EPHEMERAL RIVERS
AND THEIR CATCHMENTS

SUSTAINING PEOPLE AND DEVELOPMENT IN WESTERN NAMIBIA

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In addition to this book,
the Ephemeral Rivers Project
has also produced a video and a map,
providing further information on
Namibia's westward-flowing ephemeral rivers
and their catchments.

These materials can be obtained from
the Desert Research Foundation of Namibia
or the Department of Water Affairs.

FOREWORD

by
Mr. Nangolo Mbumba
Honourable Minister
of
Agriculture, Water and Rural Development

The western regions of the Republic of Namibia are unlike any other area within the country in terms of their climate and natural resources. The dominant features of these regions are the harsh and variable climate and the steep topography drained by a series of ephemeral river courses. These rivers, more than a dozen in all, have catchments ranging in size from less than 2 000 square kilometres, such as the Khumib River in the north-west, to more than 30 000 square kilometres in the case of the Swakop River in the central west.

Travelling westward through these catchments one passes through a steep climatic gradient, made visible through the dramatic changes in the vegetation. The Ugab River catchment provides an example, extending inland to near Otavi where one finds a lush mountainous savanna with an annual rainfall of nearly 500 mm. Where the river reaches the coast, rainfall has dropped to near zero and there is very little vegetation within the Namib Desert. The river drains from its headwaters in private commercial farmlands, across communal farmlands and finally reaches a proclaimed conservation area before entering the Atlantic Ocean.

In precolonial times, these catchments supported pastoral communities and wildlife that used the land and water by moving within this large region in response to rains. The western areas of many of these catchments were used only by small nomadic populations in years of higher rainfall. Today, a growing human population is attempting to use the limited natural resources of the region for agricultural production on a permanent basis. Past changes in land tenure have led to the development of large and sedentary human populations, many in the climatically uncertain western reaches of these catchments. How much longer the region's water and rangelands can support a growing human population is unknown.

Historically, as today, humans and wildlife alike have sought refuge from the climatic uncertainty by using the linear oases of the region, the ephemeral river courses crossing through the western arid regions of these catchments. These rivers, with their comparatively abundant water and vegetation resources have been a focus of activity for wildlife and humans alike over the millennia. The ephemeral rivers of western Namibia and the natural resources which they support are dependent upon floods which originate further inland following summer rains. These floods must be allowed to continue uninterrupted if the downstream areas within the arid western regions are to maintain their support of the rich and diverse assemblages of wildlife, as well as the human beings who use the natural resource base for economic purposes.

Currently there are a number of disturbing signs indicating that we may not be using these systems in a sustainable manner. Since the environment within the western catchments depends upon the occasional floods, any development which might reduce such flows must be carefully evaluated. The challenge ahead for Namibia will be to balance the wide range of conflicting demands within the catchments of these rivers. Achieving such a balance will require planners to think across political, ministerial and other jurisdictional boundaries and recognize the effect of upstream developments on downstream resources and users. Currently, the diverse range of private and communal land ownership is complicating such efforts. I am thus pleased that this brilliant research document points out that the river catchment should be a basic unit for development planning in the whole region.

Today, these rivers and their catchments are a critical resource for Namibia and will become even more so in the future. We must think beyond their current utility for supplying water for urban and industrial development or simply as natural resources supporting agricultural production. An integrated approach to the management of the catchments' resources is essential. The challenge now is to make the appropriate choices relating to land use in these arid areas so that they may enrich the Nation and provide a sustainable source of income. This book synthesises a broad body of information about the rivers' ecological functioning, natural resources and current state of development and utilisation. As such, this document provides a basis for co-ordinated planning in projects related to the development of this area. It is thus a useful resource which should be broadly distributed and read by all Namibians who have a role to play in developing, protecting and using the natural resources of the unique western area of Namibia.

PHOTO: The Honourable Minister Nangola Mbumba in a wetland in the Hoarusib River during a visit to the region in 1994.

HOW TO READ THIS BOOK

The aim of this book is to familiarise Namibians with the westward-flowing ephemeral rivers, their catchments, their resources, and how they are currently used. These resources, particularly water and rangelands, are and will continue to be the primary basis of development in the western catchments. As such it is essential that resource users in the region and throughout Namibia carefully consider the limited and specialized potential of this arid region's resources. Information in this book reflects the authors' review of a wide range of reports published by various sectors of the Namibian government, interviews and discussions with individuals in government and the private sector, and original research by the authors. The international literature has been reviewed for examples of how to avoid development mistakes which have devastated much of the world's drylands over the last 50 years. We hope that this book will help guide the appropriate development and management of these ephemeral rivers and their catchments.

Because this book is intended primarily as a source of information on the region, we have provided certain features to make the information easy to access.

- First, at the very beginning of the book **a general summary** entitled, 'Why Read This Book: An Executive Summary', highlights the most important points discussed in the text.
- Also near the beginning of the book is a **Table of Contents.**
- **Point summaries** in yellow boxes found throughout sections II, III, and IV summarise the relevant points, so that a quick review of the issues in the book can be gathered by reading these boxes.
- In addition, blue boxes provide **examples of issues** discussed in the text or **additional information** about relevant points. They can be read with the text or independently.
- **Numerous diagrams and illustrations** are also used throughout the book to provide a visual story of the region, its resources, and how people are using them.
- A series of individual **'Catchment Summaries'** with statistics relating to each catchment, its current state of development and the people living within it can be found at the end. Text, illustrations and maps are used to give the reader a better understanding of each catchment.
- Also at the end of the book is an **Index** to important concepts and place names, a **Glossary** which explains the meaning of important words and phrases used in the text, and a list of **References** that are referred to throughout the text (using numbers in parentheses at the end of a sentence).

The text itself is divided into 5 sections. Section I is a brief introduction to the western catchments, their resources, and how people use them. Because of the frequent and confusing use of the term 'sustainable development', we also discuss our use of the term and point out the many complexities involved in actually achieving improved quality of life for Namibians today, as well as for subsequent generations.

Section II describes the resources themselves and discusses in some detail the processes that shape and maintain them. For example, the role that flooding plays in maintaining vegetation within the rivers is discussed at length. Reflecting the information available, a fair amount of technical detail is provided in this section. This should serve as a warning to readers who are more interested in how people are actually using these resources (see section III). We feel this detail is necessary, however, as an understanding of how these resources are maintained is essential to guiding their use.

The historical, current and potential future uses of these resources are described in **section III.** The use of the catchment's resources by individuals must also be considered within the national context. In **section IV,** we therefore introduce some of the legal, economic and demographic issues which affect co-ordinated and sustainable development in the region. Finally, **section V** is a summary of the challenges that all Namibians, in their professional and private capacities, must address if the goals of sustainable development are to be achieved.

Floods in the Kuiseb River over the past million years have carved a deep canyon.

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WHY READ THIS BOOK: AN EXECUTIVE SUMMARY

This book provides basic information about the resources of Namibia's westward-flowing ephemeral rivers and their catchments; and how people living in this region are currently using them. The effects of historical and current social and economic policies, laws, and development upon these resources and their users are discussed. Given the unique features of this arid region, future development must be carefully co-ordinated. In the face of a dry and variable climate, limited and finite water resources, and a rapidly expanding population, well co-ordinated and sustainable development is a great challenge. This book provides an overview of the region in an attempt to help meet this challenge. Below are the key points discussed in the book.

Demographics of the Western Catchments

- Approximately twenty per cent of Namibia's land area and twenty per cent of Namibia's people - that is, one of every five persons - can be found within the catchments of the westward flowing ephemeral rivers. The population in this area, as in most of Namibia, is growing rapidly. Within twenty years, there will be twice as many people trying to make a living from the region's resources.

Resources of the Western Catchments

- This area is unlike any other within Namibia with a harsh, variable climate, a spectacular landscape traversed by ephemeral rivers, and a diversity of natural resources.

- Most of the area has an arid climate with low and variable rainfall and high evaporation. Consequently, the area also has only low and variable agricultural potential. Mean annual rainfall decreases across the catchments from east (over 500 mm) to west (about 0 mm).

- Ephemeral rivers flow only for short periods after heavy rains have fallen in their catchments. During the rest of the year the rivers are dry, but flood water stored below the surface provides essential water for farmers and many towns on or near the rivers. The forests that line the river banks deep into the desert are also supported by this water and are important fodder resources for livestock and wildlife in western Namibia.

Managing the Vegetation Resources

- Land tenure in the catchments is divided between private farmlands in their eastern reaches, parks and tourism areas in the western reaches, and communal farmlands lying in between. Eight of the catchments contain a total of approximately 980 private farms, nine of the catchments contain large areas of communal farmland, and all twelve rivers end in conservation and tourism areas in the west.

- All fodder for livestock and wildlife is provided by the grasslands of the western catchments and forests of the river courses. Thus catchment and riparian vegetation are the basis for all rural livelihoods derived from agriculture and tourism.

- Floods are the source of water and nutrients that keep the riparian forests of the western ephemeral rivers alive. As a result, these forests are very sensitive to changes in runoff from upstream regions caused by climate change or dam building. The effects of these natural and unnatural changes must be carefully considered to ensure the availability and sustainable use of riparian resources such as the ana trees.

- Nomadic movement of people, livestock and wildlife in response to rain is an effective means of ensuring sufficient fodder in a dry and variable environment where rains may not fall in a particular area from one year to the next.

- Decision makers and planners must be aware that the climatic variability found in the western catchments makes appropriate land use planning and drought preparedness essential in order to avoid over-use of the land, veld degradation, and disastrous famines. All land- and water-use management plans in the western catchments must take into account the finite nature of the resources and the effects of short and long-term climatic variation.

- Approaches which emphasise privatisation of communal land, including fencing and subsequent exclusion, must be recognised as inappropriate in view of the large-scale nomadic movements of livestock necessitated by the arid climate. Policies which foster livestock mobility and ensure equitable rights through grazing and water fees, must be enacted and enforced.

Managing the Water Resources

- Towns and cities throughout the region are facing serious shortages of water for human consumption. In each situation the reasons for the shortages are different (demand of rapidly increasing urban populations exceeding available water supplies, excessive use by individuals, wastage) but the result is the same: non-sustainable use of the existing water supply. At many towns within the western catchments, such as Kamanjab and Khorixas, water aquifers are almost exhausted and future sources for water provision are either unavailable or very costly to develop.

- A national settlement and physical development plan, which incorporates consideration of water constraints, does not yet exist and must be developed as a matter of absolute urgency.

- When developing water resources in a region, we do not create water. Rather, we are re-distributing it across the landscape, to the advantage of some but often to the detriment of other users. This is particularly true of dams on ephemeral rivers that eliminate large floods and reduce or eliminate downstream flow. In such cases the water resource available to downstream users is obviously reduced or eliminated.

- Agriculture is a major force driving development of water resources, often through the installation of boreholes. If boreholes are used to promote good rangeland management by allowing access to areas that have received good rains, and by encouraging the movement of stock and wildlife from dry regions with low or no grass cover to regions of good grass cover, then they can be very useful. However, if people and their livestock settle permanently at every water point, and areas are grazed year in and year out regardless of the rains, the grazing and browsing resources will deteriorate.

What Does the Future Hold for the Western Catchments?

- Annual population growth in Namibia is estimated at 3.3%, but the growth rate of the real gross national product, GNP, has averaged less than 0.3% annually. If such discrepancies persist in the long-term, Namibians will simply have to live with less. A national development plan which recognises water as a fundamental constraint for Namibia's expanding population is urgently needed. Water restrictions and conservation campaigns can reduce demand, but ultimately these reductions will be cancelled out by the basic demands of more and more people.

- Because planning regions and jurisdictional boundaries cross catchment boundaries, development decisions affecting water and rangeland resources are often made without consideration of their impacts throughout the catchment. In order to ensure sustainable use of these critical resources, planners, policy makers and decision makers must be aware of the boundaries of the catchments for which they are responsible, and actively consider how their actions in one area affect the catchment as a whole.

- Agriculture and tourism are two of the four largest sectors of the Namibian economy and are the principal land uses within the catchments. Given the low agricultural potential of the western catchment drylands, only tourism is thought to have significant potential for growth. These areas have spectacular scenery supporting an array of vegetation and wildlife unique to Namibia and, consequently, have a high potential for tourism development.

- While the agricultural sector within the western catchments has limited potential for expansion, it should remain a reliable source of continued earnings if water and rangeland resources are used sustainably.

- Land use planning and resolution of the land tenure and wildlife use issues are desperately needed to support informed decision making at all levels and to facilitate continued economic development. There is an urgent need to decide how the region's land and water resources will be used, recognising that some forms of use will conflict or are inappropriate.

- Lack of planning is currently reflected in the fact that no land use zones have yet been established within the region, and as a result development in the region in unco-ordinated.

- Co-ordinated planning is essential. All Ministries concerned with rangeland resources, soil, water and wildlife must determine the environmental sustainability of development options for the region's resources. In addition, Ministries concerned with economics, finance, trade and industry should examine economic sustainability of developments. Finally, Ministries concerned with human development, lands and resettlement, health, education and culture must ensure that the goals of social sustainability are met.

- Drying up the lower reaches of Namibia's western-flowing ephemeral rivers would be a disaster for tourism development and for the nation's economy. It is therefore essential that any upstream development which would reduce downstream flow should be restricted. Such developments should only proceed if their significance outweighs the value of these unique downstream areas to the nation.

- The greatest challenge facing Namibia as it attempts to manage its natural resources is to balance the conflicting needs of all resource users. This is particularly true in the western catchments where competition for water is especially severe. Conflicts have also arisen over grazing rights. These examples highlight the desperate need for land and water use planning, particularly in the communal areas of the western catchments.

1. THE WESTERN RIVERS AND SUSTAINABLE DEVELOPMENT: AN INTRODUCTION

The 1985 flood of the Khan and Swakop Rivers, here at Usakos on the Khan, will not be forgotten by those who saw it. (photos: D Heinrich)

Namibia's Rivers

Does Namibia have rivers? Yes, but only at the northern and southern borders of the country do we find perennial rivers which flow throughout the year. The Kunene, Okavango, Zambezi, Kwando-Linyanti-Chobe and Orange all originate in neighbouring countries where higher rainfall supports their year-round flow. Little or no water flowing within these rivers comes from Namibia. In contrast, rivers which start in Namibia are all ephemeral rivers - flowing only after strong rains have fallen over their catchments. For most of the year, these internal rivers are dry and sandy channels. When they do flow, the floods may be small and pass unnoticed during the night; or big floods may roar through their channels for many days - uprooting trees, depositing thick layers of sediment on floodplains, and sweeping away anything that is caught unaware in their broad path.

Ephemeral rivers in Namibia that flow towards the east and north start in and flow through regions of relatively high rainfall, ranging from approximately 300-600 mm per year. Because of the higher rainfall, the appearance of the vegetation which lines these river courses is not radically different from that of the surrounding savannas, both often containing many trees and shrubs. In contrast, rivers that flow southward toward the Orange River or westward toward the coast begin in areas of higher rainfall but flow through very arid lands (rainfall of less than 100 mm per year) in their lower reaches. In particular, rivers that flow westwards towards the coast pass through a steep climatic gradient. At their origins, rainfall can be in excess of 400 mm per year. By the time these rivers reach the coast, however, rainfall has declined to near zero.

Because of western Namibia's arid climate, ephemeral rivers are of special significance to this region, which supports approximately one-fifth of Namibia's 1.4 million people (1991 Census). Floods resulting from heavy rains in the eastern parts of the river catchments re-charge aquifers and maintain dense stands of riparian vegetation in the dry western reaches of the catchments. Because of the marked contrast between the riparian and desert vegetation, these linear oases provide essential water and food resources for people, livestock and wildlife living in these regions.

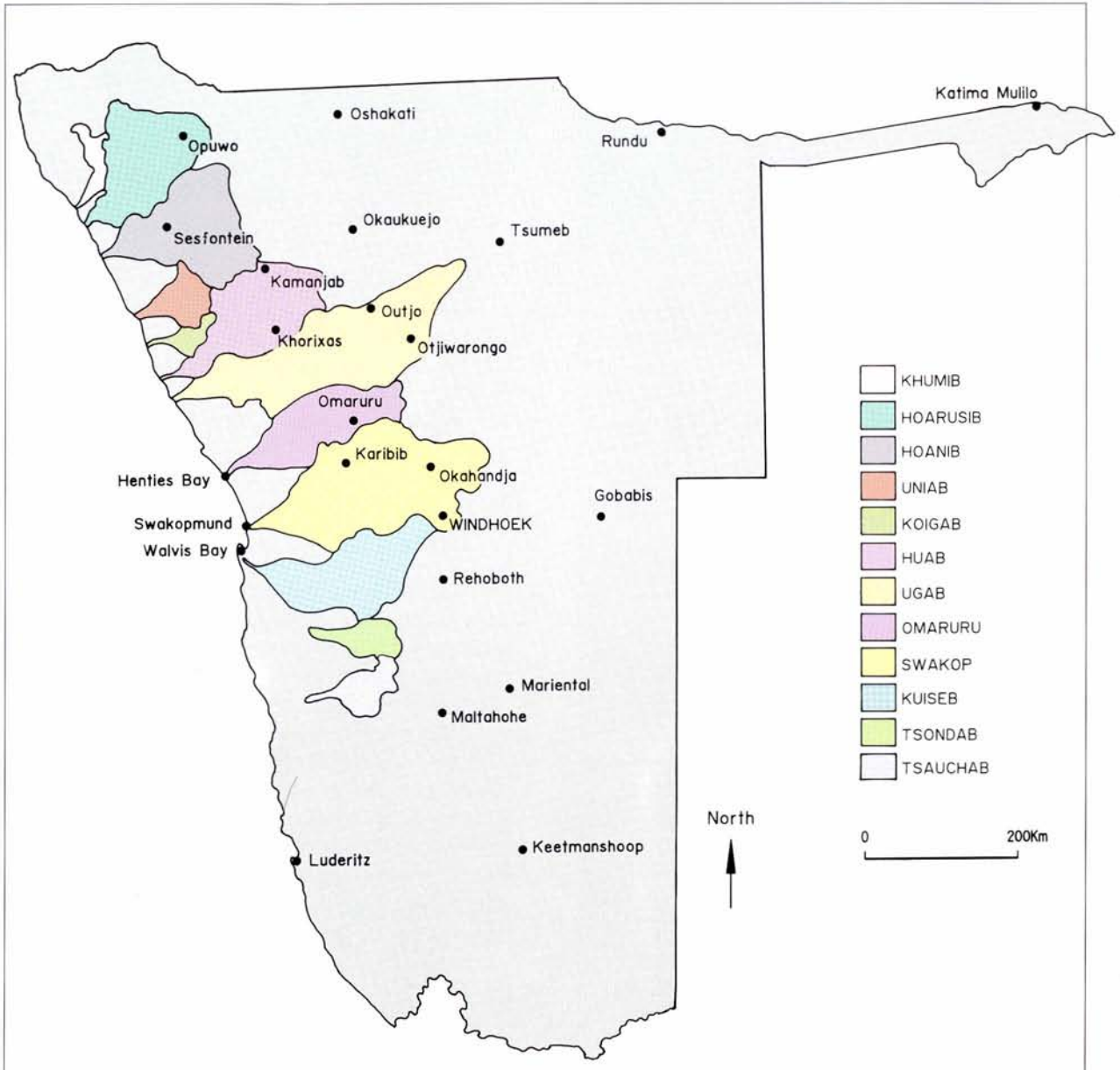
The Kunene River, here at Epupa Falls, is an example of one of the perennial rivers flowing along Namibia's borders. (photo: P Tarr)

This map shows the distribution of perennial rivers on the African continent. Namibia's perennial rivers occur only at the borders or crossing the Caprivi. The whole of the country is drained by ephemeral rivers, flowing only after heavy rains have fallen in their catchments (21).

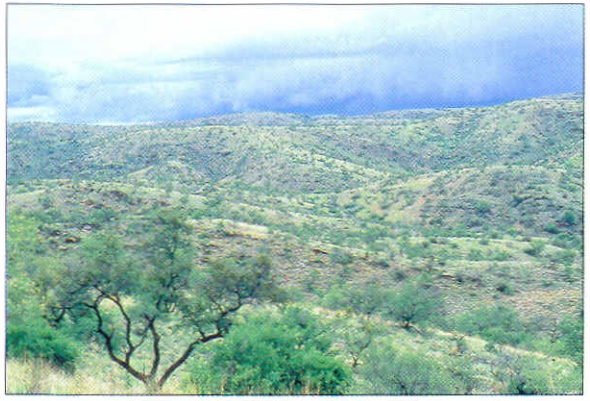
The Western Rivers and Their Catchments

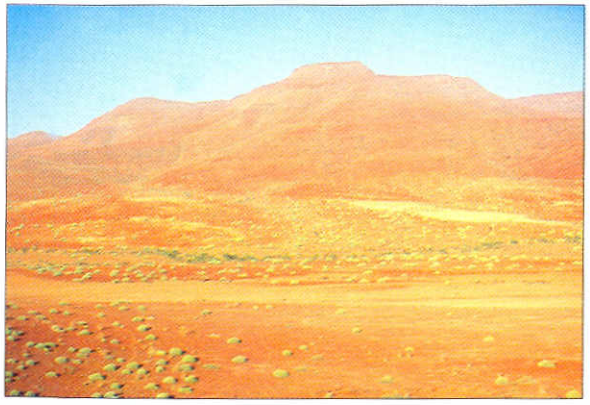
Twelve major ephemeral rivers flow through western and north-western Namibia. A number of smaller rivers originate in the arid coastlands and deserts. In total, the catchment areas of these rivers encompass 188 000 square kilometres, nearly a quarter of Namibia. The larger catchments range in size from 2 000 to more than 30 000 square kilometres. The frequency of flooding in the rivers is related to catchment size, average rainfall and in some areas, upstream dams. The frequency of flooding, which varies from river to river, affects the vegetation and water resources each river supports. These geographical, climatic and biological features, in addition to the highly variable geology, make each catchment unique.

Despite these differences, the over-riding similarities of water flow from areas of high rainfall into the desert, as well as the way the catchment resources are used, encourages us to think of the region and its rivers as a single unit. Eight of the twelve major rivers have headwaters in private farmlands. Ten of the rivers also flow through communal farmlands and, finally, all twelve either originate, drain through, or flow into proclaimed conservation and tourism areas. All of these rivers and their catchments support a rich assemblage of vegetation and wildlife critical to agriculture and tourism, two of the largest sectors of the Namibian economy (73, 145). In addition, these rivers and their catchments provide water for agriculture, tourism, and mining and are critical water sources for Namibia's most important economic centres: Windhoek, Walvis Bay and Swakopmund. Namibia's westward-flowing ephemeral rivers are clearly of tremendous significance, not only to people living in the region, but to the nation as a whole.



Twelve major ephemeral rivers flow across western Namibia. Their catchments, the area from which rainfall drains into the river, cover nearly a quarter of the country.





Vegetation varies markedly from west to east across the catchments in response to increasing rainfall.

But are the land and water resources of the western catchments being managed appropriately? This question needs to be asked because there are troubling signs that we do not fully understand the finite nature of arid region resources. Of greatest concern is the increasing dependence for bulk water supply on the limited water resources of aquifers within the ephemeral rivers, and their catchments. This is cause for concern in many regions, even at current population levels. Kamanjab, Khorixas, Opuwo, Swakopmund, Usakos, Walvis Bay and Windhoek are all struggling to meet the water demands of their current residents. Given that rural and urban populations are increasing at 3-10% annually (16), and that the region will be home to twice or three times as many people in twenty years, it is clear that water is a critical issue.

In addition, the maintenance of rangelands in the face of increasing rural populations presents an enormous challenge in a region with low and highly variable rainfall (143). Conflicts between users within the catchments are occurring as private and communal farmers, urban residents, industries and wildlife compete for the finite natural resources within the catchments (13, 111, 90). Water and rangeland resources are the common themes at the root of these conflicts. Declining groundwater tables, eroding soils and changing vegetation communities indicate that current use of these resources are unsustainable and will not maintain future development in the region.

THE BIG FLOOD OF 1963 ON THE KUISEB RIVER

'The first evidence of heavy rainfall reached us the afternoon of January 6 in the form of a brown flood. The water, muddy and of a dirty, dark colour carried with it countless pieces of wood, and scattered dry branches and tree trunks. During the night a second wave passed our station. By the 11th of January all of the water had passed by. From the 13th to the 14th of January the Kuiseb came down high again and on the 15th swelled over the banks into its high floodplain at several places. On the 18th the river reached its highest level and the wide floodplain below the station was flooded over. During the following days the river sank and rose in constant change. On the evening of the 23rd we recorded a new increase, and even the next morning the river continued to rise. With a steadily mounting roar the flood, which was to reach an as yet hardly recorded height, announced itself at noon. This time again it was not observed as a real flood wave, rather, the rise in the river took place gradually in small waves. The most impressive thing was the 'dead forest' which the river pushed along with it; for almost an hour the Kuiseb appeared as a gigantic conveyor belt for the transport of wood masses, which now, rearing up, pushing themselves over and under one another, turning, smashing, searched for their way through a much too small riverbed. In the evening the water level had reached its peak. Even the high floodplain had turned into a raging riverbed. On the southern bank where the dunes fell into the riverbed, the earth was washed away. Pouring sand masses were washed away by the huge landslide. Most trees now stood in the water. Driftwood was dammed by their trunks and where the pressure became too great, it broke them (the trees) down.

When, in the next days the flood areas were free again, shocking devastation met the eye. In many places the valley seemed completely changed. Our part of the river had carved itself almost a metre deeper. Gradually declining banks had become steep cliffs. Large treasures, in the form of very old trees, lay mowed down along the side of the river. By February 2 the river had stopped flowing.' (204)

What is Sustainable Development and Natural Resource Management?

The term 'sustainable development' is currently used throughout the developing world to explain the desires of planners and decision makers to enhance peoples' quality of life, without jeopardising the development opportunities and lifestyles of future generations (1). 'Sustainable development', as defined here, is an ideal with which every thoughtful citizen and politician agrees in principle. Reference is made to it in documents as diverse as the Namibian Constitution (36), national planning documents (146), rangeland development programmes (131, 122), biodiversity conservation strategies (80) and environmental profiles (137). While these documents set sustainable development as a goal, consideration of exactly how it will be achieved is frequently lacking. The popularity of the term results in its frequent misuse, without a critical examination of how a particular development plan will ensure long-term management of all natural resources for the benefit of future generations.

Sustainable development must involve three important aspects:

- Making plans for sustainable resource use now and in the future, and considering how these plans affect the sustainable use of other resources (economic sustainability).
- Using resources effectively and efficiently (environmental sustainability).
- Developing an appropriate social framework for equitable resource use (social sustainability).

Economic Sustainability: Planning Resource Use

Achieving sustainable development is a difficult task for a number of reasons which must be understood, acknowledged, and discussed. To begin with, how do we determine the developmental needs of future generations? As responsible citizens we should at least plan as if our children and our children's children will want the same opportunities for development as we do. Achieving sustainable development must therefore proceed from a careful consideration of the types of development that the present generation needs and desires, and whether the amounts of resources to be used are sustainable or not.

The first component of sustainable development is defining and evaluating the objectives for resource use (136), and is often a concern of economic sustainability (164). The yield of the resource must meet the objectives of the resource users. This must happen at the individual level, involving decisions such as whether a particular rangeland management strategy will work under the highly variable climatic conditions expected in dry regions. But in addition, it must happen at the regional and national level too. On the national level, development planners must define goals for resource use and development trajectories which support appropriate use of the resources by individuals. Effective resolution of the land tenure issue as well as land use planning, must account for the resource constraints of the western catchments, if individuals are to effectively define their own objectives and goals for resource management.

Environmental Sustainability: Using Resources Effectively

Having established plans for resource use, a second key component of sustainable development is ensuring the effective use of the available natural resources (environmental sustainability). Certain natural resources, such as gas, petroleum products and minerals, which are key to current forms of development, are non-renewable and thus cannot be maintained in their present form for use by subsequent generations. Realistically, sustainability of these resources can only be considered if depletion rates are equal to the rate at which renewable substitutes are developed by human investment and invention (5, 64). Given that this is extremely difficult or costly to achieve, we must accept that our resource use is not always sustainable. Then the decision as to when and how to use these resources should be carefully considered so as to maximise benefits for citizens present and future.

Minerals, such as the tin ore which was mined here at the Brandberg-West mine, are an example of a non-renewable resource. Such resources are of no use unless exploited, but when exploited, are gone forever.

Many of Namibia's resources which are currently fuelling development projects are, in principle, renewable. If harvest rates or yields of fisheries, water resources, rangelands, wildlife and soils are within the renewal capacities of the natural systems that generate them, they are renewable (64). Using a renewable resource in a sustainable manner requires a management strategy that not only accounts for the quantity of the resource, but also accurately predicts the reproductive

capacities of the natural system to maintain the resource. These must then be compared with estimates and assessments of resource demands in order to determine, as accurately as possible, whether resource use is sustainable and whether the costs of using, or not using, the resource are justified.

In most cases sustainable management of resources is easier said than done. But if we are to do more than simply hope that our resource use is sustainable, serious consideration must be given to these hard questions, their answers, and our confidence in these answers (187). This is particularly true in regard to Namibia's limited water resources, considerations for water provision schemes, and the development needs of a rapidly expanding population. For example, based on a twenty-year record of floods in the Kuiseb River, it was thought that recharge of the aquifers by flood waters would exceed the pumping rates needed to maintain the water supply to Swakopmund, Walvis Bay and the Rössing Mine during the 1980s. By the 90s, however, it was clear that recharge was not sufficient and that the Kuiseb aquifers were being mined. Water was being taken out faster than it was being replaced by floods. How did this happen? At the time of planning, not enough was known about the variability in ephemeral river flooding (20 years of records were not enough to obtain a good estimate of the river's recharge potential or of the characteristics of the aquifer). In a naturally arid country such as Namibia we now know that drought and climatic variability must be a normal consideration in our plans for sustainable resource management (176).

The coastal towns are now looking to alternative water sources to supply their water needs. The current consideration of whether these other water sources are sustainable raises an important point about planning for sustainable development. In the past, water departments around the world have defined sustainability as continuing to provide water for the people, content to treat aquifers as 'mines', removing water at rates dictated by the demands of society (158). If one aquifer was depleted, it was either expanded or a subsequent one was developed and used. Such approaches are unsustainable, in the long-term. The recent recognition of desalination of sea water as the only alternative for future water supply to the development centres in the arid west, Swakopmund and Walvis Bay (190), is an example of the human ingenuity and expense that Namibia will ultimately have to rely on to meet the basic demands of a rapidly growing human population.

Social Sustainability: Rights and Responsibilities

But can Namibia afford expensive technological fixes? Are there different ways of managing the problem other than trying to meet the ever-increasing water demands of rapidly expanding populations? Ultimately, managing essential resources for Namibia's people should be a cross-sectoral concern and not the sole mandate of any single government body, such as the Ministry of Agriculture, Water and Rural Development or the Ministry of Environment and Tourism. This brings us to the third essential component of sustainable development: social sustainability. Social sustainability (64) is perhaps the least understood component of sustainable development. Social sustainability describes the need for a social framework which empowers self-control over resources, at the individual, regional and national level.

Ultimately, sustainable development requires that all Namibians should achieve the first two components of sustainable development, namely defining resource needs and then knowing how to manage the use of the resources in a sustainable way. In order to do this effectively we must understand that Namibia's resources belong to all Namibians and that our collective 'ownership' not only entitles us to have a say in resource use and management, but also requires that we share the responsibility of managing the resources effectively. Unsustainable resource use is not something that most resource users or planners do on purpose. Rather it is usually the result of an insufficient understanding of both the resources and human needs of the resources, combined with a lack of suitable alternatives (151).

As citizens of Namibia, we are all resource users. We must therefore seek to understand our resources and how we use them, as well as the development goals and aspirations of our nation (25, 187, 189). Ultimately, the goals of social sustainability in Namibia are broad and difficult tasks - poverty alleviation, education and population stability. The social resources required to achieve social sustainability are characteristics of individuals and communities - social cohesion, cultural and national identity, honesty and discipline. These social resources are difficult to measure but must form the basis of Namibian society if sustainable development of our resources is to be achieved for the benefit of all citizens, present and future.

Water, such as the groundwater emerging at a spring, is an example of a renewable resource. If used faster than naturally replaced by rainfall and riverflow, however, it must be viewed as a nonrenewable resource, similar to the mining of minerals.

II. THE EPHEMERAL RIVER SYSTEMS AND THEIR RESOURCES

Most of the rain falling over the western catchments comes in the form of brief but strong storms, often with frequent lightning.

Rain, Floods and Water Resources

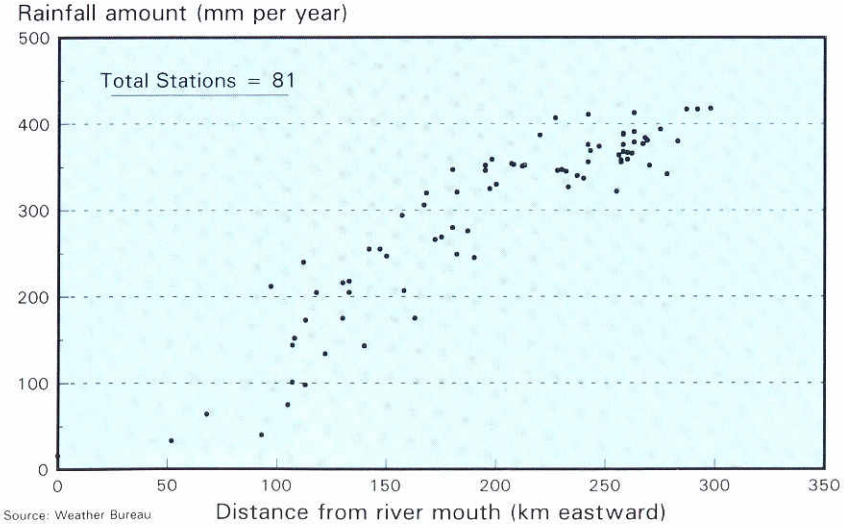
Rainfall, Evaporation and Drought

Rainfall distribution in the western catchments

Most rain that falls on Namibia has its origin over the Indian Ocean (219). By the time moisture-bearing clouds reach western Namibia, they have passed over all of southern Africa and their moisture content has declined rapidly. This decline becomes even more pronounced when warm moist air from the east meets the prevailing on-shore cool, dry air near the coast. The result is an inversion of temperature, with cool air near the ground and warm air above, and less air turbulence. This situation contributes to very low rainfall near the coast and higher rainfall inland, and hence a steep rainfall gradient across all the western catchments. Low annual rainfall, between 0 mm and 25 mm, is experienced in the western extremes of catchments along the Atlantic coast. The highest rainfall experienced in a catchment depends on how far inland the catchment extends. The eastern headwaters of the small Uniab catchment have a maximum average annual rainfall of only 125 mm, whereas headwaters of the Ugab catchment, just to the south-west of Otavi, have an average rainfall of over 500 mm. However, regardless of catchment size, the rainfall decreases from east to west along the length of every catchment.

Most people know that drylands of the world have low rainfall, but it is less well understood that rainfall in drylands is highly variable from year to year at any one site (112). Thus as rainfall decreases along the catchments towards the west, the variability in rainfall amount increases. At Khorixas in the Huab catchment, it is common for rainfall to vary as much as 50 per cent from the long-term mean of 215mm. Thus one year rainfall may be 108 mm and the next year 324 mm.

Average Rainfall in the Swakop River Catchment

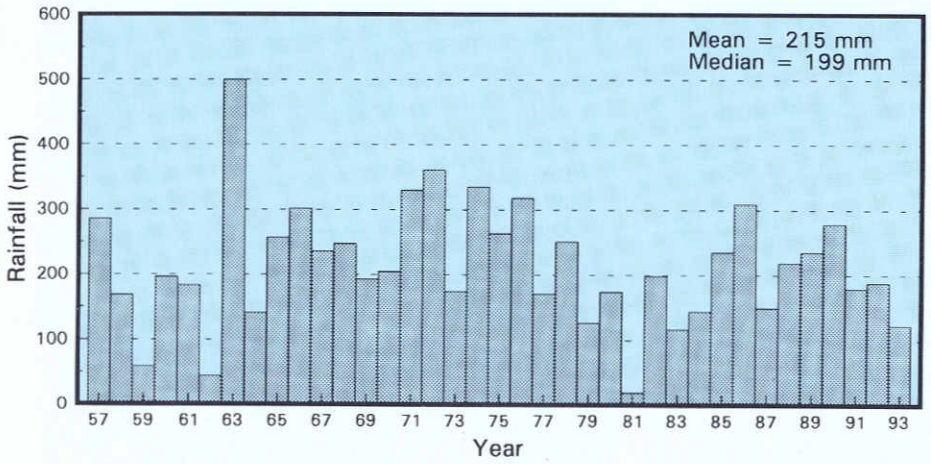


Source: Weather Bureau

Because of this variability, the mean is not a good indicator of the rainfall we can expect from year to year in drylands. It is more useful to know the range of rainfall that is possible for a region, and to plan resource use expecting, and therefore being prepared for, any rainfall within this range (46). In the case of Khorixas this would be 22 - 500 mm.

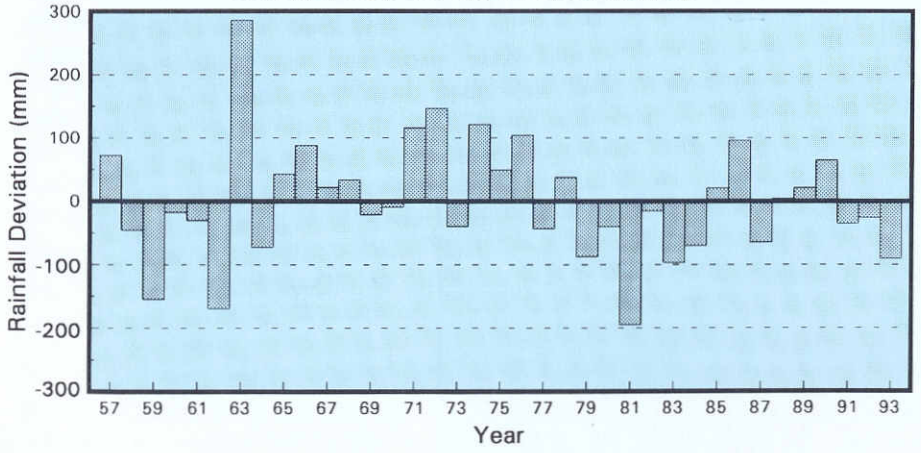
Rainfall decreases sharply from east to west across all of the western catchments, as shown here in the Swakop catchment.

