhaps no other plant is as useful as mopane or *omusati*. It supplies such goods and services as browse for livestock, firewood, mopane worms, gum which is used as a sealant, traditional medicines, roots for export, bark for tanning, building materials for houses and palisade walls, and rope to bind *iigandhi* grain storage baskets. These massive baskets are vital for the storage of grain both for general use in the future and as insurance against possible harvest failures in the years to come (see page 141).

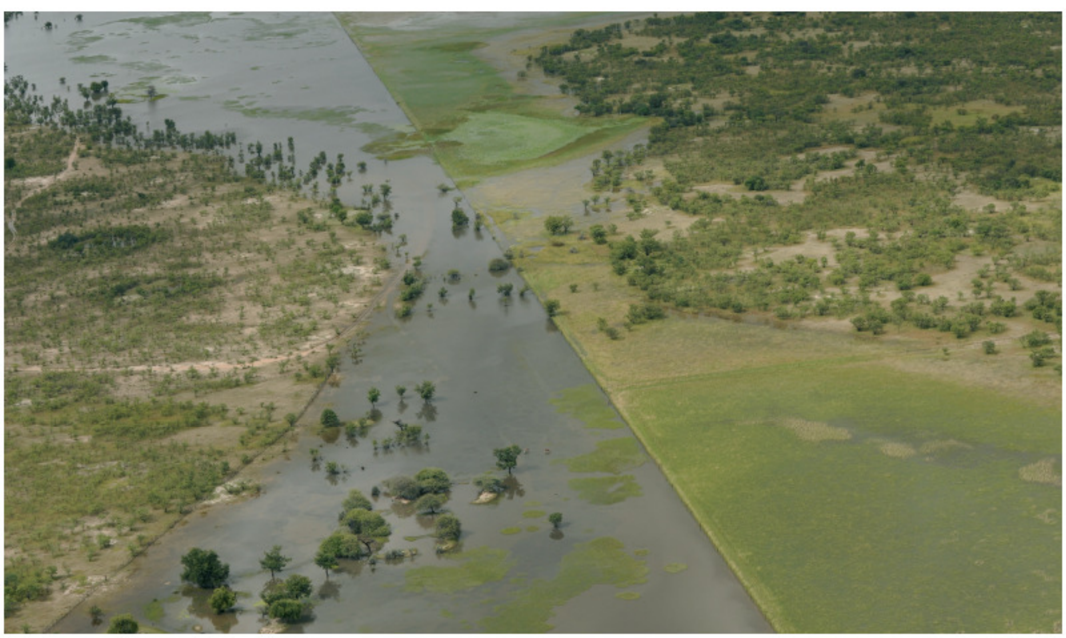
A lesser known use is of the roots (top centre) which are exported for use as ornaments in fish aquariums.

Mopane worms, which feed exclusively on mopane leaves, are harvested and dried, and often sold as a delicacy (top right). The caterpillars are actually the larvae of moths, which are slightly longer than their printed scientific name: *Gonimbrasia belina*.

These pages show a selection of plant products. There are so many more, such as the red fruit of *Ximenia* (shown on page 98), and makalani palm leaves used for thatching and fencing. In addition, hundreds of thousands of cattle, donkeys and goats graze and browse a variety of grasses, shrubs and trees.

The abuse of vegetation resources. The Namibia-Angola border that cuts the Basin in half is one of the few international boundaries that can be seen from space. This is because of deforestation on the Namibian side as a result of so many people cutting trees to build their homes. However, the woodland may be slowly recovering as increasing numbers of people use bricks and other purchased materials for building. Woodlands in most areas of the Angolan part of the Basin remain intact because of the much smaller human population there. Per square kilometre, there are about double the number of households on the Namibian side as there are north of the border (see page 18).

Ogongo Agricultural College protects about 4,000 hectares of vegetation which remains as it was hundreds of years ago. There are many more large trees within the grounds of the College than in the area adjacent to it, and even after the good rain and grass growth in 2011 the effects of overgrazing outside the College grounds were clear in this photograph.

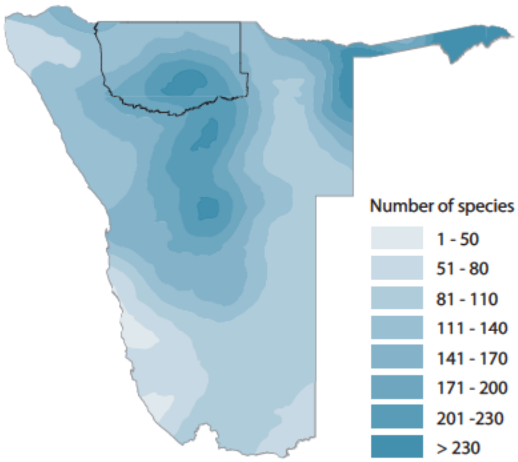


Grasses, shrubs and trees provide food for over a million cattle, goats and donkeys in the Basin (see page 160). However, most of the forage for these animals is in the commonage which belongs to no one and is therefore not managed or controlled. As a result it is in everyone's individual interest to use as much forage as possible. Almost all grass and browse is therefore removed each year, leaving much of the countryside in the densely stocked areas devoid of vegetation.

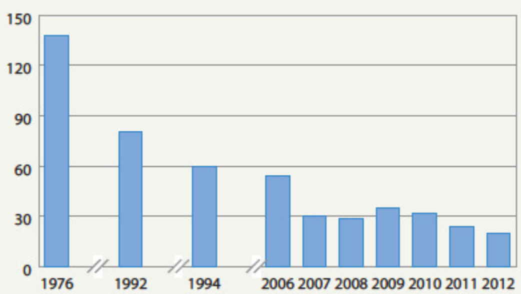
The owners of larger properties that enclose pastures first graze their livestock on the commons until its forage is depleted, whereafter their animals are moved to use their private grazing that has been fenced off and protected. Poorer people without their own grazing are at an obvious disadvantage since their livestock have to continue foraging in areas where little remains to eat. This predicament may last for months until the next season's rains bring moisture and new growth.

As the image above shows, large areas are carpeted by dense bush cover or extreme degrees of bush encroachment. This mainly affects the Mangetti farms east of Oshivelo, and freehold land in south-eastern Oshikoto and south of Etosha. Little grazing is left on these farms, many of which now support fewer livestock than before. The encroachment of bush and loss of grass has been caused by the combined effects of overgrazing and the absence of intense fire.

The use of woody plant material for charcoal has provided some farm owners with new incomes, even though the earnings are usually modest. There is also the possibility of using bush to produce electricity or even to earn international carbon credits. The reasoning behind this is that the dense bush will help absorb significant amounts of carbon dioxide produced elsewhere in the world.



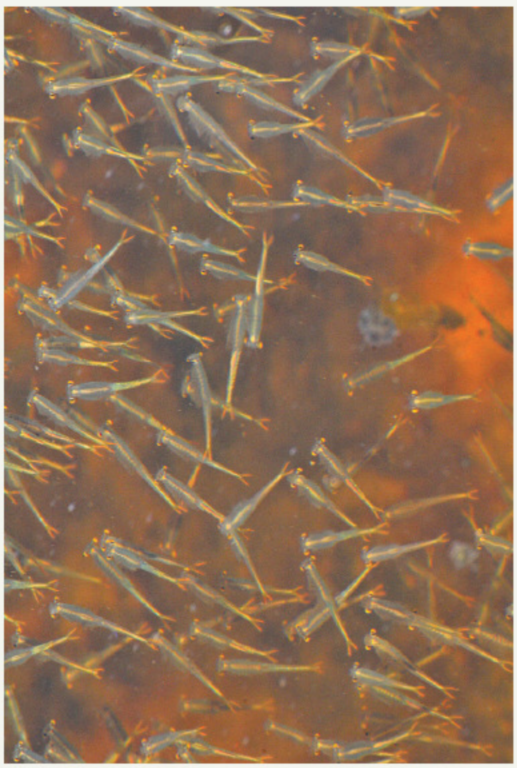
The diversity of birds.[9] Over 400 species of birds have been recorded in Etosha National Park. The largest numbers of birds are found between October and April, when the summer migrants are present. The northern areas of the Basin support fewer species and many of the wetland birds within the Cuvelai drainage are considered threatened due to the pressures caused by the dense human population.



Blue cranes in the Basin. Etosha and the grasslands around the Omadhiya Lakes are home to the only breeding population of Blue Crane outside of South Africa. This is one of Namibia's most threatened birds, classified as Vulnerable globally, and Critically Endangered in Namibia. Numbers in Namibia are declining. In 1976, 138 birds were counted, whereas a count in 2012 yielded only 18 adults and 2 chicks. The total number of chicks recorded per year between 2006 and 2011 has ranged between 1 and 9.[10]

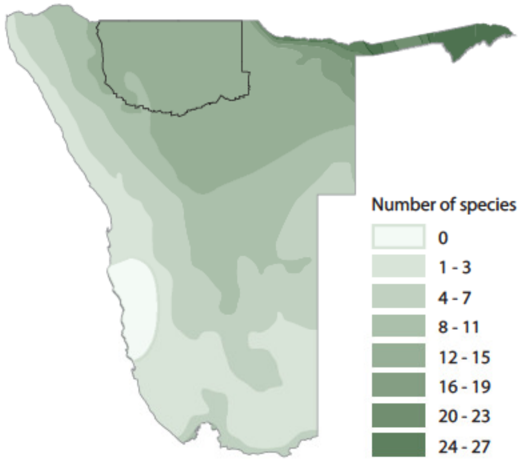
When flooded, Etosha Pan is transformed into a shallow lake where huge flocks of pelicans, flamingos and other waterbirds arrive to feed and breed. The pelicans feed on fish that have moved southwards into the Cuvelai-Etosha system with the floodwaters from Angola. The Pan is one of two regular breeding sites in southern Africa for lesser and greater flamingos. Up to one million flamingos have been recorded in the past, but more recently numbers have only reached about 20,000 and their breeding success has been limited.

For much of the time, and even for years on end, there are very few birds in the *iishana* drainage system. However, the area is transformed during high and extended *efundja* flows when hundreds of thousands of wetland birds converge there from all over southern Africa. Many of the birds breed, an indication of abundant food being available to them. The photograph is of a breeding colony of thousands of cattle egrets, just south of Uukwangula in 2011.



Many of the invertebrates that live in water are specially adapted to cycles of long dry periods interspersed with short periods of rainfall and flooding. Adaptations to this environment include having short life cycles and eggs which are resistant to drying out for months. The adults of some species survive the dry periods by slowing down their metabolism and becoming dormant. There are about 60 species of crustaceans in the Basin, many of which can complete their life cycle rapidly - hatching, growing and producing eggs within hours after flood waters have arrived. Sixteen of these species are endemic to Namibia (i.e. they are not found anywhere else).[11] These small aquatic animals are important sources of food for fish, frogs and birds.

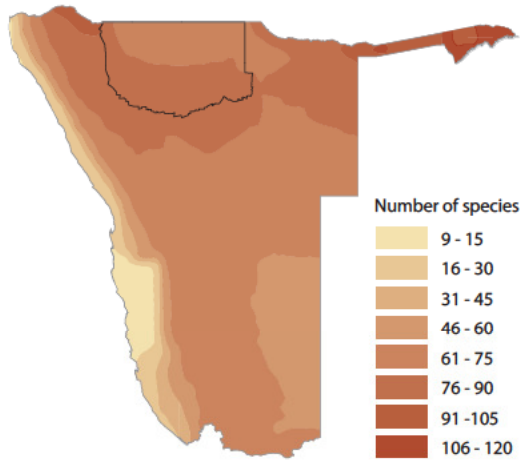
Among the crustaceans are fairy shrimps (left), triops (right), clam shrimps, seed shrimps, cladocerans and copepods.



Frog diversity.[12] Fifteen species of frogs occur in Etosha and the Cuvelai drainage. None of them are endemic. Some species can complete their reproductive cycle in 22 days and are thus able to take advantage of the sporadic flooding of the pans and *iishana*.

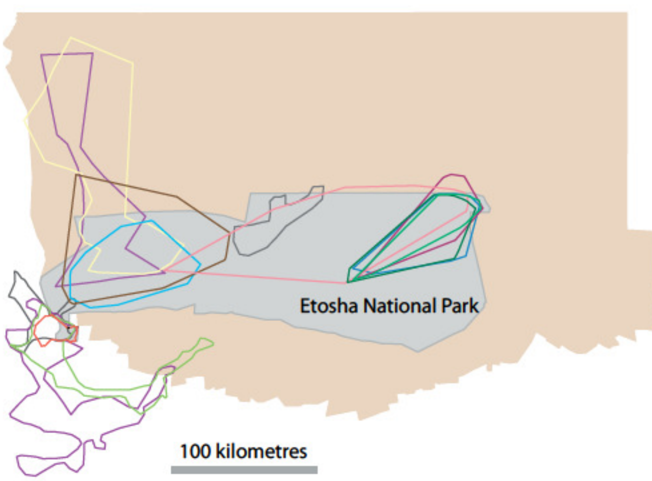
The African bullfrog (below) is sometimes very abundant when adults emerge after spending months underground in a dormant state. Large numbers of the bullfrogs are then harvested for food.

Mammal diversity.[13] Most of these are carnivores, bats, antelope and rodents. While the Cuvelai historically provided rich habitats for wetland mammals such as buffalo and reedbuck, these species no longer occur here. The traditional migration routes of wildlife have been blocked by the fencing of Etosha National Park and, although there is some movement of animals through the fences, relatively few large mammals occur outside the Park.

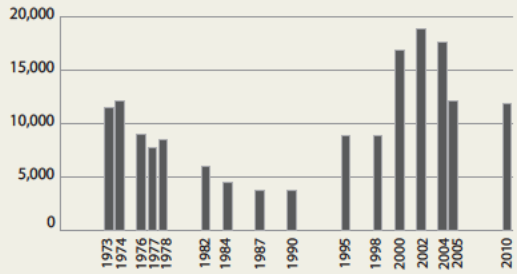


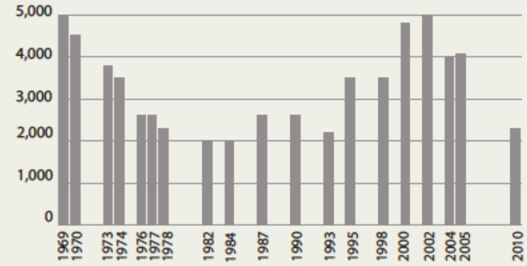
Each year, wildlife attracts about 200,000 people to Etosha National Park (see page 152). Over 50,000 large herbivores live here, largely zebra, blue wildebeest, and springbok. Other common herbivores are elephant, giraffe, black rhinoceros, gemsbok, eland, kudu, steenbok, dik-dik and black-faced impala. Predators include leopard, cheetah, spotted and brown hyena, black-backed jackal, bat-eared fox and lion (spoor across a salt pan above).

There is a network of 86 waterholes in the Park, both natural and man-made. The water-holes at the fringes of the main pan (particularly in the south) attract impressive numbers of large herbivores during the dry winter months. The animals move away in the wetter summer months to use fresh forage and temporary pools, mainly on the saline grasslands to the west of the main pan.



Movements of elephants. This map shows the ranges covered by 15 individual elephants tracked using radio transmitters that beam signals to satellites.[14] The areas covered by the giants are substantial, many of them over thousands of square kilometres. The elephants often venture outside the Park, particularly into sparsely populated areas to the west of the Basin and into freehold farmland to the south-west.

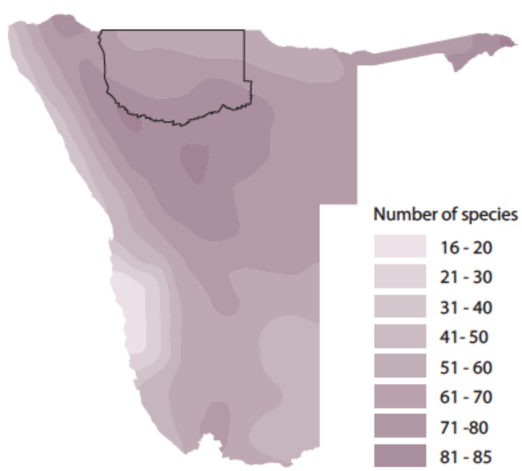




Numbers of Burchell's zebra (left) and Blue wildebeest (right) in Etosha National Park.[15] Changes in the number of large mammals can be substantial as shown in these graphs. However, rather little is known of what factors have been at play, particularly in the major decline in wildebeest and zebra populations during the 1970s and then the increase in recent years. Rainfall, through its effect of grass growth and water availability, probably has the greatest influence, but the bacterial disease anthrax and mortality due to predation also have significant effects on game numbers in the Park.