Rainfall at Khorixas: 1957-1993

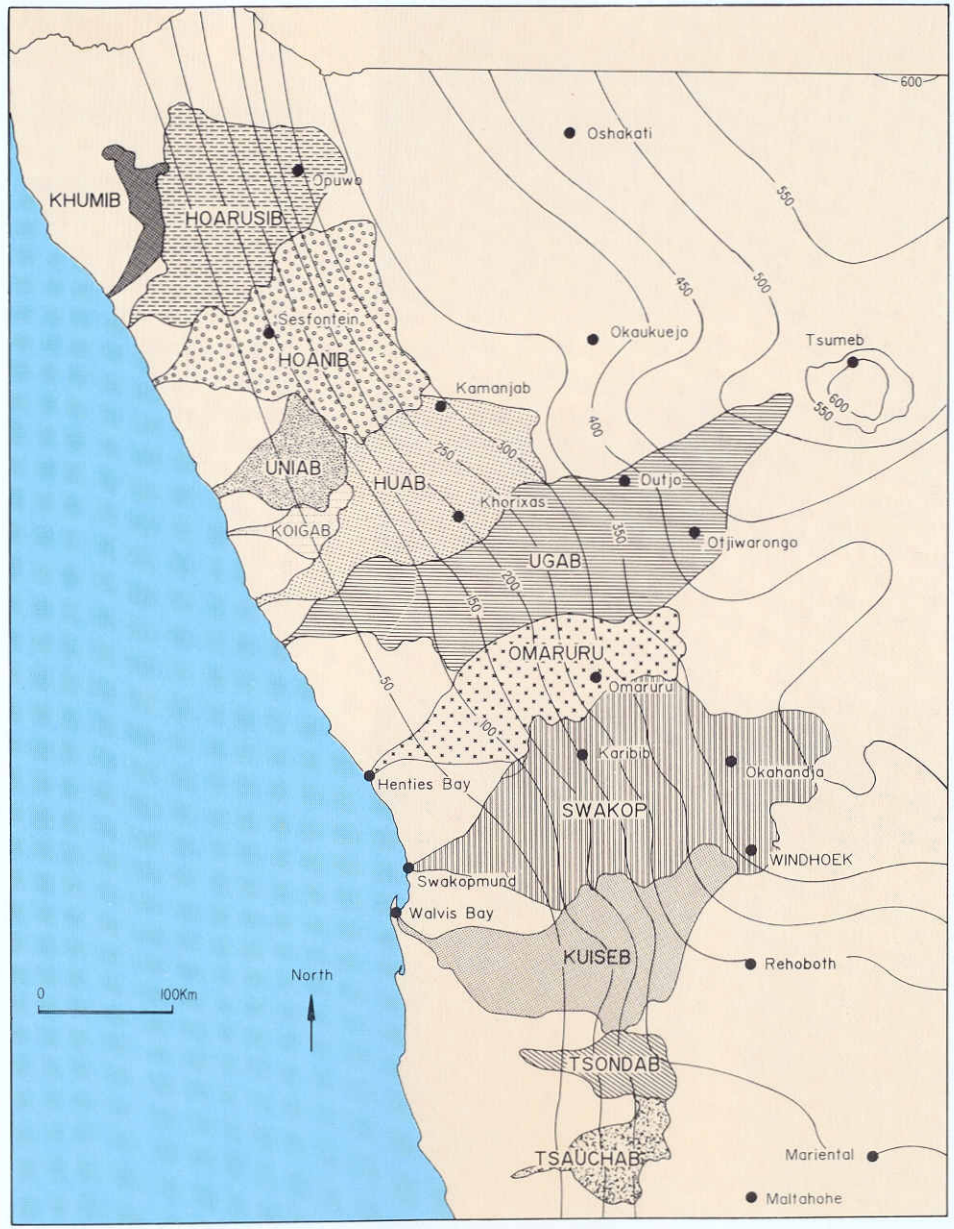


Rainfall at Khorixas: 1957-1993

Deviation from the Mean Annual Rainfall



An examination of the long-term records from Khorixas shows that rainfall is highly variable from year to year within the region. It is not uncommon for Khorixas' rainfall to vary by as much as 50% of the long-term mean from one year to the next, as has happened in 10 of the past 37 years. (Source: Weather Bureau records)



The larger catchments, extending further inland, capture greater amounts of rainfall. Nonetheless, the westward decline in rainfall is a feature common to all.

Almost all of the annual rains fall over the western catchments during the months of October to May. In the more southern catchments such as the Kuiseb, Tsondab and Tsauchab, light winter rains occasionally fall. Only in summer, however, do strong convective storms occur which cause runoff and produce flooding in dry ephemeral river channels. The seasonality of rainfall is an important driving force of biological and social processes in drylands. Historical information suggests that pastoral nomadism has long been a way of life associated with the variable climate found in the western catchments (93). These seasonal movements are still practised today by people living in the area, including Himba farmers in the Khumib and Hoarusib catchments (81). Livestock are moved wherever good rains have fallen providing grass for grazing and water to drink. In regions of the western catchments where boreholes provide drinking water for livestock, farmers are still dependent on rains for grazing. In 1994, after two years of very low rainfall in the Khorixas region, farmers moved thousands of cattle from the Hoanib and Huab catchments southward to the Ugab catchment near the Brandberg at Sorris-Sorris. In that area, heavier rains had produced good grass cover for grazing (90). These types of movement, referred to as nomadism, are essential for survival of people, livestock and wildlife in such a variable environment.

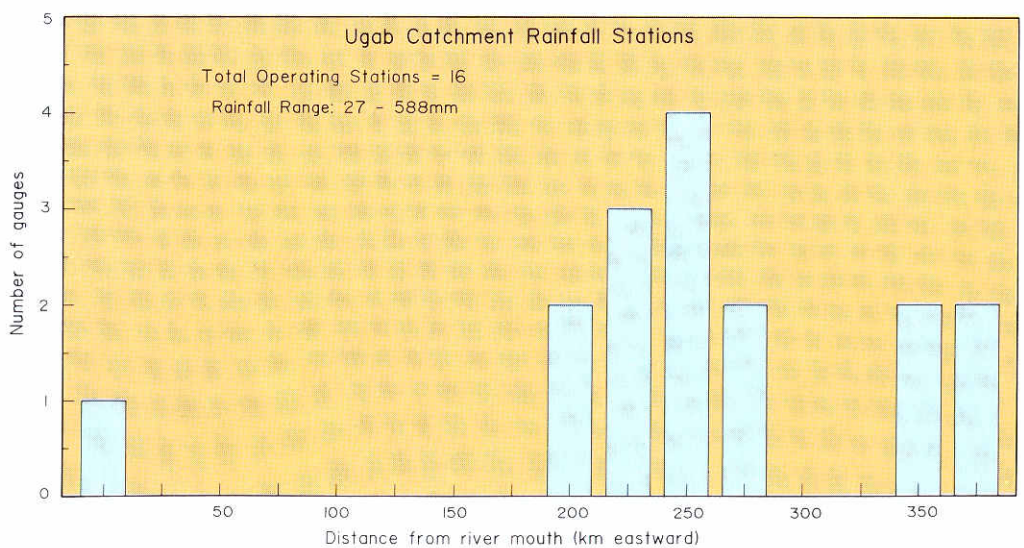
A serious constraint to understanding the variable climate in arid and semi-arid regions is a lack of long-term rainfall data. Only a long-term record will reveal what variation in rainfall can be expected so that natural, prolonged dry periods (usually called droughts) do not catch us unaware. Ideally, we would like to plan our livestock movements and sales according to the range of rainfall we can expect. Obviously, the longer the record the better the estimates of how much rain might be expected in the coming year. Because rainfall is so variable from year to year and also from site to site, we need a widely distributed set of rain gauges to improve our understanding of rainfall patterns. Regrettably, however, the rain gauge network in western Namibia is poor. Reliable long-term records are generally only available from private inland farms which have lower levels of rainfall variation than the arid west. These gauges cannot provide useful information about what we can expect in nearby western drylands. More rainfall data from western Namibia would also help us to estimate more accurately groundwater recharge rates of aquifers, and help us determine appropriate levels of land use for livestock and wildlife farming as well as conservation and tourism areas, from year to year. Rain gauges are inexpensive and easy to use, especially when located near a farm house, school or other permanently occupied place, and should become a part of extension, school and tourist programmes in the area.

Rainfall stations in the catchments and the areas that they serve

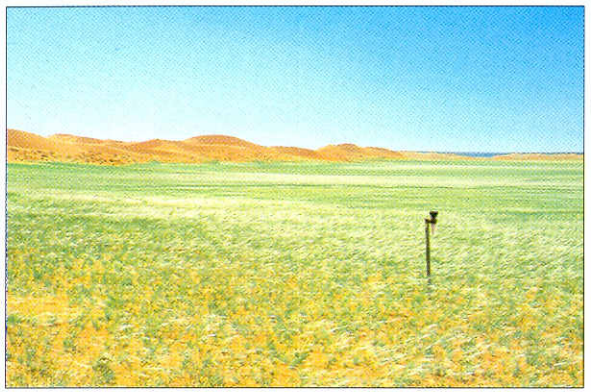
Catchment	No. of Stations	area (km^2)	km^2 / Station
Khumib	0	2 200	-
Hoarusib	0	15 140	-
Hoanib	2	17 200	8 600
Uniab	1	4 500	4 500
Koigab	1	2 400	2 400
Huab	7	14 800	2 114
Ugab	16	28 400	1 775
Omaruru	7	13 100	1 871
Swakop	38	30 070	791
Kuiseb	8	15 500	1 939
Tsondab	2	3 480	1 740
Tsauchab	3	3 950	1 317

Adapted from Weather Bureau Records

Not only are rainfall monitoring stations unevenly distributed in terms of their location, but there are also very few. Within many of the catchments, there are large areas for which there is no rainfall data, even though rainfall or the lack thereof, is the most important factor shaping the lives of the majority of all Namibians in the western catchments .



The distribution of rainfall monitoring stations across the catchments is very uneven, both within and between individual catchments. The Ugab catchment provides an example of this trend. No rain gauges occur within the catchment between 200 km inland and the coast. (Source: Weather Bureau records)



An expanded network of rain gauges is urgently needed throughout the western catchments to help increase our understanding of how the environment, particularly grassland, is responding to varying amounts of rainfall and grazing pressure. Gauges such as this one cost only N$ 10 and their installation requires only a piece of wire, a pole or fence post and a bit of oil (to prevent evaporation of collected rainwater), ensuring accurate readings even months after the rain has fallen.

The high evaporation rate of approximately 3 000 mm per year, found throughout the western catchments, causes all surface water to rapidly evaporate. The result at springs and wetlands, such as this one at Dubis on the Hoanib River, is a concentration of salt on the surface and in the surrounding soil.

Evaporation in drylands

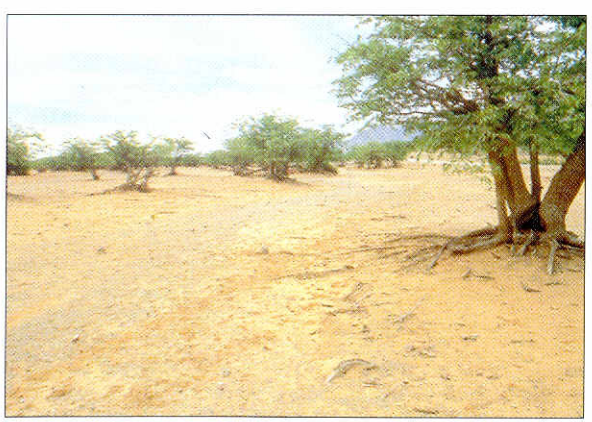
Mean potential evaporation in the western catchments is around 3000 mm a year (208). As a result, mean annual evaporation, measured from open water surfaces, is about six times greater than mean annual rainfall in the inland headwaters and more than one hundred times greater in the arid west. Thus, rainwater is rapidly lost from the ecosystem and water is generally not available on the surface for much of the year. Where surface water is available at springs and wetlands, the high rate of evaporation frequently results in highly saline soils, as moisture evaporates leaving natural salts from the water on the soil surface. Over time these salts build up, and the only vegetation which can survive around these springs is sedges, grasses, and *Tamarix* trees which can grow in the salty soils. High evaporation rates also greatly reduce efficiency of dams in drylands. With large surfaces exposed to dry air, water is easily lost from dams into the atmosphere.

Drought in arid and semi-arid regions

Drought is defined as a period of more than two years with rainfall lower than the long-term mean (235). Drought is normal in arid and semi-arid areas such as the western catchments, because rainfall is so variable (216). Examining the rainfall record in Khorixas over the past 36 years, we find that it is common to have more than two years in a row with lower than average rainfall.

Given that dry years, even many dry years in succession, happen frequently, we must be prepared to cope with them. Most importantly, provisions must be made to reduce livestock numbers on the veld so as not to over-use the natural resource base during droughts. Artificial water points allow stock to be kept in dry areas longer than if they depended only on seasonally available surface water in the form of pools or springs. The long-term effects of complete loss of natural grass cover, which can be caused by heavy grazing in times of drought, have not been studied in the arid and semi-arid regions of Namibia. However, lessons learnt in other arid regions of the world suggest that many soil types in Namibia may readily erode following periods of prolonged drought (186, 216).

The Beesvlakte area, in the Hoanib catchment east of Sesfontein, is such an easily degraded region. Soils here are composed of fine alluvial silts, which are highly erodible when vegetation is completely removed. Once erosion begins, it is difficult for grass seeds to remain on the surface and not be washed away with the upper layers of silt in the next heavy rains. Because grasses are not there to stabilise the soil, erosion continues. It is unknown what types of weather patterns and biological processes will re-establish perennial grass cover and stabilise the soils at sites such as the Beesvlakte. Silty soils are common in the western catchments and are especially vulnerable to the types of erosion seen in the upper Hoanib. Care must be taken to ensure that these unstable regions are not over-grazed.



The long-term effects of such extensive use of the vegetation, as seen here near Sesfontein in the Hoanib catchment, have not been well studied in Namibia. It is clear, however, that the removal of all grass cover and the compaction of the fine-grained, silty soils by livestock results in increased rates of soil erosion - evident here by the exposed roots of the mopane trees.

GLOBAL WEATHER INFLUENCES NAMIBIA

Low rainfall and variability of rainfall over Namibia are the result of global weather patterns and our position on the western side of the African continent and on the Tropic of Capricorn (219). Global atmospheric factors, such as dry descending air that has lost most of its moisture over the equator, limit the potential for rainfall over Namibia. When these dry air masses move northward, as they do in summer, conditions may develop that allow moisture from the Indian Ocean to reach western Namibia, although this does not happen every year. Other factors, such as water temperature in the Pacific Ocean, may affect ocean currents surrounding southern Africa and, at the same time, rainfall over Namibia.

Effects of the warm water event in the Pacific Ocean, known as El Nino, are associated with floods, droughts and famines in different parts of the world. Droughts in Namibia, such as in the early 1980s, are known to be associated with strong El Ninos.

Long-term planning in Namibia must recognise and prepare for the low and variable rainfall pattern that is the natural situation in our country (134). Continuing studies of world climate may provide more information about global influences on our climate and give us a better idea of what we might expect from year to year. Such studies may also inform us about the potential effects of global climate change which may reduce rainfall, river discharge, and water availability in our arid country and become more important in the future.

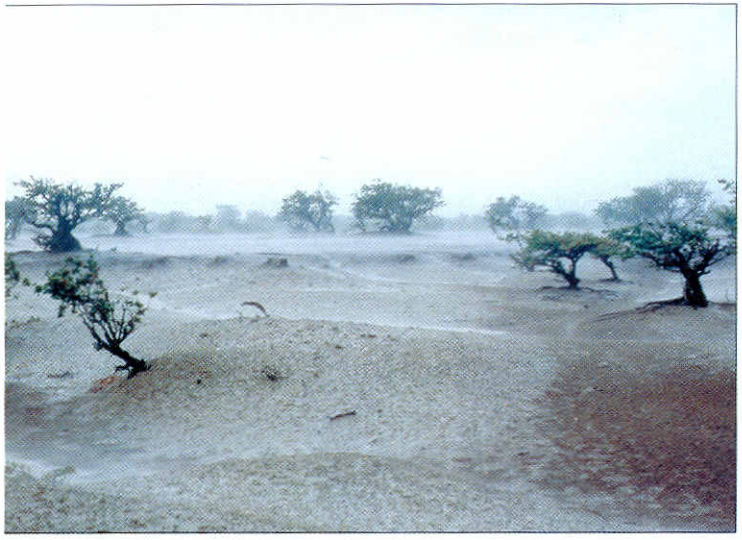
DROUGHTS ARE NORMAL IN NAMIBIA

Droughts have been recorded in Namibia over the length of its documented history. Early travellers such as C.H.L. Hahn recorded many deaths in northern Namibia as a result of drought which culminated in 1915-16 (171). In 1923 a commission on drought in Namibia investigated its occurrence and ways that people could prepare for drought and should react in a drought situation (225). During the period preceding their investigations, and for which the most information was available, they found that droughts had been experienced in: 1879, 1887-90, 1896, 1900-03, 1911, 1912-16, 1918-22. This represents 21 of 44 years, or almost half the time. Thus droughts in Namibia in the 1990s, or at any other time, should be expected.

An interesting observation of the Commission was 'it was not from want of water that stock died during the droughts, but from the want of veld.' It is clear today that few lessons from 70 years ago have been learned, and many suggestions made by the 1923 Drought Commission are still as applicable today as they were then. Drought preparedness must be an essential component of planning, by individuals and government, in a country where drought occurs naturally and frequently.

▶ What's important about rainfall, evaporation and drought in the western catchments?

- Rainfall decreases from east to west along the length of all the western catchments. Thus floods, originating from heavy rains in the upper catchments, provide essential water and food resources for people, livestock and wildlife living within the lower desert reaches of these rivers.
- As rainfall decreases towards the west, the variability in annual rainfall increases. The mean is therefore not a good indicator of the rainfall that we can expect from year to year. It is more realistic to know the range of rainfall that is possible for a region and to plan resource use expecting any rainfall within this range.
- Nomadic movement, of people, livestock and wildlife in response to rain, is an effective means of ensuring sufficient fodder in a dry and variable environment where rains may not fall in a particular area from one year to the next.
- Drought (more than two years with rainfall lower than the long-term mean) is normal in the western catchments. Farmers must therefore be prepared to remove livestock from the veld, each year if necessary, to prevent overuse of the natural resources during droughts. Risk in dryland farming is extremely high, and success is difficult to achieve.
- Decision makers and planners must be aware that the climatic variability found in the western catchments makes appropriate land use planning and drought preparedness essential in order to avoid over-use of the land, veld degradation, and disasterous famines.



Rainwater striking the ground near Sesfontein is a welcome sight. This water fills the spaces between the soil particles, slowly sinking downward into the soil column.

When water pools on sloping surfaces it immediately begins to flow downhill in small streams. As these streams of water converge they become larger and can carry away soil and organic matter. Within the western catchments, such small streams are the beginning of large floods downriver - if the rain continues to fall!

Runoff, Floods and River flow

Rainfall and runoff

Summer rains in western Namibia usually come from huge thunderstorm clouds which fill the sky with moisture, lightning and thunder. Rainfall reaching the dry earth seeps into the soil, filling air spaces between soil particles with water. As rain water moves downward to fill spaces below the soil surface, rainfall continues to soak the upper surface. If the rainfall is soft and gentle, the infiltration rate of the soil (how rapidly water moves into the soil) may be fast enough so that most of the rain soaks into the soil. However, thunderclouds over western Namibia usually produce heavy downpours, during which the rate of rainfall hitting the earth's surface is much faster than water can infiltrate into the soil. Excess water then begins to form pools on the surface in small dips and depressions. If heavy rain continues to fall, water fills these small depressions and begins to flow downhill as runoff. Flowing water, moving rapidly downhill, picks up anything in its path that it can carry, such as soil (and associated nutrients and salts), small stones, grass seeds, old pieces of grass, and sticks.

When the rate at which water soaks into the soil is slower than the rate at which it falls as rain, pools begin to form on the surface, seen here near Sesfontein. If the spaces between soil particles have been compacted by livestock walking over the surface, or clogged by fine silts, pooling may occur very quickly. The result may be that little water will enter the soil, most either flowing away or evaporating from the surface.

How rapidly runoff forms and flow begins depends upon rainfall intensity, infiltration rates of the surface upon which it falls, as well as the slope of the surface. Rain that falls on bare rock immediately forms pools and thus rainwater flows rapidly off the rock hills of western Namibia in small streams. As these streams merge on lower ground, they become larger and are able to pick up and carry even more debris and soil.

Runoff draining the land enters channel systems which carry it downhill within the catchment. These small channels merge, forming larger channels or tributaries, finally creating one main channel draining the catchment: the river for which the catchment is named. Because dryland rivers are dependent on seasonal rains for their flows, they usually only flow during the wet season and are known as ephemeral rivers. Exceptions are small spring-fed streams, such as that at Kaoko-Otavi in the Hoarusib, which flow in parts of ephemeral rivers all year round. These small surface streams are caused by bedrock interrupting the below-ground movement of water, forcing it to the surface. They are important sources of water for people, wildlife and livestock, particularly during the long dry season.

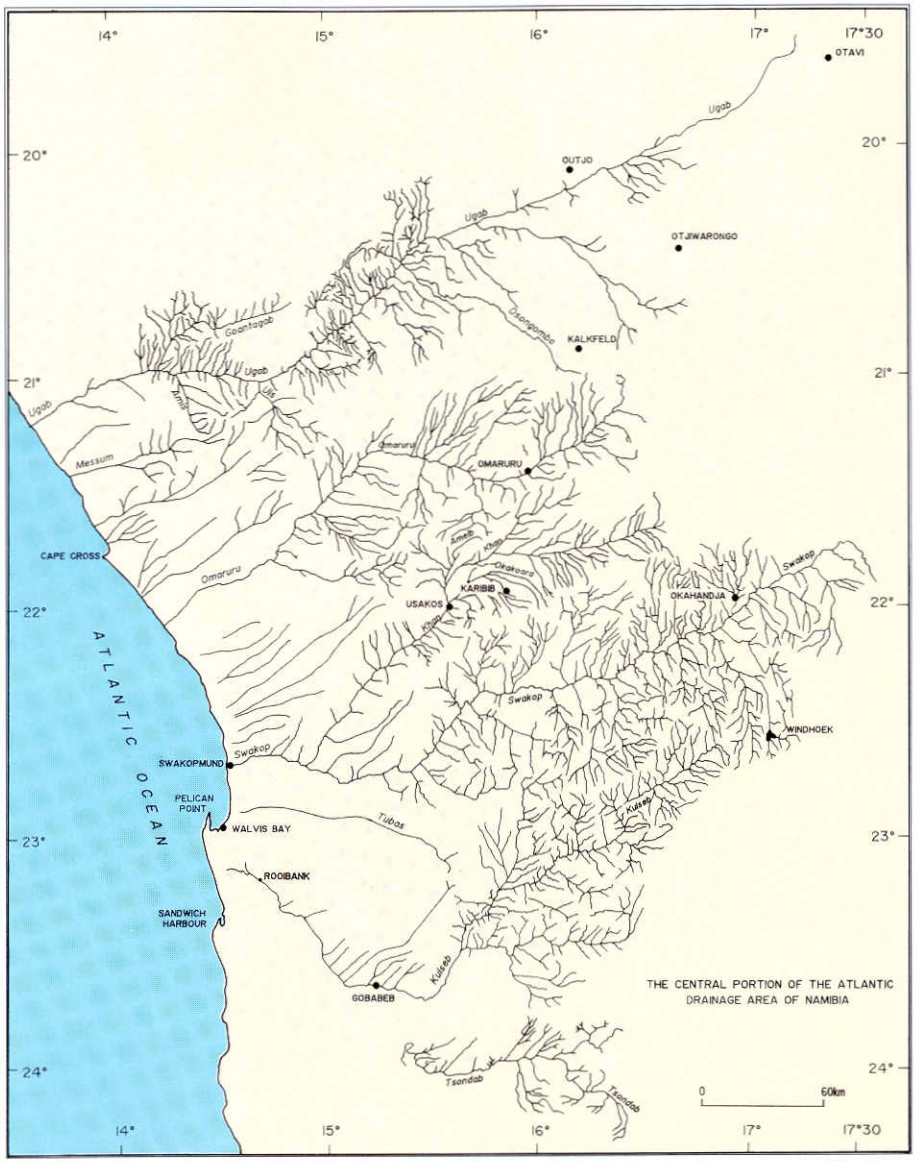
In contrast to the 12 large ephemeral rivers, the westward flowing perennial rivers, the Kunene and the Orange, are very long rivers which start outside the dryland zone in the highlands of Angola and Lesotho, respectively. Because of their very large catchments

and high rainfall in their upper reaches, these rivers flow across the drylands of the west year round, unless water flow is altered by dams or severe drought.

Floods and river flow

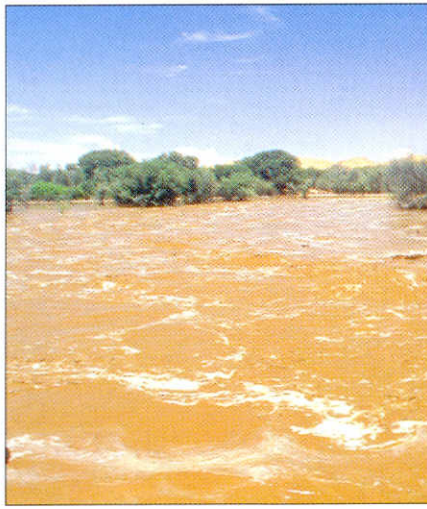
A flood is a body of water which temporarily covers land that is usually dry throughout the year. As a result, floods of perennial and ephemeral rivers are very different. A flood of a perennial river such as the Orange is caused by a seasonal increase in water which causes the river to overflow its banks and cover land that is normally dry. The flood continues as long as this land, the floodplain, is under water. In contrast, in ephemeral rivers a flood occurs whenever there is water in the normally dry channel, and the flood continues until water flow finally stops.

Floods on perennial rivers, those with water flowing in the channel year round, occur when the water level slowly increases in response to upstream runoff, often over a period of several months. The river is said to be in flood when it overflows the dry season channel and enters the vegetated floodplain. Here the Okavango River's annual flood is slowly beginning to recede in early May. (photo: D du Toit)



When rain falls over a catchment, any resultant runoff is channeled into a series of small streams and rivers. These channels eventually join one another to form the main course of the river, for which the catchment is named. These channels, the small streams and rivers feeding water into the main channel further downstream, are referred to as tributaries. This map shows the many tributaries of the Tsondab, Kuiseb, Swakop, Omaruru and Ugab Rivers (204).

A flood on an ephemeral river occurs whenever the normally dry channel fills with water, as can be seen here at Gobabeb on the Kuiseb River, dry and in flood.



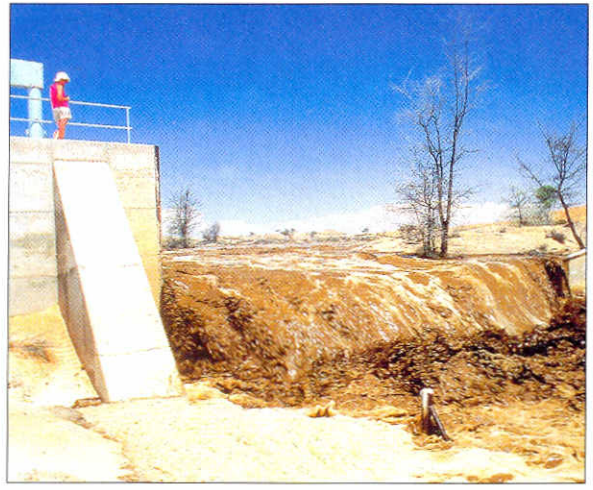
Flood discharge: The rate at which water is transported in a river channel is called the river's discharge. Discharge can vary depending upon the amount and pattern of rainfall in the catchment as well as where along the river's course you measure it. In Namibia, the Department of Water Affairs measures discharge at a number of stations in the western catchments using automatic recorders. These recorders are installed at places where the width of the channel is fixed, usually by rock walls. The recorder is placed on the edge of the river where it monitors the depth of water flowing through the channel. This record, traced on a chart within the recorder, is called a hydrograph.

Determining the discharge at a site requires a knowledge of both the channel's cross-sectional area and the water's velocity. Measuring the velocity of each flood would be a difficult and time-consuming task. Rather, by measuring flood water depth and velocity, as the depth varies over the flood, hydrologists develop a 'rating curve' - relating depth of flood water to its velocity at a particular point along the river's length. Once this rating curve has been developed for a station, the hydrograph, which simply measures water depth during the flood, provides all necessary information for determining a river's discharge (65).

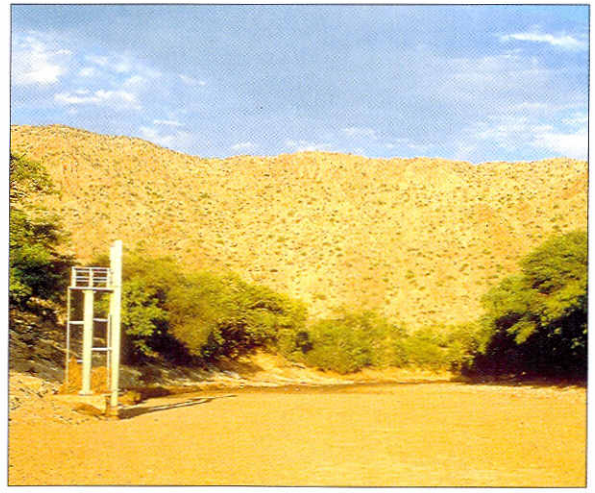
GAUGING STATIONS IN NAMIBIA'S RIVERS

One important aspect of recording river discharge is the need for a stable channel bed so that the channel shape does not vary. In many of Namibia's larger ephemeral rivers, the channel beds are composed of sand and gravel. As a result, the channel deepens as sediment is scoured away by the flood, and becomes shallower as other sediments are deposited. The recorder, measuring the surface position of the flood water, cannot account for this variation in channel size and, as a result, the hydrograph may not reflect the true volume of water passing the station. This problem can be solved by constructing a stable channel at the station. These concrete structures, known as weirs, usually eliminate measurement problems associated with sandy river beds.

Although many western rivers have weirs associated with at least some of their recording stations, the more remote rivers do not. The Hoarusib River, for example, has five recording stations but no weirs. As a result, the hydrological records from the catchment are poor and in high flow years the recording stations are often washed away. Construction of weirs at key stations would greatly improve the quality and reliability of data collected, but they can be very expensive, exceeding one million dollars each at present day costs (223). Nonetheless, sustainable management of Namibia's most important natural resource, water, demands collection of accurate information making such investments well worthwhile.



The Department of Water Affairs measures flood discharge at a number of stations along the western rivers. This is usually done via automatic recorders, such as the one housed in the blue box atop this concrete weir in the Kuiseb River downstream of Gobabeb. These data are essential if Namibia is to sustainably manage its scarce water resources.

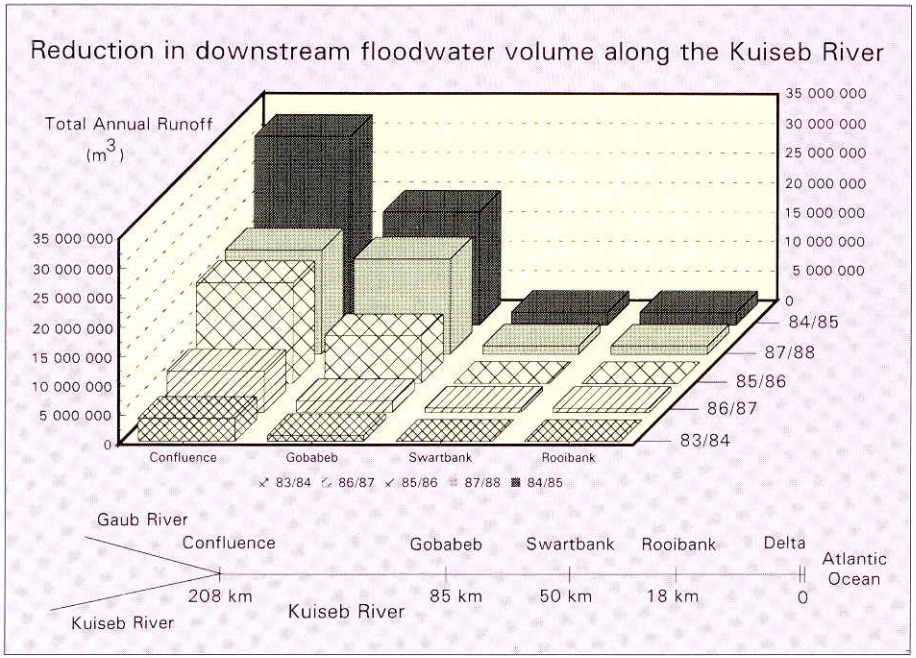


There are two basic types of discharge gauging stations in use on the western rivers, those with weirs and those without. Stations without weirs are referred to as open channel stations, such as the one here on the Hoanib River in the Khowarib Schlucht.

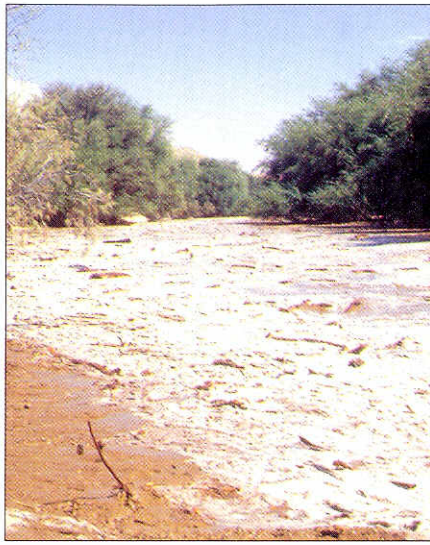
Discharge decreases downstream in ephemeral rivers: Runoff from the catchment enters channel systems which guide it downhill. Small channels merge into larger channels and finally into one main channel draining the catchment. As a result, discharge within river catchments generally increases downstream. Although this rule holds true for perennial rivers, it does not apply to ephemeral river systems. Discharge increases up to a point within an ephemeral river catchment, but it soon begins to decrease because of the combined effects of evaporation and infiltration (67). Infiltration, seepage of water into the channel bed, is the main factor contributing to downstream decline in discharge. The large volumes of sandy and gravelly alluvial deposits, typically associated with channel beds of these systems, fill with water as the flood passes. Infiltration and evaporation is so great that, in many floods on larger rivers, discharge stops before the flood reaches the river's end.

Discharge varies from flood to flood: Discharge in the western rivers is highly variable and can generally be described as: a flash flood, a single peak flood, or a multiple peak flood (67). Flash floods are stream flows which increase from zero to peak discharge within several minutes, and have a rapidly advancing bore or wall of water. This wall of water typically carries large amounts of organic debris with a frothy foam created from turbulence of the flow. These floods generally last for less than a few hours. Flash floods are associated with strong thunderstorms and, because most thunderstorm cells are relatively small with diameters of about 8km, flash floods are usually restricted to basins of less than 100 square kilometers (67).

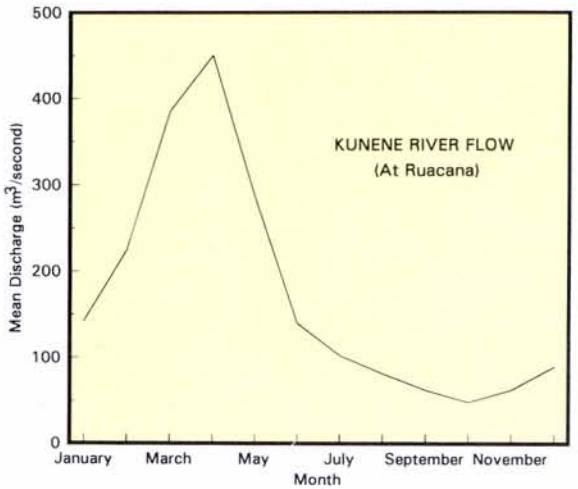
Single peak floods are longer than flash floods, lasting several days to several weeks, depending on rainfall patterns over the catchment. These floods result from broad fronts of precipitation covering thousands of square kilometres. Rainfall over such a large region causes an initial high peak in the river's discharge which then subsides to a lower stable level of flow for a time before stopping entirely. Such a flood occurred in the Khan River, a tributary of the Swakop River, in 1985. At peak flooding, the western approach to the Usakos bridge over the Khan River was washed away disrupting traffic to Swakopmund for many days. Multiple peak floods result from consecutive rainfalls over many days or in different parts of the catchment. These floods are characterised by steady flow interspersed with peaks from different rain events in the catchment.



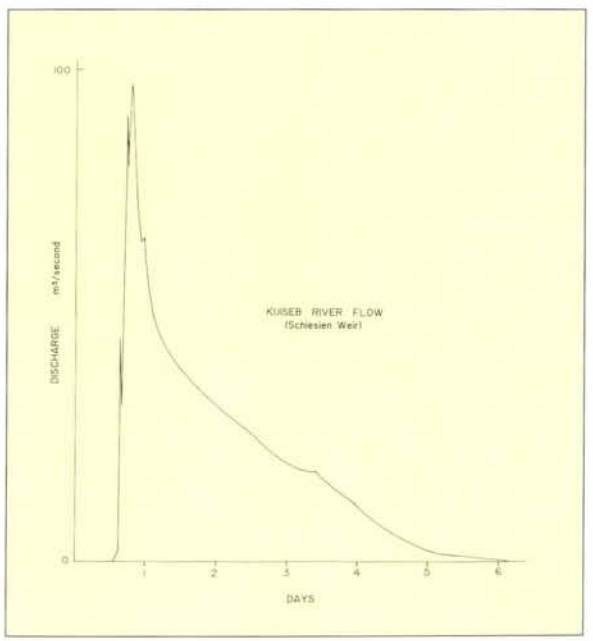
This graph portrays the downstream decrease in flood water volume during five different years on the Kuiseb River. Although the total volume of water varied between years, the pattern of a rapid downstream decrease in volume remained the same. (Source: DWA records)



These two pictures are of the same flood, taken shortly after the front edge of the flood passed two sites, one near Gobabeb (above) and the other approximately 70 km downstream near Rooibank. Both pictures show the flood at its maximum level and reveal the large decrease in discharge which usually occurs, a result of infiltration and evaporation, as a flood travels downstream. ▲ ▼



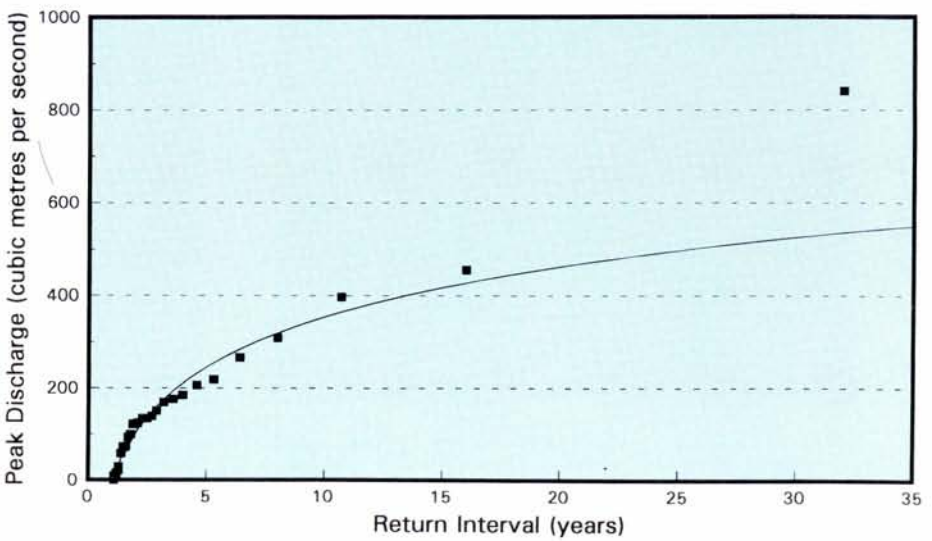
These two hydrographs reveal the difference between floods on perennial rivers, such as the Kunene, and floods on ephemeral rivers, such as the Kuiseb. Perennial river floods exhibit a gradual rise and recession in discharge, often over several months. In contrast, floods on ephemeral rivers reach peak discharge very quickly, followed by a rapid recession over a few days. (Source: DWA records).



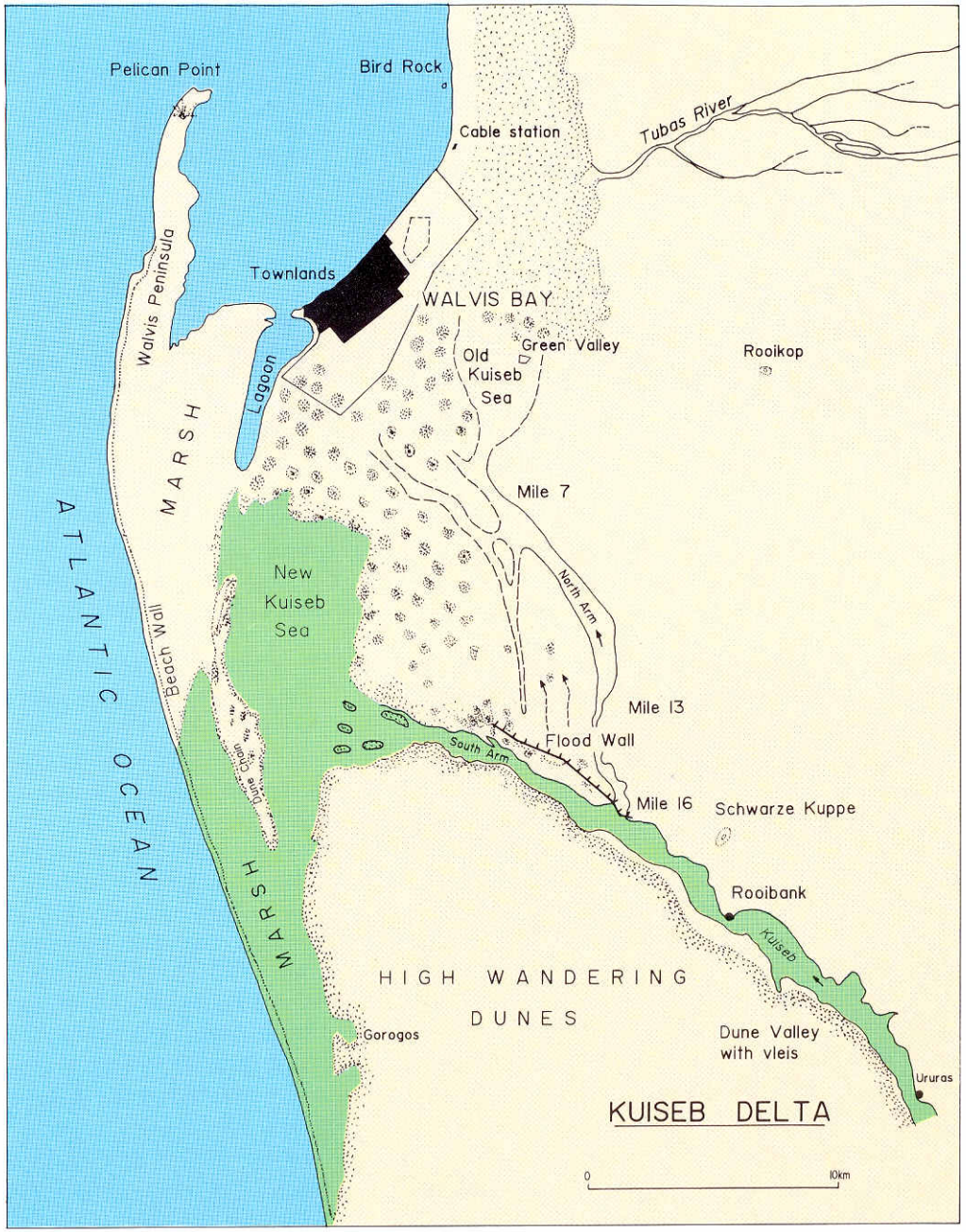
Flood Frequency: How often we can expect floods of a particular volume is a question frequently asked about very large floods because they usually overflow river banks and remind us of the dangers of building structures in a river's floodplain. The town of Walvis Bay lies in the Kuiseb River floodplain at the river mouth. During the 1934 flood the town was filled with water, and people moved between their houses in boats for weeks. In 1962, the town engineers decided to erect a diversion wall in the Kuiseb River channel to protect the town from large floods. This wall was erected just in time as the 1963 flood would have flooded the town again. Instead the diverted water formed a massive lake in the dunes that lasted for months.

How often can we expect floods of this magnitude? A common way of expressing information about flood frequency is through a flood frequency curve. This curve is a graph presenting the sizes of floods plotted against their return intervals, or how frequently they occur. An obvious and serious constraint to determining the frequency of floods is the length of our record of past floods. Once again, as with long-term rainfall data, the understanding of our resource base is hindered by lack of a long-term record, particularly given the high variability in flooding which is normal for arid land rivers.

Large floods, such as the 1934 flood of the Kuiseb River which inundated Walvis Bay, do not happen very often. (photo: K Bethune)



A flood frequency curve allows us to estimate how often a flood of a particular magnitude is likely to reoccur. This curve, based upon 33 years of records from the Kuiseb River's Schlesien Weir, shows that a flood with a discharge of 200 m³/s will typically reoccur once every five years. The return interval of a flood as big as that of 1963 (800 m³/s) cannot be accurately characterised without a longer record. (Source: DWA records)



In response to occasional floods of the Kuiseb inundating Walvis Bay, a flood protection wall was built in 1962. This long, concrete wall was constructed in the northern arm of the river, diverting flow westward into the dunes. The next year, 1963, a large flood was successfully diverted by the wall, forming a massive lake behind the dunes close to the sea. This lake lasted for months before finally drying and disappearing into the sands.

Palaeohydrology, climate change and floods

Palaeohydrology is the study of floods and flooding under past climatic conditions. Of particular interest are relationships between rainfall, temperature, run-off, and sediment yields from catchments. The basic approach of such studies is to understand present hydrological processes from sedimentological and geohydrological clues and then to use this understanding to search for ancient evidence which can be used to infer past processes and climates. Some of the types of evidence used are the dimensions of ancient channels and sediment deposits associated with drainage channels, as well as dates using various techniques that can be applied to sediments and aquifers. Classic sediment examples are the large silt and gravel deposits which occur in virtually all of the western river catchments, such as the Clay Castles in the Hoarusib (228), the Amsport silts in the Hoanib (228), and the Homeb silts in the Kuiseb River (194).

Although water associated with ancient storms and floods has long since drained from the land, it may be stored beneath it, offering clues to past climates. A classic example is the Koichab River aquifer which supplies water to Lüderitz. The Koichab is a small river, draining westward into the southern part of the main Namib Sand Sea. The river rarely flows now as its catchment is very dry, but the large aquifer suggests that this has not always been such an arid landscape. By using radiocarbon dating, scientists have determined that water in the aquifer averages from 5 000 to 7 000 years of age, which corresponds to the last wet phase of the Holocene, approximately 6 000 years before present (91). The presence of calcified reed beds and stone age tools in the area also testifies to at least a temporarily wetter climate.

Characteristics of Floods on the Kuiseb River

Recording Station	Average Month of First Flood	Average No. of Floods / Year	Average Runoff (m^3)	Distance from Delta (km)
Us	December	5	6 000 000	360
Schlesien	January	3	16 000 000	250
Gobabeb	January	2	4 500 000	85
Swartbank	February	1	1 750 000	50
Rooibank	February	1	570 000	18

Adapted from DWA Hydrological Records

The pattern and characteristics of floods observed in recent years on the Kuiseb River is a function of the current climate patterns over the catchment and the region as a whole. Any changes in rainfall patterns over the catchment will in turn be reflected in changes in the characteristics of floods within the river.

Large silt deposits found in many of the western rivers, such as this one on the Kuiseb River at Homeb, remind us that Namibia's climate has varied over the millennia. Deposited more than 20 000 years ago, these silts are indicative of a wetter climate within the upper catchment than that which exists today (194).

In present-day ephemeral rivers we can see the effect that changes in discharge and flooding frequency have on downstream travel of a flood. Because flood discharge in ephemeral rivers decreases downstream, changes in the size of an individual flood affects the distance it travels in the river bed. Larger floods from higher rainfall travel farther downstream than smaller floods from low rainfall. If no floods have occurred recently, infiltration from a flood will be high as it travels downstream, shortening the distance it will travel. In contrast, if a previous flood has saturated the sandy alluvial deposits of the river bed, infiltration will be low and the flood will travel further than a previous flood of the same volume. Thus any changes in flood size or frequency (the hydrological regimes) can alter water availability in the downstream reaches of a river. The proposed dams on the Ugab River at Sebraskop, and on the Kuiseb River at Donkersan (190), will (if constructed) radically alter the hydrological regime of these rivers (193). In the western catchments of Namibia, downstream water users affected by such changes include farmers, villages, towns and industry, tourism facilities, and the riparian forests, livestock and wildlife that depend on this water.

From palaeohydrological evidence, as well as present-day observations of flooding, it is clear that variability is a normal part of Namibia's climate. Therefore, as Namibia attempts to meet the challenges associated with land use and long-term water supply planning, a thorough understanding of the arid climate and its past and present variability is essential. Any attempts at land- and water-use management which do not account for short and long-term climatic variation, are doomed to fail.

CLIMATE CHANGE AND WATER SUPPLY MANAGEMENT

In semi-arid regions, the relationship between precipitation and runoff is known to be nonlinear (132). Small variations in rainfall caused by global weather phenomena, such as the El Nino-Southern Oscillation, can produce large changes in total runoff. As a result, the catchments of the western-flowing ephemeral rivers of Namibia may be very sensitive to changes in regional climates within southern Africa. Small changes in rainfall could produce major changes in hydrology affecting downstream plant communities, agricultural systems, water supply schemes, and conservation and tourism areas. Although such changes are difficult to predict, the possibility of their occurrence should encourage us not to manage our water resources at their limits. Sufficient resource reserves must be available to account for such variations and we must be prepared to adapt our management systems should they occur.

PALAEOCHANNELS AND GROUNDWATER SUPPLY

Sediment transported by floods is deposited downstream in the river as the flood's discharge decreases over time. Such sedimentation can give rise to the formation of new channels as the river course changes, with the older sediment-filled channel lying nearby. In the Omaruru River delta at Henties Bay, four such ancient palaeochannels occur, now covered by the present alluvial plains. Some of these palaeochannels are filled with coarse gravels, forming storage reservoirs (aquifers) for groundwater. One of these channels is regularly recharged by floods of the present Omaruru River course and contains groundwater suitable for human consumption. This aquifer is used to supply water to Henties Bay, Swakopmund and Rössing Mine.

Geological processes over considerable lengths of time (millions of years) can also change the course of a river. It is thought that the Omaruru River once flowed further north than its present course. These old palaeochannels north of the river, now covered by extensive alluvial plains, are found from the Omdel Dam upstream to Nei-Neis (217).

Recent geohydrological investigations, carried out by the Department of Water Affairs in the Sand Sea south of the Kuiseb River, indicate the presence of numerous palaeochannels of the Kuiseb River. It appears, however, that these channels contain little water of use for human consumption (217).

▶ What's important about runoff, floods and river flow in the western catchments?

- *Ephemeral rivers flow only for short periods after heavy rains have fallen in their catchments. Throughout the rest of the year the river surface is dry, but water stored beneath the river channel provides essential water for both farmers and the many towns on or near the rivers. The riparian forests that line the river banks deep into the desert, are also supported by this water and are important fodder resources for wildlife and livestock in western Namibia.*

- *Because the riverine resources are crucial for survival in the western drylands, understanding the relationship between rainfall and runoff, and flood discharge and frequency, is essential.*

- *Land-use planning and rangeland management policies must bear in mind the relationship between rainfall, runoff and vegetation growth to ensure optimal water conservation and use.*

- *Because of the importance of an accurate understanding of ephemeral river hydrology, an expanded and more evenly distributed network of automatic recorders to measure discharge should be installed within the 12 major ephemeral rivers and monitored on a long-term basis. This information is needed to plan a more equitable distribution of water resources within ephemeral catchments and to guide informed decisions about where and by whom these limited water resources should be used.*

- *Determining sustainable yields from ephemeral river aquifers, such as that of the lower Kuiseb and Omaruru Rivers, requires an understanding of the recharge rate of the aquifer. The Department of Water Affairs maintains a long-term record of measurements of aquifer recharge rates, especially those being used for bulk water supply to towns and villages. These records are essential to ensure the sustainable use of Namibia's limited water resources.*

- *If dams are built in the upper catchments, the river's discharge and flood frequency will decrease, resulting in less recharge to downstream aquifers. This in turn will decrease, and potentially eliminate, the amount of water available for downstream users: towns, farmers, riparian forests, wildlife, and livestock. Ultimately all Namibians who depend on these resources, through direct consumption or indirectly through tourist revenues, will be affected by these losses. Loss of water and food resources, as well as livelihoods, must therefore be carefully considered when dams are planned, and the cost of appropriate compensation to these downstream users included in the opportunity cost of the development.*

- *Variability is a normal part of Namibia's arid climate. Any attempts to develop land- and water-use management plans in the western catchments must account for the finite nature of the resources and the effects of short and long-term climatic variation.*

Water Resources

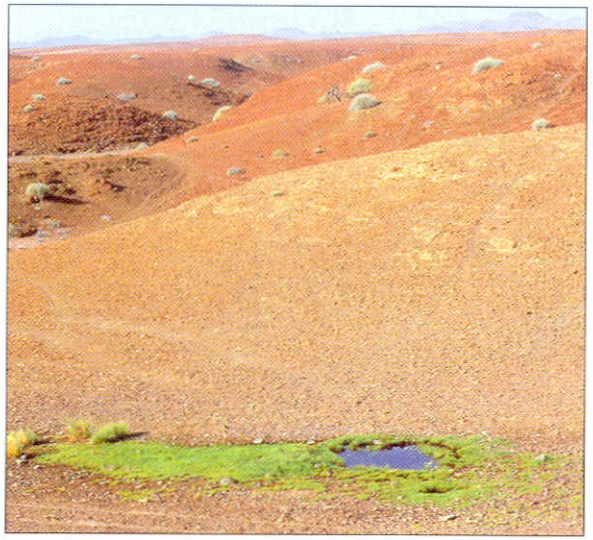
Surface water

One unique feature of the western catchments is their abundance of small streams and springs. Within river beds, small streams are fed by sub-surface river flow, whereas out in the catchment, springs are usually associated with groundwater emergence related to the surrounding geological features. Although such features have limited significance to large scale development of agriculture or industry, they are of critical importance to wildlife and people living in these arid regions.

Springs occur throughout all the catchments, associated with a wide range of geological formations. Some are large and have high flow rates, forming small streams originating at the discharge point and flowing for varying distances before the water is lost to evaporation and infiltration. Springs such as these, particularly those with high and constant flows, have served as points of human settlement in Namibia over past millennia. Archaeological artifacts, as well as names of towns and settlements (for example, Sesfontein, Twyfelfontein, Warmquelle), attest to this fact. In many cases these springs still may be important sources of water for small towns and regional settlements.

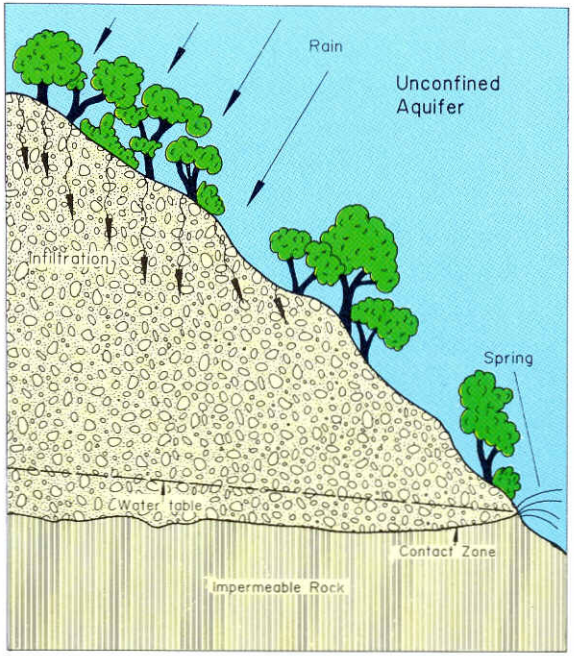
Some springs in the western catchments are thermal springs. Most famous is Gross Barmen in the Swakop catchment which now has been developed as a tourist resort. A number of springs in the area are saline, unfit as water sources for people, livestock, and sometimes even wildlife. Such springs are attractive to tourists, however, who come to view their unusual salt deposits and specially adapted plant and animal life. Most of these springs occur in landscapes that invite tourists to photograph their spectacular scenery.

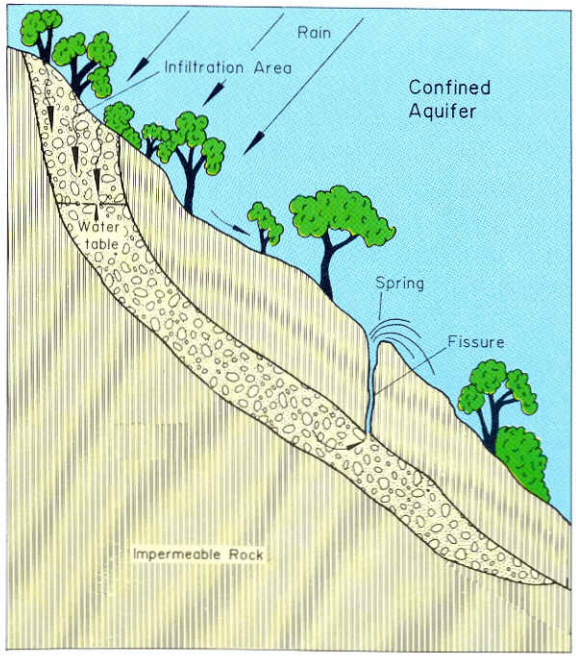
Discharge from springs may vary from year to year, in response to rainfall fluctuations. The response is often delayed, however, with springs drying up or becoming active only several months or years after the change in rainfall. Many springs in the arid west of the catchments have dried up recently. In some cases this is a natural occurrence, associated with documented below average rainfall (83, 111, 236). In these areas springs will probably recover with the return of higher rainfall. In other cases, however, disappearance of springs has been associated with groundwater withdrawal from boreholes, or with the springs being dug out to obtain water for road construction. These springs may not recover during our lifetime.



Small springs, such as this one in the Uniab catchment, are a vital source of water for both people and wildlife in the western catchments.

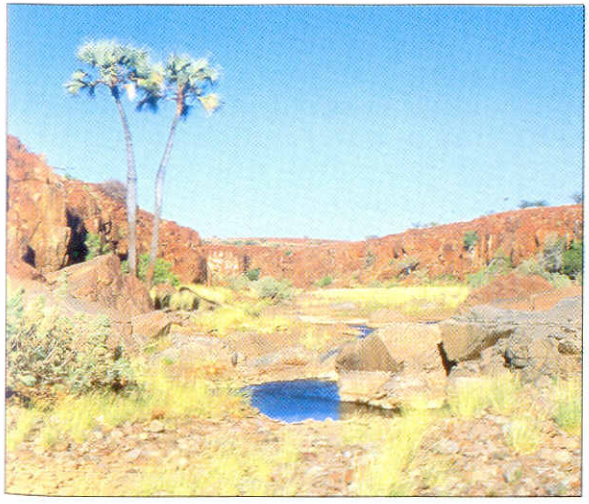
Springs occur throughout the catchments of the western rivers. Groundwater flows to the surface along contact zones between permeable and impermeable rock layers (unconfined aquifers) or is forced to the surface under pressure from within the permeable layers of rock in which it is stored (confined aquifers).





Pools and streams are also found throughout the west in ephemeral river beds. Although floods occurring during the rainy season may be brief and isolated, water movement continues below the surface of the channel throughout the year (70). The volume and rate of this subsurface flow varies widely from year to year and is never great, but where erosion-resistant rock formations cut across the river course, subsurface river flow is forced to the surface. Small pools or streams rise out of the dry channel and flow briefly on the surface, before disappearing again beneath the dry channel bed. If the bedrock is shallow and the subsurface flow is relatively high, water may flow year round. Alternatively, under low flow conditions, the stream or pool may persist for only a few weeks or months after a flood has passed. A spectacular example of a system which flows year round can be found at the Khowarib Schlucht in the Hoanib River, where flow continues for a few kilometres. Similar, albeit smaller, systems can be found in virtually all of the larger western rivers.

Floods passing through ephemeral rivers leave large pools in their path after they have passed, such as this one in the Uniab River near Palmwag. These pools, typically lasting for several weeks to several months, are an important resource for wildlife. In deeper canyons, and where fed by groundwater flow, such pools can remain throughout the year.



Any change in climate or hydrology, which alters flooding frequency, discharge and sub-surface flow, will change the occurrence and flow of these pools and streams. Some systems seem particularly resilient to changes while others dry up rapidly in the absence of occasional flooding. The Huab River provides an important example where a long-term drop in regional rainfall, combined with construction of numerous farm dams, has resulted in the loss of perennial springs and wetlands in upper reaches of the river. Similar losses have occurred in the Swakop River following construction of the large Swakopport and Von Bach Dams, which reduced downstream flooding. Examples also exist in the Kuiseb River, which has experienced changes in its hydrological regime over the last century.

▲
Rainpools in the Uniab catchment are an unusual and welcome addition to the surface water resources of the western catchments. Pools such as these generally dry up within several days to weeks.

Wetlands occur in the western rivers wherever bedrock forces groundwater towards the surface. This site, at Opdraend on the Huab River, is an important watering point for the region's elephant.

▼

THE SUSTAINABLE USE OF GROUNDWATER

All groundwater ultimately comes from rainfall via recharge. Ideally, the sustainable yield from groundwater resources is equal to the amount of water replaced by natural processes (rainfall and runoff). If water is removed from an aquifer at a rate faster than it is replaced over the long-term, its use is unsustainable and the aquifer will eventually run dry. In Namibia, rainfall amounts are low and variable and therefore recharge of groundwater is infrequent and difficult to predict. Under such conditions, the development of groundwater resources for human consumption depends initially on best estimates of the sustainable yield of the aquifer. Ultimately, however, the accurate determination of the sustainable yield of an aquifer depends upon its behaviour under operational conditions. In short, although we initially calculated a theoretical best estimate of the sustainable yield, we must determine whether our estimate is correct and adjust the use of the groundwater resource accordingly. In order to do this effectively, accurate and regular monitoring of rainfall, runoff, groundwater recharge and groundwater abstraction is essential.

How does the geohydrologist actually do this? If a borehole is drilled into a hard rock formation and water is struck in a geological feature like a fracture or fault, the geohydrologist makes an estimate of the aquifer parameters by doing a pump test on the borehole. The volume of stored water and the possible recharge, (bearing the variable rainfall conditions in mind), are used to estimate the long-term safe yield of the borehole. The accuracy of such estimates becomes apparent only when the borehole has been in use for a number of years and all relevant factors have been monitored.

If for example the geohydrologist determines that the aquifer has a storage capacity of 20 000 cubic metres and that the borehole can yield three cubic metres of water per hour over ten hours per day (or 10 950 cubic metres per year), then to be on the safe side, the pump he or she installs should only be able to abstract two cubic metres per hour or 66% of the yield determined by the pumping test. This two cubic metre per hour estimate is regarded as the long-term sustainable yield of the borehole. By monitoring the quantity of water abstracted and the drawdown in the water table over many years, it will be possible to determine if the estimated safe yield of two cubic metres per hour is too high or too low.

The safe yield of alluvial aquifers in rivers should be determined in a similar fashion, in order to ensure sustainable use for current and future generations. The volume of sediment in an alluvial aquifer is measured and, based upon that, the volume of stored water is determined. The amount of water abstracted and the volume of water recharging the aquifer are determined by measuring the runoff in the river and the recharge across the surface of the aquifer. By monitoring the behaviour of such aquifers during their use, the theoretically estimated safe yield of the system is checked, and adjusted if necessary. The Swartbank aquifer in the lower Kuiseb River serves as an example where the estimated safe yield was reduced as a result of monitoring recharge and abstraction. Based upon information available in 1960, the estimated safe yield was determined to be 13 million cubic metres per annum. In 1990, based on 30 years of additional information, however, the safe yield was reduced to 3 million cubic metres per annum.

In the long-term, a borehole cannot supply more water than is replaced by rainfall. All groundwater resources which are recharged are renewable, but their sustainable yields are finite and determined ultimately by the prevailing climatic conditions. Pumping water out of a borehole at a higher rate or for more hours per day will certainly yield more water in the short term, but the aquifer will then be depleted sooner and the borehole will run dry. Sinking more boreholes into an aquifer will also yield more water in the short-term, but again this will only deplete the aquifer sooner. Groundwater resources cannot yield more water over the long-term than what is replaced by rainfall.

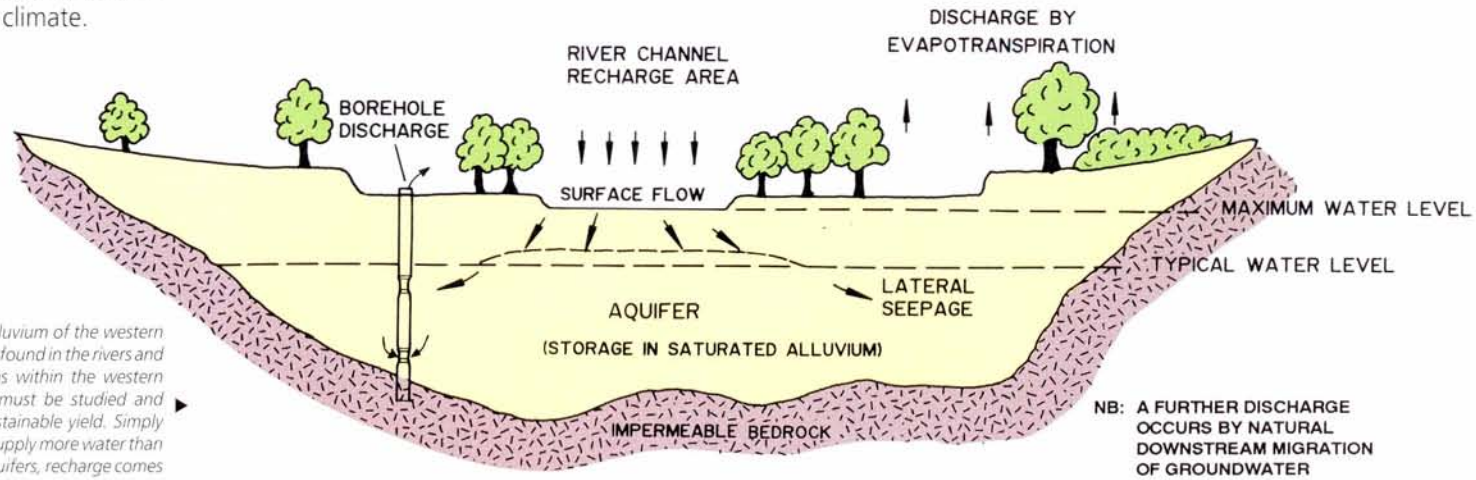
Namibia's groundwater is a finite resource. There are no oceans of water under the ground and our groundwater is not sufficient to supply the present domestic, environmental, livestock and industrial water demands. (Thus the use of groundwater for irrigation or recreational purposes is not sustainable and should not be encouraged.) Addressing the challenge of providing water to all Namibian citizens now requires new approaches. Our reliance on groundwater resources must shift to water supplied either from desalination plants or from long-distance transfers via pipeline (for example, from the Okavango River to Windhoek). The cost of such measures is high, however, and without effective efforts at reducing both the growth of water demand and the growth of Namibia's population, we may not succeed in maintaining the water resources upon which all Namibians depend.

Groundwater

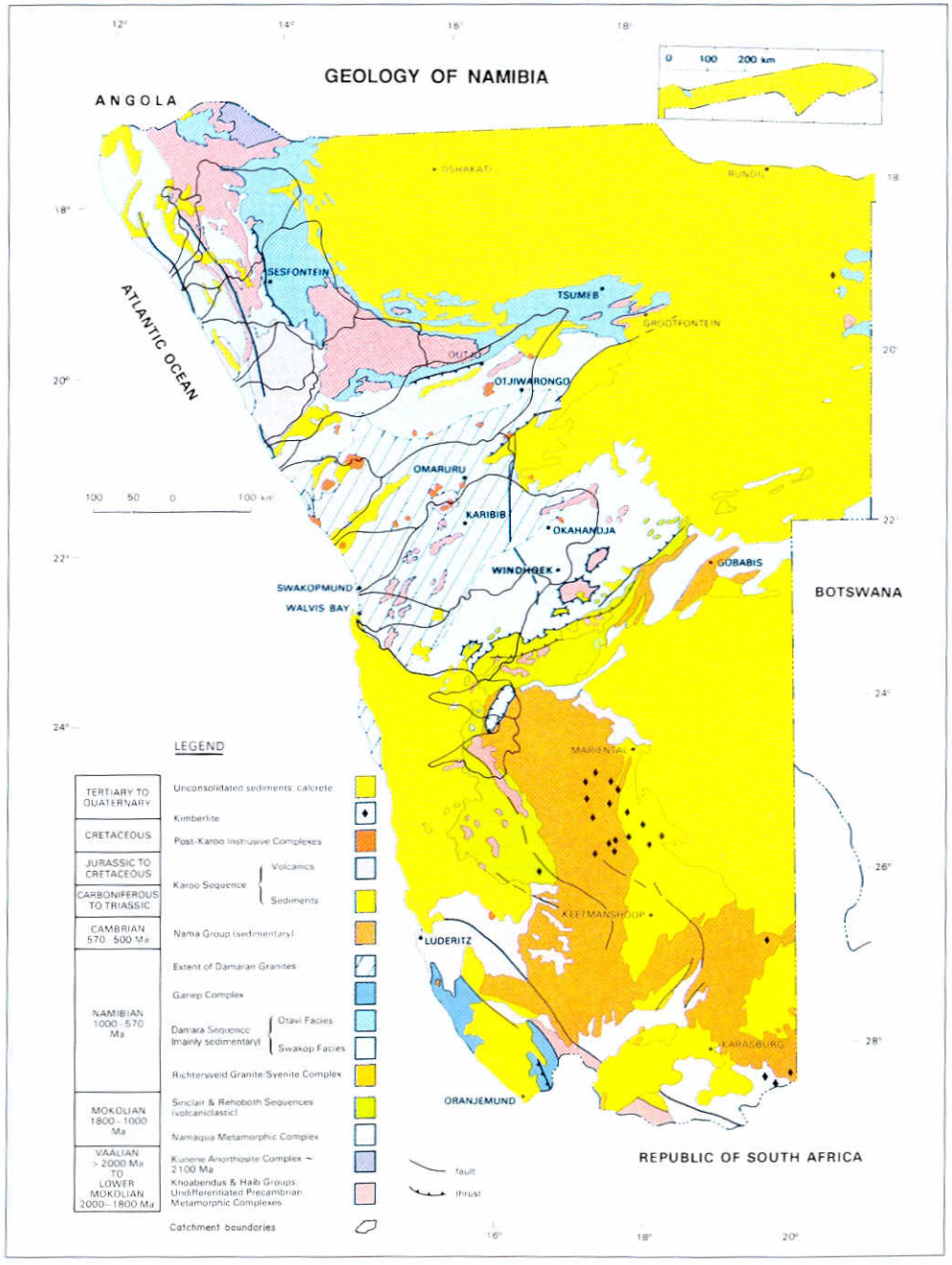
Although surface water in the midst of such arid landscapes is a striking sight, most water stored within the western catchments lies underground and out of sight. Groundwater in this region occurs in several geological environments: alluvial deposits of larger rivers, sediments representing a wide range of geological formations, and hard rocks where it typically occurs in small amounts associated with cracks and fissures (72). Groundwater stored within alluvial deposits is an important supply to the riparian forests which characterise lower reaches of the larger rivers (49, 233). It also is a critical source of water for development in western Namibia. The towns of Walvis Bay, Swakopmund, Henties Bay, Arandis, and the Rössing Mine are currently totally dependent upon water drawn from such alluvial aquifers in the Omaruru and Kuiseb Rivers (192). In addition, farmers throughout the western catchments depend on water pumped from wells or boreholes sunk along the banks of rivers and their tributaries. Such rivers form a lifeline in the arid western catchments, buffering plants, animals and people from the dry inhospitable climate.

▶ *What's important about surface and ground-water resources in the western catchments?*

- *While of no significance to large-scale development of agriculture or industry, small springs and streams that flow year round are essential for the survival of people, wildlife and livestock in the western catchments.*
- *Discharge from springs varies from year to year and deserves careful study. Recently many springs in the arid west have dried up completely, and it is unclear whether this is due to natural changes in rainfall and recharge, dams in the catchments, the withdrawal of groundwater from nearby boreholes, or the digging out of springs to obtain water for road construction.*
- *Information on recharge rates in alluvial aquifers is needed to help decision makers and planners at all levels use water wisely. Aquifers that are recharging only occasionally or not at all must receive particular attention. If water sources are insufficient to support residents, the people must be alerted in time, and encouraged to relocate to areas of Namibia where water is more abundant.*
- *All information gathered by the Department of Water Affairs from monitoring flood discharge, aquifer recharge and other aspects of water in the western ephemeral catchments is available on request. Decision makers at all levels including farmers, local, regional and national authorities, the tourism industry and other interested and affected parties should use this information to ensure the sustainable use of the country's limited water resources.*
- *Information on groundwater aquifers developed for smaller scale rural water supply for communal and private farmers, tourist resorts and other users should be gathered, incorporated into the information bank of the DWA and be available to all decision makers.*



Groundwater is stored within the sandy and gravelly alluvium of the western rivers. These aquifers maintain the dense riparian forests found in the rivers and are the major source of water for most of the towns within the western catchments. The hydrological balance in an aquifer must be studied and analysed very carefully to determine the long-term sustainable yield. Simply put, a groundwater resource cannot, in the long-term, supply more water than the quantity replaced by nature. In the case of alluvial aquifers, recharge comes from floods flowing through the channel. (Source: DWA)



The geological map of Namibia reveals that much of the country is covered by recent deposits of sand and calcrete. In contrast, the western catchments contain some of the most interesting geological features in the country. (Source: Geological Survey, Windhoek)

Geology, Soil, Vegetation and Wildlife

A Geological Wonderland

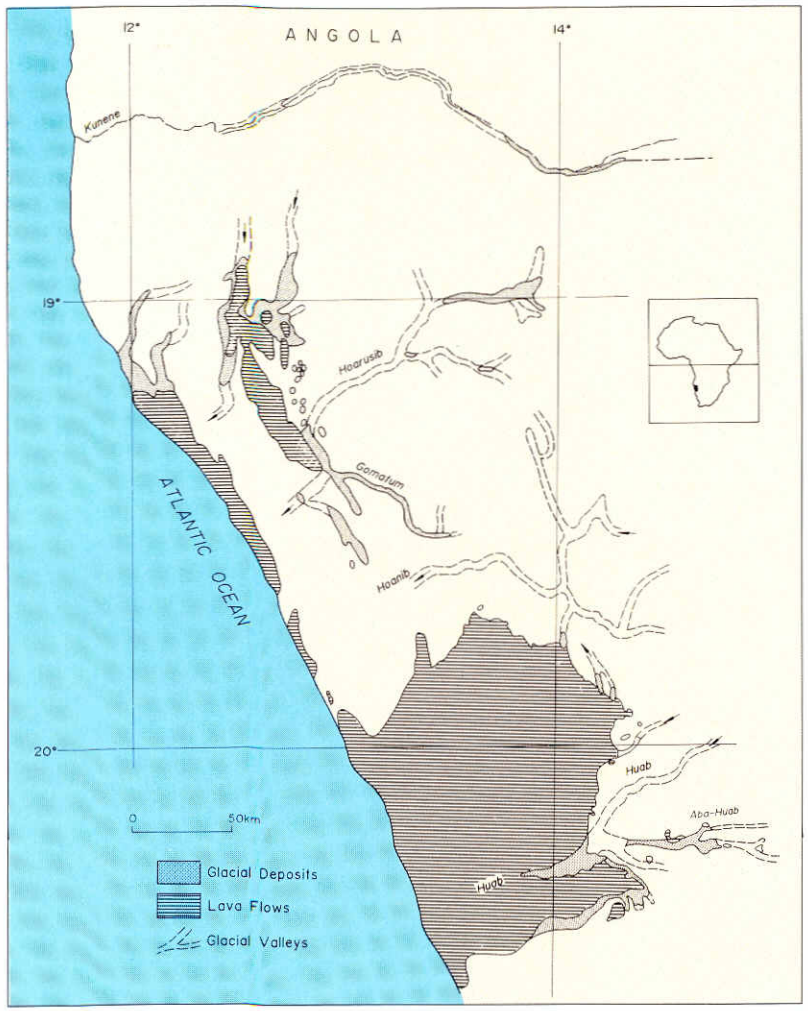
Any mention of soils must begin with a description of the parent material, or rocky substrate, from which soil is derived. Within the western catchments, that description makes for an exciting story. Although much of Namibia is covered by recent deposits of sand and calcretes, the west is different. Here much of the land is bare, because the harsh climate limits soil development and vegetation growth. As a result, an ancient landscape is visible on the surface. This landscape tells a story of collisions, fire, flood and ice; the story of a landscape shaped by colliding continents, volcanic eruptions, glacial advances, inundations by seas, continental break-up, flows of molten lava and finally, dissection by flowing rivers.

The oldest rocks within the western catchments are probably ancient granites and gneisses associated with the Kamanjab Inlier, within the Damaran Orogen west of Outjo (61). These formations, located in the upper Huab catchment, are thought to be nearly two billion years old. Similar rocks occur in the Swakop catchment.

The largest part of the western catchments is underlain by the Damaran Sequence, a group of rocks laid down approximately 850 to 500 million years ago. These rocks were subjected to considerable folding, faulting, and erosion before being covered by sedimentary deposits, followed by a long period of erosion (61). Collision of the Congo Craton and the South American continent gave rise to the Kaoko Belt, the coastal branch of the Damara Orogen, which gave rise to the mountains and folds that typify the western catchments (213).

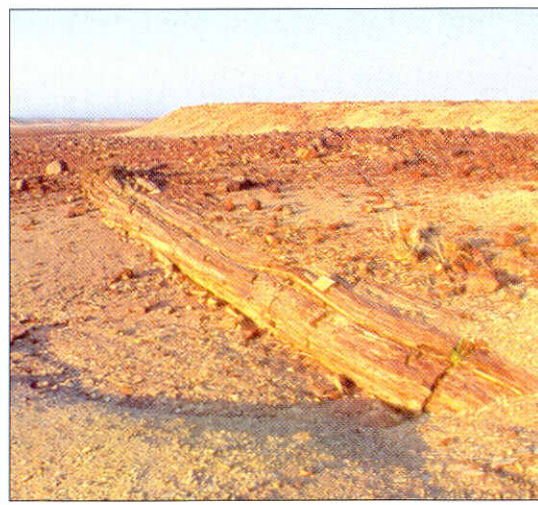
The Karoo period, from approximately 300 to 130 million years ago, is responsible for many striking components of the landscape seen today in the western catchments. The Karoo sediments in western Namibia, deposited from 300 to 130 million years ago, tell a remarkable story of changing climates, flora and fauna (78). At the base of the Karoo Sequence is the Permo-Carboniferous glaciation, when ice sheets are thought to have covered much of Namibia some 200 - 270 million years ago (119). Some of the best preserved relief related to glaciers is to be found in valleys of Kaokoland, particularly in the upper catchment of the Hoarusib River. These valleys, many with the U-shape glacial signature, contain glacially striated walls, remnants of glacial sediments, and glacial erratics (large rocks carried and dropped at random by moving ice). The direction of ice flow can be deduced from these features that indicate a westerly movement towards the present-day Atlantic Ocean. The position of glacial erratics at several places indicates that they were carried over ridges dividing present day catchments. This suggests that glaciers were not formed by a local ice cap or valley glacier. Rather, it is thought that the Kaokoveld glaciation developed as an outflow from an ice-filled interior, similar to conditions encountered today in Greenland. This ice sheet was situated further inland, possibly overlying the Etosha-Owamboland basin, where drilling has revealed glacial deposits (121). Small coal deposits in the western Huab catchment reveal a past cold and wet climate, with a plant community most similar to boreal bogs and wetlands of Canada. Other deposits reveal the presence of stromatolites, ancient algal communities formed in a marine basin or tidal lagoon.

Perhaps one of the most remarkable attributes of geology in western Namibia is its strong similarity to that which lies thousands of miles away in South America (120). Similarities in stratigraphy over large areas within the two continents are so striking that they



Glacial deposits and glacial valleys are found today within the Khumib, Hoarusib, Hoanib and Huab catchments - ancient reminders of the forces that have carved the landscapes we see today (121).

Although difficult to imagine today, scratches like these on rock surfaces within some of the western catchments were caused by glaciers 270 to 300 million years ago. (photo: R Swart)



Petrified logs, such as this one in the Ugab catchment, remind us that Namibia's climate has not always been hot and dry. In the western Huab catchment, coal deposits deep beneath the ground testify to former cool and wet climates in the region.

form one cornerstone of the theory of plate tectonics and the pre-existence of the supercontinent, Gondwana. Late Precambrian formations with ages of 1,000 to 500 million years are widespread on both sides of the Atlantic. In addition, large erratics of purple and red quartzites, which cannot be matched in Brazil, have been found in South American glacial deposits. Similar quartzites of pre-Karoo age are found in Kaokoland; these may have been the source of the South American rocks during the Permo-Carboniferous glaciation. Fossil remains of the aquatic Karoo reptile, *Mesosaurus tenuidens,* bivalves of the species *Terraia altissima,* Etjo-type sandstones and Etendeka volcanics are found in similar strata on both continents connecting the Karoo Basin of southern Africa with the Paraná Basin of South America.

The Etjo Sandstone Formation represents the uppermost sediments of the Karoo Sequence. This deposit, presumably derived from wind rather than water, overlies other Karoo sediments of the region, having been buried in many areas by flows of Etendeka lavas. With an age of approximately 133 million years, it shows a dramatic change in climate and development of a dune desert, probably over large areas of the country. Similar deposits are found at Etjo Mountain within the Omaruru catchment, where the tracks of dinosaurs are preserved in its surface, and atop the Gamsberg, in the Kuiseb catchment (232). Perhaps most striking are deposits at Twyfelfontein in the Huab catchment where engravings, done by prehistoric people in recent times, are preserved in ancient sandstone. In some areas ancient wind regimes can be deduced from sandstone structure, revealing identical patterns in both Namibia and South America.