From an aerial survey, the following numbers of large herbivores were estimated in the Park in 2010:

Blue wildebeest:	2,298
Burchell's zebra:	11,920
Eland:	1,368
Elephant:	1,305
Gemsbok:	4,810
Giraffe:	2,987
Red hartebeest:	759
Springbok:	12,351



Reptile diversity.[16] There are about 50 species of reptiles in the northern areas of the Basin and about 70 species in the southern areas where the habitats are more diverse. One small lizard known as the Etosha agama (*Agama etoshae*) is about 7 centimetres long, and does not occur anywhere else. The agama forages for beetles and termites in flat sandy areas.[17]

In addition to providing residents with occasional large quantities of protein, fish in the Basin are hardy, opportunistic creatures. Many apparently only move into the Basin channels from upstream perennial waters during periodic floods (such as the barbs on the right), while others remain dormant beneath the ground, only emerging when the *iishana* and pans are inundated (such as the catfish below). Those that can live in the most downstream sections of the drainage system, for example in the Omadhiya Lakes, are also resilient to high concentrations of salt.

Twelve fish species were known to occur in the *iishana*, but another 35 species have been introduced from the Kunene River through the pipeline and canal that runs from Calueque to Oshakati (see page 144).[18]

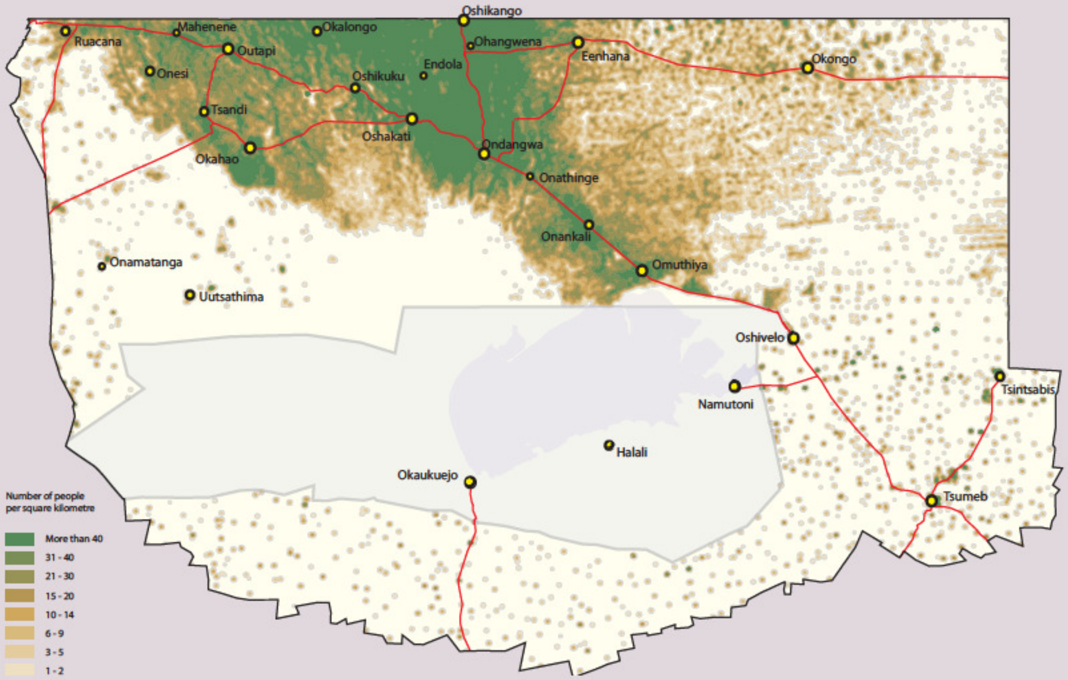
7 - People:
life and energy of the Cuvelai

In 2011, the population in the Namibian part of the Basin was about 850,000 people, or approximately 40% of all people in Namibia. About 143,000 people were living in towns with the remaining 707,000 in rural areas. These figures reflect several notable features. Firstly, the density of people is considerably greater than in other rural areas in south-western Africa (see page 19). This is largely a consequence of the fertility of the soils and the availability of fresh water in shallow hand-dug wells.

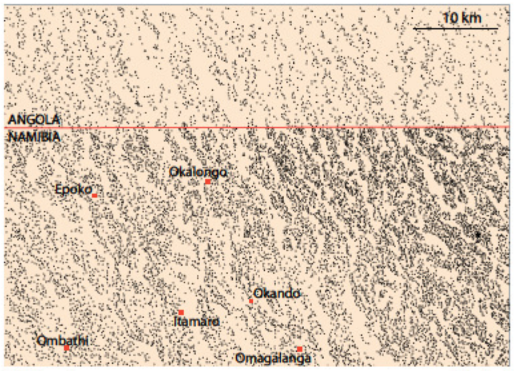
Secondly, the Basin's population is rapidly becoming urbanised as more and more people make their homes and livelihoods in towns. In addition, the majority of rural homes obtain most of their food and other basic needs from income derived outside their farmsteads, for example from wages, business earnings, pensions and remittances.[1] As curious as it might seem, most households that grow crops and have livestock actually obtain most of their income from sources unrelated to farming.

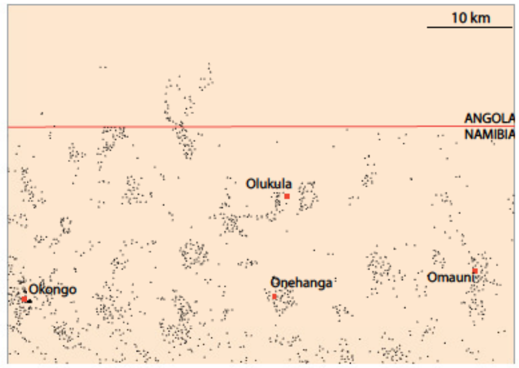
A third noteworthy feature of the Basin's population is the very close relationship between the Cuvelai wetlands and the Owambo people, a relationship that was established when Owambo people settled here some 500 to 600 years ago.[2] This is also true in the Angolan half of the Cuvelai where they are known as Ambó. Historically, all Ambó/Owambo people lived in this wetland area. In a sense, the Cuvelai and the Owambo people are synonymous; the mention of one invokes the other. There can be few other wetlands and tribes anywhere in the world where the association is as intimate.

Incomes from trading, remittances and salaries have been major contributors to the economy of the Basin. This began with the trading of livestock, salt and ivory hundreds of years ago, and later through people working as temporary migrant labourers on farms and mines and in towns elsewhere in Namibia.[3] In recent decades, more and more people have moved south permanently. Of all households in Namibia that reported Oshiwambo as their home language during the 2011 population census, 68% were in the Cuvelai and 32% were elsewhere in Namibia.[4] Most Oshiwambo-speakers living elsewhere are of a working age, and the majority are men.



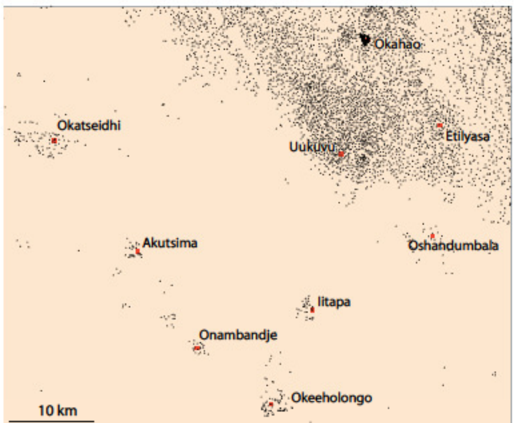
The density of people in 2010.[5] The great majority of people in the Basin live in a broad zone between Omuthiya, Okahao, Ruacana and Eenhana. The highest rural population densities in this triangle exceed 100 people/ square kilometre. Outside this zone, densities are lower and the population is more scattered. The density of rural populations is largely determined by several factors, the most important of which are the fertility of soils for crop farming, availability of higher ground which will not be flooded, access to fresh drinking water, and proximity to services and towns. The absence of water and productive soils are the main limiting factors in the large, very sparsely populated areas in eastern Oshikoto and western Omusati.

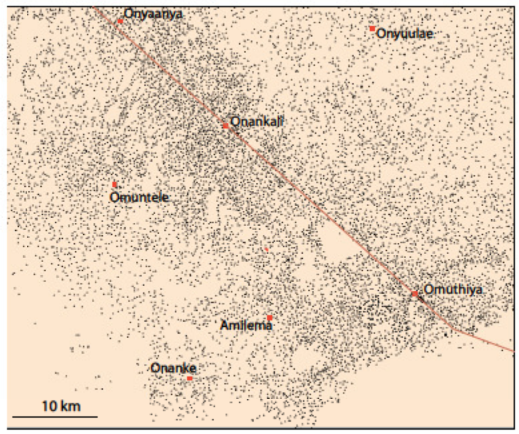


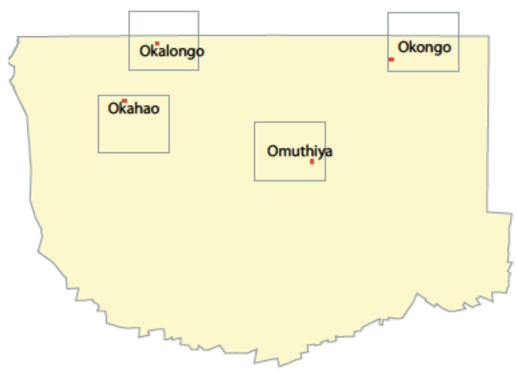


A (above) C (below)

B (above) D (below)

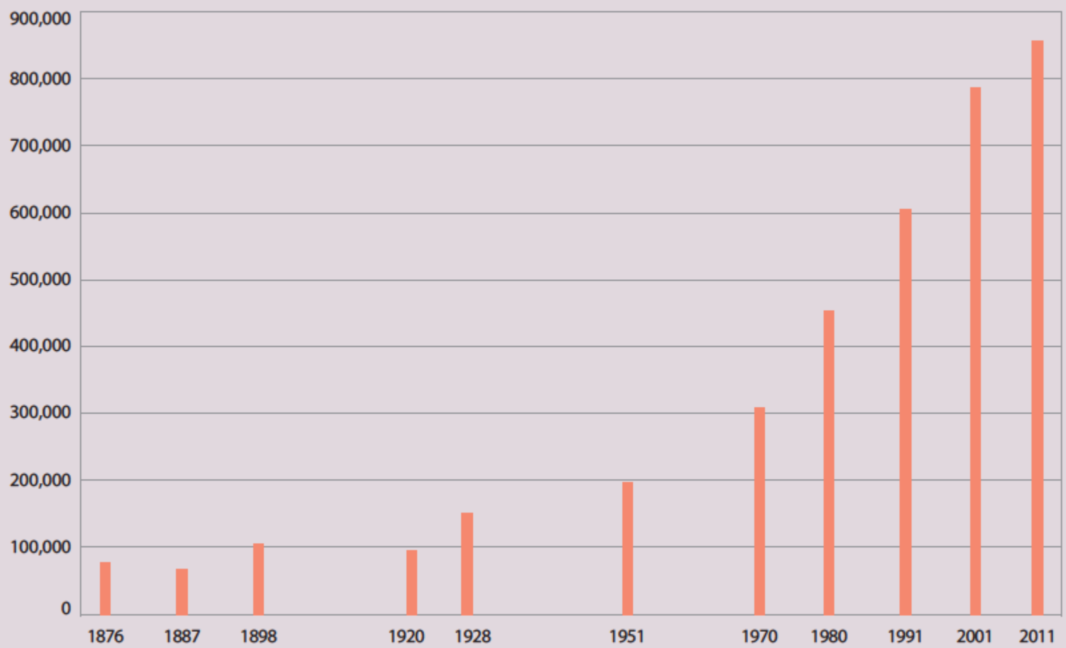






Patterns of population distribution.[6] Each dot marks the location of a homestead. In the most densely populated areas homes are spread rather evenly, each household being several hundred metres away from its neighbours, as in Areas A, D and the northern part of C. Homes in more sparsely settled areas may be one, two or more kilometres away from each other, by contrast. In A, around Okalongo, all the homes are located on high *omitunda* ground between the *iishana* which run from north-west to south-east.

Note how homes tend to be more densely congregated closer to the main road between Omuthiya and Onankali (D) In eastern Ohangwena around Okongo (B) and southern Omusati (Area C), households are clustered around pans or drainage lines where water is available close to the surface and where soils are more suited to cultivation.

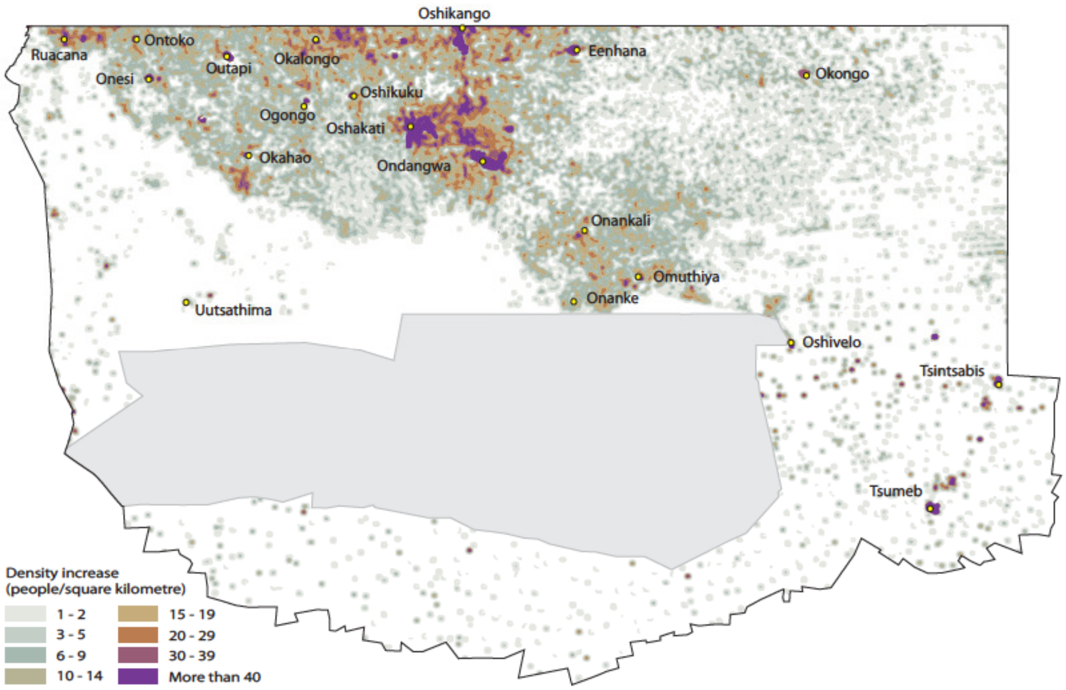


Population growth.[7] In 2011, the total population of the Cuvelai-Etosha Basin was estimated to be about 850,000 people, having grown from less than 100,000 in the early 20th Century.

The population grew very rapidly after the 1930s as a result of substantial immigration from the Angolan side of the Cuvelai. Most people moved to Namibia to escape direct taxation, forced labour and civil war, and to benefit from the services and economic opportunities. Improved survival in Namibia due to medical services at clinics and hospitals also led the population to grow rapidly.

Over the past 30 years, the population has grown by approximately 2.1% each year. If that rate of growth continues, the Basin can expect to have a population of about 1.1 million in 2020 and 1.4 million in 2030.

Although about 84% of people live in rural areas of the Cuvelai, urban populations are growing very rapidly (see the table on page 132).