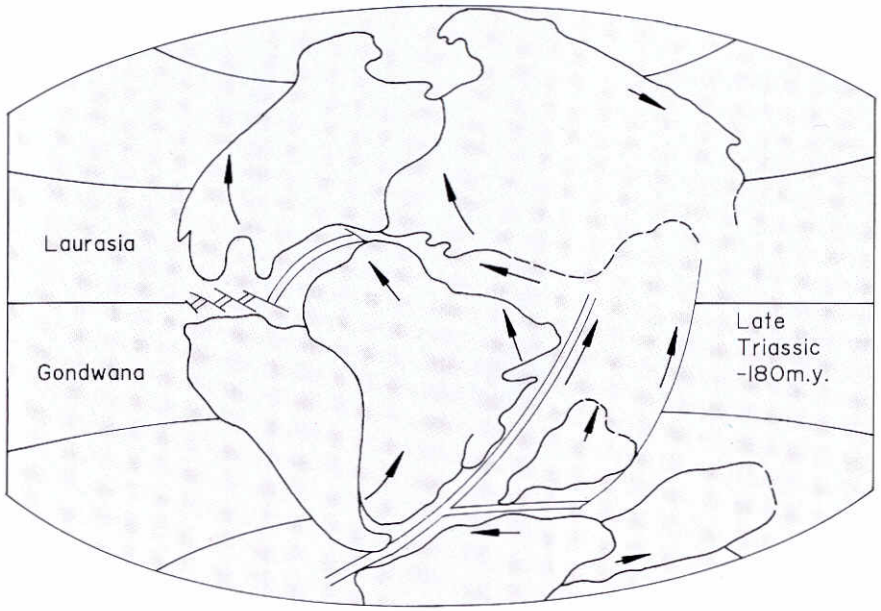
One of the most dramatic similarities linking the geology of Namibia with that in South America is the presence of massive basaltic lava flows. These lavas, which poured forth during the Cretaceous about 133 million years ago (120), cover large areas in Namibia, encompassing sections of many western catchments. The headwaters of the Uniab and Koigab catchments drain from these formations in the Grootberg Mountains. The largest volcanic deposits by far, however, lie in the Paraná Basin of South America, where an area of nearly two and a half million square kilometres was covered with lava. Nowhere else in the world have continental areas of comparable size been inundated by such large flows of basaltic lava (120). This molten rock, having cooled in fissures from which it poured forth, forms black dolerite dykes which are a common feature in the west, especially in the hills between the Spitzkoppe and Brandberg, in the Omaruru and Ugab catchments, respectively.

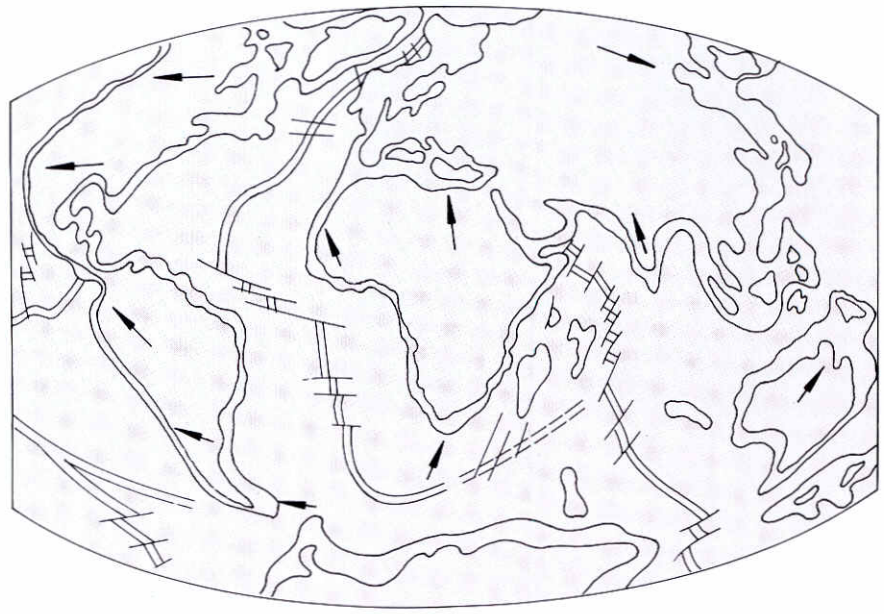
Dinosaurs roamed through western Namibia more than one hundred million years ago, leaving their tracks in today's Omaruru catchment, near the Etjo Mountain.

This outpouring of Karoo lavas and burst of volcanic activity, represented by the late- to post-Karoo granite dome complexes in Damaraland and elsewhere in Namibia, occurred in association with the final separation of the continents as Gondwana broke apart approximately 135 million years ago. When the intense period of volcanic activity associated with separation of Gondwana subsided, several large volcanoes remained. Large masses of granite entered and solidified in the bases of these structures. The actual volcanic cones have long since eroded away but masses of granite remain, forming some of the largest and most beautiful mountains in the country, including the Erongo, Spitzkoppe and the Brandberg, which is the highest mountain in Namibia, rising to 2 574 metres.

Following these dramatic periods of lava flows, volcanoes and continental separation came a less dramatic and long period of erosion, occurring in several phases associated with uplifts in the continent's surface (232). Many mountains and the Great Escarpment which we see today result from this erosion which has been ongoing for more than a hundred million years. Products of this erosion were transported both westwards to the Atlantic, as well as eastwards, where they filled the Kalahari basin with sand and gravel. The bulk of material was probably transported westward, however, although few traces remain today on land as most lies below the sea surface. Only along the larger rivers, such as the Ugab, do remains of this material occur as terrace deposits. Many of these deposits of gravel and sand are cemented together with calcium carbonate and are preserved as high-lying terraces. Deposits along the northern edge of the Ugab River, such as the Vingerklip, are particularly striking and are a popular destination for tourists.

Approximately 4 to 2 million years ago, change in the relative base level led to dramatic downcutting of the

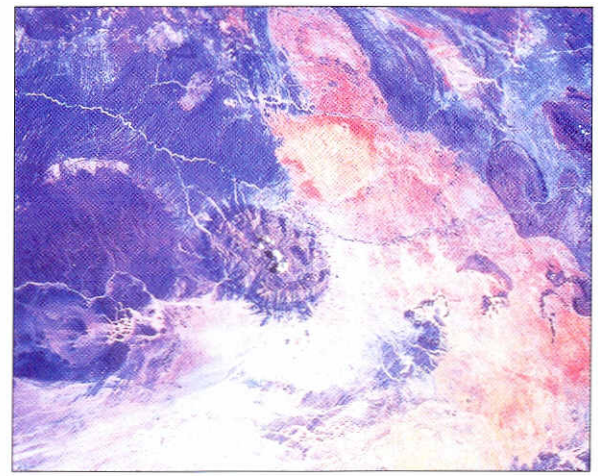




▲
A number of geological clues exist, including glacial deposits, lava flows, dinosaur bones and ancient sand dunes, to remind us that Namibia was once connected to the South American continent more than 130 million years ago (102).

major western rivers into the edge of the continent (232). This recent erosion created the deeply incised and dramatic canyons that we see today along larger western rivers such as the Kuiseb and Swakop. These rivers transect an ancient landscape, allowing us to a view an incredible cross section through the Damaran and Karoo rocks along their lengths. Associated with many rivers are gravels, deposited after this initial period of rapid erosion. These gravels provided the raw material for Stone Age industries, remains of which are associated with archaeological sites along all the western rivers (94). Raised beaches along the coastline, of Pleistocene age, are revealed by the presence of gravelly deposits from 5 to 50 metres above current sea level (155). These deposits are associated with fluctuations in sea level over the last two million years, as growth and melting of polar ice caps led to world-wide sea level fluctuations.

Since the Pleistocene, climate over the western catchments has remained largely arid to semi-arid. Periodic shifts in climate, between wetter and drier periods, are suggested by deposits of silts along many of the larger rivers (194, 228). As can be seen in some of the geology within the western catchments, Namibia's climate has always been variable.



The Ugab catchment is home to some of the most unusual geological features in southern Africa, including the Brandberg Mountain seen left of centre in this satellite view of the middle reach of the catchment. The so-called 'Mitten Fold', site of the proposed Sebraskop dam, can also be seen right of centre. (photo: CSIR Remote Sensing Centre, Pretoria)

What's important about the geology of the western catchments?

- *Dinosaurs tracks, petrified trees, and unique geological features tell stories of earthly change over the millennia. The interesting geology of the western catchments is currently unknown to most tourists visiting Namibia because of a lack of interpretive materials. The production of popular publications, guidebooks, and interpretive material on Namibia's geological resources would benefit efforts to develop Namibia's growing tourist industry.*
- *Aside from their value to the tourism industry, the geological features of the western catchments are the basis for many of Namibia's active mines and important mineral deposits. The economic and social benefits to be derived from mining these mineral resources must be carefully assessed against the opportunity costs associated with the high demands of many types of mining operations, and the potential for disruption of tourism revenues as a result of environmental degradation.*

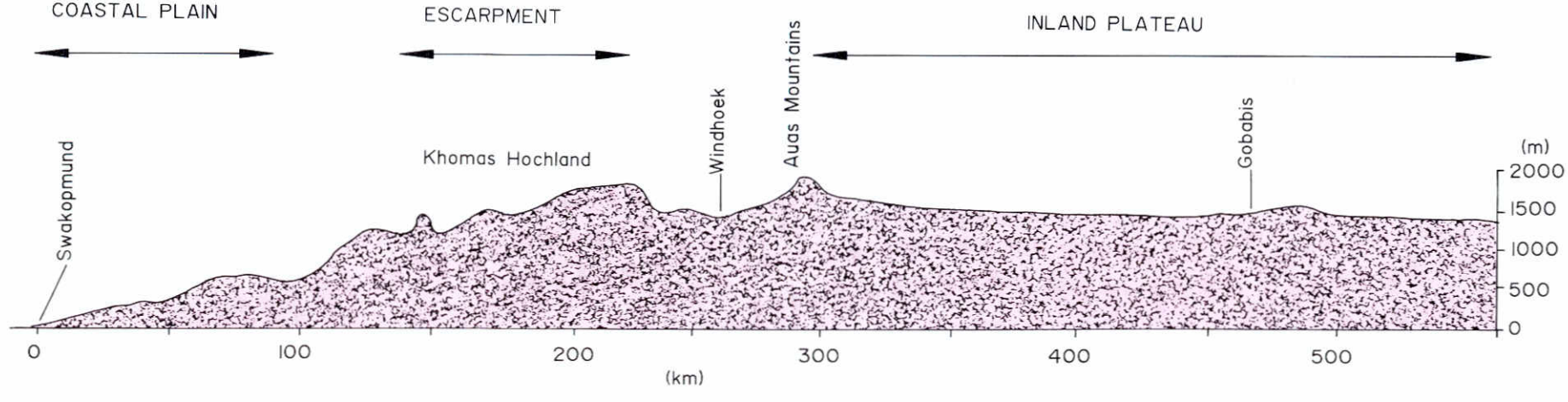
MINERAL DEPOSITS AND MINES

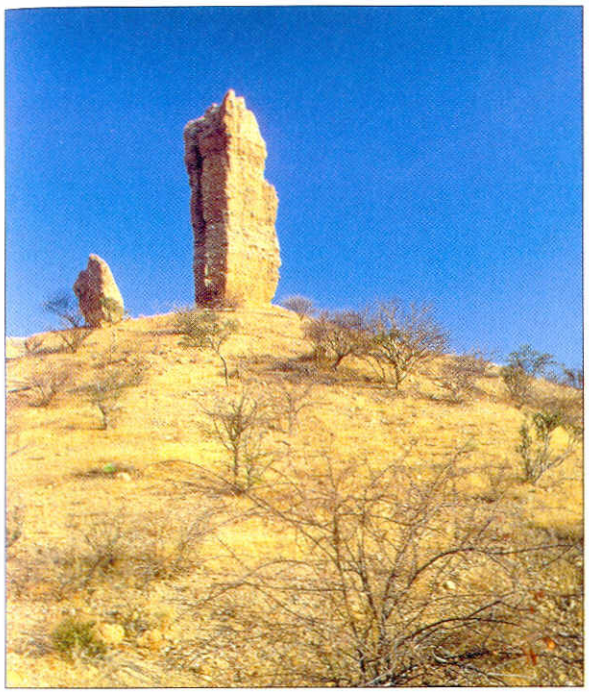
Because of their diverse geology, the western catchments include many of Namibia's currently active mines along with many of its more important mineral deposits (128, 130). The upper reaches of the Kuiseb catchment contain Namibia's first modern mine, the Matchless Copper Mine, near Windhoek. The nearby Swakop catchment is perhaps the most developed from a mining perspective, bearing a wide range of minerals. In addition to gold (the Navachab Mine in the Swakop), copper (Otjihase Mine in the Swakop) and uranium (Rössing Mine in the Swakop), semi-precious stones along with dimension stone (including marble and a variety of granites) are also mined. A graphite deposit is located in the upper Ugab catchment near Otjiwarongo. Many prospecting grants are located within the catchments, with particular emphasis on areas within the Hoarusib and Swakop catchments (142). Salt is mined and recovered at several locations along the coast while small quarries and borrow pits for gravel and road material are located throughout all the catchments.

Although economic benefits of mining are obvious, they can become economic losses should extensive environmental degradation occur. A major factor in mining operations is the amount of water necessary. The high demands of the Rössing Uranium mine, combined with those of Swakopmund and Walvis Bay, is thought to have caused the degradation of the vegetation dependent upon the aquifer in the lower Kuiseb River. Water withdrawals from this aquifer resulted in a dramatic drop in the water table. Any mine development within the western catchments must be done with consideration of the potential effects of altering patterns of water flow and availability within the catchments.

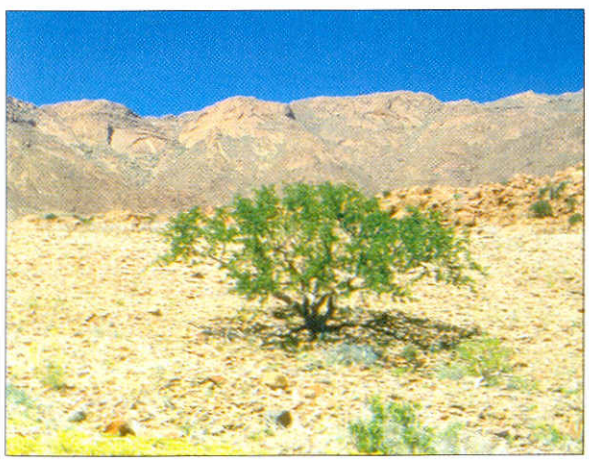
A second consideration is the effect of mines on tourism and conservation areas. Although these effects are generally negative, there is a potential to develop inoperative mine sites, such as Brandberg West mine in the Ugab catchment or Gorob Mine in the Kuiseb Catchment, as points of interest to tourists. If properly planned and interpreted, old mines can provide an interesting mix of the geological, social and economic history of an area.

The steep topography found within many of the catchments, draining from the western escarpment, is the result of millions of years of erosion. This sharp drop in elevation from the inland plateau to the coast is shown here in this cross section of the Swakop catchment (222).





The Vingerklip, a popular tourist attraction within the Ugab catchment, is one of the many striking geological features to be found within the western catchments.



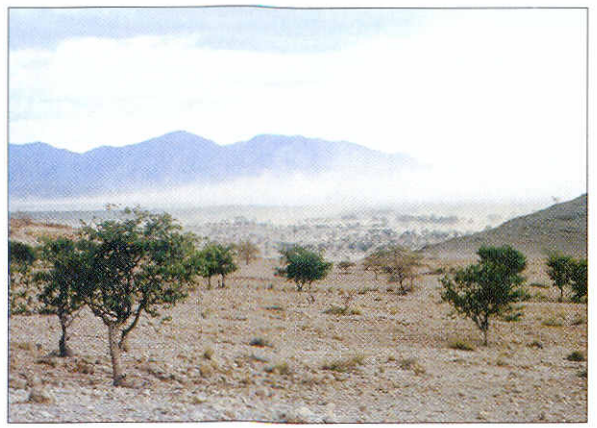
Soils within the western catchments are typically thin, rocky and poorly developed, such as those found here in the vicinity of the Brandberg Mountain.

Soils of the Western Catchments

Soils within the western catchments vary in association with the diverse geology of the region and increasing aridity from east to west. Throughout the area, however, soils are generally thin and poorly developed, a function of the arid climate and relatively slow rates of weathering. To date few studies of soils in western Namibia have been conducted. The little data available focuses mainly on irrigation potential and is based on examination of a small number of sites (24, 47, 113, 114). Alluvial and colluvial deposits are generally responsible for the thickest and most fertile soils in the region. Alluvial soils develop in deposits laid down by a flowing river while colluvial soils form in materials moved down hill slopes which have accumulated near the base of the slopes. Deep alluvial and colluvial deposits are common in many of the major valleys. Such soils are often calcareous and saline, with limited potential for irrigated agriculture (24, 113). When subjected to heavy vehicle traffic, they break down into a fine, highly erodible silty powder which is easily mobilised by wind or water (47).

Close to the coast, soils consist of either littoral sands, as seen in large dune fields of the central and northern Namib Desert, or halomorphic soils, often associated with gypsum or salt deposits. Such soils are extremely sensitive to damage from off-road driving, and tracks on these surfaces persist for decades. Further inland, soils are generally calcareous, many derived from erosion products of former ancient land surfaces transported westward during periods of fluvial activity (232). Such soils are of limited or no value for irrigated agriculture. Throughout the remainder and majority of the western catchments, soils are generally thin and weakly developed, often overlying a hard rock surface. Such soils are often very rocky, frequently giving way to the bare rock beneath. Only in upper reaches of the larger catchments, such as that of the Ugab River, are more developed soils found. Examples include sandy loams in the upper Ugab catchment, formed during periods of higher rainfall. These areas still have low potential for irrigated agriculture due to the thin soils, relatively low rainfall, high evaporation and water scarcity.

Soils within the vicinity of boreholes are often radically altered by the continual traffic of livestock over their surface. The combined effects of compaction and increased runoff are likely to reduce the rate of groundwater recharge at such sites.



Fine-grained alluvial soils, such as those found in the broad valleys of the Hoanib River valley seen here near Sesfontein, are highly sensitive to misuse. Naturally erosive, such soils are rapidly eroded when subjected to heavy livestock or vehicle traffic. Subsequent movements of wind or water over the disturbed surface will carry away large amounts of soil.

Within floodplains of the western rivers, particularly those draining the larger catchments, thick deposits of sandy loams and sandy clay loams occur. These so-called alluvial soils form after deposition of sediments transported down ephemeral rivers during floods. The result is a soil profile composed of alternating layers of sand, silt, clay and gravels, the pattern dependant upon the magnitude of individual floods and source materials available in the catchment. Alluvial soils, when associated with high groundwater tables, often support dense stands of riparian forest. It is in these sites that various agricultural projects are being considered, because of the association of deep soils with easily available groundwater. However, alluvial soils often have poor drainage and are naturally saline (or have a high potential for salinisation), reducing their suitability for irrigated agricultural development (24).

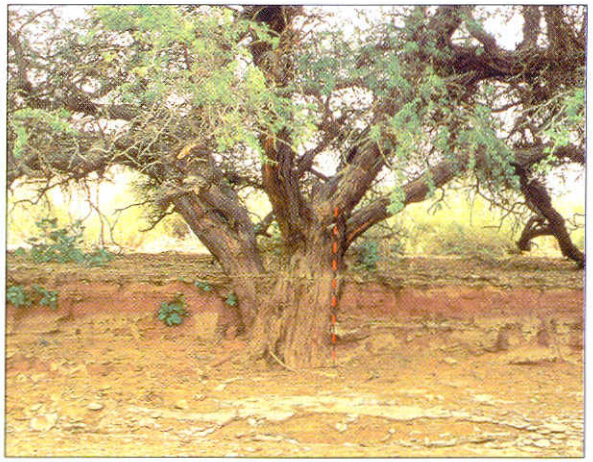
A disturbing trend is the increasing loss of vegetation and subsequent degradation of soils within the western catchments today. Existing settlement patterns concentrate people in relatively small areas. The result has been, in many areas, removal of vegetation cover and compaction of the soil surface. This process is particularly prominent in areas with fine-grained soils such as those around Sesfontein, and in the upper reaches of the Omaruru. After surface compaction, caused by the continual presence of large herds of livestock, it is difficult for rain to infiltrate the soil. Instead, rain landing on such surfaces pools rapidly and, in the absence of any vegetation to impede its movement, drains rapidly from the land. This enhanced runoff can dramatically increase rates of soil erosion. In level areas rainwater will form pools which merely evaporate over time, with little infiltration into the soil column. It has been suggested that there may be a correlation between declining groundwater tables and the limited groundwater recharge associated with this type of soil degradation (74).

OFFROAD VEHICLE TRACKS

Many soils of western catchments, particularly in the far west, are fragile. They often contain much gypsum in a crystalline form. As a result they are easily compressed when a heavy weight is applied, as in when a vehicle travels over them. Once compressed, a gypsum soil does not easily return to its previous condition and vehicle tracks may remain visible for decades. Even in the last century when ox wagons travelled northward from the Kuiseb to the Swakop River at night (to avoid the heat), the accumulation of confusing tracks over the decades on the gypsum plains was commented upon by travellers (60).

Gypsum surfaces are often very old, taking hundreds of thousands of years to form, and represent a very stable substratum for growth of plants. However, where gypsum is abundant there is little rain and lichens are the most common, sometimes the only, form of plant life. Some of the more spectacular lichen fields are already tourist attractions, such as those to the south of Henties Bay along the coast. But when a vehicle passes over a lichen field, lichens are killed, broken up, and blown away leaving permanent, ugly scars on the surface.

Another factor contributing to surface scarring by vehicle tracks is the sandiness of the soil, particularly in the western reaches of the catchments. Under the weight of a vehicle, pebbles and rocks are pressed into the sandy soil contributing to the permanence of the tracks. When occasional rains do fall, the depressions of the tracks channel runoff water which picks up soil particles and initiates erosion. All the physical and visible problems can be avoided by vehicles remaining on established tracks. Tracks such as those made by careless travellers reduce the scenic value of the western regions, diminishing or eliminating their economic value to tourism. As such, they represent a potential loss of revenue to the country.



Alluvial soils, such as these in the lower Kuiseb River, are common within the valleys of many of the major western rivers.

Bare soils such as these near the coast, containing large amounts of gypsum or other salts, are easily compressed by the tyres of passing vehicles. Thoughtless or uninformed drivers leave scars on the land which may remain for many decades.

▶ *What's important about the soils of the western catchments?*

- *Soils throughout the western catchments are generally thin and poorly developed, having little potential for irrigated agricultural production, particularly given the limited water resources and high evaporation which characterise the catchments.*
- *Soils with limited potential for irrigated agriculture are found on the floodplains of the major ephemeral rivers. These soils support dense stands of trees and other woody vegetation which provide essential fodder for livestock and wildlife. Various irrigated agricultural projects have been and are currently being considered for these sites. In evaluating the potential benefits of such developments, the poor drainage, high salinisation potential, and great volumes of water required due to high evaporation must be considered.*
- *Soils in the arid western regions of the catchments are extremely sensitive to off-road driving and tracks on these soils persist for decades. The unsightly effects of off-road driving must receive serious consideration if the tourism potential of these regions is to be maintained and further developed.*
- *Currently, vegetation loss and soil erosion can be seen throughout many areas of the catchments, resulting from poor rangeland management.*
- *Further study of soils in the western catchments is needed to improve the management of biological resources which they support, particularly the vegetation. Research should focus on rates of soil loss and development, soil degradation potential under various land use systems, as well as the effect of catchment and riverine soils upon rain water runoff, flood dynamics and groundwater recharge.*

Vegetation of the Western Catchments and Rivers

Catchment vegetation

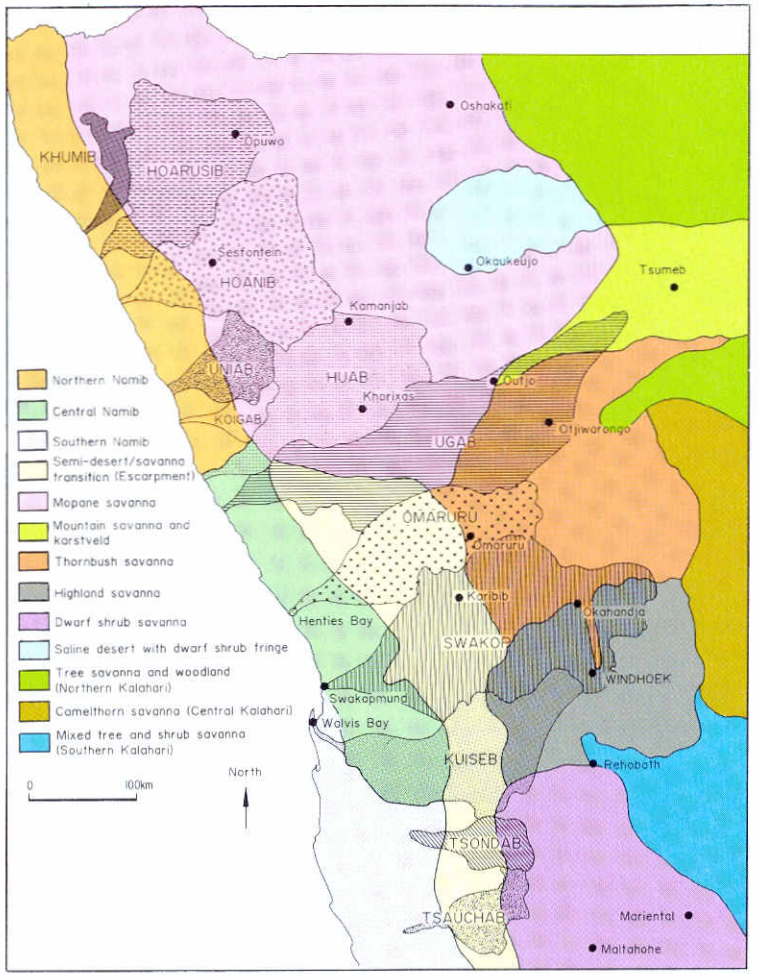
Variation in rainfall is the primary determinant of western catchment vegetation. While rainfall determines the overall pattern of a region's vegetation, it is the variability in soils, topography and temperature, that gives rise to the variability which makes so many parts of the western catchments unique. The influence of rainfall can be seen in the species composition of plant communities across the rainfall gradient, and also in the structure and productivity of individual plants. In the Hoarusib catchment, as a typical example, tall mopane *(Colophospermum mopane)* and *Terminalia* woodlands in the eastern headwaters give way to stunted mopane and *Terminalia* shrublands further west, before finally yielding to ephemeral grasslands of *Stipagrostis* species in the arid western reaches of the catchment.

The classification of Giess (63) provides a broad overview of vegetation types found in the western catchments. The upper reaches of the catchments north of the Ugab River are characterised by mopane savannas. South of the Ugab, vegetation of the upper catchments is dominated by a mixture of *Acacia* species. Further south, in the mountainous highlands associated with the headwaters of the Swakop and Kuiseb catchments, the highland savanna is composed of a complex mixture of *Acacia* species along with *Combretum, Euclea, Rhus* and perennial and annual grass species.

Thorn scrub savanna, composed of a diverse mix of Acacia species, is the predominant vegetation type in the upper Omaruru and Ugab catchments, seen here south of Otjiwarongo in the Ugab.

Moving westward off the inland plateau and towards the Namib Desert, the vegetation shifts from upland savannas to vegetation more suited to arid conditions. This transition zone between savanna and semi-desert is composed of a great variety of species, many of which are endemic to the region. Included are species of *Euphorbia, Cyphostemma, Moringa, Adenolobus* and *Acacia*. Of note are two species of endemic *Acacia: Acacia montis-ustii* and *Acacia robynsiana,* found only from the Brandberg to central Kunene Region. Also of note are the many species of *Commiphora* occurring in this zone.

Mopane savanna, seen here northwest of Khorixas, is the most widespread vegetation type within the western catchments, covering the majority of the area within the catchments north of the Ugab River.



TOP:
The transition zone between the upland savannas of the inland plateau and the arid-adapted vegetation within the Namib Desert is characterised by a diverse range of species. Seen here near the Gamsberg in the Kuiseb catchment, the transition zone contains many species of Euphorbia, Commiphora *and* Acacia.

CENTRE:
Perhaps the best known plant in Namibia, Welwitschia *is found only within the western catchments.*

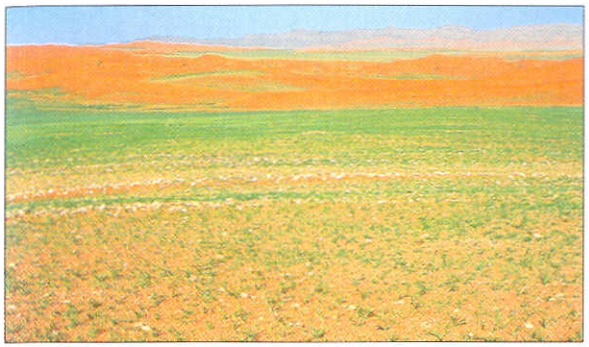
◀ *The !nara melon is found primarily in the sands of the central and northern dune fields of the Namib Desert. The ephemeral rivers draining through the region provide a reliable supply of groundwater, supporting their growth. They are particularly abundant in the Kuiseb, Uniab, Hoanib and Khumib catchments.*

▲ *Giess's classifications provide the best overview of the major vegetation types found within the western catchments (63).*

The lower reaches of all western rivers drain across the Namib Desert, which has a unique flora, including a number of plants found nowhere else in the world. Conspicuous among these are *Welwitschia mirabilis* and the !nara, *Acanthosicyos horridus*. *Welwitschia* occurs from the Kuiseb River, northward across all the catchments into southern Angola. The !nara is associated with the southern, central and northern sand seas, ranging into Angola. Also found in this region is a diverse array of succulents, many of which are adapted to use the small amounts of water provided by frequent fogs occurring along the coast (174).

The Namib Desert can be divided into three distinct vegetation types (63). The northern Namib, to the north of the Huab River, is characterised by sparse grass and shrub species that can tolerate a harsh existence in blowing sand with minimal moisture. Two narrow dune areas extend from the coast to about 40 km inland. The central Namib, between the Huab and Kuiseb Rivers, is a relatively flat sandless desert with isolated inselbergs. This region supports a sparse but diverse perennial shrub flora associated with the rocky soils. Lichen fields on gypsum and gravel flats are especially prominent between the Omaruru and Kuiseb Rivers and are a unique feature of this region. The southern Namib, to the south of the Kuiseb, is characterised by the main Namib Sand Sea and vegetation here is dominated again by plants that can tolerate a life in sand. This sand sea reaches inland as far as 140 km in some areas and grass community structure and composition across the dune field are a clear indication of the increasing rainfall gradient from the coast inland (29, 240).

Following short, isolated rains the Namib Desert is transformed into a different world. Grasslands and lily fields erupt rapidly from dormant seeds and bulbs. Within a few weeks the lilies produce fields of flowers, and the grasslands develop a silvery-blue hue, signalling

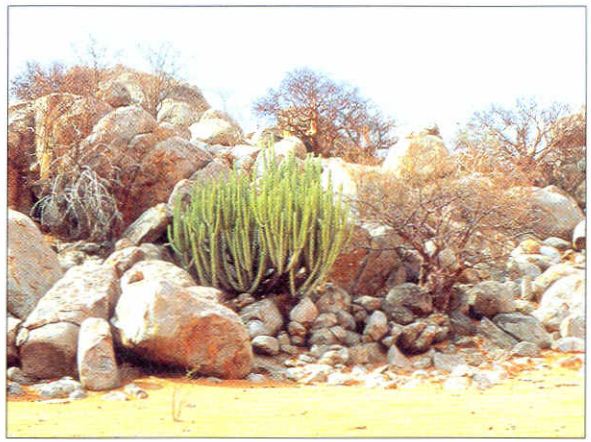


Following brief and infrequent rains, the Namib Desert within the lower reaches of the western catchments can be temporarily transformed by the appearance of lilies and grass.

the end of the 'wet period', as the plants produce seeds that will carry them through to the next rains. In the subsequent dry season the signs of past rain remain as dry grass, supporting a diverse array of organisms from ostriches to small beetles.

One drawback of Giess's vegetation types is that they are necessarily broad, not revealing the spectacular botanical diversity and physiological variation within the region. For example, high mountains that capture rainfall can dramatically alter vegetation patterns in the region. Isolated mountains, or inselbergs, throughout the western catchments are often associated with higher rainfall and different soil types than the surrounding landscapes, resulting in unique floras (63, 174). Variations in topography, caused by the evolution of drainage lines and river courses, result in sites of soil deposition, increased soil moisture and groundwater storage which provide islands of suitable conditions for plant growth and survival. Such sites are characterised by dramatic increases in productivity and unique assemblages of plant species such as we find in riparian forests associated with the western rivers.

In addition to topographic variation, temperature can also affect vegetation patterns. The lack of mopane south of the 21°S latitude is thought to relate to temperature and the plant's intolerance for frost that occurs regularly to the south of this line (154). Temperature may also limit the distribution of ana trees, *Faidherbia albida,* in the upper regions of the catchments, along with the presence of thin soils and high disturbance from flooding (63).



Variations in topography and soils can give rise to unique assemblages of vegetation within the catchments, such as in these granite hills east of the Grootberg in the Huab catchment.

One of the most striking features of the western catchments is the riparian forests which cross the arid landscapes forming linear oases, such as the Kuiseb cutting between the main Namib Sand Sea to the south, and the gravel plains of the central Namib to the north.

Riparian forests

One of the most striking vegetative features of the western catchments is the riparian forests that dissect the arid landscapes of the Namib Desert. Seen from the air, cliff or mountain, these riparian forests stand in stark contrast to the adjacent sand and rock desert. In the larger rivers, these strips are composed of dense forests of large trees, including ana trees, leadwood *(Combretum imberbe)*, mopane, camelthorn *(Acacia erioloba), Tamarix*, ebony *(Euclea pseudebenus)*, figs *(Ficus spp.)* and palms *(Hyphaene petersiana)*. These riparian forests are frequently referred to as linear oases, reflecting the importance of these systems, which provide food and water for human and animal survival in the arid landscape. It is not surprising that the word 'oasis' is derived from a word that means to drink and dwell, from the language of the Copts who live in arid Egypt.

Riparian forests of the western catchments are well adapted to the natural variability in flow regimes. Average floods fill the river to its banks, maintaining the forests by providing essential nutrients and water. If long periods of little or no flow occur, the water table will drop and older trees may die (233), opening up spaces for younger trees to fill. It is the episodic massive floods, however, which have the most long-lasting impacts on the structure of riparian forests. These floods, with return intervals that may be as long as the normal life-expectancy of trees which grow along the river, demolish whole forest reaches (204), create new channels within the floodplain, and recharge groundwater. They also provide soil moisture and nutrients and deposit seeds, thus maintaining and renewing the riparian forest. Although floods of this magnitude are rarely witnessed, evidence of these incredible events can be seen along the outer edge of current floodplains. Branches, logs and whole trees, carried in large floods over the past hundred years, are stranded along the lower reaches of the western rivers.

Although seeds of the ana tree will germinate in response to floods of any size, only large floods of long duration appear to successfully bring large numbers of new trees into the forests along the river. Smaller floods cause germination but the seedlings usually die within the year as the floodplain soils dry out.

Ana trees are undoubtedly the best known trees within the riparian forests of the western catchments. They reach their greatest abundance in the larger rivers, where regular flooding supports their dense foliage and rapid growth.

Old deposits of organic material, mostly the stems of reeds, stranded high above the river bed, give evidence of large floods that have passed through the wetlands of the lower Huab River. Although such floods seem to do tremendous damage, the wetlands and their biota are well adapted to such disturbances and quickly recover.

Ana trees have roots which sprout vigorously when damaged - an excellent adaptation to life in an ephemeral river. This root-sprouting gives rise to the large, multiple-stemmed clumps of ana trees seen in many of the western rivers.

Forest composition varies along the length of the rivers. Many of the rivers have narrow canyon reaches where flow velocity is high and the flood moves over very shallow alluvium or bed rock. Fig trees *(Ficus* species), capable of forcing their roots into rock fissures on the canyon walls, are usually the only trees that can survive in these reaches. In areas where flow velocity is generally lower, but may upon occasion still be quite high, trees such as the ana trees dominate. The ana tree has roots and shoots which sprout when damaged during floods. During the subsequent dry season, these shoots and roots sprout vigorously to form clumps of vegetation where previously only a single small upright tree stood. As a result of this vegetative growth, large clumps of trees form that are better able to withstand the force of the next flood.

The diversity and density of tree species in most of the rivers decrease from the upper reaches to the mouth (103). In the middle reaches, riparian forests are primarily composed of large woody perennial trees, with deep roots to reach subsurface water during the dry season. The species found in the forests depend somewhat on geographic latitude, but also on the frequency and size of floods. The lower reaches of small catchments with irregular flows, such as those of the Tsondab and the Tsauchab Rivers, support hardy *Acacia* and *Parkinsonia* species. Larger systems, with more regular seasonal flow, support a greater diversity of trees dependant on groundwater for survival (163, 233). This diversity generally increases from south to north. The forests of the Kuiseb and Swakop Rivers are dominated by ana trees, *Euclea, Tamarix,* fig, *Acacia* and *Salvadora* (177). In addition to these trees, the Omaruru and other northern rivers also support large leadwood trees. Finally the Ugab and other northern rivers add mopane to their forested banks.

The small southern catchments, the Tsauchab and Tsondab, support scattered forests of Acacia within their lower reaches. The Tsondab is seen here where it enters the main Namib Sand Sea.

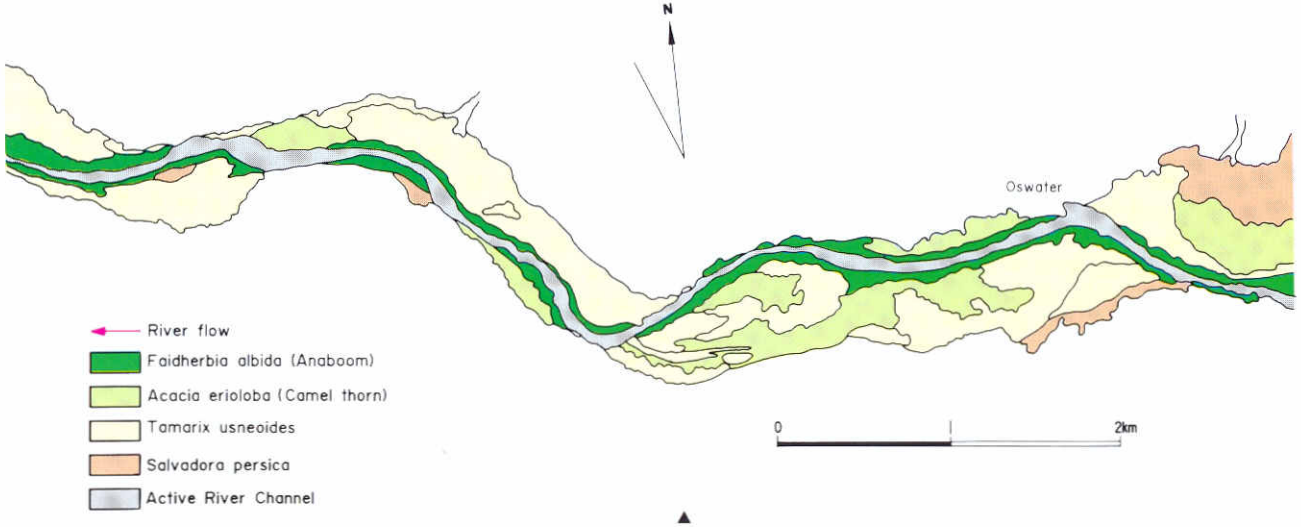
In addition to ana trees, found within the southern rivers, the larger rivers north of the Ugab may contain both mopane and leadwood along their banks. The Ombonde, a tributary of the Hoanib, supports numerous mopane and large leadwood trees.

All of the western rivers support wetlands within their lower reaches, such as this one in the Huab River close to the coast. These sites support a variety of salt-tolerant plants, including reeds and sedges. Such sites are important habitats for many species of birds and other animals.

In addition to riparian forests, all major rivers contain wetlands (109). The term wetland, in its simplest interpretation, refers to areas where soils are moist for much of the year. Such sites occur where groundwater is forced to the surface by shallow bedrock. A range of plants, typically salt-tolerant and capable of rooting in saturated soils, grow in these wet places. Most common are reeds and sedges, including *Phragmites, Typha, Scirpus, Juncellus* and *Cyperus* species, as well as large stands of bushy *Tamarix* and *Suaeda*.

Vegetation of the lower coastal regions varies from one river to the next in response to the river's hydrology and the harsh climate of the surrounding desert. Many of the river mouths have meandering channels which support saline or freshwater marsh vegetation, such as in the Kuiseb and Uniab Rivers. Rivers which have not flowed into the sea for many years, such as the Kuiseb, Hoanib and Uniab, are blocked by sand barriers from nearby dune fields. Water now dams up behind the dunes after small floods and it will take a massive flood to wash away the sand and re-establish the river's course to the sea. Such a flood happened in the Uniab River in 1982. Prior to this date there had been no flow for 6 years, and a 10 m high dune blocked the river. As a result of heavy rains in the catchment, a massive volume of water dammed up behind the dunes and finally broke through during the night. The flood swept away everything in its path including a well-developed wetland at the coast, several gemsbok resting along its banks, and a Department of Water Affairs pump station (109).

An unwelcome contributor to the flora of nearly all western rivers is the diverse range of alien plants introduced to Namibia, many of which have become established in the rivers. All of these species are easily dispersed via floodwaters and some, including *Prosopis,* are also transported by domestic stock. Chief among the aliens are *Nicotiana glauca, Datura innoxia* and *Prosopis*.



▲ This vegetation map of the Kuiseb River, upstream of Gobabeb, reveals a pattern common to all of the riparian forests within the larger western rivers. As can be seen, ana trees line the active river channel, flanked on the outside by more drought-tolerant species (215).

Alien vegetation such as these wild Datura *and* Nicotiana, *seen here growing in the Ugab River near its mouth, are an unwelcome intruder into the western catchments. There is concern that these rapidly growing plants may outcompete native species for available moisture, crowding them out and causing a permanent shift in plant species composition.*

Huge stands of *Nicotiana* and *Datura* can be seen at the Ugab River mouth. *Prosopis* has spread into all of the larger rivers with headwaters in the private farming districts. Invasion of *Prosopis* trees in the Klein Windhoek River in the Brakwater area is a well known example. The ecological effects of these introductions on the western catchments are largely unknown.

A serious constraint to our ability to ensure sustainable use of vegetative communities within the western catchments is our limited understanding of the basic life history and ecology of most of the organisms concerned. For even key species such as mopane we know very little of the plant's ecology in Namibia. How the plant responds to varying rainfall, its growth rate in differing environments, the rate of recruitment, and environmental conditions under which it will successfully reproduce are all questions that remain unanswered. Without this basic information we are left to guess as to whether or not our use of such species is sustainable. A troubling sign that our use is not sustainable is the lack of recruitment of trees and shrubs (few or no young plants) associated with areas receiving heavy use.

The apparent dependence of vegetative recruitment upon rarely occurring climatic events should also provide a cautionary note guiding our management of vegetation resources. Episodic climatic events, such as high rainfall or large floods, create conditions suitable for the establishment of some plants which may not happen again within their lifetime. Trees that grow from seed are highly dependant on favourable flooding regimes during their first few years of growth. Seedlings must rapidly develop roots to reach subsurface water, if they are to survive the next dry season. In addition, they must develop enough above-ground plant growth to survive subsequent floods. Overuse and elimination of such species can severely alter the environment and its capacity to support human populations. An example of such an episodic event and the associated plant recruitment was the large flood in the Kuiseb River in 1974 which led to the establishment of dense stands of ana trees (177). Floods of that magnitude have not re-occurred in the subsequent twenty years. Grasses *(Stipagrostis sabulicola)* currently growing in the dunes south of the Kuiseb River at Gobabeb provide another example (175). They became established in the rains of 1976, when over 100 mm fell, more than five times the mean annual rainfall. These examples emphasise the importance of regular and long-term collection of climatic data, such as rainfall and river flow.

▶ *What's important about riparian and catchment vegetation?*

- *Catchment and riparian vegetation is the basis for all rural livelihoods derived from agriculture and tourism. All fodder for livestock and wildlife is provided by the grasslands and woody vegetation throughout the western catchments and their river courses.*
- *Natural variation in abundance and diversity of catchment vegetation is determined primarily by the rainfall gradient which ranges from 0 at the coast to over 300 mm in the upper reaches of many of the catchments. Mopane or* Acacia*-dominated savannas typify the upper catchment vegetation. Moving towards the coast and down the rainfall gradient, arid grasslands give way to the spare, highly specialised vegetation of the Namib Desert.*
- *In contrast to the catchment vegetation, riparian forests lining the ephemeral rivers are largely independant of local rainfall and depend rather on river floods for nourishing water and nutrients.*
- *A serious constraint to our ability to sustainably use the vegetative communities within the western catchments is our limited understanding of the ecology of these plants and how they respond to climatic uncertainty. What are the necessary climatic conditions for optimal mopane germination and growth, particularly under different browsing pressures? What are favourable flooding regimes for germination and survival of ana trees? Do livestock affect seedling recruitment? How do plants of different ages respond to periods of very high and very low rainfall? Without answers to basic questions such as these, we can only guess whether or not our use of these species is sustainable.*

The Ecology of Floods

Flooding is the main factor which shapes soils and vegetation of ephemeral rivers. While we tend to concentrate on obvious effects of floods supplying water to these linear oases, flood waters also carry massive loads of sediments, organic matter, nutrients and seeds. Studies in the Kuiseb River show that floods transport large volumes of organic matter over long distances, enriching the soil and providing food and habitat for small animals (83). Fine organic material, transported from upstream areas within the catchment, is deposited in the lower reaches of the river, on banks and floodplains. This material, when buried under sands and silts, greatly contributes to productivity of floodplain soils. A cross section dug through the soils of a floodplain shows that most roots of riparian plants are associated with these zones of organic material or organic-rich layers of silt.

Floods travelling through the ephemeral rivers of western Namibia transport not only water but massive amounts of soil, nutrients, organic matter and seeds.

In addition to enriching soils, organic material transported during flooding plays other important roles in the ecology of riparian forests. Large logs which are deposited, sometimes after travelling distances of more than fifty kilometres in a single flood, are an important part of the structure within ephemeral river ecosystems (83). During the flood, such logs often lodge against trees growing in or along the river channel, creating small blockages. As the water rushes by, these logs act as traps which capture more and more organic material, creating a 'log jam' or 'debris pile'. When the flood recedes, these structures are covered by freshly deposited sediments and provide excellent habitat for germination and establishment of new vegetation, as well as for many small animals such as rodents, reptiles and many invertebrates. In addition these log jams also promote deposition of sand and fine gravel in bars on their downstream side. These bars not only support vegetative growth, but also help subdivide the main into several smaller channels, altering flow patterns and causing changes in the river's course.

Coarse organic materials such as sticks and logs, as well as the fine material, whether deposited in a debris pile or along a bank, form an important component of the food chain within ephemeral rivers. Following floods, these moist organic surfaces are rapidly colonised by a diverse range of fungi, algae, liverworts, plants, insects and other arthropods, adding to biological productivity of the riparian forests (86). Turning over a log resting on wet silts of a river bank after a flood can reveal an amazing diversity of organisms, contributing to the biological processes of decomposition and nutrient cycling, as long as conditions remain moist.

The point at which flood waters drop the various components of their load is determined by the magnitude of the flood as well as the size and density of

Organic materials carried downstream in flood waters, including sticks, logs, seeds and other plant remains, are deposited along a river's banks and floodplains as the flood recedes. Here the Kuiseb River is depositing its load of organic material near Gobabeb.

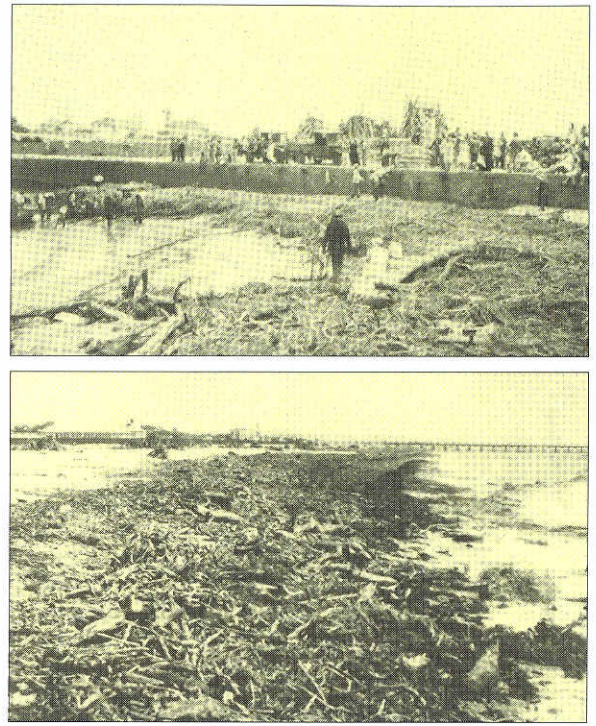
A cross-section of a floodplain within the Kuiseb River reveals alternating layers of sands, silts and organic matter. The majority of plant roots within such profiles are associated with nutrient-rich organic layers and moisture-holding silts, deposited during previous floods.

Piles of organic debris, formed when branches and logs carried by floods lodge against vegetation in or near the channel, are important habitats. The soil underneath such piles remains cool and moist for weeks or months after floods have passed, forming a refuge for a diverse array of organisms.

the material carried (83). As a flood travels downstream through an ephemeral river channel, its discharge decreases due to infiltration and evaporation. As discharge decreases, so too does the flood's capacity to transport materials. Heavier material such as logs drop out first, whereas finer organic material and silts are carried well into the western reaches and may eventually be discharged to the sea forming a plume of rich brown water which billows out into the blue-green ocean. If a flood is particularly large, even branches and logs may be carried the length of the river and out to sea, eventually washing up on beaches as driftwood.

The physical structure of ephemeral rivers is also related to the downstream decrease in discharge. The upper reaches of ephemeral rivers are characterised by more frequent flooding and narrower channels. This affects the structure of vegetation communities in two ways. First, more frequent flooding is generally associated with higher levels of physical disturbance, making it harder for plants to become established. Such effects reach their extreme in the narrow canyons of the Kuiseb and Hoarusib Rivers, where flooding occurs nearly every year. In confined channels such as these, the few plants which become established in years of low flow are scoured out during larger floods. Secondly, in the lower reaches of ephemeral rivers, soil moisture rather than flood disturbance has the greater effect on structure of plant communities. Infrequent flooding creates harsh environments where only the most hardy drought-resistant individuals survive.

Large floods occasionally push through to the sea, as did the 1985 flood in the Swakop River, seen here at Swakopmund. Although these flows of freshwater into the sea are seen by some as a waste, these rare, large floods are critical to the maintenance of a healthy riparian forest within the rivers. Large floods play an important role in recharging alluvial aquifers, depositing rich and moist soils, and establishing new trees within the forests along the river. (photo: D Heinrich)



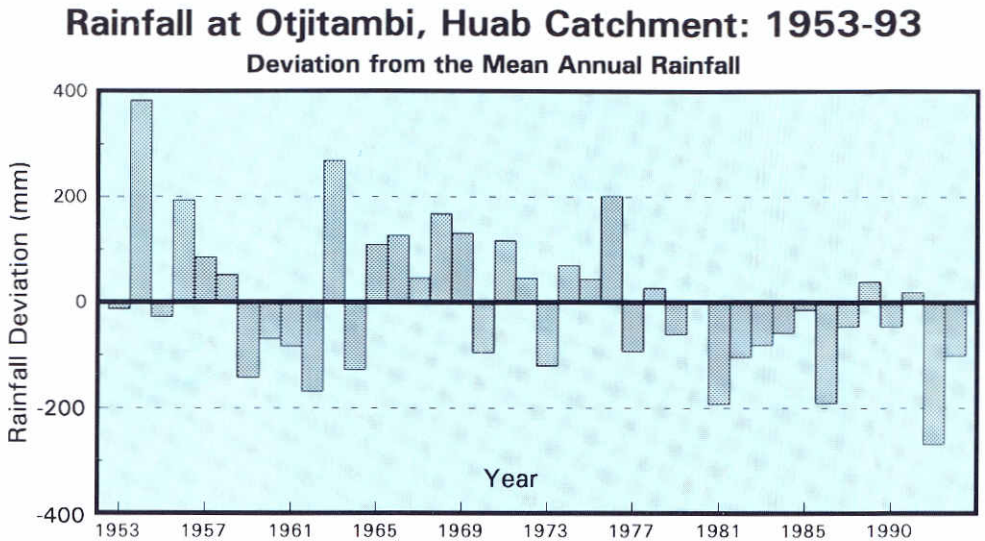
▲ *The 1934 flood of the Swakop River carried large amounts of sediments and organic matter into the sea. Woody debris was washed by the waves back onto the beach. (photos: National Archives)*

Within the narrow canyons of western rivers, physical disturbance associated with flooding is high. Although trees can become established within such sites, they may be washed away when large floods pass through these narrow canyons, contributing organic material to downstream floodplains.

Ana trees, seen here along the Kuiseb River in the Khomas Hochland, are well adapted to the physical disturbance associated with flooding.

The 1985 flood within the Swakop catchment washed out this camelthorn tree, seen here lodged against the bridge over the Khan River at Usakos. (photo: D Heinrich)

Depth of the groundwater table beneath the alluvial soils also plays a critical role in structuring vegetation communities and is directly related to flooding. In the lower reaches of rivers in the larger catchments, groundwater can be close to the surface. Depths ranging from near surface to more than ten metres are common, with variation partially reflecting the position of bedrock relative to the surface. Although no studies have been conducted to examine relationships between groundwater dynamics and vegetative communities, numerous anecdotal observations shed light on this issue. A cursory examination of vegetation within the western rivers reveals that only the larger rivers have dense stands of ana trees, a species that depends on continued access to groundwater. During the early 1980s, a dramatic decrease in flooding in the Kuiseb River resulted in a rapid decline in the groundwater table, initiating a large die-off of mature ana trees in the reach from Harubes to Soutrivier (233). Similarly, a decrease in flooding in the upper Huab River, attributable both to decreased rainfall and increased numbers of farm dams, has led to the recent die-off of large numbers of young and old ana trees in the upper reaches of the river on the privately-owned commercial farms (83). The die-off of the ana tree forest in the lower Kuiseb River from Swartbank to Rooibank, associated with the continued extraction of groundwater for the central Namib region, including Walvis Bay, Swakopmund and the Rössing Uranium Mine, is yet another example of the sensitivity of riparian vegetation to changes in the hydrological regime.



◀ *A decline in rainfall over the upper Huab catchment in the past 15 years, combined with an increased number of dams on private farms (49 in 1974 to 91 in 1989), appears to be responsible for the dramatic die-off of ana trees along the river. Springs and wells have also dried up, indicating a general decrease in the groundwater table. Management plans for the water resources within the catchments must take into consideration the possibility of such changes in regional climate. (Source: Weather Bureau / National Remote Sensing Centre)*

An unusual sight within the Namib Desert is mushrooms fruiting on a small log. Such sights are common, however, after a flood has passed through an ephemeral river, wetting the silty soils and depositing large amounts of sticks and logs and fine organic material. Fungi such as these are an important part of the environment in ephemeral rivers, decomposing plant remains and enriching the soil in the process.

UNKNOWN BIODIVERSITY IN RIVERS

Animals and other organisms yet undescribed are associated with the western ephemeral rivers. This biota, although seemingly unimportant, has a critical role to play in supporting the biological productivity upon which a large number of Namibians rely. Species of fungi, millipedes and isopods - many of which were only described for the first time recently - play an important role in essential ecological processes such as decomposition and nutrient cycling which ultimately make essential nutrients available for the growth of the riparian forest. The recently described millipede, Cnemodesmus riparius, *is abundant on the surface of wet silts shortly after flooding (184). Also associated with moist silts and organic matter is a diverse community of algae, mosses, liverworts and fungi. The existence of such formerly unknown biota within the western rivers reminds us that we have more to learn about the functioning of these important systems.*

'COMPENSATORY DISCHARGES': WILL ARTIFICIAL FLOODS WORK?

Recognising the environmental effects of reducing frequency and volume of downstream runoff within ephemeral rivers, the Department of Water Affairs (DWA) initiated a study in 1989 to evaluate the suitability of water releases from dams to compensate for a lack of natural flooding (224). This study is based upon the release of water from the newly built Oanob Dam on the Oanob River at Rehoboth (one of Namibia's easterly-flowing ephemeral rivers). Concern had arisen over potential effects of the dam on one of the largest and densest stands of camelthorn trees in the country. The dam was completed in 1990, and in 1993 enough water had accumulated to enable the DWA to stage the first 'artificial flood' without jeopardising water supply to Rehoboth. The significance of this experiment is great in that such 'artificial floods' are viewed as a means of reducing the negative environmental effects of additional dams on the western-flowing ephemeral rivers.

Although the idea of such 'environmental releases' was well conceived, and is similar to practices used elsewhere in the world on perennial rivers (209), it may be largely ineffectual in the western ephemeral rivers for several reasons. Firstly, scaling releases to match the size of natural floods is not feasible. For example, on the Oanob River an average of approximately 14 million cubic metres of flood water passed the site of the Oanob Dam annually during the past 52 years. These floods had an average peak discharge in excess of 150 cubic metres per second (52). The artificial flood released from the dam in 1993 had a peak discharge of 15 cubic metres per second and totalled less than 5 million cubic metres. As a result of the low discharge and small total volume, the flood travelled less than 30 km downstream from the dam.

A second important factor to be considered is the very different character of materials carried by these floods. Natural floods on ephemeral rivers carry heavy loads of silts, organic matter and nutrients - all deposited in, and enriching, the downstream riparian ecosystem. In contrast, the artificial flood on the Oanob River carried almost no organic material and nutrient and sediment levels were low compared to natural floods (84). A final factor was that the sediment-free water released from the dam picked up sediments from below the dam, redepositing them further downstream as the flood diminished. The net result was a slight decrease in the river's elevation gradient below the dam. Such effects are well known, as they have been frequently recorded in association with dams on perennial rivers that flow over alluvial beds (238). This bed scour associated with downstream flow of artificial floods will inhibit their effectiveness. Because of scour of the sediments from below the dam, and their redeposition downstream, the frequency of overbank floods will decline, impoverishing floodplain soils. In addition, the change in the river's gradient will reduce the distance subsequent floods travel.

These observations suggest that similar releases will be of limited use in reducing the environmental effects of large dams on western ephemeral rivers. In the case of the Swakop River, the downstream effects of the Swakopport and Von Bach Dams are unknown. Some people say that the effect is small given the large size of the Swakop catchment and the large number of tributaries feeding the river below the Swakopport Dam. Other people refer anecdotally to a large decline in the groundwater table after closure of the Swakopport Dam in 1978. What is known is that much of the ana tree forest in the lower Swakop River within the Namib-Naukluft Park is now dead. Regrettably, no studies have been done to document the relationships between surface flow, groundwater dynamics and vegetation growth to resolve this debate.

A large body of research shows that riparian vegetation within arid land streams and rivers is structured and maintained by flooding (67, 79, 83, 109, 209, 210). Floods transport large amounts of nutrient-rich organic matter and sediments, contributing to downstream production upon which many farmers, livestock and wildlife depend. Large and infrequent floods are known to play a major role in the recruitment of new trees into floodplain forests. The last major recruitment of new ana trees at Gobabeb on the Kuiseb River was in 1974, when the river flowed a remarkable 102 days, more than 5 times its average recorded to date. At the same time, adult trees are sensitive to changes in flood frequency. An absence of flooding for four years on the lower Kuiseb River triggered a massive die-off of large ana trees (233).

In the final analysis, the most disturbing aspect of Rehoboth's water situation is that the projected water demand of the town will match the supply capacity of the dam shortly after the turn of this century (224). Artificial floods, effective or not, will then become impossible. Attention will not be directed at the local environment, and the wood and grazing it supplies, but rather towards meeting the increased water demands of the region's residents. This larger issue of how both economic and human population growth can be sustained within the constraints of finite water supplies has not yet been resolved in Namibia, regionally or nationally.

THE GOOD SIDE OF SILTS

Silt within the western rivers is generally viewed with disdain because of its potential role in sealing river beds during flooding, preventing infiltration and recharge of groundwater aquifers (41). Although this effect may be to our disadvantage in terms of bulk water supply, silts play an important role within the riparian forests. Because of their fine grain size, deposits of silt particles can form thick layers across a floodplain. As the upper surface quickly dries in the hot desert sun, it prevents evaporation of moisture from lower layers. As a result, moisture which has soaked into the floodplain during overbank floods remains in place, available for plants, soil-inhabiting animals, bacteria and fungi - allowing decomposition and mineralisation of organic material deposited during the flood to proceed. These organisms could not exist in such an otherwise harsh environment, were it not for the presence of the silt layers which slow the drying of floodplain soils.

Within the Kuiseb River, more than 12 months after a flood, fresh fungi (mushrooms) have been found fruiting from the wet soil beneath a thick silt cap on the floodplain (85). In addition, as silts dry they contract, leaving large cracks separating the angular blocks of silt, commonly seen throughout the western rivers. These silt blocks and the deep cracks between them are an important component of the post-flood environment. Frogs, shrews and scorpions have all been observed within the cracks. Such sites provide cool and moist retreats for these animals and are also good places to find the small insects upon which they feed. Underneath larger blocks of silt a wide range of animals can be found year round, including snakes and small rodents. Baboons actively search for these animals by turning over the silt 'plates' along the river channel. As can be seen, silts have an important role to play within the western ephemeral rivers.

▶ What's important about flood ecology?

- *Floods are the primary source of water and nutrients that keep the riparian forests of the western ephemeral rivers alive and functioning. Because of this dependence on flooding, riparian forests in the western catchments are sensitive to changes in runoff from upstream regions caused by climate change or dam building. The effects of these natural and unnatural changes must be carefully considered to ensure the availability and sustainable use of riparian resources such as the ana trees.*

- *The effectiveness of water releases from dams on ephemeral rivers to maintain downstream environments is limited for two essential reasons:*

  1. *The frequency and volume of water released will be much less than natural floods. Artificial floods will also not travel far enough down the channel or up on to the floodplains to provide the water inputs required to maintain growth of the vegetation, or to stimulate germination.*

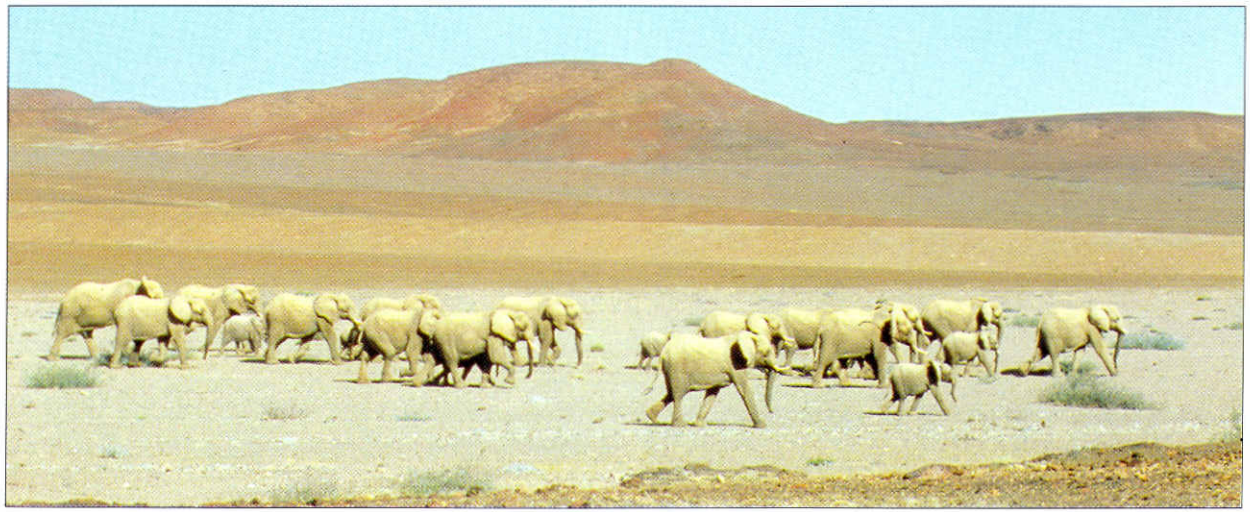
  2. *Water releases from dams carry very little organic material, nutrients or sediments in comparison to natural floods. Downstream vegetation and all other organisms that depend on these periodic inputs are thus deprived of essential materials for growth.*

◀ *The moist silty banks left by floods within ephemeral rivers provide a unique habitat for many species of fungi, algae, liverworts and small insects - all adding to the biological productivity of the environment within these systems.*

Wildlife in the Western Catchments

Large vertebrates survive in deserts by being nomadic. Their movements centre around the search for food and water. Herds of springbok, gemsbok, Hartmann's zebra and ostrich graze grass patches wherever rains have fallen. These resources are used throughout the dry period, as long as sufficient drinking water is available. Springs in the catchments, particularly in the arid west, are essential watering points. Wildlife also use the rivers as refuges from seasonally extreme conditions (177, 179). In general though, riparian vegetation is preferred fodder year-round for animals such as elephant, rhino, giraffe, baboon, and kudu (109, 179, 227) whose ranges extend down from higher rainfall regions inland. Regular movements in and between the catchments and their rivers are a normal part of life for animals in northwestern Namibia. During such movements, rivers and springs act as rungs in a ladder, allowing successful passage across the dry landscape. Any developments that eliminate surface water and degrade or eliminate vegetative resources (for example, the ana trees) in one of the rivers, will have an impact comparable to that of removing a rung from a ladder - causing gaps and making movement between resources difficult. Large scale water development schemes, such as those being considered for the Kuiseb and Ugab Rivers, will cause gaps in resource availability downstream which will have a marked effect on movements of wildlife in these arid regions.

Although the distribution and taxonomy of many species of vertebrates and invertebrates has been studied (234), little is known about the ecology of the region's wildlife, other than anecdotal information about animal movements in search of water and fodder (231). Even this work has focussed only on large mammals and avian fauna. Current management of the region's wildlife necessarily focusses on maintenance of population numbers through anti-poaching efforts and community involvement (107, 110). This takes the form of monitoring, law enforcement and resolving conflicts between wildlife and people. While such efforts achieve short-term conservation goals, the long-term future for wildlife is very much in question, as viable wildlife populations are also dependent on availability of suitable habitats.



Rock engravings scattered throughout the west, such as these at Twyfelfontein in the Huab catchment, reflect the importance of wildlife to the region's prehistoric inhabitants.

At present there are disturbing signs that increasing pressures on the environment in the northwestern areas, caused by the increasing human population's demands for agricultural and water development, may be contributing to long-term degradation of critical wildlife habitats, as well as decreasing tourism potential. Use of natural springs as stock watering points, continuing provision of artificial watering points in arid and semi-arid landscapes, and alteration of river flow through dam building will continue to place increasing pressure on the area's potential to maintain its wildlife populations and to serve as a centre for tourism development. There is a pressing need for a land use policy on which to base development plans for the northwestern catchments. In the absence of such a policy, conflicting developments will continue unabated.

◀ *The survival of wildlife in the western catchments depends not just upon one catchment where they may be seen on a given day. Rather, wildlife move between the rivers, springs and different vegetation types found within the western catchments. Nomadic movements between the patchy resources is essential for survival in this arid region. Here, elephant are shown moving northward from the Hoanib into the Hoarusib catchment, where open water can be found. (photo: P Tarr)*

This vegetarian lizard, Anglosaurus skoogi, which eats flowers and tender shoots of the !nara plant, is a unique addition to the biota of the western catchments. It is found only in the sand dunes of the northern Namib Desert.

Although most Namibians know about the wildlife of the western catchments, little emphasis has been placed on the value of these animals, in this particular setting, to the nation as a whole. The populations of rhino, elephant, lion, giraffe and other wildlife within these areas are unique in the world. Nowhere else does one find such a diverse assemblage of wildlife in such a dry landscape. At the same time, nowhere else in Namibia does game exist in such a spectacular and varied topography. The desert areas of western Namibia are largely wilderness and, as such, have a great value for the country as a tourist attraction. Their capacity to generate revenues, both locally and nationally through tourism, should not be underestimated. In contrast, the agricultural potential of the area will make little further contribution to the well-being of the local population or the country as a whole.

LOWER LEFT:
The western catchments are home to a diverse range of animals found nowhere else in the world. The beetle, Onymacris bicolor, found only within the sand dunes of the northern Namib Desert is but one example. (photo: M & P Fogden).

The majority of animals within the western catchments have been little studied. This complicates our attempts to sustainably use the environment within these regions. Although small animals such as this harvester termite, Hodotermes, are often overlooked, they play a critical role in maintaining the environment upon which all Namibians lives depend.
▼

FENCES AND WILDLIFE

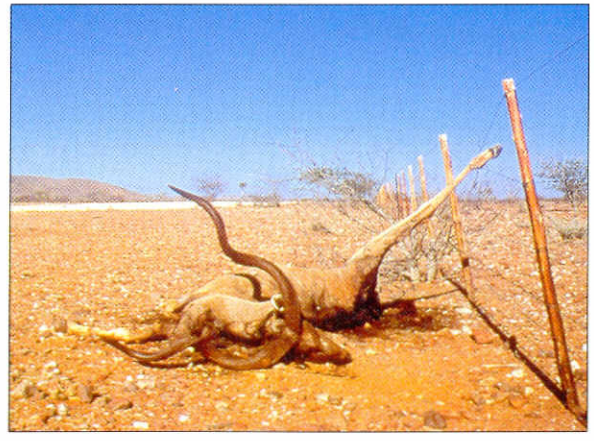
In Namibia, fences and wildlife have a mixed history. The veterinary cordon fence cutting across the Hoanib, Uniab and Koigab catchments prevents movement north and south of wildlife in the western catchments. Traditionally, herds of game would migrate to where rains provided grazing or water was available. By restricting these movements, the total number of animals has been reduced. Such a result has been particularly evident in Etosha National Park where fences and associated overgrazing are thought to be at least part of the reason why previously vast herds of over 25 000 wildebeest have been reduced to less than 2 500 animals (26). On the other hand, fences such as those surrounding Etosha serve, at least partly, to prevent encroachment of cattle and loss of wildlife. More importantly, in the case of the veterinary cordon fence, they enable the commercial agriculture sector to maintain disease-free populations of livestock - a critical contribution to Namibia's economy.

In the Namib-Naukluft Park fences have been a mixed blessing. Before the late 1960s, game from the central Namib would migrate eastward when grazing was scarce in the west. Some would be hunted on commercial farms while others were poached within the Park. A fence was erected to prevent eastward movements and to help control poaching. In the mid-1970s, exceptionally high rainfall caused populations of wildlife to increase sharply within the Park. By the early 1980s normal dry conditions had been re-established. Instead of being able to move eastward, however, the increased numbers of wildlife overgrazed areas of the Park and many died (27).

To some animals such as elephants, fences are only a mild annoyance. By using their weight, they can make a passage through or over fences for themselves, their young and even other animals. Certainly, simple wire fencing around a borehole installation will not deter a thirsty elephant. Only more substantial fences or a suitably constructed rock wall will prevent the destruction of water installations by elephant.

Fences, constructed and used in various ways, are one of many management tools available to people caring for domestic stock and wildlife, but should be used with their negative as well as positive aspects firmly in mind.

A rock wall can be used to protect borehole installations from thirsty elephants.



Fences can interfere with the natural movements of wildlife.

The veterinary cordon fence protects Namibia's agricultural industry by ensuring disease-free populations of livestock. Goats from Sesfontein, seen here at the Palmwag Gate, are being trucked south to market, after spending the required period in a quarantine camp.

▶ *What's important about wildlife in the western catchments?*

- *Abundance and movements of wildlife throughout the catchments are determined by availability of suitable fodder and water. Watering points, springs in the catchments, and streams in the ephemeral rivers, are essential for long distance movements associated with a nomadic existence in search of suitable forage.*

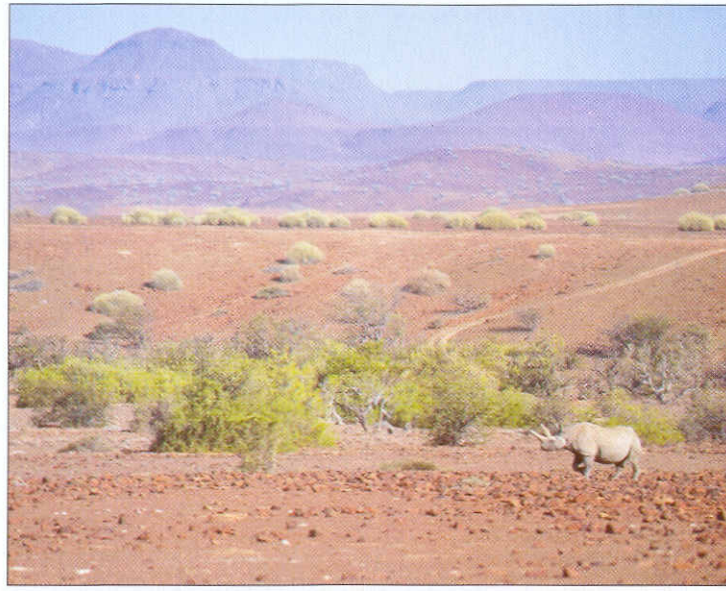
- *The Skeleton Coast Park alone cannot support significant numbers of wildlife. Rather, animals are constantly moving between the communal areas of the Kunene and Erongo Regions and the Park using well-known watering holes to access regions where rains have fallen and grass is now growing.*

- *The potential for sustainable uses of wildlife for consumption by local communities in the communal areas requires investigation. Because of the low and variable rainfall of this arid environment, the number of animals which the region can support is lower and more variable from year to year than in the upper catchments or elsewhere in Namibia, where rainfall is higher. The variability in sustainable offtakes from year to year provides a factor of risk and uncertainty that communities must be prepared to respond to if they are to derive part of their income from wildlife use.*

- *Wildlife living in the western catchments are of tremendous value to local communities and Namibia as a resource for tourism. While wildlife are not as abundant as in the parks like Etosha, the scenery of the rugged northwest is the most spectacular in the country, providing a unique desert setting for gameviewing, found nowhere else in the world.*

- *Livestock and wildlife are dependent on the same limited resources: water and forage. Given the limited availability of both resources in the west, determinations of sustainable wildlife and stock populations must be based upon combining the total number of livestock and wildlife as a single unit using the same resources, rather than as independent entities. At the same time, communities that wish to benefit from both wildlife and livestock enterprises must also take into account the free-ranging nomadic movements of wildlife throughout the Kunene and Erongo regions, in contrast to the much more sedentary nature of livestock populations.*

- *The economic potential of agriculture and tourism in the western catchments should be thoroughly analysed as a basis for appropriate land use planning in the area. Sustainable uses of the resources, as well as mechanisms for equitable distribution of benefits from such uses, must be identified. Analyses must consider the local, regional and national perspectives, and should include consideration of all types and combinations of tourism and agriculture, as they are currently practised, and as they could be enhanced in the future.*



The combination of a diverse assemblage of wildlife within spectacular desert landscapes makes the western catchments unique around the world. This heritage has enormous potential to generate revenues through tourism, improving the lives of many of the region's inhabitants. (photo below: P Tarr)

III PEOPLE'S USE OF RIVER AND CATCHMENT RESOURCES

Archaeological remains such as this stone tool are found throughout the western catchments, often in association with springs or wetlands.

Water

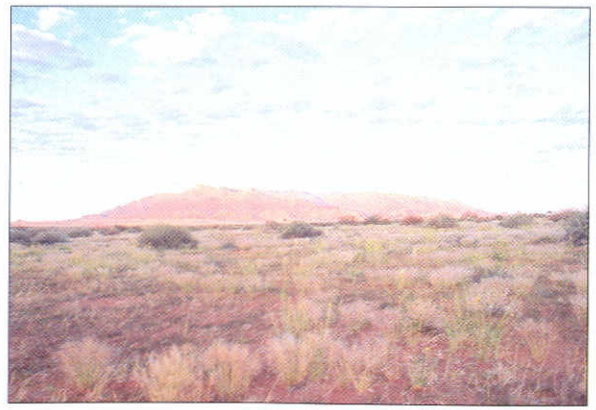
Water and Settlements

Before the colonial era, people in the western catchments moved and settled in response to changes in availability of water, food and grazing that typify a highly variable environment (93). Today environmental uncertainty remains a key factor governing the way people move and settle but, in addition, the rapidly growing number of people in Namibia is putting an ever increasing demand on the limited resource base. Namibia's successes or failures at managing water, grazing, wood and other resources within the western catchments in a sustainable manner depend on how wisely more and more people use less and less of the available resources. Of the resources, the availability of water markedly affects the way people, livestock and wildlife make use of other resources. In fact, water is without question the ultimate regulator of how people live, move and settle in an arid country.

Historical evidence of people living in the western catchments is centred around natural surface water. Archaeological artifacts and rock engravings and paintings have been found on mountain sides where water was, and still is, stored in deep rain pools or released from mountain springs, for example at the Brandberg and Twyfelfontein (94). Stone circles, thought to be dwelling places, and stone implements found along many western rivers and often near wetlands, remind us how the lives of our ancestors focused around obtaining adequate water. Almost every water source in the central Namib, no matter how unpredictable or brackish, shows some indication of settlement during the last two thousand years (93). If the water dried up, the site was no longer used. Dry boreholes found on abandoned farm posts throughout the western catchments remind us that this is still true today.

During the past hundred years, accessible surface water or shallow groundwater remained an important factor in determining where people settled in the catchments. Throughout most of western Namibia, permanent settlements developed on sites with reliable springs, such as Sesfontein, or along river courses with shallow groundwater tables, such as at Okombahe on the Omaruru River. Although many settlements originally established on fountains appeared to have a secure water supply, increasing numbers of people and economic development fuelled an ever-increasing demand for water. In many cases, this demand far exceeded limits of the original supply. A classic example is the city of Windhoek, established in the 1890s at an already well-used site near mountain springs in the present-day suburb of Klein Windhoek. Most of these springs dried up early this century as the number of people dependent upon them increased, and satisfying their demands led to a drop in the region's water tables.

Finding reliable water supplies in an arid country is an enormous challenge, one which Namibians have faced over thousands of years. Today that challenge has grown greater, fuelled by an ever expanding population.

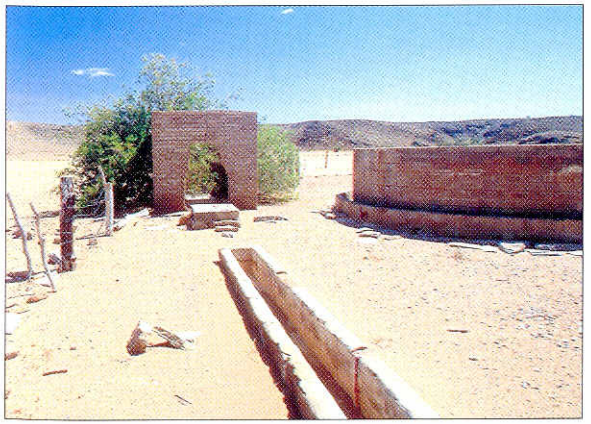


Small pools stored in rocky crevices of large mountains, such as the Brandberg, met the water demands of some of Namibia's past inhabitants.

INTEGRATING WATER AND LAND MANAGEMENT

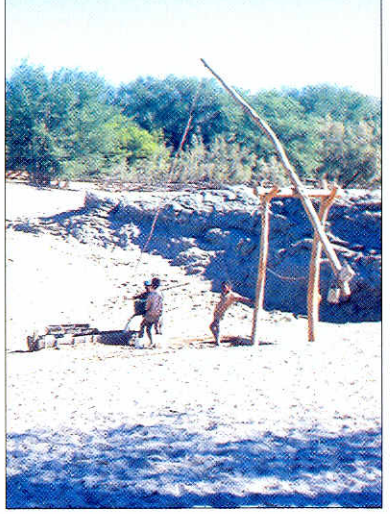
Throughout the farmlands of the western catchments are numerous wells and boreholes, many of which are dry. At some sites the old wind pumps have broken down or pipes and casings have deteriorated and collapsed. Many of these wells and boreholes were abandoned because of a drop in the groundwater level at the site. Although no record exists for the volume of, or rate at which, water was pumped, the drop in the water table resulted from pumping water from the ground in excess of its rate of recharge. This so-called 'mining' of groundwater is a common problem throughout the western catchments where farmers, villages and towns depend upon the limited groundwater resources. Overuse of vegetation near such sites, combined with compaction of the soil by livestock, may further contribute to decreasing water infiltration and groundwater recharge rates. Deepening boreholes only prolongs the period of use, as the water table continues to decline. Once dry, aquifer recharge at such sites may not occur within our lifetimes.

Within the western catchments, water tables are falling at many sites and it has been estimated that up to five per cent of the active boreholes are drying up each year. Further, extensive subsidies for water supply, particularly in communal lands, contribute to high use and wastage. In the three years from 1989 to 1991, approximately 6.4 million Namibian dollars were spent on boreholes, pumping equipment and diesel fuel, all provided free of charge (148). Although such subsidies are aimed at meeting the basic needs of rural populations, there is an urgent need throughout the western catchments to reduce the amount of water use to levels that aquifers and the rangelands can sustainably support. Current efforts (51) to reduce or eliminate subsidies and to transfer greater logistical and financial responsibility for water supply to rural communities may help to reduce excessive use and prevent wastage of water.