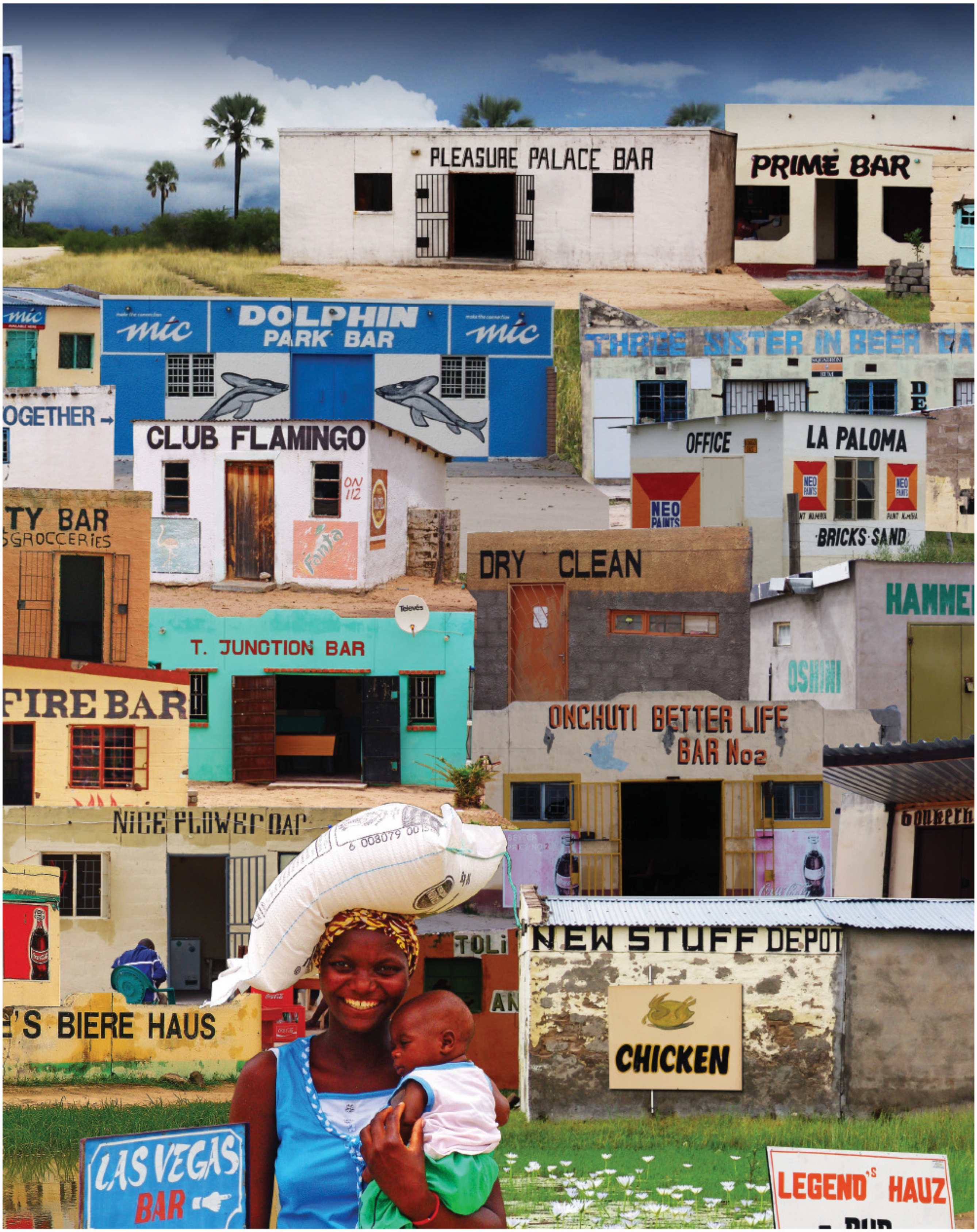


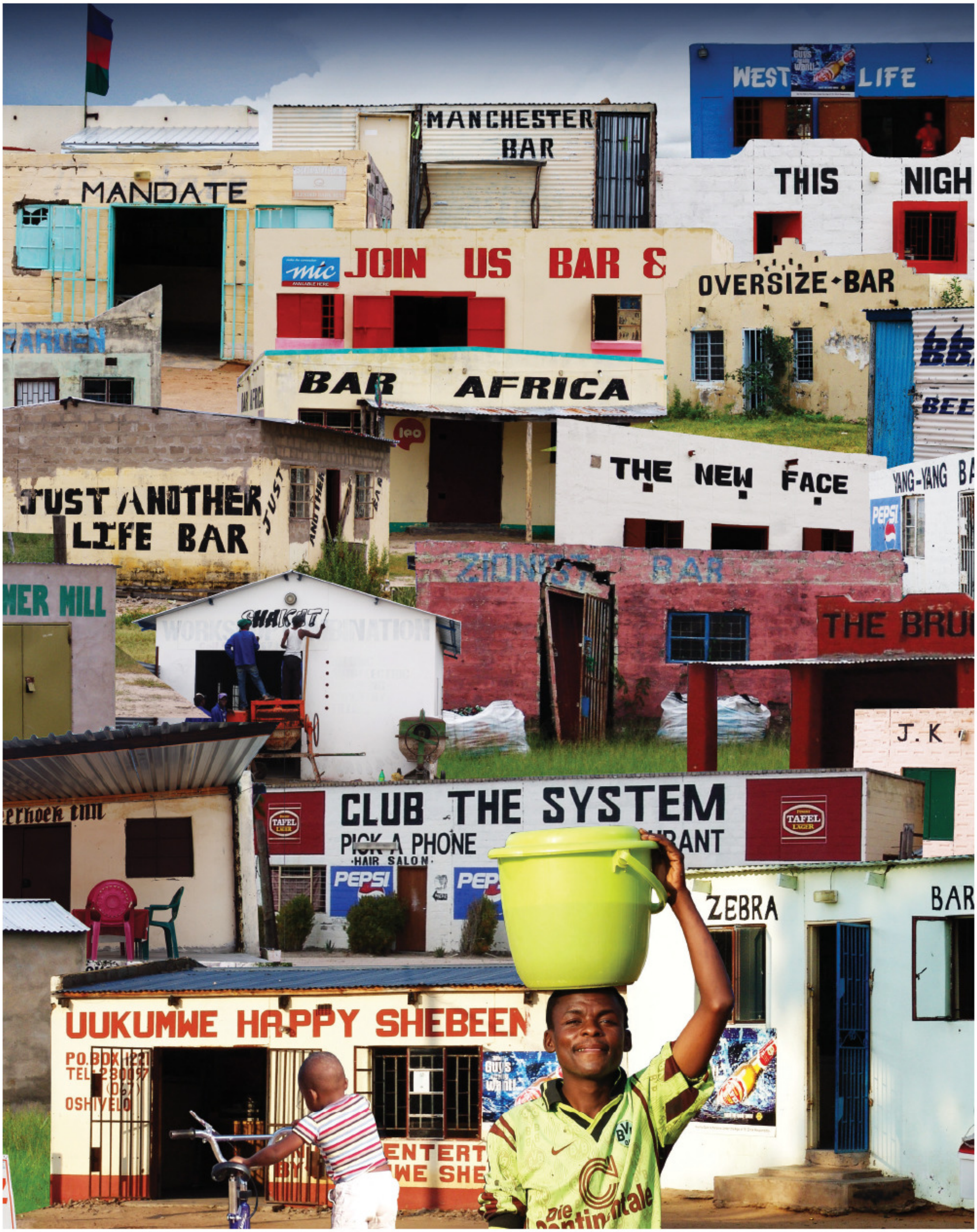
Growth in the population from 2000 to 2010.[8] In recent years most population growth has been around the urban areas of Oshakati, Ondangwa and Oshikango. Commercial and economic growth in these areas has been so substantial that large metropolitan expanses have developed at Onethindi-Ondangwa, Ongwediva-Oshakati, and Oshikango-Onuno-Engela-Ohangwena.

There has also been rapid population growth in the many smaller emerging towns, such as Okongo, Oshikuku, Outapi, Okahao, Tsandi and Onesi. Further from towns, significant numbers of rural homesteads have recently been established south of Okahao, near Ruacana and in areas around Onankali and Omuthiya.

Onehova is one of several villages that straddles the boundary between Angola and Namibia.

The actual border line is on the right while the line on the left is a cut-line that was cleared during the liberation war.


PLEASURE PALACE BAR
PRIME BAR
mtc
DOLPHIN
PARK BAR
mtc
CLUB FLAMINGO
OFFICE
LA PALOMA
NEO PAINTS
BRICKS SAND
DRY CLEAN
T. JUNCTION BAR
FIRE BAR
ONCHUTI BETTER LIFE
BAR No2
NEW STUFF DEPOT
CHICKEN
BIERE HAUS
LAS VEGAS
BAR
LEGEND'S HAUZ



WEST LIFE
MANCHESTER
BAR
THIS NIGH
MANDATE
JOIN US BAR &
OVERSIZE-BAR
BAR AFRICA
JUST ANOTHER
LIFE BAR
THE NEW FACE
YANG-YANG BA
ZIONIST BAR
THE BRU
J.K
CLUB THE SYSTEM
PICK A PHONE
HAIR SALON
PEPSI
ZEBRA
BAR
UUKUMWE HAPPY SHEBEEN
OSHIVELO

The economies of Oshakati (above left) and other large towns are dominated by trade, a large part of which is directly or indirectly associated with cross-border exports from Namibia to Angola. This is particularly true for Oshikango, which makes up most of Helao Nafidi, the formal urban area listed in the table below.

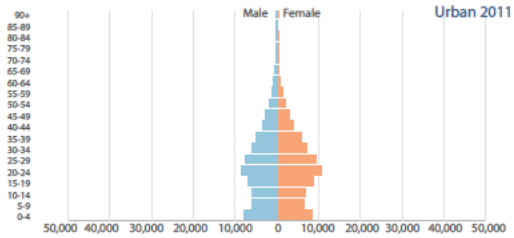
In addition to the emerging cities of Oshakati (and its twin Ongwediva), Ondangwa, Oshikango and Tsumeb, several other towns are growing rapidly as administrative and commercial centres. The biggest are Outapi, Eenhana, Omuthiya and Okahao, while others that have grown significantly are Oshivelo, Tsandi, Oshikuku, Okalango, Onesi, Okongo and within Helao Nafidi: Onuno, Engela and Ohangwena.

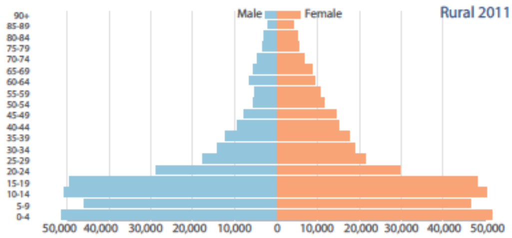
All these places are commercial centres, to which many young people are attracted by the potential of finding jobs and other sources of cash. While some of the towns first developed around missions and their schools and hospitals – such as Engela and Oshikuku – most have grown from groups of small shops and shebeens, popularly known as cuca shops. There are hundreds of clusters (called *uundingosho*) of these shops across the Cuvelai (above right), many of them decorated and named with considerable flair (see the previous page).

Public services also contribute significantly to the urban economies, especially for Oshakati, Outapi, Eenhana and Omuthiya (the capitals of the four administrative regions (see page 14) and Ondangwa and Tsumeb.

The number of people living in the largest towns in 1991, 2001 and 2011.[9]

	1991	2001	2011
Oshakati	9,300	26,800	36,541
Ongwediva	12,100	14,350	20,260
Ondangwa	17,213	19,600	22,822
Helao Nafidi	12,500	16,100	19,375
Tsumeb	16,200	14,100	19,275

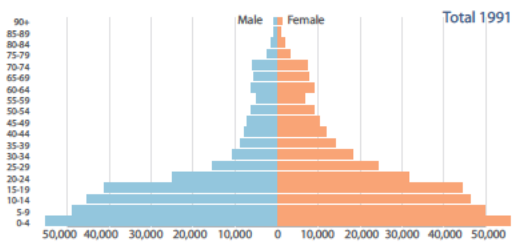


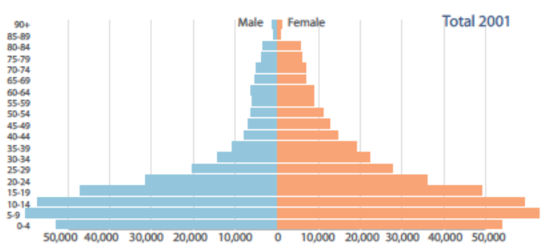


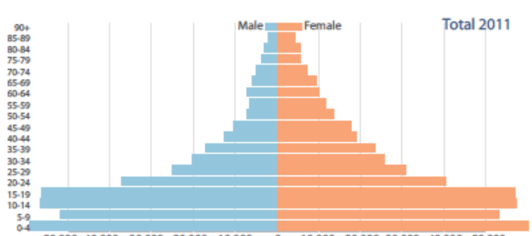
The structure of the population.[10] The age and sex composition of rural and urban populations is very different, as shown in the two graphs at the top. Rural residents consist of large numbers of people younger than 20 years, and far fewer people of working ages in their 20s, 30s, 40s and 50s. There are considerably more women than men aged 25 and above in rural areas. By contrast, urban areas are dominated by working-aged people in their 20s, 30s and 40s, with fewer children and people aged over 60 years.

These patterns are the consequence of the migration of working age people in search of work (especially men) to urban areas both within the Basin and to other areas of Namibia. Pressures to seek incomes are such that many boys leave secondary school prematurely, with the result that senior secondary grade classes generally have fewer boys than girls.

The three graphs at the bottom compare the total population in 1991, 2001 and 2011. There was a substantial drop in the number of children aged 5 or less between 1991 and 2001 as a consequence of a major reduction in fertility rates (see next page). Fertility continued to decline after 2001, but not to the same extent as before, and relatively more babies were thus born in the Basin between 2001 and 2011.







The average number of children born to each woman in 1991, 2001 and 2011.[11]

Region/Area	1991	2001	2011
Ohangwena	7.7	5.3	4.6
Omusati	5.7	4.0	3.8
Oshana	5.6	3.7	3.0
Oshikoto	6.7	4.6	4.1
Namibia	*6.1*	*4.1*	*3.6*

The proportion of the population made up of children has declined in recent decades. This is due to a significant decline in fertility, as shown by these figures. Declining fertility is correlated with the increasing levels of female education and employment which means that many women now spend more time as wage earners than as full-time mothers. The greater use of condoms to reduce the risk of contracting HIV probably also led to fewer pregnancies.

Infant and child mortality rates in 1991, 2001 and 2006.[12]

INFANTS UNDER 1

Region/Area	1991	2001	2006
Ohangwena	59	56	63
Omusati	49	39	38
Oshana	62	44	51
Oshikoto	66	60	68
Namibia	*67*	*52*	*50*

CHILDREN BETWEEN 1 AND 5

Region/Area	1991	2001	2006
Ohangwena	109	78	94
Omusati	64	61	30
Oshana	80	64	78
Oshikoto	86	74	51
Namibia	*87*	*71*	*63*

Infant mortality is the number of babies out of 1,000 live births that die in their first year of life, while child mortality is the number of children that die between their 1st and 5th birthdays out of 1,000 infants that have reached 1 year of age. Both infant and child mortality dropped in all regions between 1991 and 2001, but then increased in some regions between 2001 and 2006.

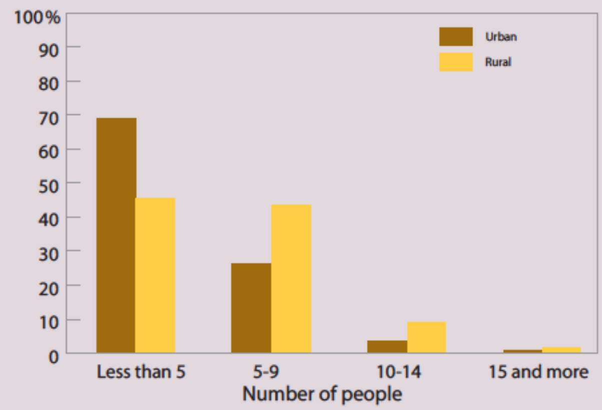
The proportion of households headed by women in 2001 and 2011.[13]

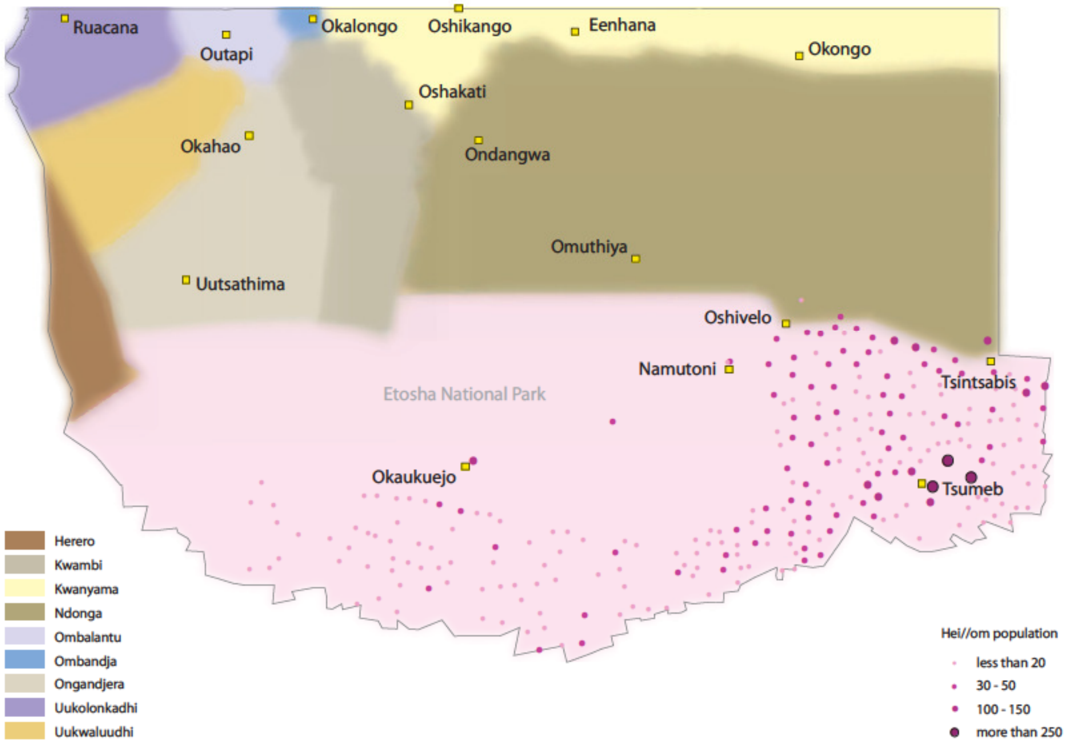
Region/Area	2001	2011
Ohangwena	59.7	56.5
Omusati	62.0	55.3
Oshana	54.0	53.7
Oshikoto	50.0	48.6
Namibia	*44.7*	*43.8*

The figures in the table are percentages of homes with female heads. A much higher percentage of homes are headed by females than elsewhere in the country, largely as a result of the high rates of emigration by men to work elsewhere in Namibia. On average, three out of five homes in the Basin are headed by women. A high proportion of female-headed families support orphans and/or the children of parents who are working elsewhere.

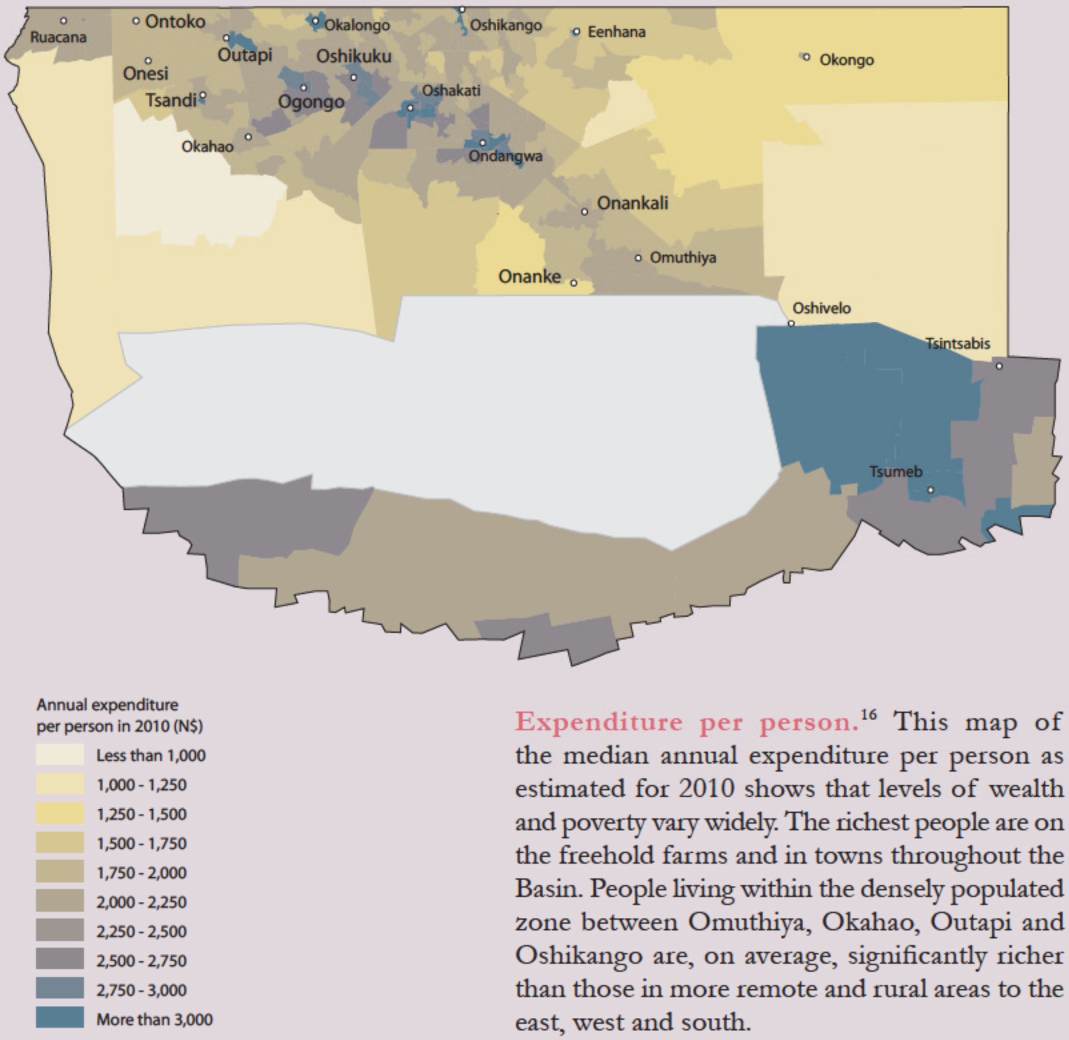
Household sizes.[14] Rural households are generally bigger than those in urban areas. Families in towns tend to be more nuclear, frequently consisting only of adults or of parents with one or two children. Rural homes often consist of more extended families which include grandparents and cousins.

Among rural homes, those with the largest number of household members are generally wealthier and more resilient to misfortune than those with fewer members. This is because large households have a greater number and variety of incomes, and more labour available for farming and domestic work.

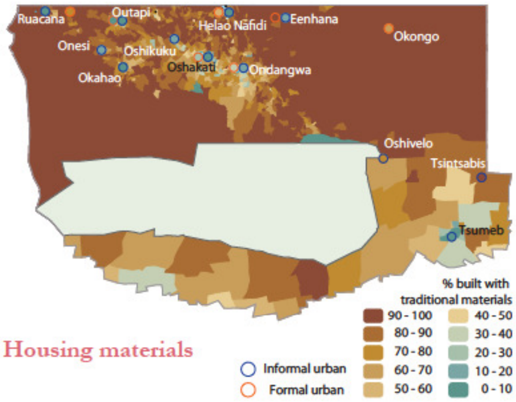




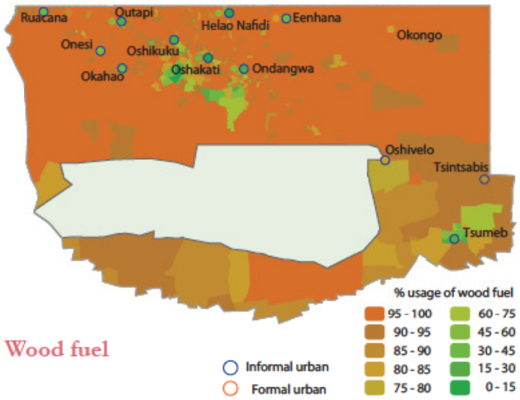
Tribal areas.[15] The great majority of people in the Basin are Oshiwambo speakers, usually called Owambo in Namibia and Ambó in Angola. There are eight major Owambo traditional authority areas, some with their own distinct dialects: Kwanyama, Ondonga, Ombalantu, Ombandja, Ongandjera, Uukolonkadhi, Uukwaluudhi and Uukwambi. Each of these is headed by a chief, king or queen, who is supported by senior councillors. The councillors represent different wards or districts, within which there are local headmen who authorise land allocations and solve local problems using customary law. Significant numbers of Zemba people live close to the Kunene River within the Uukolonkadhi area, while a mix of people live south of Etosha and in southern Oshikoto which is traditionally a Hei//om area, shown in pink on the map. Only two of the Oshiwambo dialects are widely used in the written form, and their speakers form the largest groups: Kwanyama and Ondonga.



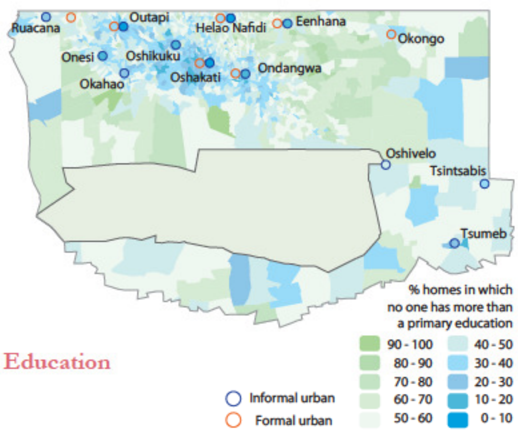
Expenditure per person.[16] This map of the median annual expenditure per person as estimated for 2010 shows that levels of wealth and poverty vary widely. The richest people are on the freehold farms and in towns throughout the Basin. People living within the densely populated zone between Omuthiya, Okahao, Outapi and Oshikango are, on average, significantly richer than those in more remote and rural areas to the east, west and south.



Housing materials



Wood fuel



Education

Sanitation

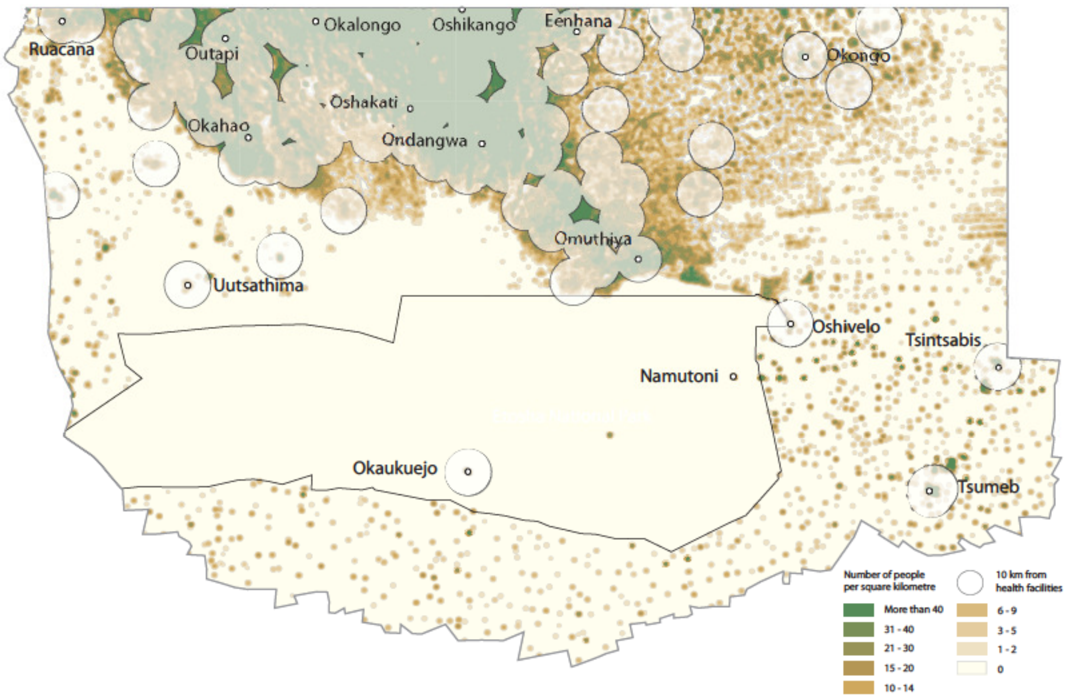
Measures of wealth and poverty.[17] The four maps provide other indices of welfare by showing proportions of homes in different areas that are built largely of local materials as opposed to bricks and other purchased construction materials (top left), in which no one has more than a primary school education (bottom left), that use wood for cooking as opposed to purchased fuels (top right) and that use the bush as a toilet (bottom right). All four indices show that the poorest households are in the most remote areas, and that higher proportions of wealthier homes are found in the densely populated zone between Omuthiya and Outapi and Oshikango, in towns and on the freehold farms in the south.

Of course, substantial numbers of extremely poor people also live within the zones that are generally relatively better-off. Those poorer homes are typically small and headed by elderly women with perhaps only two or three other family members, normally children or other elderly people. Their farms usually consist of just one or two hectares of fields which are often on less fertile soils than those of their neighbours. In addition to having fewer household members of working age, poorer homes generally have no goats, donkeys or cattle, and are often on lower ground which is more prone to flooding (see page 80). Few of the buildings are built with materials bought with cash, whereas those of richer households are often at least partially built of bricks, corrugated iron and other purchased materials. In short, poor homes live largely off labour supplied by their few family members while wealthier households live off cash incomes from larger families.

Increasing urbanisation and reliance on cash incomes are major trends in the Basin. This is a consequence of the fact that it is hard to make a decent living in rural areas where crop yields are low, access to markets where surpluses can be sold is very limited, and where most land rights have no economic value. These are topics for the next chapter.

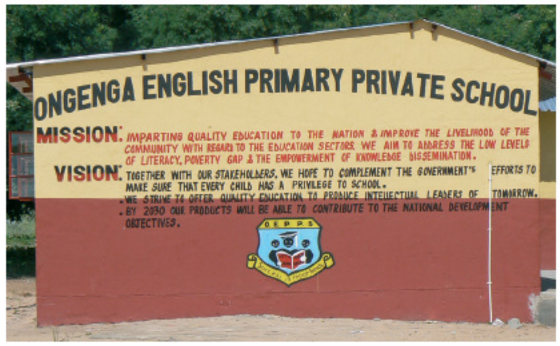
Many households have improved their livelihoods by having diverse incomes, for example from wages, business enterprises, remittances, pensions, as well as harvests of food. This is particularly true in larger homes. Access to a variety of incomes also greatly increases resilience to the effects of drought or other calamities. This is a huge improvement on conditions in the past when drought and plagues of locusts and worms caused severe famine. The worst recorded famines occurred in 1877/79, 1907/08, 1915, 1920 and in 1929-1931. It has been estimated that about 30-40% of the entire population died during some of those famines. These photographs from the National Archives were taken during the 1929 famine when people excavated dams in return for food.

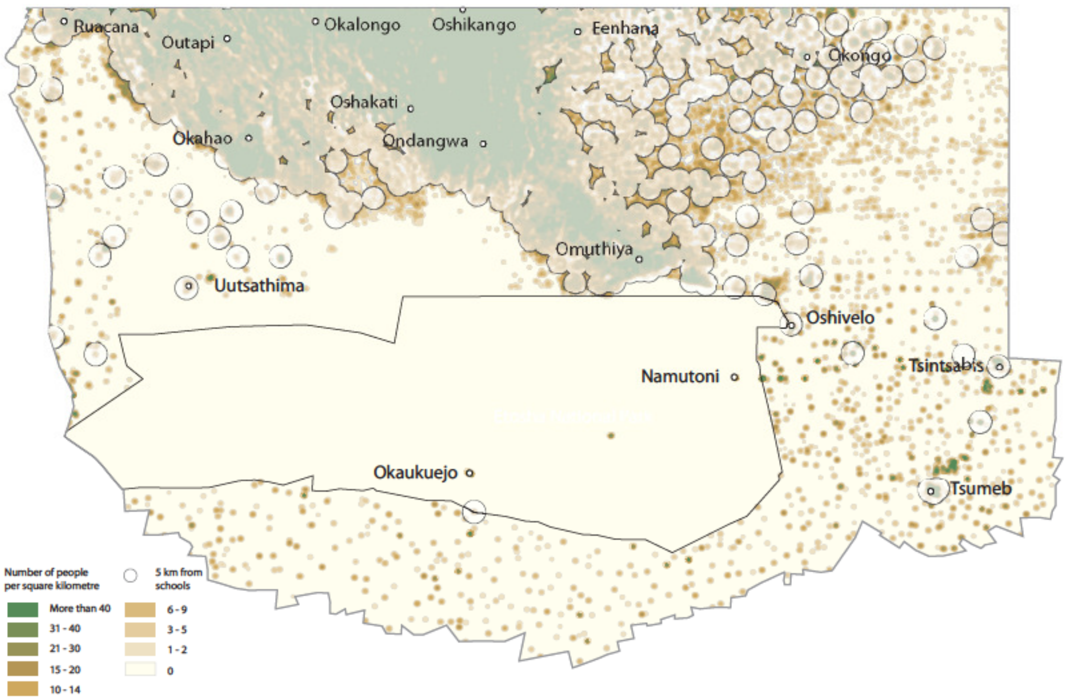
It is these famines that led to the development of huge *omashisha* baskets in which *mahangu* grain can be stored for years. People in the Basin have indeed developed a variety of strategies to 'be prepared' and to improve their living conditions.