Abandoned farm posts and dry boreholes in the western catchments are a reminder of the importance of water in our lives and suggest that in many cases our use has not been sustainable.

Meeting the growing water demands of Walvis Bay has always been a challenge. Before the turn of the century brackish water was collected from a spring in the lower Kuiseb River and rolled into town in wooden barrels. Fresh water was also brought from Cape Town via ships anchoring in the Bay.



Shallow groundwater stored within the alluvium of riverbeds is an important water source for many farmers who live along rivers of the western catchments, such as the Kuiseb. (photo: M Seely)

Meeting Demand

Historically, as today, meeting demand meant finding more water. Long ago this may have meant digging a deeper hole in a dry riverbed or climbing a nearby mountain to search for water-filled crevices. Today, humans have found additional ways to search for and obtain water. Boreholes, dams and desalination plants are now a regular part of the Namibian vocabulary. Development of these installations started with colonial settlers who were looking for secure, regular supplies of water to support their agriculture. Some of these first installations were dams, river wells and boreholes built soon after the turn of the century, which can still be seen on farms in the upper catchments of the Swakop, Kuiseb, Omaruru and Ugab Rivers (205).

Of interest today, as Namibia considers the option of supplying its coastal towns with desalinated water, is the fact that one of the earliest historical records of water supply infrastructure relates to desalination of sea water. The history of desalinated water supply in Namibia started before the turn of the century when the German administration established the first distillation plant in the 1890s to supply the coastal town of Lüderitz. At first only solar power was used for distillation but soon steam was also used to drive the process. This

plant was producing as much as 600 cubic metres of water per day as recently as 1961, although this supply was subsequently replaced with water pumped from a nearby alluvial aquifer (205).

Early in this century, farmers constructed dams and drilled boreholes to provide themselves with water. Many developing urban areas were struggling, however. Windhoek rapidly outgrew the water supply provided by the area's springs and boreholes. Today, boreholes in the vicinity of Windhoek supply only 10 per cent of the city's water; the rest is brought in via pipeline from dams far to the north of the city (192). As the agricultural sector developed, small urban centres were established to serve the growing needs of scattered farming communities. As these towns expanded, so too did their demand for water. In response to this continually increasing demand in Otjiwarongo, Omaruru, and Okahandja, boreholes were deepened, wellfields expanded, dams built and canals and pipelines constructed (205, 190).

SAND DAMS

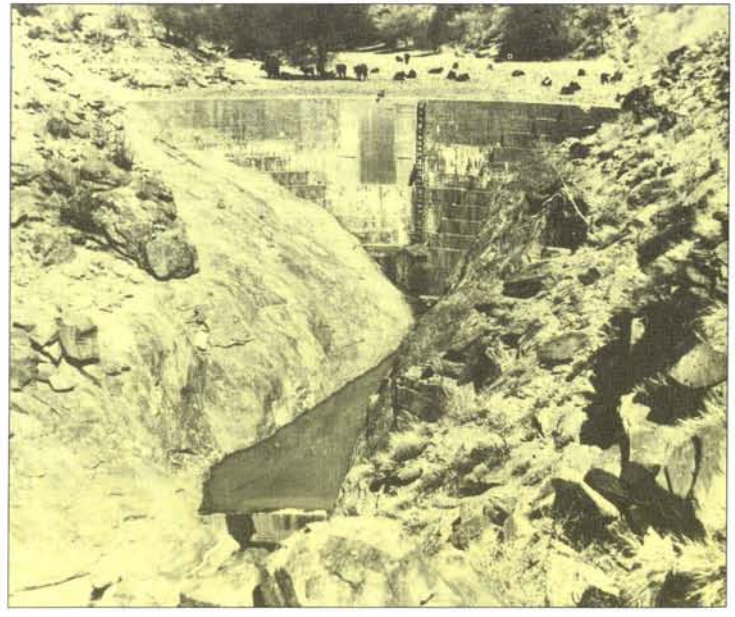
One of the more environmentally sound ways to develop small scale water supplies was developed in 1907 and later researched by a former director of the Department of Water Affairs, Dr. O. Wipplinger (205, 239). Sand dams rely on the artificial creation of water-saturated, sand-filled basins by building low walls in river beds. These walls are not large enough to stop full river flow but they capture its coarser sediments. Over the years, with each flow of the river, the basin fills with these porous sediments, and the wall is built higher. The saturated bed of alluvium behind the wall yields a reliable supply of water, the volume of which is dependant upon the texture and amount of material filling the basin. Coarser sediments store larger volumes of water.

An obvious advantage of sand dams is the limited interruption they cause to downstream flow and the fact that they are very efficient, with much less evaporation than from open surface reservoirs. One serious drawback of such structures, however, is the length of time needed for their completion, often several years depending upon river flow. In addition, sand dams are only effective in certain parts of Namibia where rivers carry coarse sand or gravel. In rivers carrying large amounts of fine-grained silts or clays, sand dams usually do not work, such as the example found in the Hoanib River within the Khowarib Schlucht.

The rapidly increasing water demands of Windhoek have necessitated construction of large dams, such as the Von Bach Dam seen here in the upper Swakop catchment. ▶

Some of the first engineered water works in Namibia were sand dams built in headwaters of the western catchments around the turn of the century. Sand dams, such as this one in the upper Swakop catchment east of Okahandja, can provide an efficient and reliable supply of water if properly designed and sited. (photo: DWA) ▶▶

High-yielding wells with electric pumps have been installed in aquifers of the lower Kuiseb and Omaruru Rivers. These wellfields have had to supply the ever-increasing demands of the coastal towns. It is clear today that our use of these supplies has been unsustainable, with pumping rates far in excess of recharge. Plans are currently underway to augment supplies through desalination of seawater and recharge enhancement. ▶



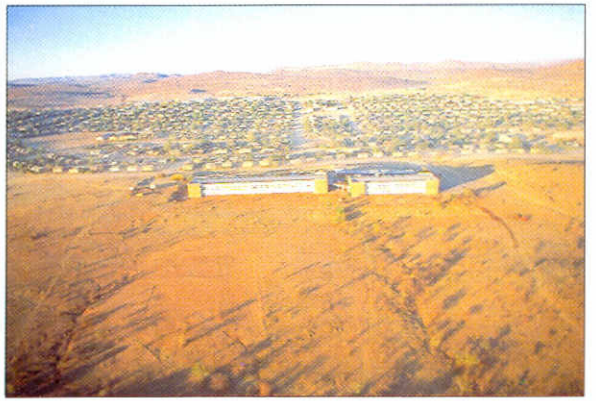
The process of continually enlarging supply infrastructure goes on today. However, because of high costs associated with water supply infrastructure, changes are under way. Plans are being developed for commercialisation of the bulk water supply component of the Department of Water Affair's responsibilities (3). This effort is intended to improve efficiency in water supply and management by providing better access to capital, obtaining additional expertise, achieving full cost recovery and ensuring sustainable water use through improved awareness and control measures.

Today, only some parts of Namibia are designated 'subterranean water control areas', the use of which is regulated by the Department of Water Affairs. Ideally, all water use in Namibia should be regulated by the Department. Individuals, as well as other Ministries, should apply for permission to develop any water resource. This would provide the possibility for management of Namibia's water resources on a catchment, regional and national basis. Moreover, the Department should be the repository of all information concerning water resources and water use. Basic information relating to water use patterns should be required of all water users, private and public, for regional and central data banks. Such information would provide the essential basis for good management. This information about water, including its scarcity, current use patterns, potential for further development and appropriate use should be widely disseminated, throughout Namibia, to all people who use water. With all these changes in place and operating, it may be possible to meet Namibia's demand for water, at least for the immediate future.

Demand Management - The Missing Agenda

The history of water supply in Namibia is a history of continually meeting the demand: water is always on tap. Water saving measures are introduced only in times of drought, when water levels in dams are low and supply is threatened. No permanent change in lifestyle is required of people using the water. Although there are attempts to regulate water use in towns where supply is limited, the quest for more continues (104).

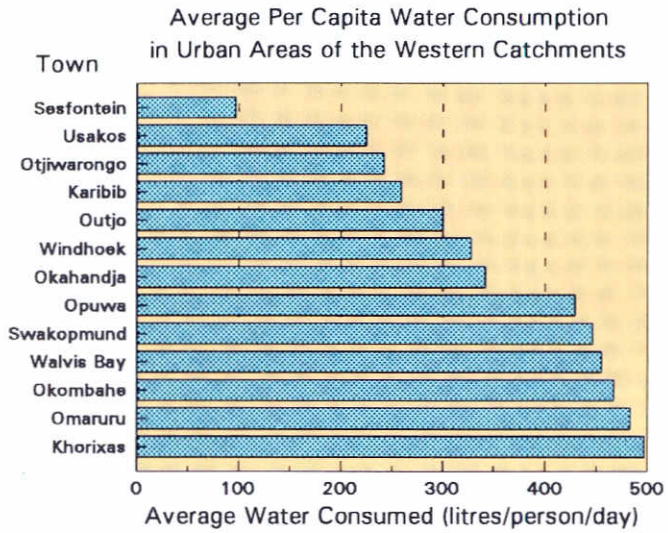
Water supply in an arid land is a serious challenge to the water engineer. Effective solutions require creative approaches, demanding the best engineering and hydrological approaches available. These solutions can be costly, however, requiring large outlays for construction and maintenance. Equally important are the environmental costs associated with such solutions, costs which are often unnoticed, ignored, underestimated or trivialised. In an effort to reduce these costs, an analysis is usually undertaken to evaluate options for meeting the existing demand. These analyses are often inadequate, however, because they only explore means of meeting current and future demand through supply augmentation, rather than questioning or trying to reduce the demand itself (191).



The bright green lawns and heavily-watered gardens of alien plants found throughout Windhoek's more exclusive suburbs are a striking contrast when compared to the brown hills seen outside the city during the dry season. These gardens provide one explanation for the excessively high water demand within these areas.

It is not necessary to consume large amounts of water to have an attractive garden. As seen here in Windhoek, a wide range of arid-adapted plants are available, providing attractive alternatives to the water-demanding species commonly used.

◀ *Khorixas has the highest water demand per person in all of the urban areas within the western catchments. Residents consume an average of nearly 500 litres per person per day, even with water restrictions in place. It is unclear how this water is being used, but recent studies suggest that much of it may be wasted due to broken pipes and taps left open and running. Whatever the cause, this use is unsustainable and the aquifer is being rapidly depleted.*



Urban water consumption is high throughout the western catchments. (Source: DWA records).

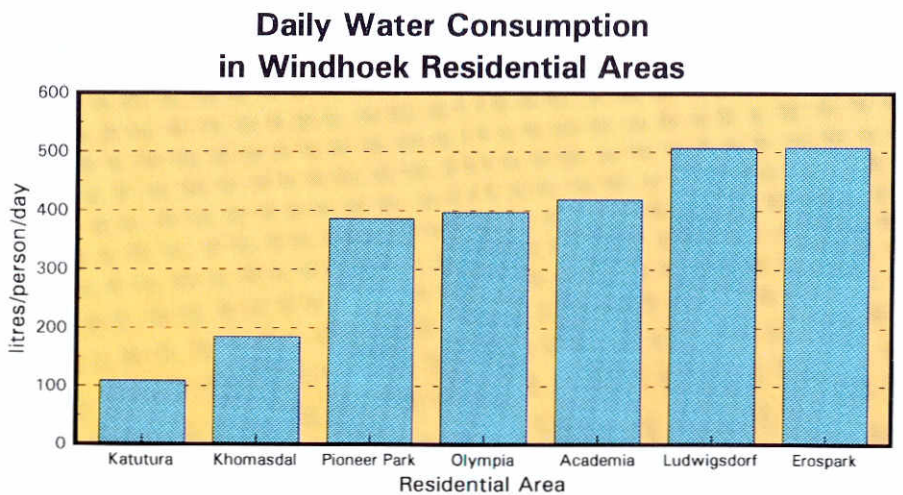
Urban Water Consumption in 1991 (Litres)

	Total Water Consumed	Population	Litres Consumed Person/Day
Karibib	282 000 000	2 978	259
Khorixas	1 334 000 000	7 358	497
Okahandja	1 379 000 000	11 040	342
Okombahe	240 000 000	1 408	467
Omaruru	855 000 000	4 851	483
Opuwa	662 000 000	4 234	429
Otiwarongo	1 404 000 000	15 921	242
Outjo	497 000 000	4 535	300
Sesfontein	290 000 000	806	97
Swakopmund	2 876 000 000	17 681	446
Usakos	291 000 000	3 548	225
Walvis Bay	3 817 000 000	23 000	455
Windhoek	17 630 000 000	147 059	328

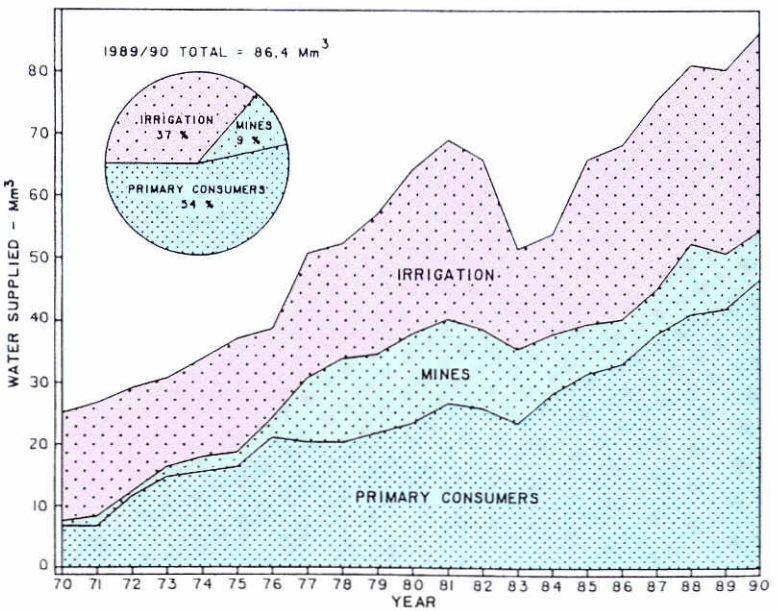
It is now very clear that people and their livestock in Namibia are grossly over-consuming the country's most precious resource, water. This over-consumption, and the unfailing attempts to continually meet demand, have resulted in serious depletion of supplies to a number of major urban centres (191). The state-run bulk water schemes at Anixab, Anker, Terrace Bay, Kamanjab and Khorixas are all pumping water in excess of their operating contracts, which are based on the Department of Water Affair's determinations of each aquifer's sustainable yield.

As a result of such over-consumption, Namibia is now faced with two choices. An attempt can be made to continue to try and meet demands imposed by a rapidly growing population, accepting the enormous financial and environmental burdens this will impose on Namibia, or demand can be reduced. The choices ahead are no better illustrated than in Windhoek and Khorixas.

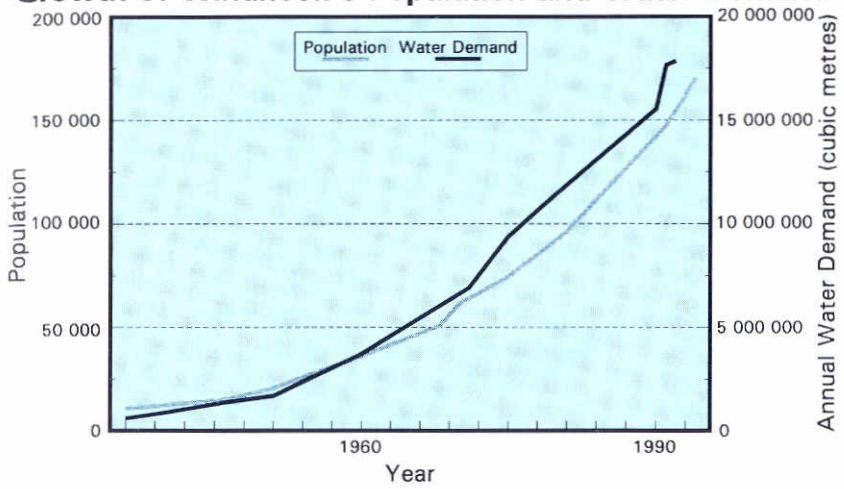
Residents of Windhoek's suburbs differ widely in their use of water, with those in Erospark consuming nearly 15 times the average daily amount of a resident in Katutura. At the same time, although individuals in Katutura consume less water, their rapidly expanding numbers due to increased rates of urbanisation also place a heavy burden on available supplies (29).



The total volume of water supplied in bulk by the Department of Water Affairs has increased steadily over time. Although the drought of the early 1980s temporarily reduced the amount, it increased rapidly soon after. The large increase in water supply to mines, seen in the late 1970s, is attributable to development of the Rössing Mine. Of particular note is the rapid and continued growth in water supplied to primary consumers - Namibia's towns and villages. (Source: DWA records)

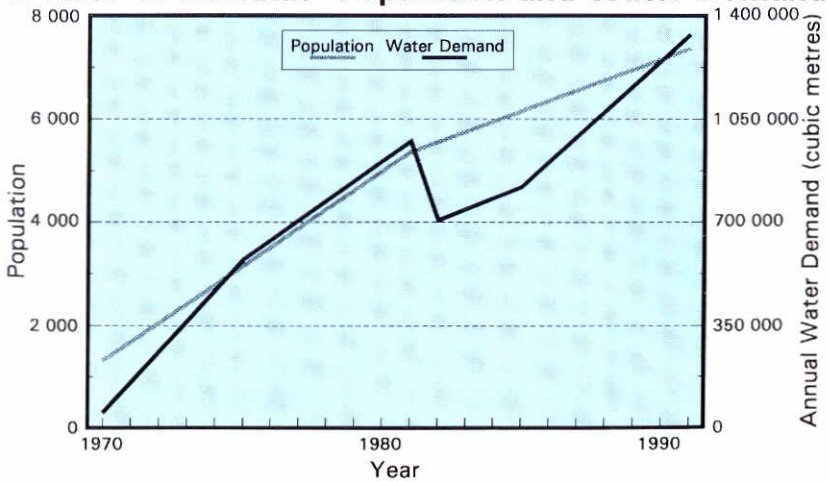


Growth of Windhoek's Population and Water Demand



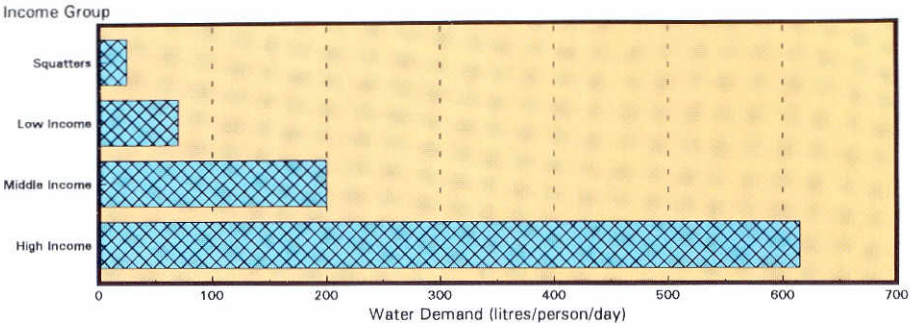
In the absence of demand management there is a direct correlation between the growth of the human population and the growth in water demand, as seen here for Windhoek and Khorixas. Water restrictions can reduce demand, however, as is seen for Khorixas in 1981. But even with restrictions in place, the growing human population will eventually absorb any previous reductions in demand, as has happened in Khorixas. Ultimately if human populations continue to expand, people will have to live with less in the face of finite supplies. (Source: DWA records).

Growth of Khorixas' Population and Water Demand



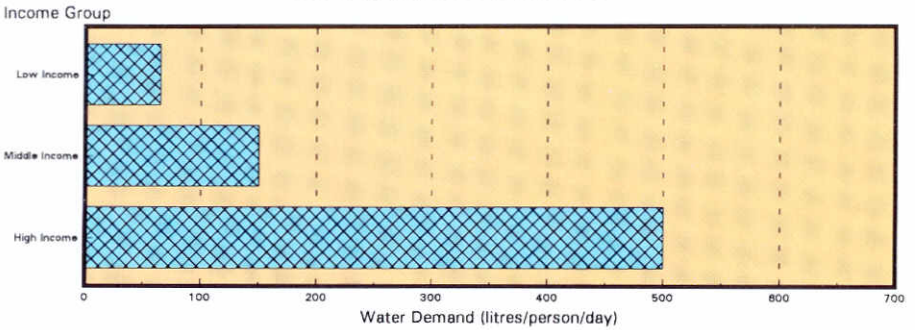
City of Windhoek

Income Category versus Water Demand



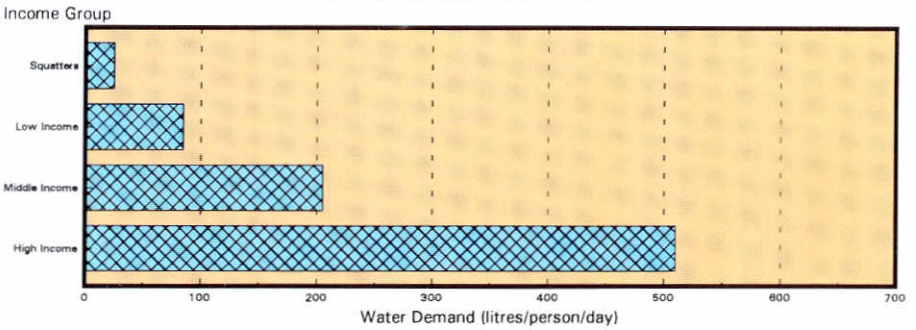
Town of Walvis Bay

Income Category versus Water Demand



Town of Swakopmund

Income Category versus Water Demand



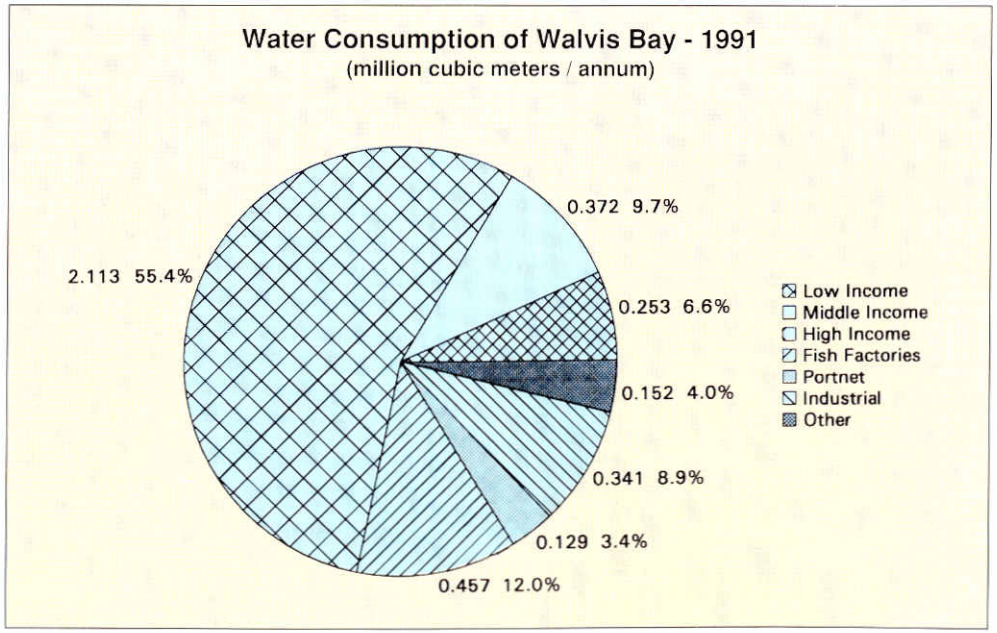
There is a close relationship between income and water consumption. As income rises, so too does the average volume of water consumed. There is an urgent need to find ways to uncouple high water demand from a luxurious lifestyle.

The rate of water consumption within certain areas of Windhoek has been described as exorbitant (35). A survey done in Windhoek in 1986 showed a strong positive relationship between erf size and water use (35). The results of a survey in Windhoek on the average daily per capita residential consumption show the following tendency: In 1987/88 the daily per capita consumption was 186 litres. The consumption increased to 209 litres per person per day in 1990/91 and then decreased in 1992/93 to 152 litres per person per day after the introduction of punitive block water tariffs and a public campaign to lower water consumption. This figure included consumers serviced by standpipes, using only 14 to 20 litres per day, those in city flats using 150-180 litres per day, as well as consumers in suburbs such as Erospark or Ludwigsdorf, who are using as much as 500 litres per person per day. This high consumption is almost all because of gardens and it is estimated that 60 per cent of this water is consumed for garden purposes. Some of the most blatant residential consumers in Namibia's capital have average daily consumptions in excess of more than 25 cubic metres (25 000 litres) per erf (35).

Even with the current extension of the Goreangab water reclamation works, Windhoek's available water sources will only supply the city until the year 2003 (35). This assumes that the growth in annual water demand can be restricted to no more than 5 per cent (35). This will only be possible through the introduction of an aggressive water demand management programme approved by the City Council of Windhoek. Punitive block tariffs introduced in 1992 should be retained, and even tightened in the future, to cope with higher water demand associated with rapid growth of the city.

Recognition of this imminent shortage motivated the currently ongoing Central Area Water Master Plan Study (190). The main purpose of this study is to develop a plan to meet the water demands of the central area of Namibia, particularly Windhoek and the coastal towns, until 2020. What has emerged clearly from this study is the fact that Namibia must invest over N$2400 million (based on 1993 estimates) during the next 20 years to provide water to the central area to keep up with increasing demand. Another major outcome of the study is the realisation that an effective demand management programme, prioritising and reducing demand within the region, is urgently needed (190). During the public workshop to discuss the CAWMP in November 1993, water demand management was confirmed as one of the most important short term issues.

In Khorixas, approximately 7 400 people consumed nearly 1.4 million cubic meters of water in 1991 (139). This amounts to an average daily consumption of nearly 500 litres per person. In an attempt to meet this high demand the aquifer supplying the town has been severely depleted. Water is withdrawn at a higher rate than it is recharged, even though efforts to regulate the amount of water used have been implemented since 1980. The water supply is turned on for three periods during the day - morning, noon and early evening - to try to control the levels of demand. This form of regulation may in fact be contributing to the high rate of water use, because many people leave their taps open all day. When the main supply is turned on, water continually runs from taps throughout the town (111). The fact that many households are unmetered or meters are inoperative further contributes to overuse. All residents are charged the same amount for water, no matter how much they use (111). Finally, recent investigations by the Department of Water Affairs suggest that a large amount of the water which is consumed in the town may actually not be reaching the individual consumer at all. Rather, broken pipes throughout the town may be allowing as much as 66 per cent of the town's water to be wasted.



More than 55% of the water consumed annually in Walvis Bay is used at the residences of high income earners, the majority being used to water large gardens of alien plants. Of the entire fresh water consumption of Walvis Bay, 37% is used on private gardens. (191).

Currently, rest water levels in the aquifer supplying Khorixas have been lowered more than 50 metres. Since 1978, the pumping rate has exceeded the sustainable yield of the aquifer, resulting in a drop of as much as 4 metres per year. The aquifer is now regarded as exhausted in terms of it potential for further development (139). Although restrictions have been in place and desperate measures have been taken with the drilling of multiple boreholes to supplement the deteriorating yields of several critical production boreholes, no demand management programme has been initiated in Khorixas.

In an effort to meet this unregulated demand, plans are being considered to build a dam on the Ugab River, possibly on the Farm Sebraskop (50). While this dam will increase water supply to Khorixas, it will also have a severe effect on the environment in the Ugab River and the nearly 1 000 people below the dam site whose livelihoods it supports. One suggestion has been that rather than investing the large amount of money in a dam and pipeline (estimated to cost upon completion more than N$100 000 000), the Government should instead invest its resources in replacing the old water reticulation network beneath the town. Although the cost of such an effort would also be high (but certainly much less than the dam and distribution pipeline), in the absence of functioning pipes and water metres, attempts at achieving a sustainable use of water in Khorixas will not succeed.

Contributing to the misuse of water in both these towns, and throughout Namibia, has been the heavily subsidised capital cost of water provision. Existing policy of the Namibian Government has been to recover only operational costs from bulk consumers (for example, the municipalities). In practice though, the bulk supply rate for urban areas does not recover these operational costs (including overheads). For the past 7 years, income from bulk water sales was 14 per cent less than actual costs of operating the existing bulk water services (35). If capital cost were to be included in the bulk cost of water supply to Windhoek, the bulk water supply tariff would increase from N$0.95 to N$2.77 per cubic metre. In Khorixas, costs would increase from N$1.05 to N$3.12 per cubic metre. In the case of small schemes such as Kamanjab, the price would rise from the current rate of N$1.10 to N$7.07 per cubic metre.

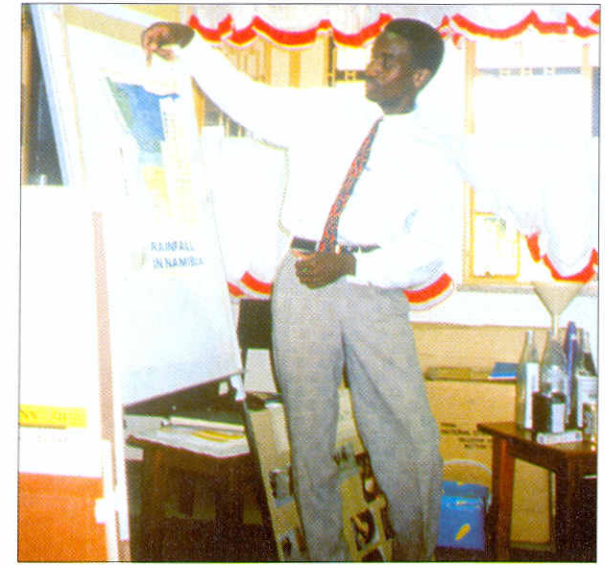
Although provision of subsidised water for basic health purposes is advocated in the new Namibian Water and Sanitation Policy, it is not clear how tariffs will be collected for use in excess of this amount (51). Costs associated with adding to existing supplies, estimated at upwards of N$ 2.4 billion for Windhoek and more than N$100 million for Khorixas, are very high and will entail high costs for consumers. But will these costs ever be recovered? In towns such as Khorixas, where a high number of people are without jobs, cost recovery is not possible.

Should the demand be reduced, or should Namibia continue to try to supply all the water people want? Serious examination is needed of whether or not it is appropriate to continue to expand the existing water supply network for areas such as Windhoek and Khorixas, as well as many other urban centres in the western catchments. It is unclear whether or not it is in Namibia's best interests to make massive and unrecoverable capital investments in water supply infrastructure, particularly when such investments mean that other developments or water uses cannot take place. There is no other choice than to implement an aggressive demand management policy, including a reappraisal of the tariff structure for high

1995 / 96 Projected Bulk Water Supply Costs and Tariffs

Supply Point	Actual Cost (N$ / cubic metre)	Current Tariff (N$ / cubic metre)	Proposed Tariff (N$ / cubic metre)
Henties Bay	3.24	1.10	1.43
Kamanjab	7.07	1.10	1.43
Karibib	4.07	1.10	1.43
Khorixas	3.12	1.05	1.37
Okahandja	2.40	0.75	0.98
Rössing Mine	4.11	1.14	1.48
Swakopmund	3.03	0.85	1.11
Usakos	5.07	0.99	1.29
Walvis Bay	3.01	0.85	1.11
Windhoek	2.77	0.95	1.24

The actual cost which the government pays to supply water is not reflected in the tariffs which it charges the various local authorities. These subsidised costs mean that people do not know the true value of water and are therefore not motivated to curtail excessive and wasteful use. (Source: DWA)

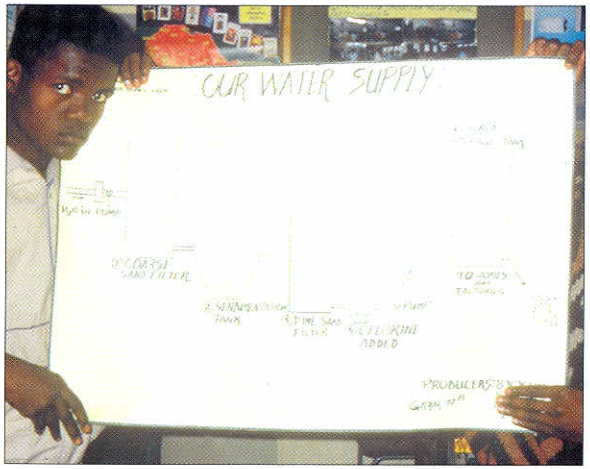


Namibia will only succeed in managing its scarce water supplies if there is widespread knowledge and frank discussion of the issues relating to its availability. Here, an educator from the Desert Research Foundation of Namibia discusses rainfall and the Namibian climate with a group of teachers. (photo: B Flannery)

consumers of water, as was suggested and approved for Windhoek by the City Council (35). 'Supplying water to all is essential - supplying all the water people want is not!' (19).

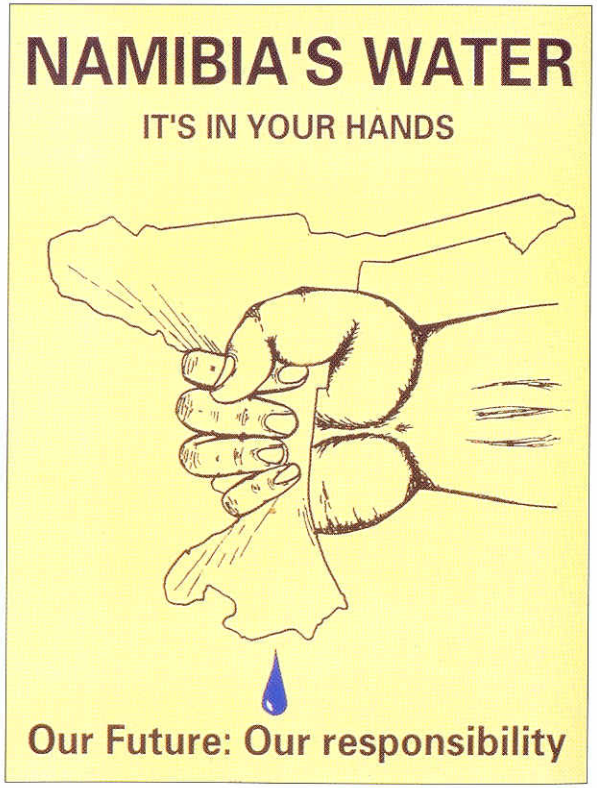
The greatest constraint to the success of a demand management programme is a lack of awareness by water users. Water supply has not yet become an issue of national concern and it receives very little media attention. The 'public workshop' on the Central Area Water Master Plan study is a case in point. Although this workshop was advertised in newspapers as a 'public' event, not a single member of the public attended, even though the topic discussed was one of the most important issues affecting the future of Namibia. A few politicians and media persons attended the workshop for brief periods and then left. No representatives of the Ministries of Trade and Industry or Finance attended, although water, or lack thereof, will be the most important factor limiting economic development in the long term. And afterwards? A few articles appeared in the local press (9), although it was not regarded as front page news. To what can this apathy be attributed?

An oft-quoted saying is that 'you know the worth of water when the well runs dry.' It is time for the public to learn that Namibia's wells are running dry. It is time for Namibia's political leaders to recognise that agencies in government charged with water provision are being asked to achieve the impossible. It is time to make some hard decisions. Current development plans around the country must be seriously re-evaluated in light of both regional and national water availability. The public needs to know the national and individual costs that they are going to have to pay for a resource to which they have given little thought. The public needs to be made aware that even while incurring these costs, their lifestyles are going to have to change. The government must accept that the public will be reluctant to change their water consumption behaviour willingly and will therefore have to be dealt with appropriately. Namibia's well must not be allowed to run dry for lack of awareness.



Environmental awareness regarding Namibia's water resources begins in the schools. Here, two students in Khorixas show a poster they have prepared highlighting some of the many steps involved in providing a clean and reliable supply of water to Namibia's consumers. (photo: B Flannery)

Getting students involved in hands-on experiments and demonstrations will ensure a proper understanding of the importance of water conservation in their daily lives. Here, teachers are seen preparing for a demonstration to their learners regarding water usage patterns within the home. (photo: B Flannery)



This awareness poster was prepared by a group of student researchers from the University of Namibia, while based at the Desert Research Foundation of Namibia investigating water use patterns in the Kuiseb catchment. As it shows, the future of Namibia's water resources is in the hands of every single Namibian.

▶ *What's important about water management and use in the western catchments towns and cities?*

- *Towns and cities throughout the region are facing serious shortages of water for human consumption. In each situation the reasons for the shortages may be different (demand of rapidly increasing urban populations exceeding available water supplies, excessive use by individuals, wastage) but the result is the same: non-sustainable use of the existing water supply. At many sites within the western catchments, such as Kamanjab and Khorixas, aquifers have been almost completely exhausted and future sources for water provision are unknown, unavailable, or uneconomical to develop.*

- *A co-ordinated multi-sectoral approach to water demand management and development planning must be initiated at the ministerial level, because current use in many areas is unsustainable. Supplying water to support human habitation in arid and semi-arid environments can be prohibitively expensive once local aquifers have been depleted. No Namibian tax dollars should be spent to support excessive or inappropriate water use in desert towns and cities.*

- *Supplying water to Namibians in the western catchments is a serious and expensive challenge. Immediate attention is needed to ensure that sustainable development of this important region continues. The following recommendations would help to achieve this:*

- *Settlement and physical development plans, whether local, regional or national, must incorporate a consideration of the constraints imposed by scarce and finite water supplies.*

- *Establishment of so called 'wet industries', which require large volumes of water, should be reviewed on a national level, involving the National Planning Commission and the Ministry of Trade and Industry. Establishment of such industries in the central region of Namibia, or anywhere in the western catchments, should not be encouraged given the water supply situation (35). The only exceptions are industries wishing to be sited along the coast that can factor the costs of desalination into their operating expenses.*

- *All of Namibia's high income residents must take it upon themselves to set examples of water-efficient lifestyles. Use of water-saving appliances and gardening techniques should be standard protocol. All gardens should contain only water-efficient indigenous plants. A common goal must be to reduce water consumption rates to the 100 litres per capita per day target consumption, thus uncoupling high water consumption from a luxurious lifestyle.*

- *Water consumption statistics should be on public record, available upon request. Of note is the fact that some of Windhoek's residences use an average of more than 25 000 litres per day, more than 130 times the capital's average.*

- *The recommended target for Windhoek, of 100 litres of water per person per day, should also be set as a target for consumers in all western catchment towns and cities, to be reached within five years. Along with this, a higher tariff for individuals consuming more than 200 litres per day should be enforced. This policy should be enacted immediately in all municipalities.*

- *An education and awareness campaign which reaches all segments of Namibian society, and all visitors to the country, should be established immediately (35).*

- *Local nurseries should provide guidance to the public about water consumption of plants offered for sale. Purchase of drought-resistant trees and shrubs should be encouraged (35). The municipality should heavily tax or ban the further sale of alien plants with high water needs.*

- *Given the established relationship between water consumption and erf size, erf size should be reduced in the planning of residential developments (35). If individuals want large plots, a municipal ordinance should encourage the maintenance of native vegetation.*

- *Parks, sports fields and public gardens should only be watered with purified effluent (35) and watering should not be done between 10am and 5pm to minimise losses due to evaporation.*

- *Compulsory use of low-flush toilets, low-flow showers, and small bathtubs should be required in all future construction projects and be incorporated into the building regulations for Namibia (35).*

Water Supply and the Environment

The present policy of the government regarding multiple claims on a single water source is that:

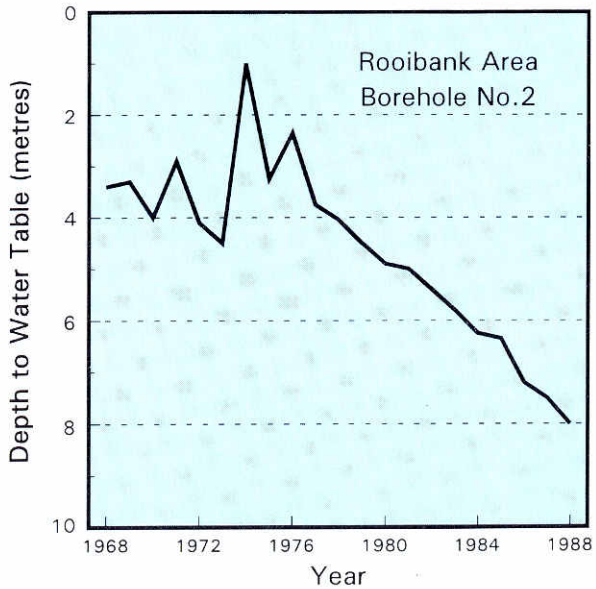
'The following priority ranking is given to the allocation of water for competing demands:

First priority: Water for domestic purposes, including livestock watering for both subsistence and commercial farming

Second priority: Water for economic acitivities such as mining, industries and irrigation. Priorities for these acitivities will in each individual case have to be determined by their respective value in relation to the overall development objectives and plans for the country' (51).