Health facilities. There are 127 health facilities in the Basin comprising clinics (93), health centres (14) and hospitals (10). The most prevalent serious diseases are malaria, gastro-enteritis and HIV.

Travel distance is an important factor when planning the location of health facilities and a maximum distance of 10 kilometres to the nearest clinic or hospital is generally regarded as acceptable. This map shows areas and population densities within and beyond 10 kilometres from health facilities. From this information, we can calculate that about 85% of the Basin's population lives 10 kilometres or less from a health facility and 15% of people live outside these 10 kilometre catchment areas. Most of these people are in eastern Oshikoto and the southern and western parts Omusati. However, the Ministry of Health & Social Services also operates mobile clinics which visit remote areas.

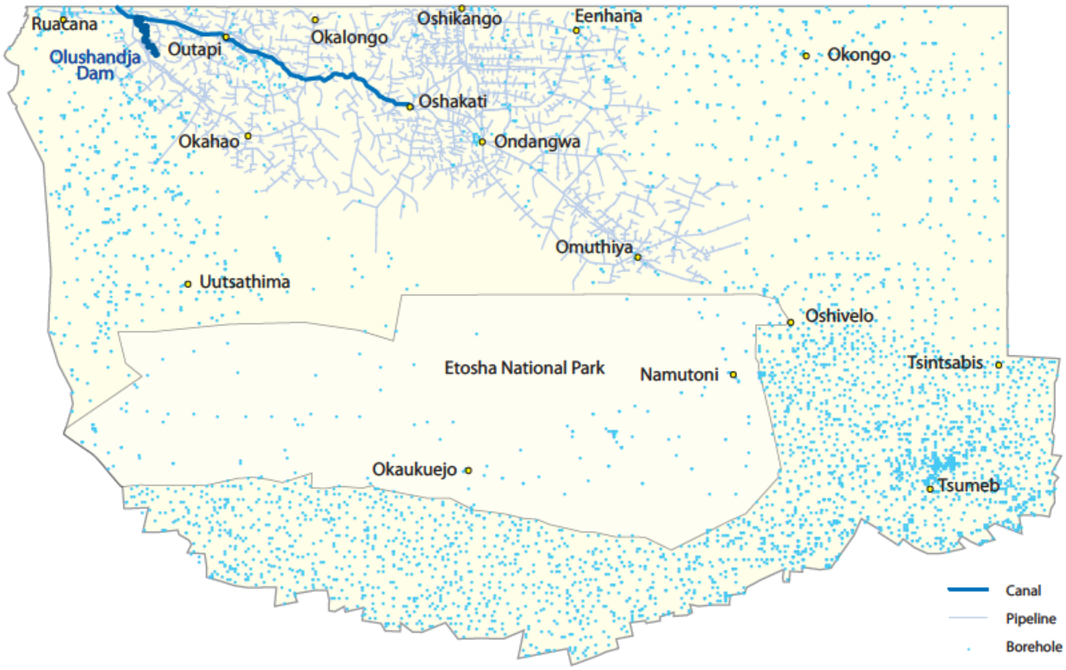




Schooling. There are about 840 schools in the Basin with the greatest concentrations in the most densely populated areas. Of the schools, 54% are primary schools, 10% are secondary schools, and 36% are combined schools which offer one or more primary and secondary grades. Most secondary schools are in larger urban centres while most schools in remote rural areas offer only primary grades.

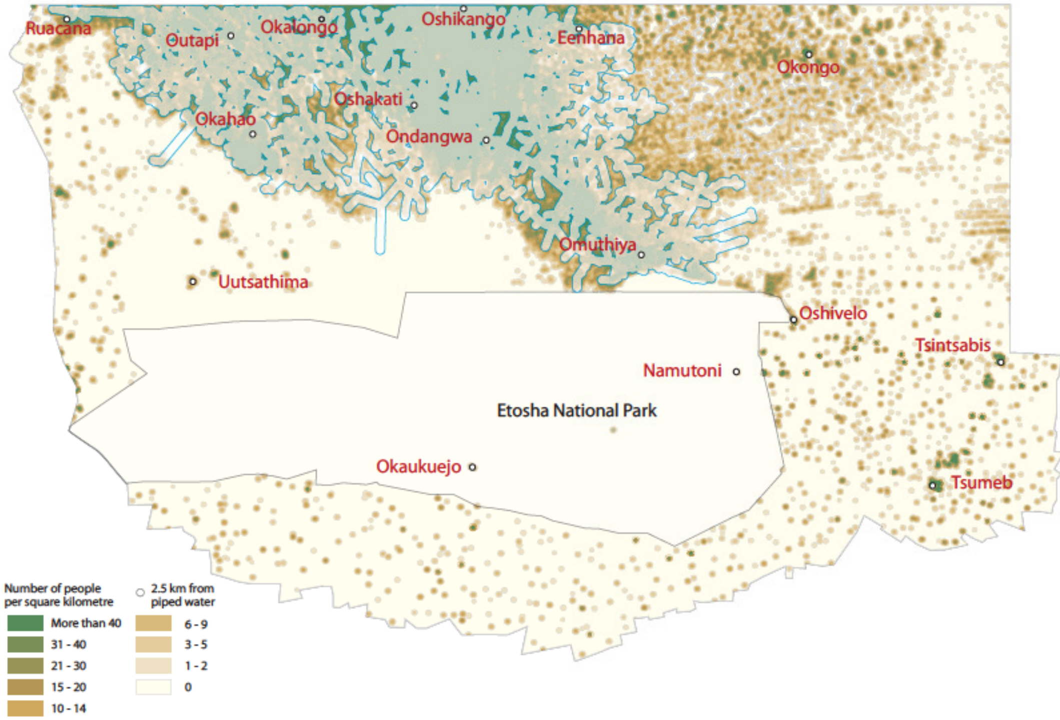
Assuming pupils can walk 5 kilometres to school, this map provides an assessment of areas where access to schooling is limited by distance. The vast majority of the population lives within the buffered catchment area of 5 kilometres around each school. However, 6% of families live further than 5 kilometres from the nearest school, and most of these are in the eastern parts of the Basin.

Demands for schooling have been high for many decades in the Basin, to such an extent that the great majority of schools were started by parents in rural areas and enrolment rates for children of primary schooling ages have long been above 90%. A demand for higher quality education is manifested by the growing number of private schools.

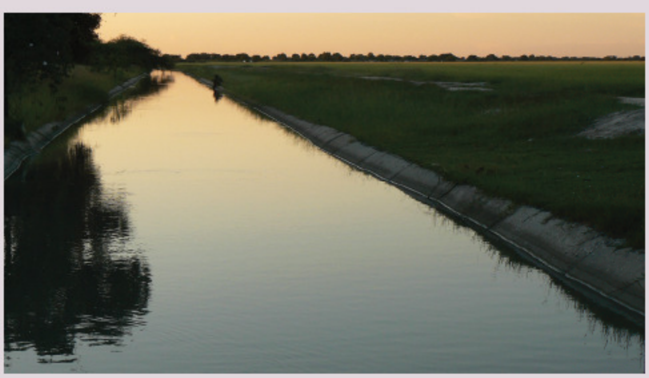


Water supply infrastructure. Traditionally, all freshwater supplies were obtained from shallow hand-dug wells and sporadic flows of water in the *iishana* and small ponds known as *eendobe* (see page 86). Nowadays, most people and a high proportion of livestock obtain their water from a network of pipes, and boreholes. There are about 4,000 kilometres of pipelines, all of which radiate out from purification schemes at Olushandja, Outapi, Ogongo and Oshakati. These schemes are fed by water pumped since 1973 from the Kunene River at Calueque just across the border in Angola.[18] Back-up storage is held in the Olushandja Dam and in water towers at Ogongo, Oshakati and Ondangwa. Not all the boreholes shown on the map pump water since many of them were found to be unproductive.

Since the late 1920s, over 100 surface dams have been dug in the Basin, largely to supply livestock with water. Most of the dams are in *iishana* where they trap and continue to hold water long after the *iishana* have dried out. The majority of dams are 5 to 10 metres deep and cover areas of between 1 and 2 hectares.

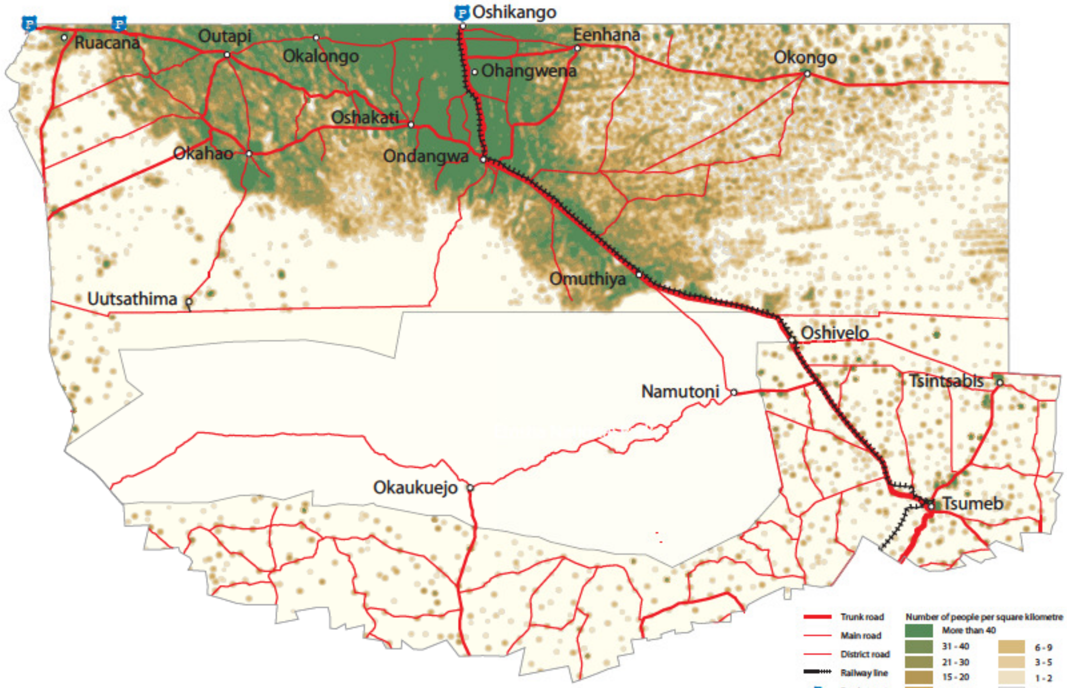


Access to safe piped water. The map shows areas that are within 2.5 kilometres of the pipeline network as well as population density in the Basin. About 82% of all people live within these areas and it can be assumed they have access to purified water. However, users are required to pay for the water and even though the rates are fairly nominal, some poorer households prefer to keep their meagre cash earnings for other uses. Instead they use untreated water from shallow wells. Elsewhere, many boreholes provide safe, clean water.



The canal supplying water from the Kunene River runs from inside Angola to Oshakati via the Olushandja Dam. Another canal from this dam to Okahao and Uuvadhiya is now non-functional.

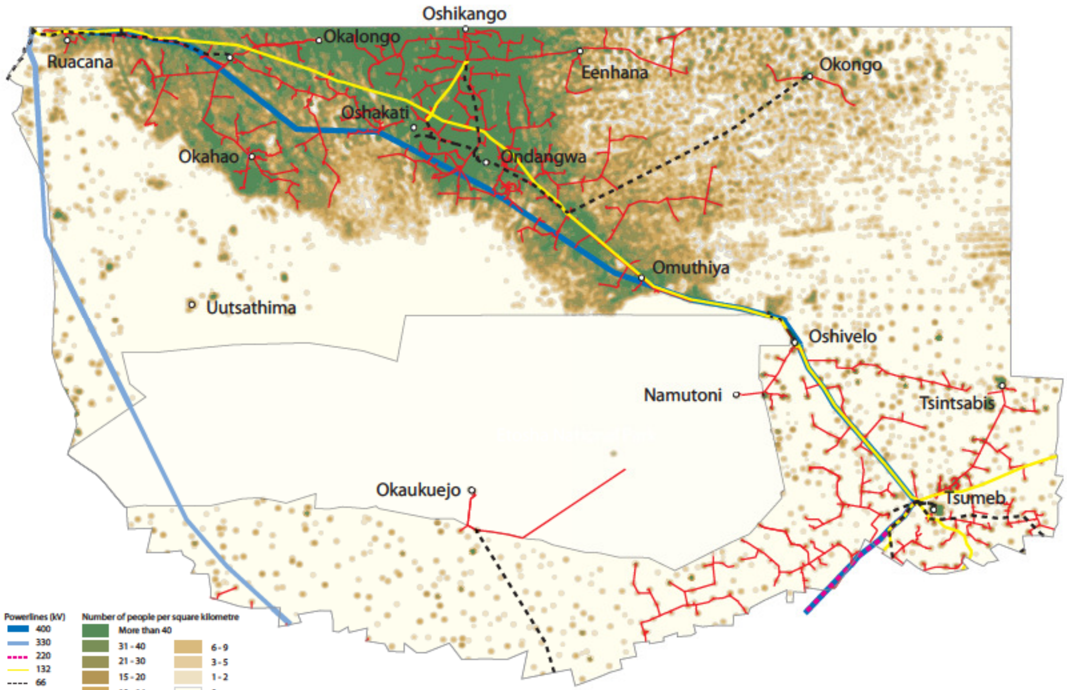
The main supply canal is open along most of its course to Oshakati, allowing livestock and people living nearby to make free use of the water.



Transport routes. Much of the Basin's economy is based on cross-border trade at Oshikango, particularly of goods transported from areas south of Tsumeb for import into Angola. The main road and railway from Tsumeb northwards is therefore an extremely valuable trade route.

Other important trade and transit routes run from Ondangwa to Ruacana and from Ohangwena to Okongo and on to Kavango. The road between Oshakati and Ondangwa is said to be the busiest rural road in Namibia.

Many of the roads in the *iishana* area were constructed with little regard to the potential for flooding. Another cause of flooding is the lack of maintenance work to keep culverts clear to allow the free flow of water under the roads.



Electricity supply. Although there is an impressive network of power lines across many areas of the Basin, most of the electricity is for use in urban areas and rural public services such as health facilities and schools. The vast majority of people in rural areas therefore do not have access to electricity, mainly because connections to the grid and usage costs are high.

The hydro-electric plant at Ruacana generates up to 330 megawatts of electricity which is then carried south along a 330 kilovolt line. Just less than half of Namibia's total electricity consumption is supplied by Ruacana.

8 - Land: its uses and values

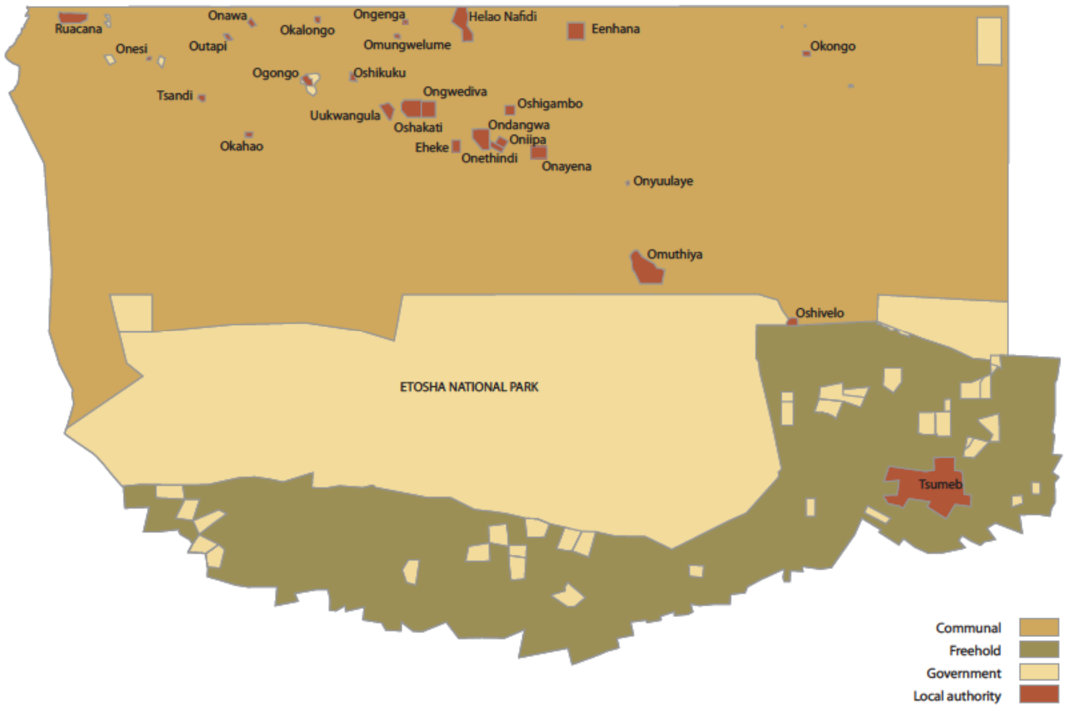
The Cuvelai Basin covers some 97,620 square kilometres, equivalent to 12% of Namibia's surface area. Parts of the Basin are sparsely populated, particularly those areas which are protected conservation areas, freehold and very large farms on communal land, or open communal grazing. Other areas, by contrast, have the highest rural population densities in Namibia and in much of southern Africa (see page 19).