The fact that the environment is not specifically recognised as a consumer of water in this list of priorities is very troublesome. The overwhelming majority of Namibia's citizens derive their livelihoods directly from the environment through various agricultural uses. Although livestock watering is listed as a first priority, so too must be the production of livestock forage which also consumes water. In the western catchments, particularly within communal farmlands, vegetation found within ephemeral rivers is a critical resource for livestock and wildlife. This vegetation, riparian forests in arid areas, is clearly dependent upon the availability of water for survival. However, as a result of environmental water needs not being listed, the value of this resource is not considered. Policies which set priorities for water usage must take a more realistic view of the environment as a primary resource upon which the agricultural and tourism sectors in western Namibia depend. Lack of consideration of water needs of the environment in western Namibia today, resulting in the loss of riparian forests, will mean the loss of agricultural and tourism revenues to future generations.

Because water is a critical factor limiting the survival of organisms living in arid regions, any changes in availability of water will in turn change the environment. Herein lies the root of most environmental problems associated with water supply development in arid lands. In attempting to capture, store or transfer water, we change its availability somewhere else. Drilling a borehole may increase water availability for a nearby town. At the same time, if the pumping rate is in excess of recharge, the water table will drop, and water availability for tree growth or a farmer's well will be reduced or exhausted. Similarly, a dam may increase water availability for a town or mine in its vicinity but reduce water availability below the dam where flooding and groundwater recharge become less frequent. The fundamental principle is that in developing water resources of a region, we are not creating water. Rather, we are redistributing it across the landscape, often to the detriment of another user.



The rapid decline of the water table in the lower Kuiseb River, beginning in the late 1970s, is due to the increasing water demands of the Rössing Mine, Swakopmund and Walvis Bay. The recharge effects of the 1974 and 1976 floods are also shown. No significant recharge has occurred since and water tables continue to drop in the region. (Source: DWA records)

As early as 1904, the following idea regarding ephemeral river floods was expressed in Namibia:

> *'storage dams of massive capacity have to be constructed to collect the water which otherwise runs unused into the sea' (161).*

The role that large floods play in maintaining the natural resources upon which downstream users and riparian forests depend was certainly not considered. During that period, the German colonial government was also providing subsidies to people who constructed dams on their farms. They had even established a 'dam building squad', which roamed the country to assist in planning additional farm dams. All of this occurred without any recognition of future effects that such a proliferation of storage works would have upon the downstream environment. In a similar way, in 1968 the Department of Water Affairs emphasised that: 'every use is made of local supplies first before resorting to pumping with attendant high operating costs' (48). Although this is logical from a short-term financial view, it does not necessarily imply that the effects of such use on the local environment, or even long-term national security, will be factored into the operating cost. When the environmental costs of water supply are not factored in, such 'local options' appear comparatively cheap. As a result, water resource development around the world has more often than not proceeded without a realistic assessment of its effects upon the environment and their associated costs in

From early settlers experimenting unsuccessfully with dynamite to road crews enlarging outlets and pools with bulldozers, springs in the western catchments have been abused. This spring, in the Uniab catchment, was bulldozed to obtain water for road building. Sites such as these are critical to the survival of wildlife in these arid western regions and in turn, to the maintenance of Namibia's rapidly growing tourist industry.

realistic economic terms. Who will pay these costs? The costs will be paid by downstream users and by future generations.

Destruction of springs throughout Namibia over the past century provides one of many examples. Springs have been seriously damaged or destroyed by people trying to 'improve' them. A common theme has been enlargement of the basins where water emerges, and pools. Early missionaries experimented with dynamite to increase spring flow or create larger storage basins. Instead, they sometimes reduced flow or caused springs to dry up completely (101). More recent examples may be found in the western catchments, associated with road building. To obtain water supplies for road construction, springs are often bulldozed open to form storage basins from which water can be easily drawn. Aside from unpleasing aesthetic effects, such efforts frequently reduce outflow. Several springs in the vicinity of Palmwag in the Uniab catchment were seriously damaged when the road north to Sesfontein was constructed during the early 1980s (111). Destruction of springs can have serious economic consequences in areas such as the Uniab catchment.

Such springs are critical resources for the region's wildlife which, in turn, supports a growing tourism industry, a mainstay of Namibia's economy.

Agriculture is a major factor driving water development in Namibia. Water for agriculture comes from springs or boreholes, or from dams in streams and rivers. Use of water from all these sources entails environmental costs. Springs provide a cheap and convenient source, but their use by livestock frequently displaces wildlife. Water from natural springs is an issue of particular importance in the arid western regions of the catchments, where increasing numbers of people and livestock are competing with wildlife for water (8, 13). Boreholes can be an appropriate solution to meeting surface water needs. If mismanaged, however, they can have severe environmental impacts. In nomadic systems, both pastoralists and wildlife move about in search of water and forage. The introduction of boreholes, however, allows the activity of people and livestock to become uncoupled from surface water availability. With water availability no longer limiting livestock numbers, the surrounding vegetation becomes the limiting resource. As a result, vegetation cover may be degraded or completely eliminated from around boreholes.

Irrigation projects can also have serious environmental effects because of the large volumes of water usually required. In this regard, large-scale projects such as the expansion of the gardens at Khowarib, Warmquelle and Sesfontein are cause for concern. Plans to extract groundwater from the Hoanib River aquifer will likely have a negative effect on riparian vegetation and wetlands within the river west of Sesfontein (47). The deterioration of these resources would endanger wildlife in the region and seriously undermine the area's tourism potential.

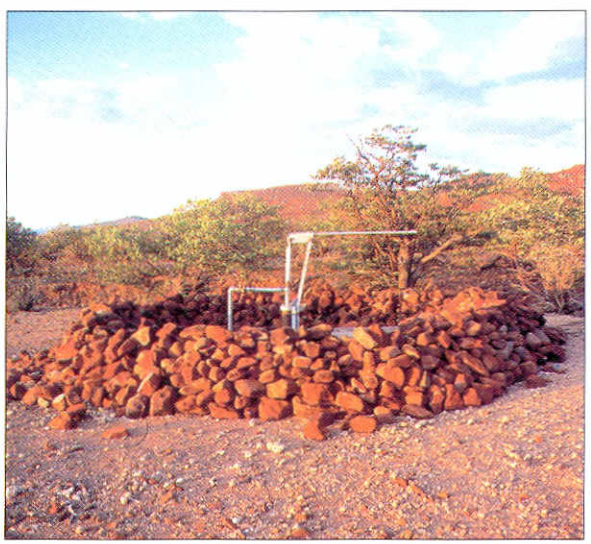
The die-back of ana trees and !nara plants in the lower Kuiseb River, associated with pumping of water for

This aerial picture of the lower Swakop River shows the effects that a dropping water table has had upon the ana trees there. Many of the larger and older trees have collapsed and died as the water table dropped, following the completion of the Swakopport Dam.

coastal development, provides another example of water development with as yet undetermined environmental costs. Continued pumping from boreholes in the river has dropped the water table more than 10 m in some areas (49), below the reach of the plants' roots.

Finally, small and large dams, reducing or eliminating downstream flooding, can have severe impacts upon the downstream environment. If the proposed Donkersan and Sebraskop Dams are built on the Kuiseb and Ugab Rivers, respectively, they will substantially reduce downstream flow, seriously degrading or destroying the downstream environments upon which many Namibians depend. The economic costs associated with the deterioration of these environments are unknown but may be high. In the case of the Ugab River, the value of the seed pods produced by the ana trees growing below the proposed dam site is estimated to be between N$1-5 million in a single year. This excludes the value of the tree's foliage, which is also important forage for livestock and wildlife. In addition, the economic implications for the tourist industry and the costs of finding alternative livelihoods for the people living below the dam are unknown. Costs such as these, among others, must be considered when evaluating options for water supply development.

Excessive stock pressure around water points can result in severe soil erosion as seen here at a water point in the Huab catchment. Such sites, once degraded, may recover very slowly.



Water development in the absence of land use planning is a common theme in the western catchments. This borehole, installed to provide water for livestock during the 1993 drought relief programme, was sited in the Uniab catchment - a key area for tourism and conservation. The rock wall around the pump protects it from elephant which are common in the area.

FARM DAMS AND THE ENVIRONMENT

Dams on farmlands throughout the western catchments represent a threat to ecosystems on the lower reaches of the ephemeral rivers. Dams may, if properly sited and constructed, hold water throughout a large portion of the dry season, providing an important source of water for livestock. At the same time, however, they withhold downstream runoff from farmers, livestock and riparian forests in the lower river.

At present, no permission is required to construct dams smaller than 20 000 cubic metres, although they were often registered with the Department of Agriculture prior to 1990 in order to obtain 'property improvement' or 'soil conservation works' subsidies. These subsidies were dropped with Namibian independence. Permission is required from the Department of Water Affairs to build or renovate dams larger than 20 000 cubic metres, although they are often constructed or repaired illegally (52, 181). As an example, some farms in the Kuiseb catchment have no officially registered dams but a visit to, or a flight over, the area reveals a dozen or more. Individually, such dams represent no threat and are of tremendous benefit to the landowner. However, when dams on more than a hundred farms in a catchment such as the Kuiseb are added together, they may represent a major loss of downstream runoff. Lack of an accurate inventory of dams within the western catchments greatly complicates attempts at effective water management within them.

Small excavation or embankment dams have recently been recommended as a means of reducing the environmental degradation associated with permanent settlement at boreholes in communal farmlands of the western catchments (105). It is thought that such structures, holding only 3-4 months of water, would distribute livestock and increase access to grazing without encouraging settlement and possible degradation of the environment. Although such an approach appears well conceived, it may contribute few long-term benefits to environmental management in the region. Because of infrequent and violent runoff in the region, the tendency will be to increase dam size to prevent their destruction and maximise storage when runoff does occur, thus encouraging settlement and negatively affecting downstream environments. Such structures will also be irresistible to the region's elephant populations. Given the difficulty in protecting even small dams, conflicts will undoubtedly arise. The decision to initiate construction of any such water-works should be taken only after development and approval of a regional land use plan, and then only with recognition of the effects downstream.

Farm dams, such as this one in the upper Huab catchment, occur throughout the western catchments. Although they provide water for stock farmers in the headwaters, they also reduce downstream flow. When added together over an entire catchment, such dams may have a major effect on the downstream environment. Large numbers of ana trees are dying in the upper Huab catchment, due to the combined effects of farm dams and decreased rainfall. Although needed, no thorough study has been conducted to accurately determine the effect that such dams have on runoff patterns throughout the western catchments.

▶ ***How does water supply for human use affect the environment?***

- *When developing water resources in a region, we do not create water. Rather, we are redistributing it across the landscape, often to the detriment of another user. This is particularly true of dams on ephemeral rivers that eliminate large floods and reduce or eliminate downstream flow. In such cases the water resource available to downstream users is obviously reduced or eliminated. In addition, these users also lose the resources of the riparian forests, namely fodder for livestock and wildlife which are essential resources for rural agriculture and tourism.*

- *Agriculture is a major force driving development of water resources, often through the installation of boreholes. If boreholes are solely used to allow access to areas that have received good rains, and encourage the movement of stock and wildlife from dry regions with low or no grass cover to regions of good grass cover, then they can be very useful. However, if people and their livestock settle at these water points, regardless of the current rains, and areas are subjected to continual grazing year in and year out, the grazing and browsing resources may deteriorate. If this degradation is severe, the cost of this long-term loss in productivity affects the country as a whole.*

- *Environmental Assessments (EAs) should be conducted on all water supply policies, programmes and projects being used or considered. This is particularly important in view of impending commercialisation of bulk water supply. These EAs must adopt a broad view of the potential environmental impact and assess the interconnections of impacts at many levels: local, regional and national. Such integrated approaches are also necessary because of the national and international implications of bulk water supply plans, envisaging long-distance transport of water within Namibia from the borders to the central regions of our country.*

- *Studies of water availability and options for provision to users must be initiated and proceed from a catchment view of water supply systems. From the level of farm dams to state water schemes, the effect of upstream developments on downstream users must be evaluated and used in development planning in all western catchments. Such planning must ensure appropriate and equitable use of water resources.*

Living Off the Land

The Old Way: Hunter-gatherers and Pastoral Nomads

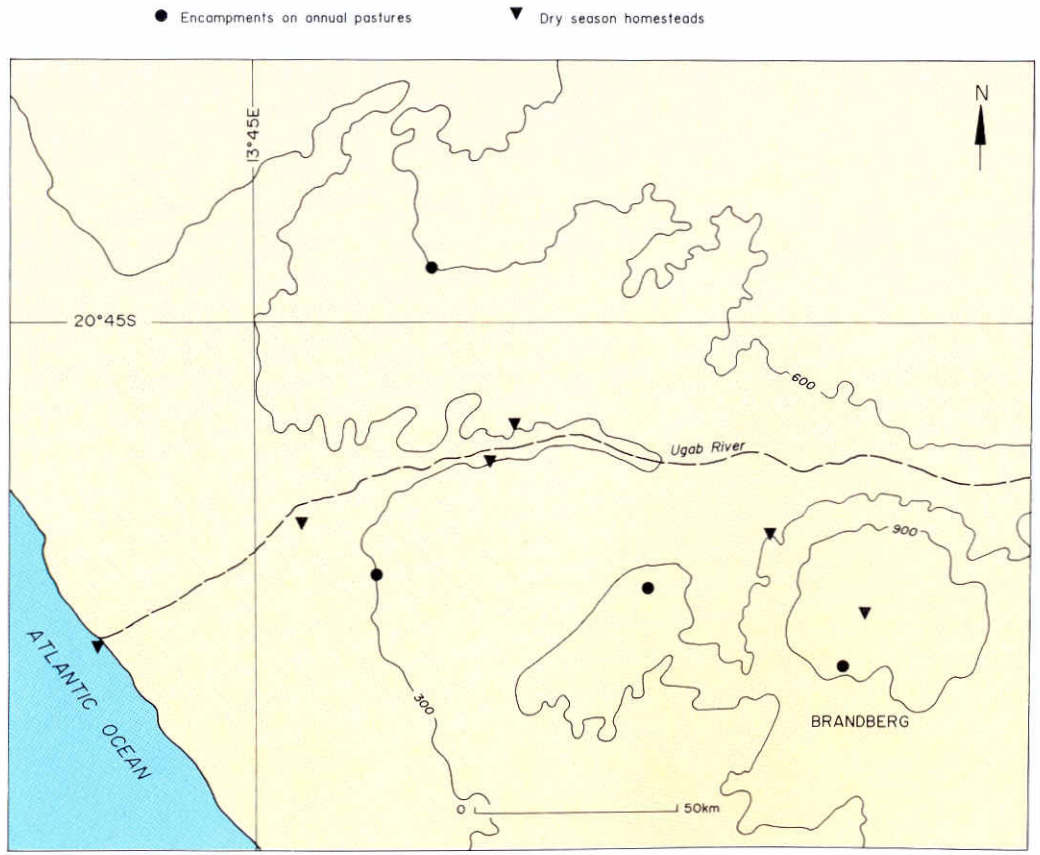
Archaeological evidence indicates that people lived as nomadic hunter-gatherers in the western catchments from the mid-Pleistocene, a lifestyle which changed only within the past four thousand years (93, 92). Archaeological sites are found in every catchment, especially in close vicinity to springs and river courses (94). These people, gathering near reliable water, left paintings and engravings scattered throughout the hills and mountains of the western catchments. Sites such as the Brandberg Mountain, the Twyfelfontein Escarpment and the Spitzkoppe are well known. Evidence from the Erongo Mountains, on the boundary of the Omaruru and Swakop catchments, indicates that people made regular movements over the past two thousand years to find water and food. These movements tracked the seasonal changes in resource availability within the vicinity of such sites. During the rainy season, resources on the mountains were used until the dry season caused a retreat to the Omaruru River (229). This dependence upon the river's resources within the dry western regions is a pattern echoed in much of the archaeological material known to date, and persists today.

Hunter-gatherers lived within the western catchments, such as the Kuiseb, Tsondab and Tsauchab, leaving their stone tools at sites where water was accessible (182). Archaeological sites are usually found near inselbergs or along ephemeral rivers where water could be more easily found and game and plant foods are more abundant than in the adjacent stone and rock desert. These patterns suggest that ephemeral rivers, such as the Kuiseb, served as migration routes for both people and wildlife throughout

Stone circles seen along the western rivers are thought to be evidence of early pastoral settlements. It has also been suggested that they are the remains of hunting blinds, from which passing animals would be ambushed. Whichever is the case, these circles along the Kuiseb River provide evidence of the importance of the western rivers to their early inhabitants.

much of the Pleistocene (183). In further support of this fact are coastal settlements, some containing evidence of links with inland regions. Within the Kuiseb catchment, copper was worked at several places along the river, more than 200 kilometres from the coast. Fragments of !nara seeds at these inland mining sites, as well as copper beads at coastal sites, demonstrate that movement was occurring along the catchment from headwaters to the coast (97). Mussel shell middens in the Kuiseb River delta dunes, near the Atlantic Ocean, are remnants from a long history of people living in the lower Kuiseb River. Similar middens are found elsewhere where freshwater occurs along the coast such as at the Ugab River mouth, along the Atlantic coastline, where remains of a whalebone hut settlement date from 200 to 600 years ago. Access to these coastal sites and their comparatively rich resources was probably gained via the river courses themselves (95).

Agricultural development in the western catchments began with the introduction of livestock from the northern parts of Africa resulting in development of subsistence patterns based upon nomadic pastoralism. There is evidence at the Spitzkoppe of a hunter-gatherer settlement which underwent this transition within the past four thousand years (92). At the base of a ravine on the Brandberg Mountain in the Ugab catchment, the remains of a large encampment testify to the existence of a pastoral community living in this region during the last one thousand years (93). It is apparent from these remains that people and their stock moved between seasonal pastures around the base of the mountain to more reliable perennial pastures higher up. These movements revolved around seasonal variations in water and forage availability. Other traces of Namibia's earliest farmers include sheep dung at the Mirabib inselberg in the Kuiseb catchment, from livestock living there more than 1 500 years ago (169). Tracks preserved in silts of the lower Kuiseb River provide a record of cattle from the eighteenth century (96).



Early pastoral nomads living in the vicinity of the Brandberg more than a thousand years ago, moved between annual pastures and dry season homesteads in response to annual rains. These patterns of seasonal movement are similar to those practised today by OvaHimba pastoralists living within the Khumib and Hoarusib catchments. (Reproduced with the permission of J. Kinahan (93))

Changing Lifestyles: Sedentarism and the Colonial Era

Nomadic pastoralism, based primarily on the search for adequate water and fodder, began to disappear with the arrival of Namibia's first colonisers in the nineteenth century. The history of colonial occupation in Namibia began in 1884 with Germany's declaration of the country as a protectorate. The German administration lasted until 1915 when the German colony was handed over to South African forces. In 1920, South Africa was entrusted with a mandate over the country on behalf of the League of Nations. This period should have come to an end in 1945 when the United Nations took the place of the old League. Instead, a long struggle ensued and in 1966 the UN General Assembly officially revoked South Africa's mandate over Namibia, observing that it had violated the UN provisions for the mandate by establishing its apartheid-based administration (214). In particular, introduction of the 'Odendaal Plan' in 1964, which consolidated and expanded a series of ethnic homelands, undermined the economic independence of Namibian communities. What followed was a long period of conflict, culminating in Namibian independence on March 21, 1990. This brief history provides the basis for our discussion of agricultural patterns in the western catchments.

Before the turn of the twentieth century, the colonial government established a series of 'native labour reserves' such as Sesfontein, Fransfontein, Otjohorongo and Okombahe (102). These served nearby settler farming communities which were developing rapidly. In subsequent years, minor additions of land were made to these areas, increasing their size to accommodate increasing numbers of 'natives' being resettled. These resettlements were driven by the early colonisers' desires to secure the most valuable farmland in the country for their personal use (123). Nevertheless, for a period these 'reserves' supported viable farming enterprises providing dairy and other products to national and international markets (102).

The most desirable farming areas, where sedentary European farming methods could be applied in most years, were in the upper catchments which had relatively high rainfall. Farmers derived support from the 1948 Long-term Agricultural Policy Commission whose findings suggested introduction of various schemes to enhance meat production through cattle ranching. A series of subsidies were introduced to help individual farmers establish fenced camps with boreholes and ground dams. These subsidies contributed to a proliferation of ground dams (102) in the upper catchments that still persists today. Subsidies continued until 1989, when they were dropped prior to independence.

To obtain prime areas of the upper catchments for cattle ranching, the government removed the people living there and 'settled' them on the reserves. Within the western catchments, people were moved from more productive areas in the east to the more arid west, where agricultural potential for the large numbers being settled was marginal at best (2, 165). In earlier times, these western regions were used only on a seasonal basis or during years of high rainfall by small numbers of people, but now large numbers of people were expected to settle there permanently.

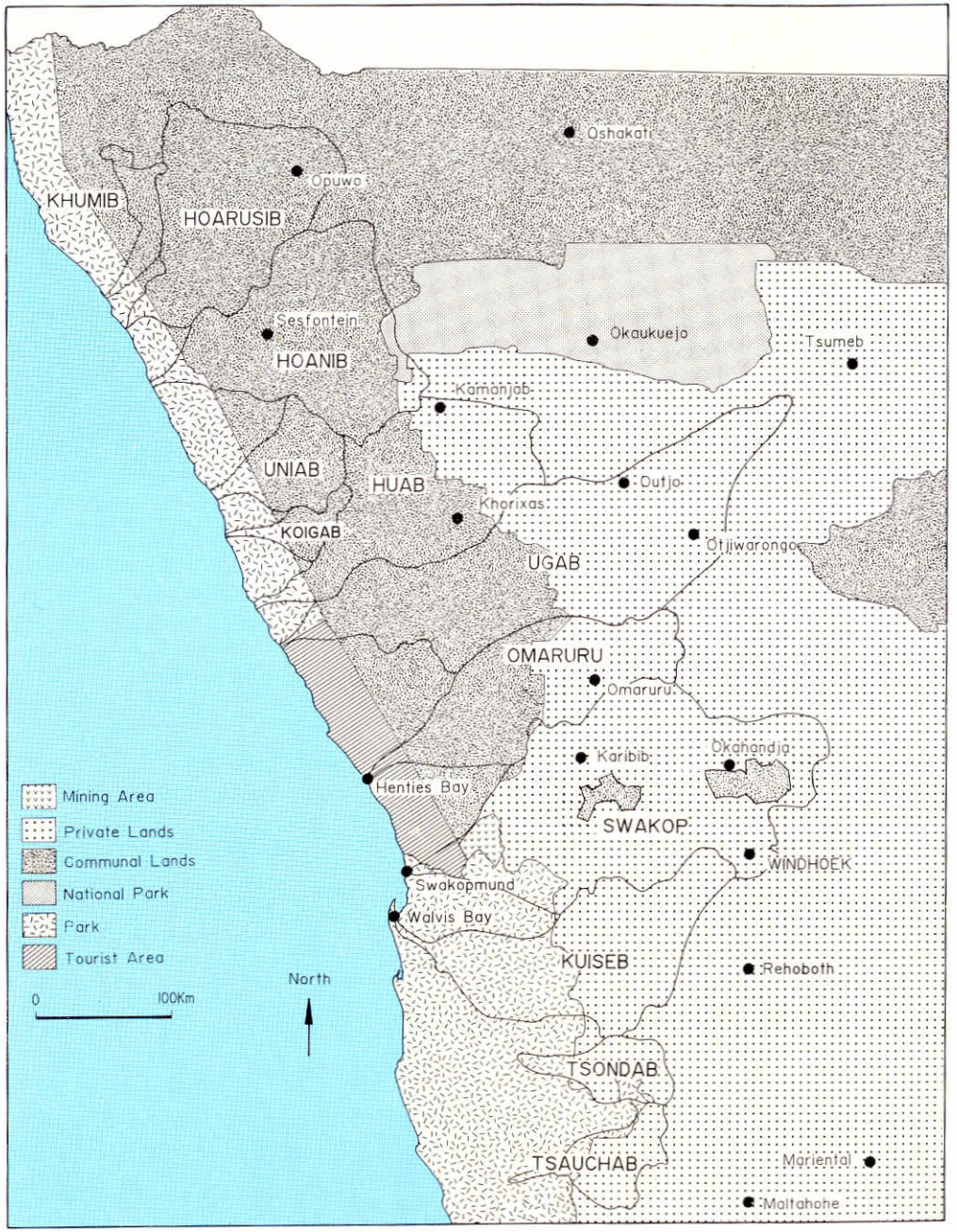
Farming the arid and semi-arid west

Because of its unique history, former Damaraland (now divided between the Erongo and Kunene Regions) deserves special consideration. Its boundaries were recommended in the report released by the Odendaal Commission, the South African government's mechanism to achieve separate development. Within this area 223 farms had been surveyed and settled by colonial immigrants during the 1930s (162). These farms, the most westerly farms in Namibia, could at best be regarded as marginal. They were operated as cattle or small stock farms and some were used for karakul sheep.

Because of unreliable production associated with the highly variable climate, many farms in Damaraland had already been abandoned by 1964 when the Odendaal report was released (165). In other cases, these farms were used as additional grazing reserves by farmers living elsewhere. Stock were occasionally moved onto these western farms to graze and then returned to inland farms. This pattern mimicked movements of nomadic pastoralists in response to rain. It was these western farms that were bought by the government, on recommendation of the Odendaal Commission, and added to existing 'native reserves' to form the new homeland of the Damara. The Odendaal Commission stated that Damaraland would offer 108 hectares per individual to its residents. However, this figure does not reflect the fact that well over half of the region is desert and unsuitable for stock farming (165).

What we have inherited in the west

The end result of the processes of colonisation, resettlement, and implementation of the Odendaal Commission's recommendations, over a period of approximately seventy years, was a stratification of land ownership within many of the catchments. The upper reaches of seven of the twelve major catchments were now occupied by privately held commercial farms (approximately 980 farms throughout the catchments) while middle and lower reaches were absorbed into communal farmlands and proclaimed conservation areas.



The end result of colonisation, resettlement and finally, the implementation of the Odendaal Commission's recommendations, is the division of many of the catchments between private farmlands in their headwaters and state-owned communal farmland or tourism and conservation areas in their lower reaches.

One of the most serious effects of this forced stratification of land tenure within catchments was the concentration of large numbers of people in areas of inherently low biological productivity, with no access to inland areas of higher rainfall. With land tenure distributed in this fashion, the catchments could no longer function as complete ecological units. The boundaries between private and communal lands prevented the east-west nomadic movements of livestock that characterised former times. (Wildlife, to some extent, still continued to move between the higher and lower rainfall areas.) Although an open and semi-nomadic farming system would have been the most appropriate land use, it would have required large amounts of space because of limitations in the resource base. In addition, floods which originated in headwaters of the rivers were now being held back by increasing numbers of dams, to meet water demands of livestock on private farms. These dams reduced downstream river flow, affecting water and vegetation availability for downstream farmers and conservation and tourism areas.

Farming Today

Farming systems throughout the catchments

In the upper reaches of the larger catchments, rainfall is relatively high and less variable compared to the arid west. In this setting, fenced camps with seasonal stock rotation, and destocking when necessary, have generally provided a suitable management strategy for privately-owned farms operating commercial livestock enterprises.

In a similar way, livestock are also the economic mainstay of communal farmers, although uses are much more varied than in the private farmlands. For most farmers in the communal areas, livestock is, to a greater or lesser degree, an investment in household food security, present and future, and a repository of wealth (144). In ad-

dition, milk, meat, blood, dung and skins are critical resources in many households (115, 206). Milk is consumed fresh, sour or curdled and is also converted into butter. The OvaHimba women of the Khumib and Hoarusib catchments prepare butter as food, as well as a cosmetic when mixed with ochre (81). Cattle are also used for ceremonial purposes and occasionally for draught power, in those regions of the catchments with higher rainfall, where cropping is done on a small scale. Cattle may also be farmed commercially by farmers in the communal areas both in terms of the scale of the enterprise as well as the turnover and investment of cash in other enterprises.

The main constraint that farmers face in arid and semi-arid communal regions of the western catchments is the inherently variable climate, where annual rainfall can deviate as much as 70 per cent above and below the mean from one year to the next (236). Rainfall is also variable in space, falling in widely scattered localities in any one year. As a result, it is impossible, and inappropriate, to set a fixed carrying capacity applicable to the region (23). Any figure set will lead to under-stocking in one year, limiting potential livestock production, or overstocking in another year, resulting in fodder shortages and possible rangeland degradation.

To cope with this variability, livestock farmers in western catchments do what pastoral nomads have always done in this region: they move their stock to wherever rain has fallen. Movements of OvaHimba within the Khumib and Hoarusib catchments have

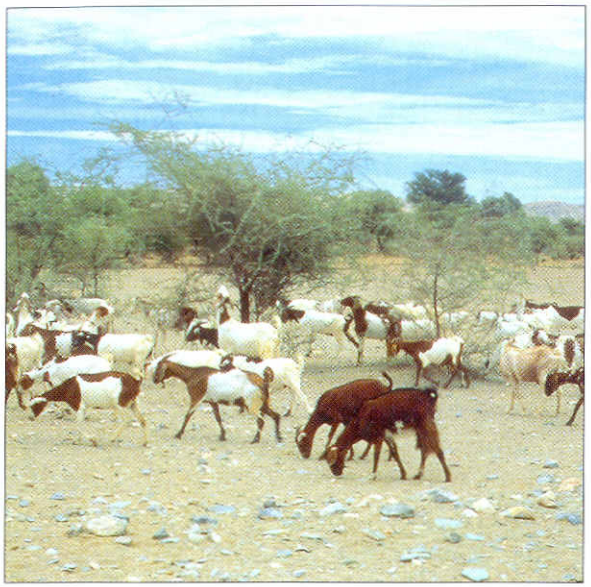
Livestock farming, such as these cattle on a private farm in the Kuiseb catchment, is the economic mainstay of the majority of people living within the western catchments.

THE AGRICULTURAL (COMMERCIAL) LAND REFORM ACT

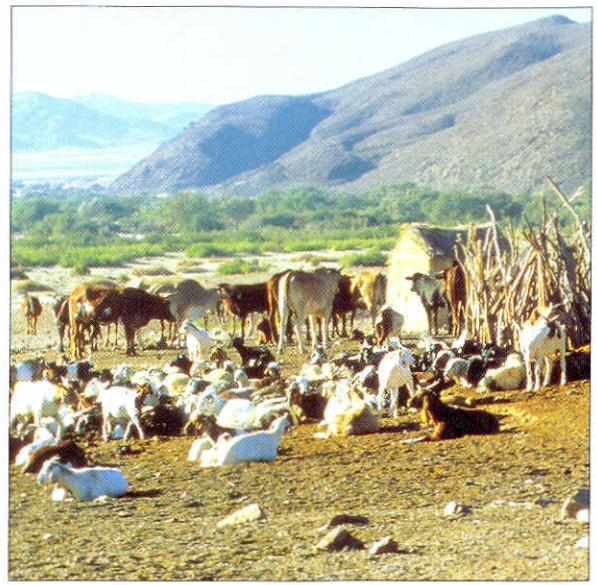
This Act was signed by the President of Namibia in February 1995. As it applies to land in the upper catchments of eight of the twelve major ephemeral rivers of north-western Namibia, it has a direct bearing on their management. Perhaps most important is the focus on production from livestock and game farming, and the omission of alternative economic uses of agricultural land such as guest farms, hunting farms, wildlife or tourism conservancies and other non-production (meat or crops) oriented uses. In an arid, water-limited country such as Namibia, with variable rainfall and grazing from year to year, production must also vary considerably. Less dependent on variable rainfall, and hence a more economically stable use of land, are applications independent of grazing availability such as tourism. Land uses other than production-orientated wildlife and game farming should be duly recognised, given their economic and environmental benefits.

In a similar way, according to the Act, occupants of leased farm units must beneficially use the farm through practising sound methods of good husbandry and proper care and maintenance of improvements on the farm. Annual cultivation or maintenance of livestock is also stipulated. Nowhere within the Act is 'beneficial' use stated to include appropriate, sustainable management of natural resources on the farm. Annual cultivation and maintenance of livestock in dry years will have a marked influence on the farm and the downstream users when rains again fall and erosion is marked. Should use of groundwater be maintained even as the water table drops, and what will be the effects on downstream users? If additional farm dams are encouraged, how much water will find its way to recharge aquifers in downstream communal areas or maintain the pod production of ana trees for the downstream farmers' livestock? The new Act also dictates that production must be maintained in a single place. Given that farmers in this region have for centuries been moving their livestock in response to variable rainfall and grazing, this requirement is problematic.

Another unanswered question in the Act is the definition of an economic unit. Is it something that provides a minimum revenue for the country in terms of taxes, or is it something that provides a livelihood, if not a cash income, for a certain number of people? Which management objective will be of greatest benefit to the country in the short term and in the long term? When viewed from a catchment perspective, which management objectives used on the private farms upstream will have the greatest benefit, or the least negative influence, for the many downstream users? All of these questions need serious deliberation if the Act is to be properly applied.



Goats are better adapted to the arid western regions of the catchments, such as here near Sesfontein.



Livestock farmers such as the OvaHimba living within the Hoarusib and Khumib catchments cope with climatic variability the way pastoral nomads always have - they move their stock to wherever rain has fallen. (photo: P Tarr)

been cited as an excellent example of an appropriate rotational grazing system in an arid rangeland (156). It is thus impractical to consider establishing fenced farms with seasonal rotation between camps in the more arid communal regions of the western catchments. In many years an individual farm might receive little or no rain and therefore controlled access to large areas of land is essential.

For example, in the early 1980s, in response to a severe drought in the region, the previous Damara Authority had to arrange emergency grazing in commercial areas further inland, as far away as Gobabis, subsidising transport of stock to and from these areas (111). Although such cases have been poorly documented, they illustrate the importance of a flexible strategy that facilitates opportunistic management of livestock populations. The communal system of land tenure works well where there is an adequate amount of land and where communal farmers are able to negotiate access to better pastures during years of drought.

If it is not possible to move stock to better grazing during dry years, easily accessible markets which allow sale of stock are essential to avoid heavy losses to farmers. Establishing such markets remains a problem, however, as destocking and restocking are not accepted as part of good management by most communal farmers. Many farmers prefer to try to maintain their livestock herds at all costs, rather than convert them to cash income during dry years. This is the suggested explanation for the general observation that as market price climbs, numbers of cattle sold decrease in the western communal areas (156). Low market prices during drought are a further disincentive. These factors all complicate efforts to reduce grazing pressure during the dry years. In the absence of cash needs, stock will not be sold. If communal farmers paid even minimal fees for services the State now provides free of charge, for example, water, grazing and veterinary services, cash flow would be encouraged. Plans to reduce subsidies and encourage the supply of such services through private sector development are currently being made (124).

An additional problem in western communal areas is that livestock distribution amongst farmers is highly skewed, with 84 out of 2 223 (i.e. less than four percent) registered farmers owning approximately 25 per cent of livestock in former Damaraland (166). Government policy aimed at alleviating this imbalance offers these large-scale farmers low interest loans through the Agricultural Bank of Namibia to purchase private farms outside the communal area. It is hoped that by encouraging owners of large numbers of livestock to move onto private lands, grazing pressure on communal lands will be reduced. To date this programme has not been successful, with only two communal farmers using these loans to purchase private

Ownership of Large Stocks Units in Damaraland in 1993[1]

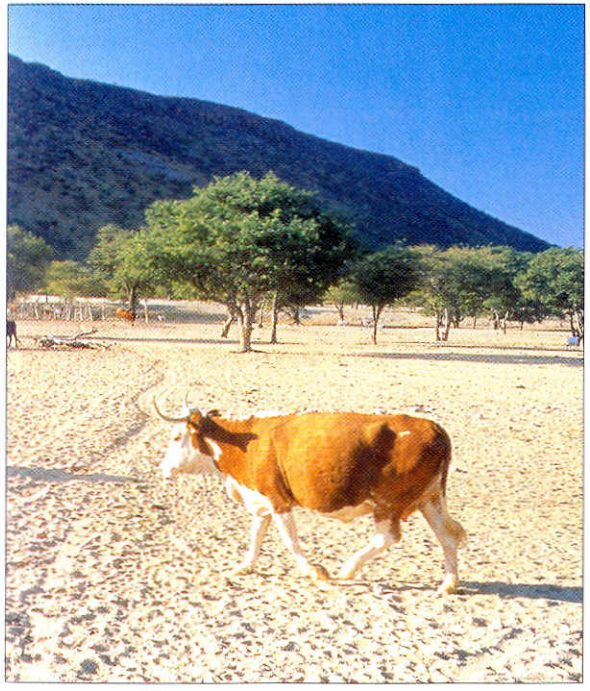
No. of Farmers	% of Total Farmers	No. of LSU's	% of Total LSU's	Average No. of LSU's / Farmer
84	4.0	14 237	25	169
176	8.0	11 917	21	68
1 963	88.0	31 067	54	16

[1]Excluding Sesfontein and Otjihorongo Adapted from Rohde, 1994

Livestock ownership is strongly skewed in the communal farmlands of the western catchments, where nearly 50% of the stock is owned by only 12% of the farmers. Efforts are being made to try to encourage these 'commercial farmers' to leave the communal lands, thereby reducing pressure on communal rangelands.

land. Regrettably, these two farmers continue to use communal areas in addition to their inland farms (166), having adopted an approach similar to that used by occupants of the former Odendaal farms, shifting livestock from one grazing area to another in response to resource availability. At present, political will and legislative instruments required to amend this situation are lacking.

Small loans are now also available for farmers to purchase livestock (166). The intention of this programme was to assist economic development of 'progressive' communal farmers to a level where they too could acquire private property and leave the communal areas. In two years of operation, this scheme has attracted only 95 applicants throughout Namibia, and only 20 farmers were awarded loans. Rather than alleviating stock pressure in communal regions, it has only served to increase animal density (166).



Increased access to markets for communal farmers has been suggested as one means of reducing environmental damage during droughts, allowing rapid destocking and restocking in response to climatic conditions. (photo: D Heinrich)

In view of the large-scale movements of stock within the region, northward and eastward in 1990-1992 and more recently southward in 1994, former Damaraland has been described as 'one large farm, supporting over 33 000 people within its borders' (166). A serious challenge faced by the managers of this 'farm', some 2 223 registered farmers, is the co-ordination of any individual's activities, relative to those of everyone else.

For example, in 1994, communal farmers moved large numbers of cattle from the drought-stricken Grootberg area in the Huab catchment southward to the Ugab catchment, in the vicinity of Sorris-Sorris, in some cases without the approval of the local inhabitants. The influx of Herero-speaking farmers into the northern areas of this 'farm' is another example where conflicts have arisen (141). In most cases, such conflicts revolve around decreased access to existing resources because of increasing population pressures, and because there is a lack of definition regarding rights of access to communally held natural resources throughout the region. In addition to defining such rights, the Government must recognise the necessity of local and regional representative organisations which can adjudicate the occasional disputes which do arise (167).

Prior to establishment of the 'second tier authority' in former Damaraland in 1978, there was no known traditional system of land allocation; during the late 1960s and early 1970s, settlement of the area proceeded largely without any control (165). A form of traditional leadership was created when the 'second tier authority' was established in 1978. The area was divided into twelve wards, each having its own head and councillors, reporting back to the Damara Council, based in the newly established administrative seat of Khorixas. This structure exercised some control over access of individuals to land, water and grazing, particularly when conflicts arose. However, at independence, the laws which established such 'second tier authorities' were repealed (218) and their powers removed (38). Thus, all property within former Damaraland with respect to land and infrastructure, including water points and roads, reverted back to control and ownership of the central government. Existing common and customary laws were left in place, providing they did not conflict with the Constitution or any other statutory law.

Currently, control over access to resources such as land, water and grazing is blurred between traditional leadership and representatives of regional and central government. Absence of any form of land tenure or long-term planning seriously complicates efforts of the growing number of people in the region to achieve control over their livelihoods. As communities living within the western catchments are almost totally dependent upon natural resources for their livelihood, their greatest challenge is to maintain equitable access to these resources. As the population grows, available natural resources will diminish. It will become more difficult to maintain enough stock to fulfil the needs of each and every person. Current conflicts between farmers suggest that there is already insufficient space for everyone. To ensure the sustainable use of the region's natural resources, the region's economy must be diversified, and rights to resources must be defined. In this regard, the recently announced plans to establish Land Boards at a regional level, 'responsible for land allocation and administration and for promoting sustainable land utilization' may be a positive development (124).