The vast majority of people live on small farms to which they have customary user rights, but do not own. There are perhaps as many as 100,000 of these holdings, most of which each cover less than 10 hectares. *Mahangu* (pearl millet) is grown on most of these farms, along with some vegetables and sorghum. Roughly half of these rural families have some goats, cattle and donkeys.

While all these families are engaged in farming activities, contrary to expectations and widely held assumptions, most of their livelihoods depend largely on incomes derived from employment or businesses away from the rural homesteads: in local towns, schools, health facilities or urban areas elsewhere in Namibia. Pensions, social welfare grants and remittances from migrant family members working outside the Basin are also important incomes for most rural households. This is one fundamental, but widely misunderstood characteristic of most rural households in the Basin.

Another important feature is the high degree of variation between households. This, too, is not clear to most observers who assume that all rural homes are the same because their external appearances are similar. Instead, the wealthiest families are many times better off than the poorest ones. Wealth is closely linked to household size, with the biggest homes generally having more income, a greater variety and number of incomes, more livestock and larger fields than poor families. Around 20-25% of all families in the Basin are really poor, and these families are typically headed by women. Most have only two or three family members who are either too old or too young to work. These families have few if any livestock, very small fields (typically less than one hectare) which are often in low-lying flood-prone places and where the soils have poor fertility. Pensions are often their only cash incomes.

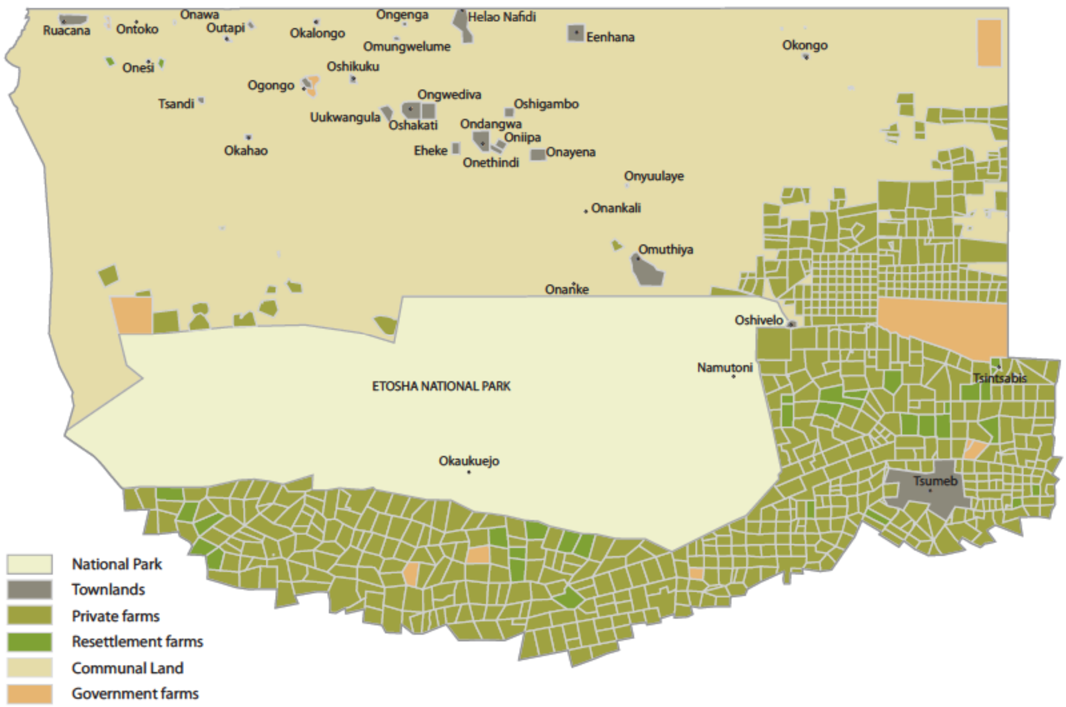
A major benefit of having off-farm incomes is that households are no longer as sensitive to environmental calamities. They are thus more food secure than 50 or so years ago when farm produce was the main livelihood. But many families with little revenue from other sources remain poor and vulnerable, however.



Land tenure in the Basin is broadly divided in three systems: a southern zone of freehold privately owned farms, the northern and much bigger area of state owned land, and urban land.

All communal land, the resettlement farms and Etosha National Park belong to, or are vested in the state. The vast majority of residents in rural communal areas have traditional rights to the use of the land, portions of which are allocated to individuals by local traditional authorities. Legally, these are called customary rights which permit residents to use the land and its resources but they do not confer ownership or the right to trade their land rights. As a result, most people have no capital value in their land, their land may not be used as security, and they consequently lack incentives to invest in land as tradable assets.

Urban local authorities are divided into municipalities (Tsumeb), towns (Eenhana, Helao Nafidi (which includes Oshikango), Okahao, Omuthiya, Ondangwa, Ongwediva, Oshakati, Oshikuku, Outapi and Ruacana) and settlements (Eheke, Ogongo, Okalongo, Okongo, Omungwelume, Onawa, Onayena, Onesi, Onethindi, Ongenga, Oniipa, Onyuulaye, Oshigambo, Oshivelo, Tsandi and Uukwangula).



Land uses in the Basin. About three-quarters of the land area of the Basin is used for farming, predominantly on communal land where most people have customary rights to their homes and fields, and to the surrounding commonage. Etosha National Park makes up much of the remaining quarter which is used for conservation and tourism. Most of the other land used by the government is in the three quarantine farms at Omatambo Maowe, Mangetti and Omauni, and the Ogongo Agricultural College.

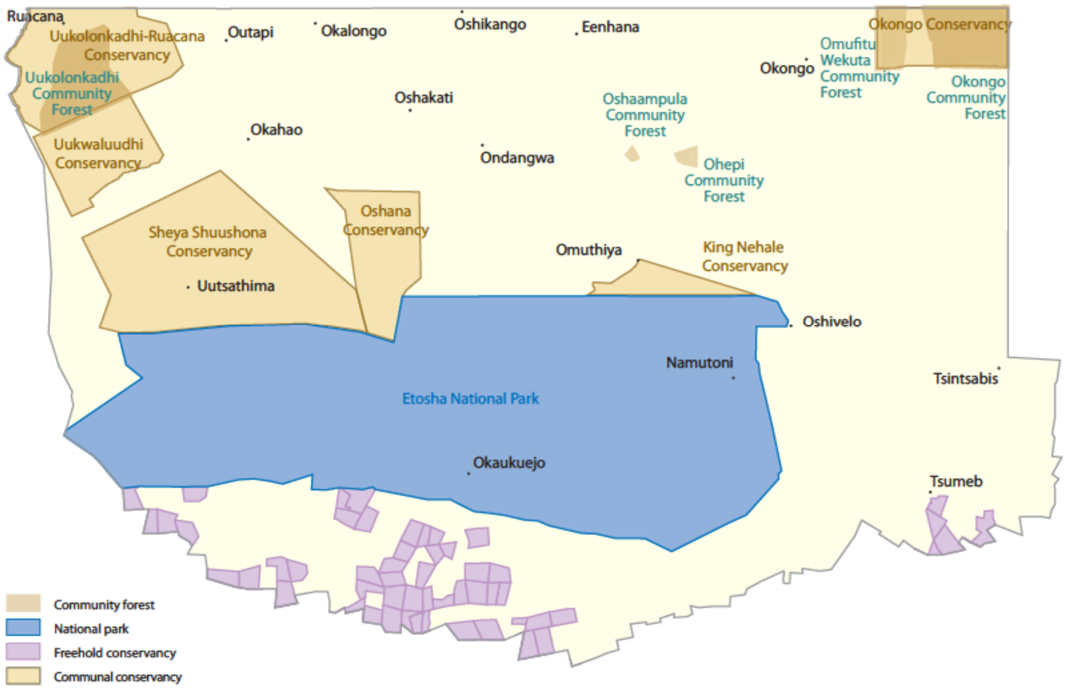
Communal land is intended to be a safety net for the poor so that they may have free access to land. This land is, however, also free for people who are not poor. As a result, many wealthy, influential people have acquired large farms, most covering thousands of hectares, which they occupy exclusively. There are approximately 170 of these large farms which were mostly obtained with the agreement of traditional authorities. The majority of the farms are in eastern Oshikoto and north of the Etosha National Park.

Proportions of the Basin and its population in different land use areas

Land use	% of Basin area	% of population
Large private farms	19.8	2.2
Protected area	23.0	0.2
Government farms	1.8	0.4
Resettlement farms	1.7	0.5
Urban townlands	1.2	15.9
Customary homes and small farms	52.4	80.8

Most densely populated rural areas are occupied by individual homes and farmsteads, each demarcated by fences or other locally known boundaries (yellow lines). In between the homesteads on soils not suited to cultivation are areas of commonage which are used mainly for grazing and for the harvesting of common property resources such as firewood, fish and water.

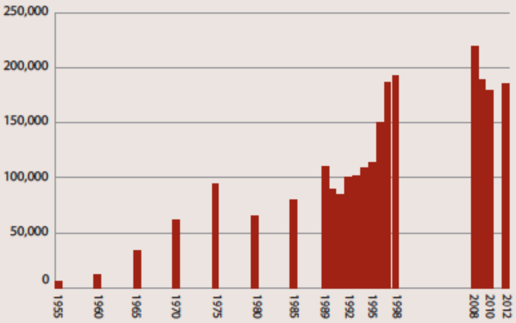
The line at the top of the image is the Angolan border, while the road across the bottom runs between Outapi and Ruacana. The ponds of the Epalela fish farm are clearly visible just north of this road. Note the dam (see page 144) in the *oshana* in the top left of the image. In Google Earth, you can see this area at 17.45 South and 14.78 East.[1]



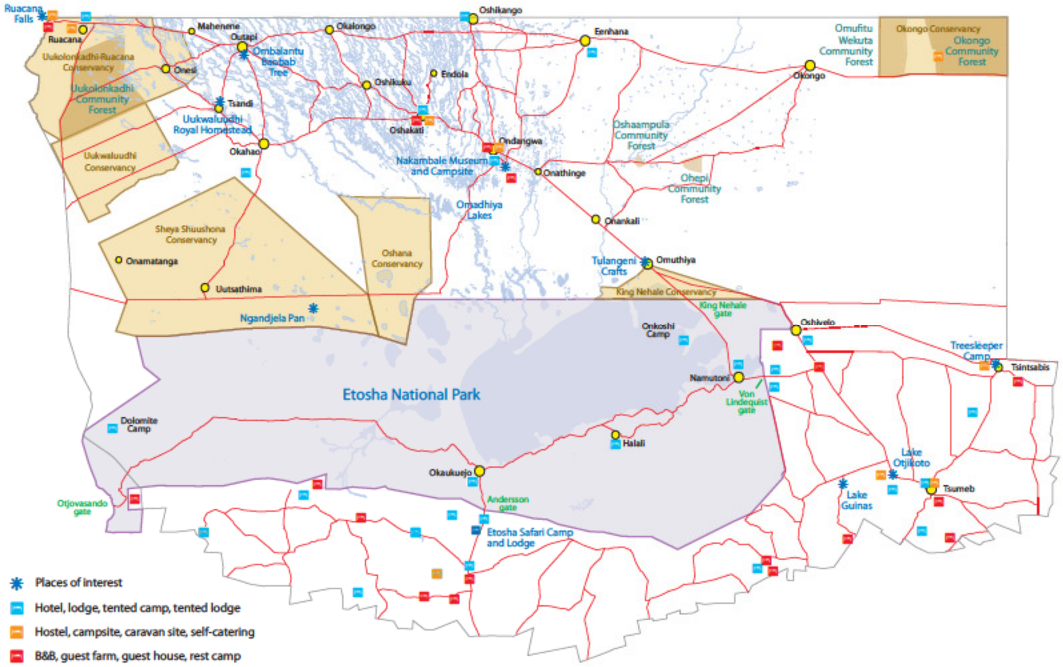
Conservation areas in the Basin. In addition to Etosha National Park, six conservancies and five community forests are managed for conservation by local residents with the purpose of providing benefits to residents. Members of conservancies have rights over wildlife and tourism while community forests provide for rights over all natural resources. Three of the community forests fall within communal conservancies. Several of the conservancies have established facilities for tourism (see page 153). There are also a number of emerging communal conservancies and community forests.

The variety and abundance of wildlife in the Etosha National Park, including charismatic species such as elephants and lions, are the major attraction for tourists. Etosha recently celebrated its centennial anniversary 100 years after its proclamation in 1907 as a Game Reserve. At that time it had an area of approximately 76,000 square kilometres. Subsequent changes to the boundaries in the 1950s and 1960s reduced the Park to its current area of 22,935 square kilometres. The 4,850 square kilometres of the Etosha Pan covers one fifth of the Park area.

The number of visitors to Etosha National Park.[2] Etosha National Park is one of Namibia's flagship destinations for foreign tourists. The number of visitors has increased considerably since the Park first opened its gates in 1955. Most visitors spend two or three days in the Park. All aspects relating to tourism fall under Namibia Wildlife Resorts which manages commercial aspects relating to marketing, operations and product improvement of government-owned tourism resorts.



Responsibility for the management of the Park lies with the Ministry of Environment & Tourism. This includes wildlife surveys, fire control, anti-poaching patrols and water hole maintenance, for example. There are 86 water holes in the Park, both natural and man-made. Many of the boreholes were drilled in the 1960s to attract elephants into the Park from farms in the Outjo and Kamanjab districts. The Etosha Ecological Institute is at Okaukuejo. Much research over the years has focussed on the population dynamics of large mammals and anthrax – a bacterial disease which regularly kills wildlife in the Park.



Tourist accommodation and attractions. Historically, tourism in the Basin has been concentrated entirely on Etosha National Park and its wildlife attractions. In recent years new tourism enterprises have developed in other parts of the Basin, including cultural, historical and craft-based enterprises in the conservancies and community forests and elsewhere. Many of the tourism facilities south and east of Etosha capitalise on the proximity of the Park, attracting visitors who make use of accommodation outside the Park and visit Etosha as day visitors.

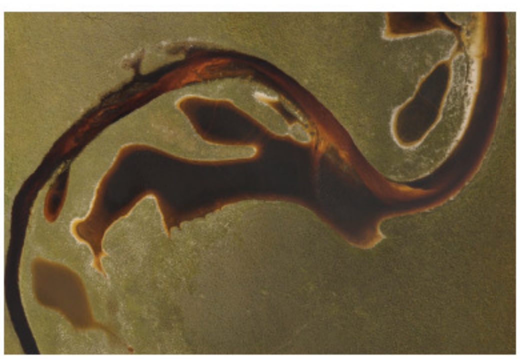
Although the potential for wildlife-based tourism north of Etosha is low, tourism in this northern area can be expected to develop as increasing numbers of tourists drive through the Basin en route to northern Kunene, Angola and Kavango. There is considerable scope for guides to accompany tourists to show and explain the many interesting facets of domestic life and farming, for example.

Some conservancies offer accommodation and interesting attractions, for example: the Otjipahuriro Community Campsite in a spectacular location immediately below Ruacana Falls, the Uukwaluudhi Royal Homestead at Tsandi, the Tulangeni Crafts shop at Omuthiya, and the Omauni Campsite and Cultural Village.

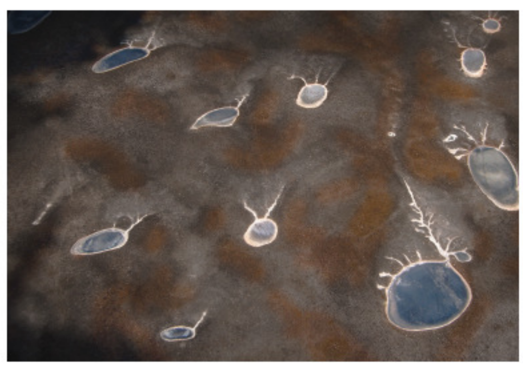
Tourism in The North. Owambo is popularly known as 'The North', but this part of Namibia has never been attractive to tourists. There is little wildlife and no rugged, spectacular scenery of the kind seen in many other areas of the country. Much of The North is densely populated, its environment degraded and littered in many places.

However, as the images on these pages and elsewhere in the book show, there is much colour, vibrancy and energy to be encountered, as well as unusual and dramatic landscapes, lakes, pans, *iishana* channels and plant life. Moreover, this is an area in rapid transition: from a subsistence to cash economy, from dependency to self-sufficiency, and from simple customary to modern diverse lifestyles. Such vitality is hard to see elsewhere. The faces that greet visitors to the North are open, direct, friendly and confident.

It is our hope that this book contributes to the development of tourism in The North. Those who go to Owambo will come away enriched, having come to know a society and landscape that is quite different from other parts of Namibia or, indeed, anywhere else in the world.




THE stone age social scene,
BAR
&
: Nestar
BAR BER
SHOP

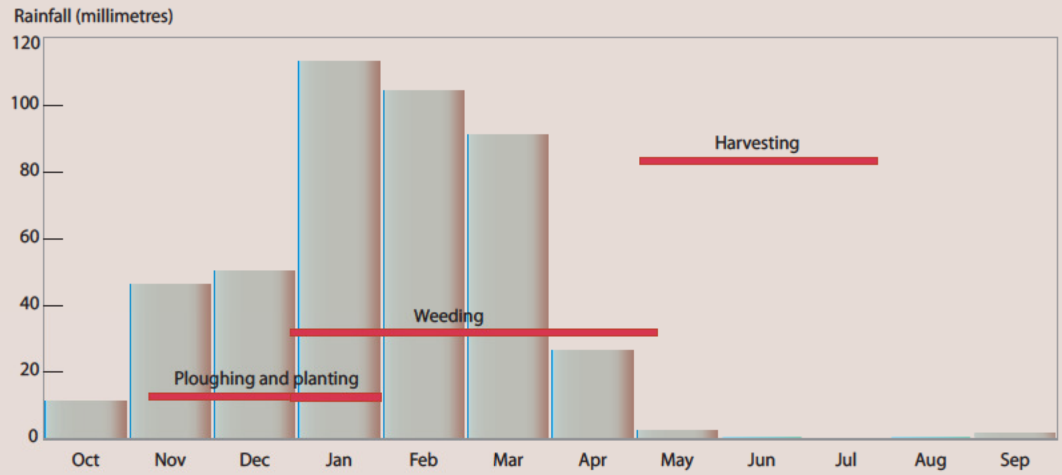


Farming. The vast majority of crops are produced on dryland or rain-fed fields where the plants depend entirely on moisture supplied by rain. Of all the crops, *mahangu* (pearl millet) is by far the most common and most widespread. Smaller areas of sorghum (for beer), maize and various vegetables are grown as well, but *mahangu* is the favoured staple cereal. As a result, virtually every household has fields of *mahangu* growing nearby, as shown in the photographs. The more modest home (middle left) has two *iigandhi* baskets just outside the palisade walls of the homestead, while the wealthy household (bottom) which has a substantial cash income, has seven baskets in which to store grain.

Mahangu is the only cereal that grows reasonably well in the Basin. There are several reasons for this: compared to other crops, it requires little moisture, can grow on soils that are relatively nutrient poor, and *mahangu* tolerates more heat than other cereals. In addition, *mahangu* has been subject to selective breeding over hundreds of years which has produced varieties suited to local conditions. And its taste gives *mahangu* preference over other cereals; another quality that has developed over a long time. Despite its suitability to the environmental conditions in the Basin, yields are amongst the lowest anywhere in the world, averaging 300 kilograms per hectare.[3]

Very few sales of crops are made because surpluses are seldom produced. In any event, most production is inadequate to meet household needs for cereals and any extra production is stored in *omashisha* or *iigandhi* baskets as insurance against possible crop failures in the future. The costs and risks of marketing are also high.

In addition, crop production has evolved over countless generations to be a 'low-input, low-output' system, primarily because the chance of crop loss due to inadequate rainfall or pests is substantial.



The crop calendar. A large part of the summer is spent cultivating *mahangu*, which begins with field preparation, followed by planting, thinning and weeding and finally the harvest. Further work follows: threshing, winnowing to sort and clean the grain and then storing of the grain in granaries.

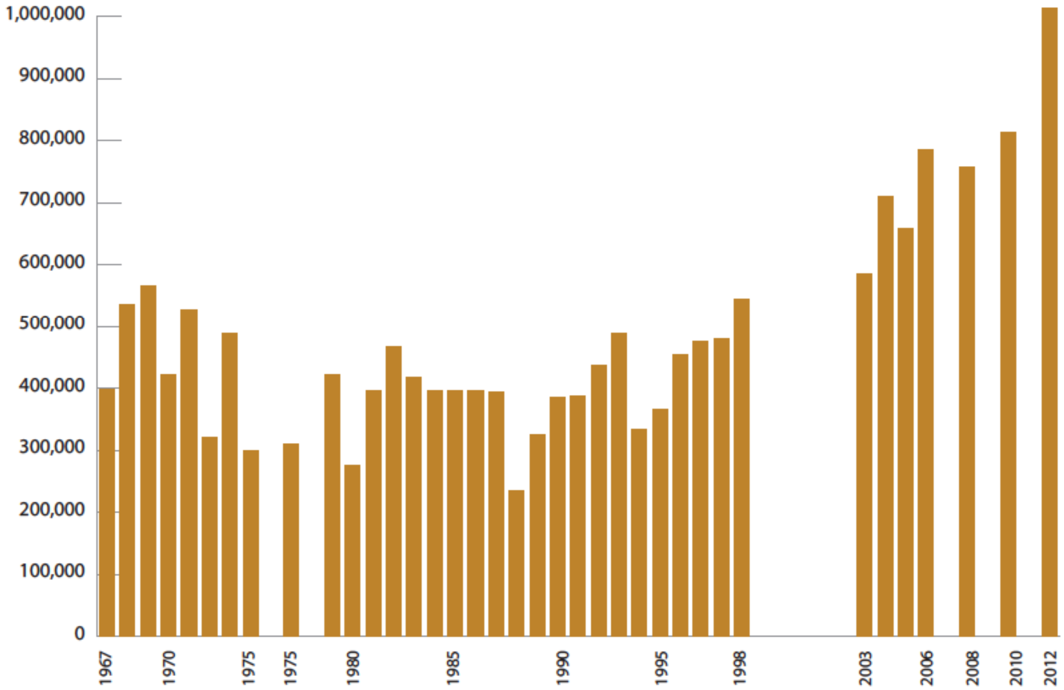
Weeding is the most labour consuming stage of *mahangu* production. Thus, an average hectare requires one person to spend 13 days of manual ploughing, 8 days planting, 27 days weeding, and 7 days for the harvest.[4]

The time table shown here is a general one, since each year differs according to the timing of rainfall (see page 43). Crop production starts in November or December if the rains are early, but it may be halted or delayed if rainfall is erratic or late.

One might imagine that irrigated agriculture would be prevalent in such an expansive wetland, but reliable, permanent and sufficient sources of non-saline water are available only in the Tsumeb area and near the piped water supply from Calueque on the Kunene River (see page 144). A number of small irrigation farms have been established along the Etaka Canal downstream of the Olushandja Dam (top left), while the government-owned Etunda agricultural project irrigates with water from the Kunene River. Maize, sunflowers, wheat and some fruit and vegetables are the main products of these irrigation schemes.

On average, only about 7% of cattle are sold each year in the Basin, which is several times lower than the off-take rate of most commercial producers in Namibia, and half the off-take by pastoralist communal farmers in Kunene north of the veterinary cordon fence.[5] Most meat sold in the Basin comes from livestock in the communal areas of Kunene or from freehold farms south of the Basin.

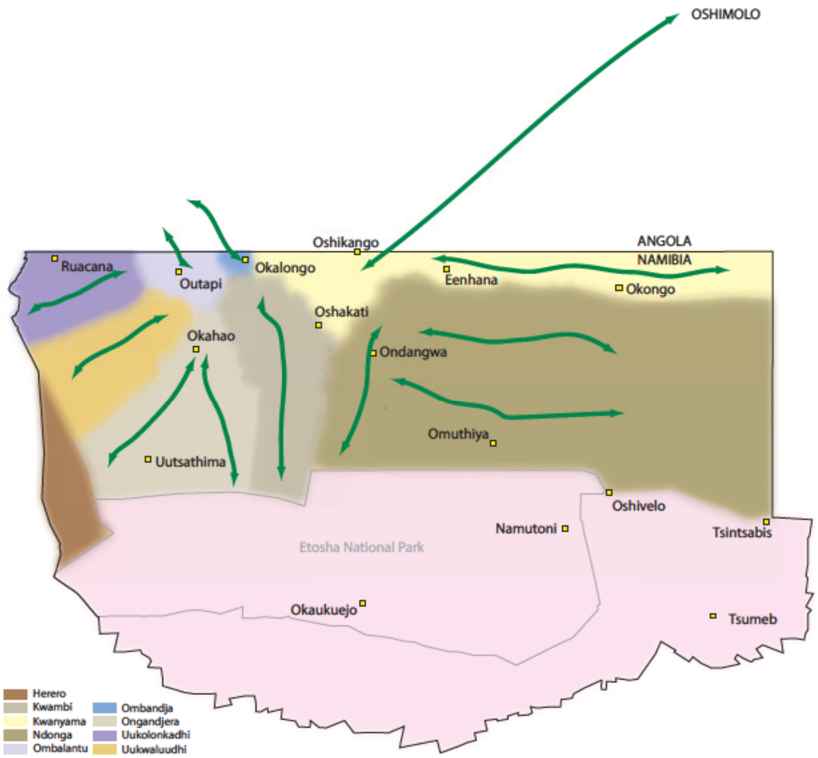
Of those cattle and goats from the Basin that are indeed harvested and sold, most belong to households who own small herds. Contrary to expectations, livestock owners with large herds generally seldom sell their animals. This is probably because cattle, and to a lesser degree goats, serve largely as savings and capital assets that are only sold when their owners have a particular need for cash.



The number of cattle in the Basin[6] varied between about 300,000 and 500,000 between the 1960s and late 1990s, the numbers being limited by shortages of rain and grazing, and by disease. In recent times, however, numbers have increased dramatically and stood at over one million when the last livestock census was conducted in 2012. Much of the increase has been due to the good rains, improved disease control and increasing wealth of non-resident cattle owners who have invested in cattle as capital.

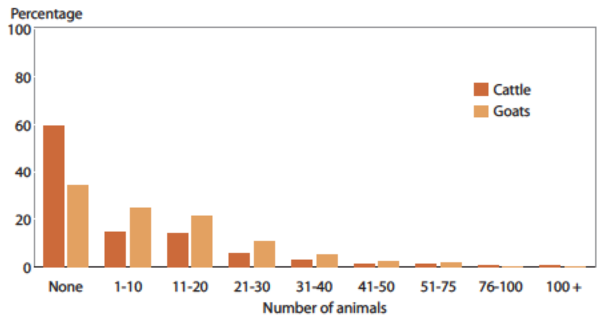
The number of cattle is now more than double the population in 1994/1995 when the Basin last experienced a significant drought, during which about 150,000 cattle died. Since then, pasture areas have declined significantly – perhaps by as much as 20% – as a result of the appropriation of large farms (see page 151) and increasing settlement in areas that were open for grazing.

It is not hard to imagine the severe calamity that is certain to occur during the next drought when double the number of cattle competes for less grazing than was available in 1994/1995!

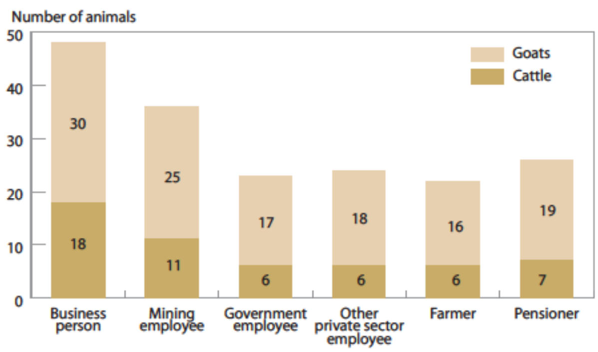


Seasonal grazing. Many cattle are moved seasonally between the residences of their owners in densely populated areas and distant grazing grounds. This is known as *ohambo*, and the arrows show the approximate directions and destinations of the migrations. Most movements are within the areas of jurisdiction of the cattle owners' traditional authorities. Cattle belonging to Ondonga owners used to graze largely in eastern Oshikoto, but this has been severely limited by much of that area being fenced-off into large farms (see page 151).[7]

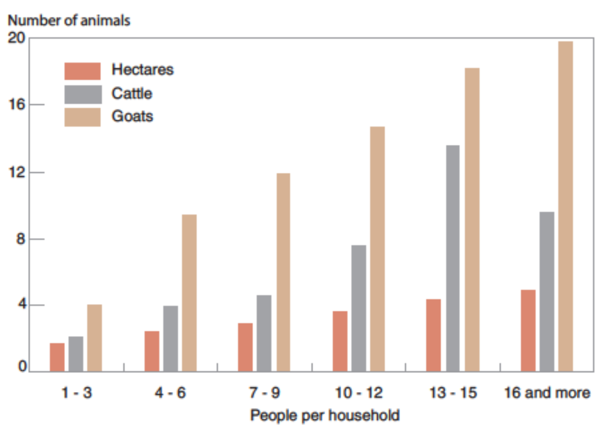
The most spectacular movements are of cattle belonging to Kwanyama owners which graze for months on end in the Oshimolo area, about 150 kilometres north of the Namibian border (photo below). Tens of thousands of cattle are involved, both from Kwanyama farmers in Namibia and Angola. Hostilities around Oshimolo in the 1980s led farmers to move their cattle to Kavango for seasonal grazing. That caused further strife when Kwangali farmers began fencing their own large farms that stopped the migration between the Cuvelai and Kavango.



Variation in agricultural holdings.[8] There is a high degree of variation from household to household in the number of livestock. The graph to the left shows the percentage of households having different numbers of cattle and goats. For example, 59% of homes do not have cattle and 34% have no goats. Half of all cattle are owned by just 8% of all households, and many of their owners do not live in the Basin.



This graph shows the average number of cattle and goats in relation to the occupation of the head of the household. Heads of households with good incomes from other sources generally have more cattle and goats than people dependant on local incomes. For example, a business person has double the number of cattle and goats of a locally-resident farmer, on average.



There is a clear relationship between the numbers of people in a household and its agricultural activity. Large households have far bigger fields and many more cattle and goats than small families. The figures shown here are averages and, in fact, most small households have neither cattle nor goats.

The availability of labour has a substantial effect on crop production. Larger and wealthier families with several people (left) who can help plough, weed and harvest produce higher yields and can farm on bigger fields than households where all this work must be done by one person, who is often an elderly woman (right). Poorer families are also unable to hire causal labour, unlike those with cash resources to hire helpers as and when needed.

Commonages are public areas outside the boundaries of individual properties, and are generally used by local residents to graze their livestock and harvest firewood, timber and wild fruit and animals. Little commonage remains in densely populated zones, whereas there are large areas of grazing lands in the sparsely populated areas of southern Oshana and in south and west Omusati.

All commonage resources are free and may be used to the full extent by anyone until they are exhausted. Under these circumstances, it is in everyone's interests to harvest the resources as much as possible. Failure to do so means that the resources will be used by someone else.

These circumstances create hardships for residents who lack off-farm incomes, and therefore live off local resources entirely. Their few livestock then compete for forage with the large herds and flocks belonging to wealthy residents who, arguably, have little need to consume the local resources on which their poorer neighbours often depend.

Notes and sources

Chapter 1 - Introduction

1. Processed from Shuttle Radar Topography Mission (SRTM) elevation data. http://www2.jpl.nasa.gov/srtm.
2. Miller RM, Pickford M & Senut B. 2010. The geology, palaeontology and evolution of the Etosha Pan, Namibia: implications for terminal Kalahari deposition. *South African Journal of Geology* 113: 307-334.
3. Compiled from Diniz CA. 1973. *Características mesológicas de Angola*. Missâo de Inquéritos Agricolas de Angola, Luanda; FAO & ISRIC. 2003. SOTER database for Southern Africa. International Soil Reference and Information Centre (ISRIC), Holland; and Mendelsohn, JM, el Obeid, S & Roberts, CS. 2000. *A profile of north-central Namibia*. Gamsberg Macmillan, Windhoek.
4. Williams F-N. 1991. Precolonial communities of southwestern Africa; a history of Owambo kingdoms 1600-1920. *Archeia* No. 16. National Archives of Namibia, Windhoek.
5. Based on an interpolation of average seasonal totals calculated from records obtained from the Global Historical Climate Network database, and the Botswana and Namibia Meteorological Services.
6. Detailed information on climatic variables is available in SINFIC, SARL. 2005. *Plano de Urbanização da Cidade de Ondjiva*. Report for Governo da Província do Kunene - Gabinete de Estudos, Planeamento e Estatística; and Mendelsohn JM., el Obeid S & Roberts CS. 2000. *A profile of north-central Namibia*. Gamsberg Macmillan, Windhoek.
7. Compiled from the mapping of households throughout the Basin, as reported in Mendelsohn JM & B Weber. 2011. *The Cuvelai Basin: its water and people in Angola and Namibia*. Development Workshop, Luanda and RAISON, Windhoek.
8. From Afripop database: http://www.clas.ufl.edu/users/atatem/index_files/AfriPop.htm.
9. Bittner Water Consult. 2004. *Demarcation of water basins on national level*. Report for Department of Water Affairs, Windhoek.

Chapter 2 - landscapes

1. Based on Mendelsohn JM, el Obeid S & Roberts CS. 2000. *A profile of north-central Namibia*. Gamsberg Macmillan, Windhoek.
2. Pickford M, Senut B, Hipondoka M, Person P, Segalen L, Plet C, Jousse H, Mein P, Guerin C Morales J & Mourer-Chauvire C. 2009. Mio-Plio-Pleistocene geology and palaeobiology of Etosha Pan, Namibia. *Communications of the Geological Survey Namibia*. 14: 95-139.
3. Miller R, Pickford M, Senut B. 2010. The geology, palaeontology and evolution of the Etosha pan, Namibia: implications for terminal Kalahari deposition. *South African Journal of Geology* 113: 307-334; and Buch M. 1997. Etosha Pan - the third largest lake in the world. *Madoqua* 20: 49-64.
4. Adapted from Mendelsohn JM, Jarvis AM, Roberts CS & Robertson T. 2002. *Atlas of Namibia*. David Philip, Cape Town.
5. Same as end note 4.

Chapter 3 - Climate

1. Analyses of data from www.fews.net.
2. From Mendelsohn JM, Jarvis AM, Roberts CS & Robertson T. 2002. *Atlas of Namibia*. David Philip, Cape Town updated with recent data from the Namibia Meteorological Services.
3. From data assembled for Namibia Resource Consultants. 1999. *Rainfall distribution in Namibia: data analysis and mapping of spatial temporal and Southern Oscillation Index aspects*. Report for Ministry of Agriculture, Water & Rural Development, Windhoek.
4. Data from Namibia Meteorological Services.
5. Same as end note 2.

6. Same as end note 2.
7. Same as end note 4.
8. Same as end note 2.
9. Same as end note 4.
10. Same as end note 2.
11. Same as end note 4.
12. Same as end note 2.
13. Same as end note 4.
14. Same as end note 2.
15. Same as end note 4.
16. From Bicon Namibia and Ministry of Mines & Energy.
17. Same as end note 4.

Chapter 4 - Surface water

1. The existence of the Cuvelai Delta as a remarkable inland delta was first and recently described by Luis Verrisimo in SINFIC, SARL. 2005. *Plano de Urbanização da Cidade de Ondjiva.* Report for Governo da Província do Kunene - Gabinete de Estudos, Planeamento e Estatística.
2. Much of this information on the Omadhiya Lakes is derived from van der Waal B. 2000. *Fish resource management study of the Omadhiya Wetland Complex, Oshana Region.* Report to Northern Namibia Environmental Project, Ministry of Environment and Tourism.
3. Miller R, Pickford M & Senut B. 2010. The geology, palaeontology and evolution of the Etosha pan, Namibia: implications for terminal Kalahari deposition. *South African Journal of Geology.* 113: 307-334.
4. Assembled from information provided by Stengel H. 1963. Die Cuvelai, ´n bydrae tot die waterkunde van Suidwes-Africa in Waterwese in Suidwes-Afrika. Africa. *Verlag Der Kreis,* Windhoek, p 218-232; van der Waal B. 1991. Fish life of the oshana delta in Owambo, Namibia, and the translocation of Cunene species. *Madoqua* 17: 201-209; Guido Van Langenhove of the Department of Water Affairs, Ministry of Agriculture, Water & Forestry, Windhoek; and Mendelsohn JM, el Obeid S & Roberts CS. 2000. *A profile of north-central Namibia.* Gamsberg Macmillan, Windhoek.
5. Data kindly provided by the Hydrology Division, Ministry of Agriculture, Water & Forestry, Windhoek.
6. Detailed information on these problems were provided by the late Guido Van Langenhove in his 2011 unpublished report on flooding in the Cuvelai.
7. Directorate Disaster Risk Management (DDRM). 2008, 2009 and 2011. *Reports on national response to flood disasters.* Office of the Prime Minister, Windhoek; Flood Emergency Management and Coordination (FEMCO) 2011. *Final Report: North & North Eastern regions of Namibia*; and Government of Namibia, 2009. *Post Disaster Needs Assessment (PDNA).* Report prepared by the Government of the Republic of Namibia.
8. van der Waal B. 1991. Fish life of the oshana delta in Owambo, Namibia, and the translocation of Cunene species. *Madoqua* 17: 201-209.

Chapter 5 - Groundwater

1. Most information provided here was supplied by Arnold Bittner of BIWAC Water Consulting CC.
2. As reported in the 2012 BGR project report *Groundwater for the North of Namibia. Summary Report of Activities of Phase I: Exploration of Ohangwena II Aquifer and Preliminary Isotope Study* for the Geohydrology Division of the Ministry of Agriculture, Water & Forestry.
3. Same as end note 2.
4. Data kindly provided by the Geohydrology Division of the Ministry of Agriculture, Water & Forestry.

Chapter 6 - Living resources

1. Berry HH. 1997. Historical review of the Etosha region and its subsequent administration as a national park. *Madoqua* 20: 3-12.
2. Adapted from Mendelsohn JM, el Obeid S & Roberts CS. 2000. *A profile of north-central Namibia*. Gamsberg Macmillan, Windhoek.
3. Same as end note 2.
4. Hillyer AEM, McDonagh JF & Verlinden A. 2006. Land-use and legumes in northern Namibia - The value of a local classification system. *Agriculture, Ecosystems and Environment* 117: 251-265.
5. Adapted from Mendelsohn JM, Jarvis AM, Roberts CS & Robertson T. 2002. *Atlas of Namibia*. David Philip, Cape Town.
6. Analysis of the Tree Atlas of Namibia database compiled by Barbara Curtis and Coleen Mannheimer (www.the-eis.com).
7. Klintenberg P. & Verlinden A. 2008. Water points and their influence on grazing resources in central northern Namibia. *Land Degradation and Development* 19: 1-20.
8. INP Market Bulletin. Indigenous Natural Products in Namibia (Issue 3, December 2011) www.mcanamibia.org/files/files/PDFs/INP Docs/INP Market Bulletin Issue III.pdf.
9. Analysis of the Avifaunal database compiled by Tony Robertson and Alice Jarvis (www.the-eis.com).
10. Figures provided by Ann Scott and reported in *Namibia Crane News* No 48, May 2011.
11. Curtis B, Roberts KS, Griffin M, Bethune S, Hay CJ & Kolberg H. 1998. Species richness and conservation of Namibian freshwater macro-invertebrates, fish and amphibians. *Biodiversity and Conservation* 7: 447-466.
12. Analyses of information provided by Mike Griffin and adapted from Mendelsohn JM, Jarvis AM, Roberts CS & Robertson T. 2002. *Atlas of Namibia*. David Philip, Cape Town.
13. Same as end note 5.
14. From data kindly supplied by Werner Kilian and Keith Leggett, and Lindeque M & Lindeque P. 1991. Satellite tracking of elephants in north-western Namibia. *African Journal of Ecology* 29: 199–206.
15. Compiled from various aerial counts conducted by the Ministry of Environment & Tourism.
16. Same as end note 5.
17. Branch B. 1998. *Field guide to snakes and other reptiles in southern Africa*. Struik, Cape Town.
18. van der Waal B. 1991. Fish life of the oshana delta in Owambo, Namibia, and the translocation of Cunene species. *Madoqua* 17: 201-209.

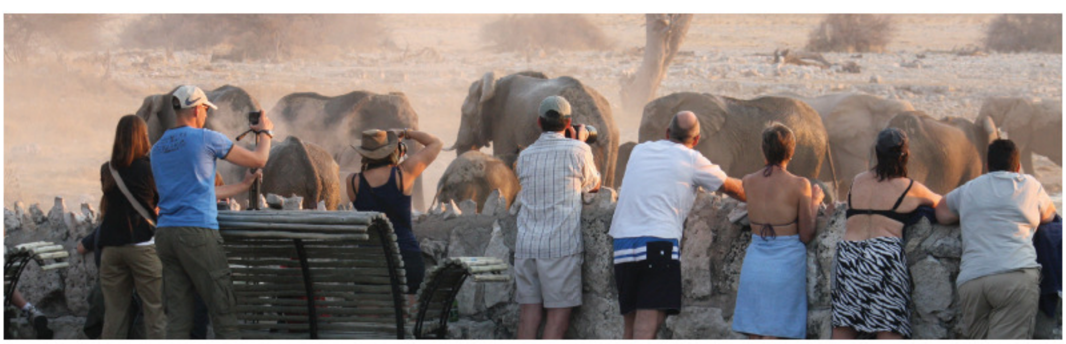
Chapter 7 - People

1. Keyler S. 1995. Economics of the pearl millet subsector in northern Namibia. A summary of baseline data. *International Crops Research Institute for the Semi-Arid Tropics*. Working Paper 95/03; Analysis of data in the 1994, 2004 and 2009 Income & Expenditure Surveys; and Mendelsohn JM, el Obeid S & Roberts CS. 2000. *A profile of north-central Namibia*. Gamsberg Macmillan, Windhoek.
2. Williams F-N. 1991. Precolonial communities of south-western Africa; a history of Owambo kingdoms 1600-1920. *Archeia* 16. National Archives of Namibia, Windhoek.
3. Siiskonen H. 1990. Trade and socio-economic change in Owamboland, 1850-1906. *Studia Historica* 35. Societas Historica Fennica, Helsinki.
4. In 1991, only 13.5% of Oshiwambo-speakers lived elsewhere in Namibia. In 2001, the equivalent figure was 18,4%. These are measures from the 1991, 2001 and 2011 Population & Housing Censuses.
5. Analysis of mapped households on aerial photographs taken in early 2008 by the European Union Rural Poverty Reduction Programme, and adjusted for population growth by an annual growth rate of 2% to 2010. Much of the mapping was done by the Namibia Statistics Agency.

6. From mapped households as described in endnote 5.
7. From the results of population censuses conducted over the years as collated by Mendelsohn JM, el Obeid S & Roberts CS. 2000. *A profile of north-central Namibia*. Gamsberg Macmillan, Windhoek, and updated with the results of the 2011 Population & Housing Census and density estimates described in endnote 5.
8. Estimated by subtracting the grid densities for 2010 (as described above in endnote 5) from a similar set of data compiled for 2000 by Mendelsohn JM, el Obeid S & Roberts CS. 2000. *A profile of north-central Namibia*. Gamsberg Macmillan, Windhoek.
9. From 1991, 2001 and 2011 Population & Housing Censuses.
10. Same as endnote 9.
11. Same as endnote 9.
12. From 1991 and 2001 Population & Housing Censuses, and 2006 Inter-Censal Demographic Survey.
13. From the 2001 and 2011 Population & Housing Censuses.
14. From the 2011 Population & Housing Census.
15. From Hipondoka M. 2008. *Boundaries of traditional authorities*. Unpublished report for the Ministry of Lands & Resettlement, Windhoek, and Mendelsohn JM, el Obeid S & Roberts CS. 2000. *A profile of north-central Namibia*. Gamsberg Macmillan, Windhoek.
16. Derived from 2001 Population & Housing Census and 2004 Income & Expenditure Survey data analysed and prepared for the publication Central Bureau of Statistics. 2011. *An atlas of poverty in Namibia*. Central Bureau of Statistics, Windhoek.
17. As endnote 16.
18. Stern C & Lau B. 1990. Namibian water resources and their management, a preliminary history. *Archeia* 15. National Archives of Namibia.

Chapter 8 - Land and farming

1. Boundaries of customary land rights mapped by the Ministry of Lands & Resettlement.
2. From data provided by the Ministry of Environment & Tourism and Millennium Challenge Account, Namibia.
3. Ben Bennett personal communication, and Mendelsohn, J.M. 200. *Farming systems in Namibia*. RAISON, Windhoek.
4. Mendelsohn JM, el Obeid S & Roberts C. 2000. *A profile of north-central Namibia*. Gamsberg Macmillan, Windhoek.
5. Vigne, P. 2001. *Cattle marketing in the Epupa, Ruacana and Onesi Constituencies of the Kunene and Omusati Regions*. Report to the Meat Board of Namibia, Windhoek; MAWRD. 2000. *Livestock Marketing in the Northern Communal Areas of Namibia (Livestock Producer Marketing Strategies and Informal Trade in Live Animals, Meat, Hides and Skins)*. Northern Regions Livestock Development Project (NOLIDEP); Liagre, L. 2000. *Cattle Marketing in Northern Namibia: A Commodity Chain Approach*. NEPRU Research Report No. 20. May 2000. Windhoek.
6. From recent Annual Reports of the Directorate of Veterinary Services and older data collated by Mendelsohn JM, el Obeid S & Roberts C. 2000. *A profile of north-central Namibia*. Gamsberg Macmillan, Windhoek.
7. Verlinden A. & Kruger, A.S. 2007. Changing grazing systems in Central North Namibia. *Land Degradation and Development* 18: 179-197.
8. Data in the three graphs are from analyses of original data of Annual Agricultural Censuses in the Basin, conducted by the then Central Bureau of Statistics and Ministry of Agriculture, Water & Forestry.



PHOTOGRAPH CREDITS

Ann Scott: 111 top right, 115

Chris Hines: 19 bottom right

G. Heussen: 121

Gabor Salamon: 38

Gondwana Collection: 130, back cover top

Google Earth: 19 bottom left, 26 top, 31 top, 64, 86 2nd from top

Helge Denker: front cover, 12 both, 20 all, 25 top, 27 top, 29 top, 44, 46, 70 bottom right and top left, 71, 77, 80 top, 81 both, 82, 86 4th from top, 97 both, 108, 109 bottom, 110 top left, 112 bottom, 116 bottom, 129, 132 top left, 133, 135, 146, 156 bottom left, 157 bottom and 3rd from top right, 158 all, 160 top, 168

Hentie Burger: 119

Judy and Scott Hurd: 154

Ken Watkins: 57 top

Kevin Roberts: 117 both

Martin Hipondoka: 31 all at bottom

Manni Goldbeck: 83 bottom, 100, 104 top, 118, 123 both, 132 bottom right, 142, 148, 156 3rd from top, 157 3rd from top left and top right, 159 left, 162, 163, back cover middle right

Namibia Community Based Tourist Assistance Trust (NACOBTA): 124

National Air & Space Administration (NASA): 8, 10, 23, 32, 58, 68, 69, 74 top, 79 top, 112 top

National Archives of Namibia: 140 both

Peggy Kakururu: 98

Peter Lambrecht: 4, 15 top, 33, 75, 102 bottom, 116 top

Paul van Schalkwyk: 28 top, 52, 147, 156 2nd from top, 157 2nd and 4th from top right, and top left, 170, back cover bottom and middle left

RAISON: 1, 15 2nd, 3rd and 4th from top, 19 top, 25 bottom, 27 bottom, 28 bottom, 29 bottom, 47, 51, 60, 63, 65, 66 top, 67 bottom, 70 bottom left and 70 top right, 72 panorama, 73, 79 bottom, 83 top, 84, 86 bottom, top and 3rd from top, 88, 90 bottom, 96 both, 101 all, 102 middle and top, 103 all, 104 bottom, 105 both, 109 top, 110 bottom and middle left, 111 bottom, top left and top middle, 113 both, 114 both, 120 both, 122, 132 top right, 136, 141 top, 143, 144, 145, 153, 156 bottom, bottom right and top, 157 2nd and 4th from top left, 159 right, 160 bottom, 161 all, 165 all, 167

Rod Davis: 76 both

Rural Poverty Reduction Programme: 26 bottom, 36, 37, 66 bottom, 67 top, 72, 74 bottom, 80 bottom, 90 top, 152

Salome Kruger: 110 middle right

Tony Robertson: 49, 57 bottom, 169

Victoria Shifidi: 166

9 789991 678078

THE CUVELAI - ETOSHA BASIN