RANGELAND DEGRADATION: IS IT HAPPENING?

Recently, claims that widespread environmental degradation is taking place within arid rangelands, both in Namibia and abroad, have been questioned on the grounds of a lack of scientific evidence (23, 166). In a similar vein, it can be argued that little scientific evidence exists that rangeland degradation is not taking place.

The debate regarding the presence or absence of rangeland degradation can be compared with that focussing on the management of Namibia's marine fishing industry. Today's fisheries policies encourage increased use of marine species and ecosystems until there is irrefutable evidence of negative impacts. The results of similar policies have been collapses of major fisheries throughout the world. Namibia's pilchard fishery was previously depleted in this way (89). As a consequence, there have been calls for the burden of proof to be placed directly upon the user, in this case the fishing industry itself (149). Why should natural resources on land be treated differently from those at sea? Given the current absence of scientific proof regarding rangeland degradation, should not the use of these natural resources from which a majority of Namibians gain their livelihood, be treated with caution?

Within the western catchments, possible evidence concerning presence or absence of degradation may be derived from examining livestock population numbers which fluctuate widely in response to drought. Numbers in former Kaokoland, incorporating the Khumib, Hoarusib and part of the Hoanib catchments, typify these trends (156). In 1980 cattle numbers were estimated at approximately 110 000, dropping to 15 000 in 1982 due to a severe drought in the region. Only a small number of the region's cattle were marketed, and most died in the veld. By 1989, the population had recovered to about 80 000. What is not known is the significance of these fluctuations or the effects of continued maintenance of large herds on the region's ecological stability. Will the region maintain its capacity to provide sustainable resources for livestock production over the long-term?

Such recoveries of herd size have been assumed to be both an indication of the environment's resilience (ability to recover) and evidence that degradation of the natural resource base is not occurring. In reality though, these observations tell us very little about the past state of the environment, its ability to sustain herds of a particular size, or the extent of its use. We do not know if the areas open for grazing were expanded to regions previously not accessible, through the installation of boreholes. Livestock being supported on these 'new' lands would thus inflate the 'recovery' period figures. In addition, drought relief programmes provide fodder, masking the effects of any long-term reduction in grazing availability or stock numbers. It is thus very difficult to assess from livestock figures alone whether or not any permanent degradation of rangelands is occurring. Further research is urgently needed to clarify such issues.

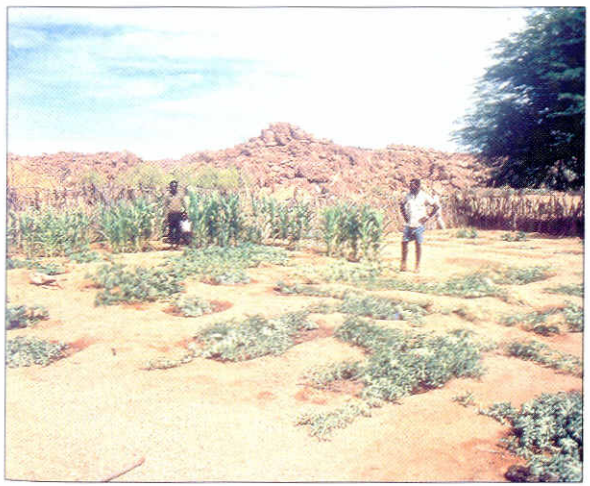
A further point is that such statements make the assumption that the area's value can only be expressed in livestock units. Other resource values, including suitability for tourism, as well as ecosystem services such as groundwater recharge and wildlife production, are ignored in such assessments, and may in fact be seriously affected by continued high levels of stocking!

There is an urgent need for a region-specific understanding of the functioning of Namibia's arid rangelands (178). A region-specific approach is emphasised because comparisons with other areas, for example Botswanan rangelands, have little relevance to the much more arid regions of western Namibia. Recent claims that livestock will die or have to be moved before irreversible damage occurs have been made largely without any thorough long-term study of the rangeland and its ability to recover, or the effects of 'emergency' fodder provision. Stock numbers and rangeland condition must be monitored, in association with rain gauges, in order to effectively distinguish between the effects of overgrazing and those of low and variable rainfall.

Fencelines, such as this one in the upper Hoanib catchment, are a common sight throughout western Namibia. Where heavy grazing has eliminated the vegetation on one side of the fence, as seen here, the question is often asked, 'is it degraded or just overgrazed?' The assumption is made that if the site is degraded, it will not recover when rains fall again in the area. Presently, there is little research in the western catchments which would allow us to answer such simple yet important questions.

IRRIGATED AGRICULTURE

By the turn of the twentieth century, well developed settlements existed at Otjimbingwe, Gross Barmen, Otjiseva and Okombahe, supported largely by cultivation in the beds of the Swakop and Omaruru Rivers (102). These gardens produced large amounts of vegetables for use by local communities. Such sites were associated with springs or bedrock highs in the river beds, providing moisture conditions favourable to crop cultivation in an otherwise arid region. Regular flooding prevented deterioration of soils in these regions, removing accumulated salts and depositing nutrient-rich sediments. At the same time the region's springs were also being developed. At Warmquelle, near Sesfontein, springs were used for irrigated agriculture as early as 1906 and continue to be used today. Other springs in the vicinity, such as at Sesfontein, Ongongo, Kaoko-Otavi and Fransfontein, have a long history of supporting irrigated agriculture. In addition to cropping in rivers and near springs, some dryland cropping is practised in the wetter headwater regions of many catchments, although such gardens are often supplemented by boreholes and ground dams when available.



Small gardens, irrigated by water pumped from boreholes, stored in small dams, or channelled from springs, occur throughout the western catchments and provide an important nutritional supplement to the diets of people living in the region. (photo: C Hines)

Within the past year, interest in irrigated agriculture within the western catchments has rapidly expanded. This is reflected both in allocations within the 1994/95 national budget, as well as the commissioning of studies of groundwater potential for irrigation development along the rivers. This trend is being driven by a desire to achieve food self-sufficiency within the region and, at the same time, to reduce the existing pressure on the rangelands through a reduction in stock numbers. At the level of the individual household such efforts may be worth pursuing. A major problem with irrigated agriculture in arid lands, however, is the requirement of a settled lifestyle, transforming formerly semi-nomadic pastoralists into sedentary gardeners. If livestock accompany such sedentarism, local degradation of rangelands will result, as evident in the vicinity of settlements such as Sesfontein, Warmquelle and Khowarib. Households at Khowarib reportedly have an average of 32 goats each, supplementing the diet derived from the garden (212). It is thus unclear what effect large-scale irrigation developments will have upon grazing pressure in the region. The above examples within the Hoanib catchment suggest that such developments may, in fact, lead to local increases in grazing pressure. A further constraint on irrigated agriculture in the western catchments is the high evaporation rates and poor water and soil quality often encountered, which can lead to salinisation if not carefully controlled.

In the case of large scale development projects, there are additional reasons for concern. First, large withdrawals of groundwater required for most developments may lower the water table. This decline in the water level may dry up springs within the region, affecting other farmers, wildlife and tourism revenues. In the case of developments within river channels, declines in the water table may not only dry up springs but also reduce productivity of the riverine vegetation. If such withdrawals are excessive, the naturally productive vegetation may be eliminated. The expansion of the Eersbegin Date Plantation, currently under way in the Huab River, is a cause for concern in this regard. There are numerous signs that the ana trees within the Huab River are already under stress, possibly due to a decline in the groundwater table associated with a reduction in flooding. Withdrawal of groundwater for the plantation can only aggravate this situation and may ultimately negatively affect the large wetland downstream at Opdraend, a site with national significance for tourism and conservation. Groundwater monitoring wells downstream of the plantation are urgently needed to assess effects of water withdrawals. Ultimately, in an arid country like Namibia, with high evaporation and scarce water supplies, irrigation in areas far from the perennial rivers cannot be recommended.

The water consumption for flood irrigation amounts to approximately 15 000 cubic metres per year for one hectare of land. The value of the potential yield may be a maximum of approximately N$10 000 per hectare per year. If the water needed for one hectare of irrigation is utilised for tourism at a rate of 100 litres per person per day, a total of 150 000 tourist days per year can be supported instead. If only N$10 is generated from every tourist, this represents N$1 500 000 per year.

One of the largest and best know examples of irrigated agriculture within the western catchments are the gardens at Sesfontein, in the Hoanib catchment.

These gardens at Warmquelle, in the Hoanib catchment, are watered from a large thermal spring emerging at the base of the mountain, to the east of the gardens.

Two major constraints on gardening in the western catchments are the high evaporation rate combined, in some cases, with high groundwater salinity. These gardens at Anixab along the Ugab River show the effects of inefficient flood irrigation - white deposits of salts on the surface of the soil. This accumulation of salt within the soil will eventually render it unusable.

The Eersbegin Date Plantation is located on the floodplain within the broad valley of the Huab River.

THE UPS AND DOWNS OF DATE PALMS

Date palm plantations have a long history in the western catchments of Namibia. In 1901 a date plantation was established in the Windhoek valley, in the area of today's Sport Klub Windhoek, with 5 533 date saplings. The plantation was completely destroyed by frost the following winter. An even larger plantation was started on the banks of the Swakop River at Ukuib, directly south of Usakos, in 1902. By 1916 the plantation had grown to include more than 10 000 date palms. In 1921, however, due to a scale insect infestation, the entire plantation was destroyed. Some cultivation continued although it was not until 1987 that date farming was fully revived with development of a plantation in the Huab River west of Khorixas at Eersbegin. This project is run by the Namibian Development Corporation (NDC), and is in the process of expanding. Currently, a total of 12 million dollars have been budgeted by the Namibian government for date production (1993-1997) with 4 million dollars alone for the Eersbegin plantation over the period (147). Of concern is the fact that date irrigation demands large volumes of water. The effect of withdrawal of water from the Huab River aquifer on the groundwater table downstream is unknown and not being monitored. Over-abstraction of this aquifer could have serious negative effects upon the ana tree forest and the wetlands downstream. These resources are critical to farmers downstream, as well as wildlife, upon which the region's developing tourist industry depends. A thorough economic analysis, incorporating the potential environmental effects of the plantation's high water demand, is urgently needed.

The call for privatisation

Calls for privatisation of communal lands have occasionally been made. An issue of great concern is the emphasis of such calls upon enclosure - the fencing of land (166). Even more disconcerting is the view expressed in the Government's Report from the Technical Committee on Commercial Farmland that:

> *'. . . a tenure system be investigated and developed in a standard format for the whole country and appropriate legislation passed' (150).*

This effort to simplify the process of agricultural land reform by enacting legislation in a standard format, applicable to the entire country, is an attempt to provide a simple solution to a very complex issue. What may apply in wetter regions further inland, however, particularly in regard to enclosure and rotational grazing, will not be applicable in the arid west. Agricultural reform efforts emphasizing individual tenure and enclosure, without a radical shift in land management practices, will devastate the arid rangelands of western Namibia. Failure to recognise the constraints that an arid climate imposes on agriculture in the western catchments will have a severe negative impact on the region if inappropriate legislation is drafted.

Rather, reform should focus on ensuring equitable access to critical resources, water being foremost amongst them. The current unco-ordinated and unplanned approach to water supply development within the western catchments, highlighted by recent drilling campaigns, emphasises the urgent need for appropriate reform in this area. One authority should be ultimately responsible for all water development and all areas of the western catchments should be designated as water control areas.

In arid rangelands such as those found within the western catchments, land use policies and related legislation must recognise the importance of a rapid response to short-term fluctuations in rainfall and the resulting patterns of forage availability. Policies and legislation must include mechanisms to enhance the ability of stock owners to rapidly destock, restock, or increase stock numbers to take advantage of occasional surpluses in forage availability (203). Approaches emphasizing privatisation of land, including fencing and subsequent exclusion, should be recognised as inappropriate without radical changes in land management practices. Rapid destocking and re-stocking through marketing or large-scale movements, are necessitated by the arid climate in the western regions. Policies which foster this flexibility and ensure equal rights through grazing and water fees should be enacted and strongly enforced. It is encouraging to note that the recently drafted National Agricultural Policy of the Ministry of Agriculture, Water and Rural Development states that 'the communal system of land tenure will be continued. Fencing of open grazing land in communal areas will not be allowed except in cases of properly planned schemes approved by the Government (124).' In addition, the planned introduction of a 'natural resource user fee system' should help ensure equitable access to the region's natural resources (124).

The riparian vegetation, such as these ana trees in the Ugab River, provides a critical source of dry season forage - supporting a large percentage of the livestock within the arid western regions of the catchments.

Appropriate rangeland management in western Namibia

The veld near Khorixas was barren again in 1994, with only scattered grass stubble, due to poor rains resulting in little grass germination. With no cover on the bare soil and a persistent browse-line on the mopane shrubs and trees, the area had clearly been heavily grazed over the past few years. But is it overgrazed and degrading? Low rains, even exceptionally low rains, are a common occurrence in arid and semi-arid rangelands, and the vegetation is well-adapted to survive these long dry periods (76, 230). But does the grazing pressure affect how the vegetation will recover during subsequent years of higher rainfall? This is a question that concerns every rangeland user who wants to use the environment sustainably for stock or wildlife. Unfortunately arid grasslands and their management have received little attention, and applying our understanding of temperate grassland ecosystems to these dry regions has not been successful (22).

In temperate grasslands, under conditions of ample and consistent rainfall and good soils, grazing regimes are easily manipulated to maintain the productive capacity of the rangeland. Stock numbers (or carrying capacity) can be determined and maintained from year to year, with some fluctuations to account for exceptional wet and dry years. Signs that this grazing pressure is too great and that the area is at risk of degradation include changes in plant species composition, changes in grass cover, and increases in bare soil which can result in soil loss. Depending on the extent of ecosystem change, alterations of stocking rates and grazing periods will usually quickly return the rangeland to a highly productive state.

While the signs of temperate grassland degradation are frequently seen in arid rangelands, in arid areas

they do not always indicate degradation - they may simply reflect the naturally low rainfall. Productivity in dryland systems is generally low and highly sporadic in response to rains. Large expanses that have had no rain for 3-5 years, can have bare soils - even without any grazing (55, 85). Current thinking questions the utility of applying conventional rangeland management techniques, derived in temperate grasslands, to drylands (55, 58, 173). Rather, managers and scientists have turned to the wisdom of ancient rangeland users to understand and learn how to use arid rangelands effectively (23, 37, 55, 59, 172).

In dry regions throughout Africa (Ethiopia, Somalia, Kenya, Namibia, Zimbabwe) rangelands have historically been used by nomadic pastoralists and ungulate herds. When rains were good, these rangeland users would remain in a place as long as water was available. Given the availability of water in the ephemeral rivers, and at the numerous springs throughout western Namibia, grazing pressures may have been quite high following good rain years with high grass productivity. When rains were poor, however, wildlife and pastoralists moved to areas of higher rainfall where fodder and water were available. Annual rainfall dictated the way the arid grasslands were used: heavily during high rain years, or allowed to rest in times of drought. Thus the primary determinant of rangeland use was rainfall, as this determined the water available for plant growth as well as that needed for drinking (55, 173).

Today rangeland users of arid regions throughout Africa have access to groundwater from boreholes that are independent of annual rains. This uncoupling of moisture for drinking and moisture for plant growth can have both positive and negative implications for arid rangeland productivity and use (57). Access can be achieved to large areas that previously received only minimal grazing because of the great distance to natural water points. Throughout Namibia, recent installations of boreholes have increased accessibility of rangeland in arid regions. If boreholes are used to allow access to areas that have received good rains, and to encourage the movement of stock and wildlife from dry regions with low or no grass cover (allowing these areas to rest) to regions of good grass cover, then these artificial watering points can be extremely useful. However, people and livestock frequently settle permanently at these watering points, regardless of current rains. Areas receiving no or little rainfall do not rest under continual stocking conditions, resulting in increased erosion, decreasing seed banks, and, in general, decreased resilience to the arid conditions - a lowered ability to recover in subsequent good rain years. This has occurred extensively in the Sahel where artificial water points have been provided for the last 20 years (30, 186).

The uncoupling of drinking and plant moisture also results in altered expectations from the ecosystem. It is generally well understood by Namibians that rainfall in arid and semi-arid areas is low. Less well understood by many Namibians is that rainfall in any one part of this arid region is highly variable from year to year, and that 'average' rainfall is meaningless (46). Because of the variable climate, constant stocking rates used in temperate rangelands are inappropriate in arid and semi-arid regions of Africa (237). Economically and ecologically effective arid rangeland management must be 'opportunistic management'. Because climatic conditions are so variable, adhering to a single, conservative stocking rate will rarely be applicable from year to year. The object of effective dryland rangeland management should be 'to seize opportunities and to evade hazards' (237). If rains are poor, stock must be moved from the land to other regions, or be sold. The scale involved in such moves can be very large. Further complicating effective dryland rangeland management is the common occurrence of 'absentee farmers'. Often the actual owners of livestock work in distant towns leaving family members in charge who may have knowledge of the current grazing conditions but do not have full decision making powers over management practices. Opportunistic management is not possible when communications are slow and decision makers are not fully aware of current grazing conditions.

An alternative strategy for coping with the normal drought conditions experienced in arid regions, the provision of drought relief, has been applied ineffectively throughout Africa by well-meaning donors, resulting in 'bad Samaritan' situations (10, 116). The parched nature of arid regions after many years without rain can be very shocking to those not familiar with the variability of production in arid systems. It is thought that current 'drought' conditions are unusual and hence an emergency which can be alleviated this year by providing drought relief fodder and emergency water supplies and food (75, 220). As a result, stock are maintained on land which should be rested to avoid degradation, and land users develop expectations of the arid land which exceed the realities of its naturally low and highly variable productivity. Because use of the rangelands is completely uncoupled from moisture availability, the risk of overuse of the rangelands is now a reality. Overuse resulting in altered soil conditions, soil erosion and loss of seed banks can take decades rather than years to recover in arid regions, simply because of the extremely low and unpredictable rainfall necessary to re-establish the productive capacity of the system (237).

▶ *What's important about farming practices in the western catchments?*

- *Prehistoric inhabitants of the arid and semi-arid regions of the western catchments lived a nomadic existence as hunter-gatherers or pastoralists. Springs within the ephemeral rivers and their catchments provided water as people moved extensively throughout the region in search of wildlife they hunted or for grazing for their livestock. Then, as now, strategies for living in the arid environment required people to deal with the high risk of low and variable rainfall amounts. This risk was minimised by nomadism over large areas, allowing people to search for and use the necessary resources. Once depleted, people would move into other regions. As a result of changes in land use and land tenure in recent times, people have stopped these nomadic or seasonal movement and have been forced to settle at springs, boreholes or along rivers.*

- *The challenge to modern day rangeland users, as well as decision makers who must ensure Namibia's arid lands will be used sustainably, is to understand and apply the ancient knowledge of nomadic pastoralists to the present day situation. Essential points to consider are:*

  - *Arid ecosystems will always have lower production than more mesic systems. Installing new boreholes can increase access to available vegetation but cannot increase the productivity of the vegetation itself, which is dependent on rainfall.*

  - *Arid ecosystems will always support fewer people, stock and wildlife than temperate systems where production is higher. At a time when Namibia's population is growing rapidly, this point must not be forgotten by decision makers.*

  - *Effective arid rangeland management must be 'opportunistic management'. Because climatic conditions are so variable, adhering to a single, conservative stocking rate will rarely be applicable from year to year.*

  - *Because of climatic variability in dry regions, large areas are needed to maintain nomadic stock herds. This movement must be facilitated by stock owners with either high physical labour or high monetary costs for road transport.*

  - *In years when rains are low throughout western Namibia (a common occurrence), land users must be allowed and encouraged to remove stock from arid lands either by sale or by movement to other regions.*

  - *Risk of failure is much greater in arid systems than in temperate systems.*

- *The following actions are therefore recommended:*

  - *Farming practices must take into account the variable rainfall of the western catchments. Approaches which emphasise privatisation of land, including fencing and subsequent exclusion, could only be successful in the eastern, higher rainfall parts of the catchments, and then only if rapid stocking and destocking accompanied changes in grazing availability. In the more arid western parts of the catchments, such an approach would require complete destocking for years or even decades. An alternative approach would be to facilitate co-ordinated large scale movements throughout the area in response to rainfall variability. In this case, policies which foster mobility and ensure equal rights through grazing and water fees must be enacted and strongly enforced.*

  - *The need for 'opportunistic management' strategies of livestock in variable arid climates, which allow rapid and appropriate responses to both good and bad years, must be made known to resource users throughout the western catchments.*

  - *Market and financial systems which enable the rapid stocking and destocking necessary to respond to the variable climate, must be developed and implemented.*

  - *Widespread market knowledge is essential for market functioning. Information about functioning of marketing and financial systems, along with their advantages and disadvantages, must be provided to resource users.*

  - *Basic information concerning functioning of the rangelands in the western catchments, including the role of resources provided by ephemeral rivers, must be obtained through integrated, high quality, participatory research. Livestock numbers and movements, range condition and similar information should be monitored on an ongoing basis and synthesised with other basic information such as rainfall and river flow. Results of this research should be made accessible on a regular basis to decision makers on all levels, especially farmers within the western catchments.*

- *Investigations of the sustainability of current and alternative land use practices should be undertaken. Alternative development trajectories for the western catchments, which alleviate some of the increasing pressure on the decreasing natural resource base, must be urgently identified and implemented. Results of these studies should be made available to decision makers at all levels, and based on this an integrated land use plan for the western catchments should be developed and implemented immediately.*

Plant Use Today

Current patterns are much like the past

Plants constitute a critical resource for people living in the western catchments. A wide range of uses have been recorded, ranging from foods and building materials to cosmetics and poisons for hunting (115, 206). A potent toxin is extracted from roots of *Adenium boehmianum*, (a small tree growing in the Khumib and Hoarusib catchments), and applied to arrows for hunting. Certain species of *Commiphora* are commonly used for manufacturing utensils for domestic purposes, as well as toothbrushes, soaps and body powders. A large number of *Acacia* species occur across the catchments, many producing pods which are important food for wildlife and livestock. Some, such as *A. erubescens,* produce a sweet, edible gum. Thorny branches of many species are used for fencing and wood of many species is used for fires. In addition, species of *Grewia, Salvadora persica, Berchemia discolor* and *Ficus sycomorus,* to name just a few, produce edible fruits. In many cases native plant foods are eaten not only as a basic necessity but also as an important cultural component of a household's dietary intake. One study within the Hoanib and Ugab catchments revealed that use of indigenous plant resources as food and medicines was not restricted to the poorest households. Rather, a more widespread use suggested some preference for certain species (212).

A recent study in the Khowarib settlement in the Hoanib catchment showed extensive use of a wide range of woody plants (211). Fruits from a number of species are an important component of the local diet and such trees are conserved accordingly. Resins from several trees, especially *Acacia* species, are used as a seasonally available delicacy. Plants are also used medicinally, for manufacture of household utensils (such as the wood of *Acacia montis-usti*), as dyes and tanning agents for leather, and as browse for livestock.

The Topnaars, living in two different areas of the western catchments, have been recorded as using at least 81 species of plants for foods, medicines, cosmetics and fuel (221). On the Kuiseb, !nara is the most widely used of 46 plant species: seeds are roasted and eaten or sold, melon pulp is eaten boiled or raw, roots are used in various ways as medicine, oil from seeds is used as a cosmetic, and peels and seeds are fed to goats, donkeys and chickens. In Sesfontein on the Hoanib River, higher rainfall means a larger variety of plant foods. At least 55 species are used there, and bulbs, tubers and wild fruits feature in the local diet.

Within catchments from the Ugab northward, mopane is probably the single most important plant for people and livestock. In addition to its use as the principle construction material in homes, kraals, fencing and any other construction works, it is also the preferred firewood in the region. Finally, it is an important forage for both wildlife and livestock throughout its range, particularly in the western reaches where grazing is often limited or non-existent. Branches may be cut and fed to goats and cattle in their kraals.

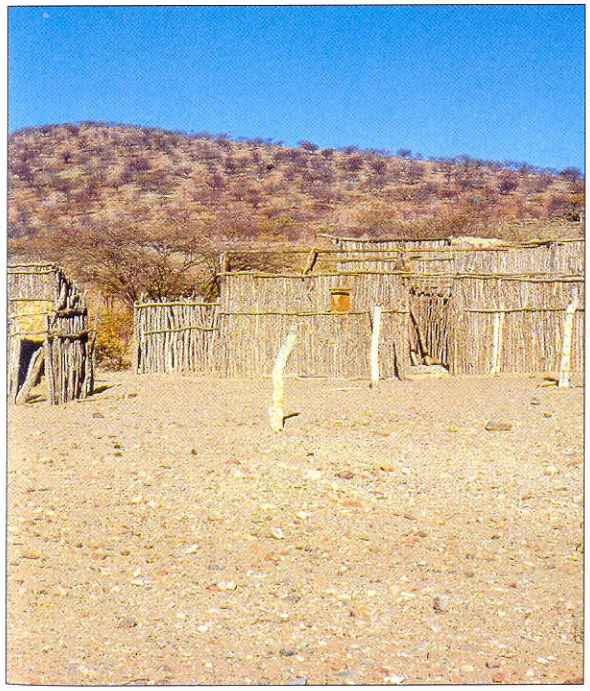
The ana tree is a riparian species of tremendous significance. Its nutritious pods, dropped toward the end of the dry season in September through December, are critical to livestock and wildlife. Many farmers throughout the western catchments collect pods from the trees, storing them for dry season forage. In the Ugab River, private farmers from the Usakos and Karibib regions buy large numbers of pods collected by the local residents (111). In the Kuiseb River, the Topnaar community is dependent on ana tree leaves and pods as forage for their goats and cattle. In the 70s, prior to drought relief, they collected and stored pods in hessian bags, lodging them on branches in trees, for use later in the year. Underscoring the importance of pods for livestock fodder, the Topnaar community considered requesting drought relief in 1994 when large floods early in the season washed away much of the year's

The !nara melon, common within lower reaches of the Khumib, Hoanib, Uniab and Kuiseb Rivers, has been an important part of the diet of the Topnaar, living along the lower Kuiseb River. The melons are collected when ripe and the nutritious seeds separated. They are then stored for later consumption or sold, for eating or use in making candies. Recently, interest has been expressed in using the oil within the seeds in cosmetics. The flesh of the ripe melons is also eaten. (photo: M Seely)

Mopane, with its characteristically shaped leaf, is one of the most important trees in western Namibia, occurring in all of the catchments from the Ugab northward. Wherever found it is preferred for firewood and construction timber. It is also an important forage for wildlife and livestock.

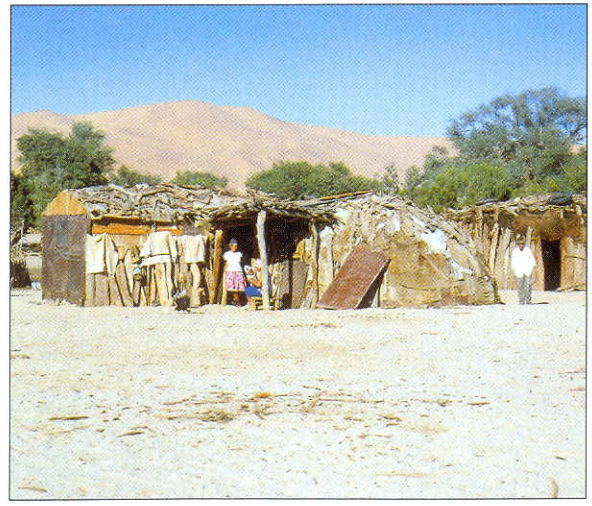
production of pods, before they could be collected (43). In addition, ana tree wood is used extensively for housing construction along the Kuiseb River.

Plant products are also used for production of crafts for sale in and outside the region. Kernels of the vegetable ivory palm, *Hyphaene petersiana*, are perhaps the best known example within the western catchments. Carvers in the northern Erongo and Kunene regions engrave depictions of local animals on the 'makalani nuts' which are then hung on leather thongs for use as necklaces, key chains or ornaments.

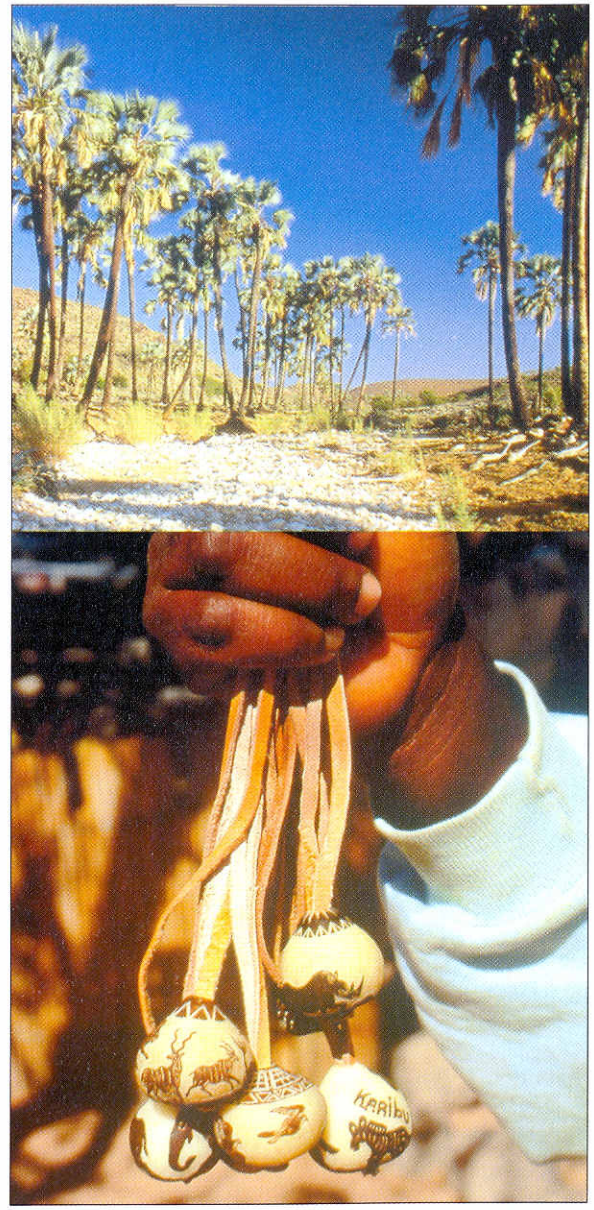


This house within the Huab catchment is constructed from mopane.

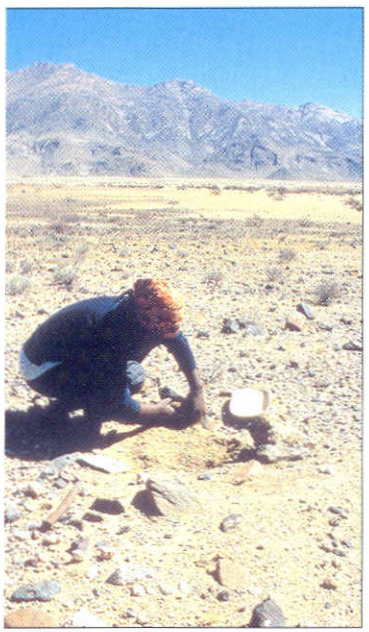
The ana tree is the most important tree to people and wildlife living along the larger rivers of the western catchments. Its prolific production of nutritious seed pods, typically falling to the ground in September through December, and dense foliage are critical sources of dry season forage in the catchments. Within the Kuiseb River, ana trees produced an average of 200 kilograms of pods per tree in 1993.



Ana trees are also a source of construction material. Logs left along river banks after floods are used to construct houses and kraals, while bark is used for roofing materials, as seen here at Oswater along the lower Kuiseb River. (photo: M Seely)



The hard seeds of makalani palms, which grow in the Uniab, Hoanib and Hoarusib catchments, are used to carve small ornaments which are often fashioned into attractive jewelry.



An unusual yet widespread use of a plant resource is that of seeds collected from nests of harvester ants. Seed harvesting species comprise the overwhelming majority of all ant species in the region. These ants are very efficient at locating and caching seeds of annual grasses, and accumulate a below-ground food reserve to carry them through long periods from one rain to the next (117). These nests are large and can be easily located. Seeds of several species of *Stipagrostis* grasses and the small herb, *Monsonia umbellata*, are dug from ants' nests and winnowed in flat, wooden bowls. The seeds are then ground into flour, typically with the aid of a grinding stone, and then boiled with water to form a porridge. This is eaten as is, or with milk, meat or sugar. Seeds are also used in beer-brewing, being mixed with water and sugar and allowed to ferment (206). A liquor is also distilled from the seeds. The sale of this can earn several thousand dollars a year for some women, especially if the liquor is transported to urban markets such as Swakopmund (212). Women who harvest these seeds are careful to leave some seed behind in the nest, hoping to ensure the survival of the ants. Disturbance to the nest is also minimised by the careful replacement of stones and vegetation around the nest (167). In the more densely settled Sesfontein area, some women claim use rights over particular ant nests (212).

Grass seeds dug from nests of seed-harvesting ants have long been a component of the diet of people within the arid western regions of the catchments, such as here near the Brandberg Mountain in the Ugab catchment. Once located, the nest is carefully excavated and the large cache of seeds removed. The seeds are then winnowed in a flat, wooden bowl to separate them from sand and small stones. They may then be stored and later milled into flour, mixed with hot water, and eaten as a porridge. The seeds are also used in brewing a beer-like beverage. (photos: R Rohde)

Vegetation change - are we using too much?

In many areas throughout the western catchments, concern is growing that current use of the region's plant resources may be unsustainable, leading to a gradual loss of certain species. The basis for such claims is the bare and degraded areas around towns and settlements, particularly in the communal areas of the catchments. Here, high human population densities place a much greater pressure on the available resource base than in less populated regions. The effect on trees is well known and easily seen. A study at the Khowarib settlement showed that extensive use of vegetation by people and animals was having an impact as far as 4 km from the settlement (211).

Firewood consumption within the western catchments is an issue of serious concern, particularly in rural areas where people do not have any alternative energy sources. Firewood is chiefly used for cooking, but large amounts are used in winter for heating and throughout the year for ironing and heating water. In almost all cases wood is burned in inefficient open fires. Although use of fuel-efficient stoves would greatly reduce wood consumption, they are rarely used. Wood dealers in Khorixas say that collectors often walk more than three hours from town to collecting points (207). During the past several years, extensive collecting in the region has resulted in a deficiency of dead mopane wood and in many areas around Khorixas living wood is cut and left to dry before collection. Some collectors are concerned about wood cutting, however, because they recognise the value of mopane browse for their goats. They have expressed an interest in planting mopane seeds and seedlings but 'only if they grow fast.' Unfortunately the growth rate of mopane in the region is presently unknown.

Percentage of Households Cooking with Wood			
Catchment	Rural	Urban	All
Khumib	100	-	100
Hoarusib	98	78	90
Hoanib	97	-	97
Uniab	93	-	93
Huab	91	68	80
Ugab	93	40	60
Omaruru	89	53	75
Swakop	80	10	17
Kuiseb	81	-	81
Tsondab	88	-	88
Tsauchab	82	-	82

Based on 1991 Namibian Census

Common Uses of Some Plants in the Western Catchments	
Plant	Use
Acacia species	edible resins, stock forage, household utensils, firewood, housing, fencing
Berchemia discolor	edible fruit
Colophospermum mopane	stock forage, building material, firewood, medicinal uses, bark for tanning
Combretum imberbe	firewood, dyeing and treating leather, medicinal, ceremonial
Commiphora species	household utensils, soap, body powder, perfume, medicinal , firewood
Cyperus species	edible bulbs, stock forage, basket making
Faidherbia albida	stock forage (pods and leaves), housing, fencing, dyeing leather, bowls
Ficus sycomorus	edible fruit
Grewia species	edible fruit
Myrothamnus flabellifolius	tea, medicinal for headache, asthma, pain, colds
Salvadora persica	edible fruit, medicinal for stomach problems, treat rashes
Sesbania sphaerosperma	tea
Terminalia prunoides	tea, edible fresh seeds and resin, medicinal roots, firewood, stock browse
Ziziphus mucronata	edible fruit

The collection of firewood by tourists is also increasing as more people visit the area. Tourists at campgrounds and lodges throughout western Namibia enjoy fires as a part of their holiday experience, although they have other means at their disposal for cooking and staying warm. Also associated with tourists is an increasing pressure on species used in making crafts for sale. Species such as makalani palms and *Acacia montis-usti* (carving), which have restricted ranges, may be particularly susceptible to unsustainable use. Currently, palm nuts are imported from the Grootfontein district where collectors are paid for their efforts (133).

Although claims are often made that changes are occurring in the region's vegetation, studies are mostly limited to those discussed here. Clearly there is a great need for more research to determine sustainable yields of plant resources in the region to assist with implementation of appropriate management plans.

Inefficient open fires are used for cooking by the majority of people living within the western catchments. (photo: R Rohde)

The use of fuel efficient stoves would greatly reduce the amount of wood consumed in the western catchments.

▶ *What's important about the use and management of plant resources in the western catchments?*

- *In addition to using plants as fodder for livestock, people living in rural areas of the catchments use plant resources for a wide range of purposes including food, beverages, firewood, building materials, medicine, cosmetics and hunting poisons.*
- *Increasing human populations throughout the catchments place increased pressures on plant resources, particularly firewood. Harvesting living trees, such as mopane, is not sustainable, unless accompanied by efforts to grow more trees. Studies are urgently needed to determine the sustainable yields of plant resources, which must include basic botanical research concerning seed germination, recruitment rates and growth rates under natural (highly variable) climatic conditions. This information should be used to establish successful nursery and tree planting programmes.*
- *If studies show that current rates of firewood use are unsustainable, the use of fuel-efficient cooking stoves should be required by law. Even in the absence of further data, educators and donors should combine their efforts to ensure that mechanisms exist for people to obtain such stoves and that they understand why and how to use them.*
- *While involving high costs, the use of solar power to replace fuel wood should be promoted for heating and light. It should be mandated by law that all tourist facilities use solar power in place of firewood for heating water.*

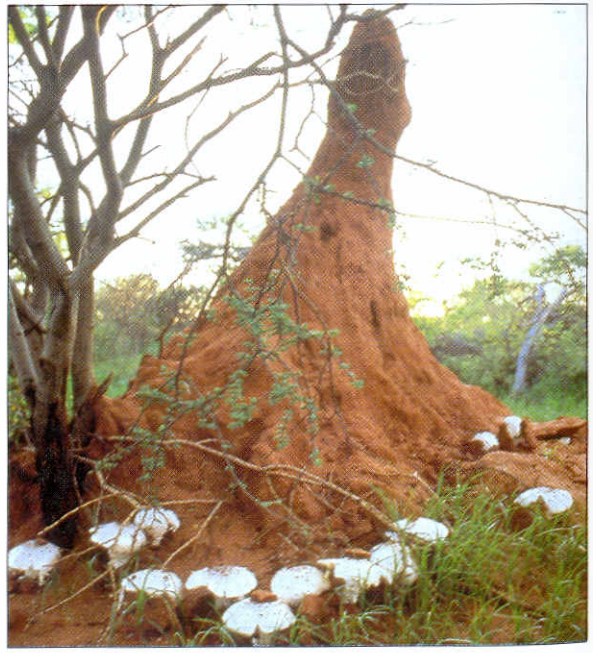
Wildlife and Its Use Today

As with the region's plant resources, wildlife has long been a part of the diet of people living in the western catchments. Over thousands of years, diverse and ingenious techniques have been used to harvest wildlife food resources including poisoning of water pools, use of snares, stone traps and pits, fires, spears, arrows and recently high-powered weaponry (206). Early travellers in the Kuiseb catchment saw large pits on the river banks, reportedly used to capture rhino (4). Traditional means of harvesting include poisons that were, and still are, obtained from a wide range of plants including *Euphorbia* species, *Adenium boehmianum* and *Fockea multiflora* (115).

In addition to the wide range of large herbivores found, a number of other animals are commonly used. Birds are eaten throughout the western catchments, especially ostrich, guinea-fowl, francolin, pigeon and several species of doves, bustards and korhaan (206). The sap of *Adenium* is reportedly used to kill pigeons and doves by poisoning water in small troughs. The crop and stomach is then removed before the bird is roasted and eaten. Sandgrouse are caught with snares at surface water along the Ugab River (212). Several reptiles are eaten, including tortoises and leguaans. Honey from bees' nests is a delicacy and is used whenever nests are found (206). Other insect-derived foods and insects themselves, including termites, mopane worms, locusts and caterpillars, are commonly eaten as well. Clearly wildlife have been, and still are, an important source of protein for people in western Namibia.

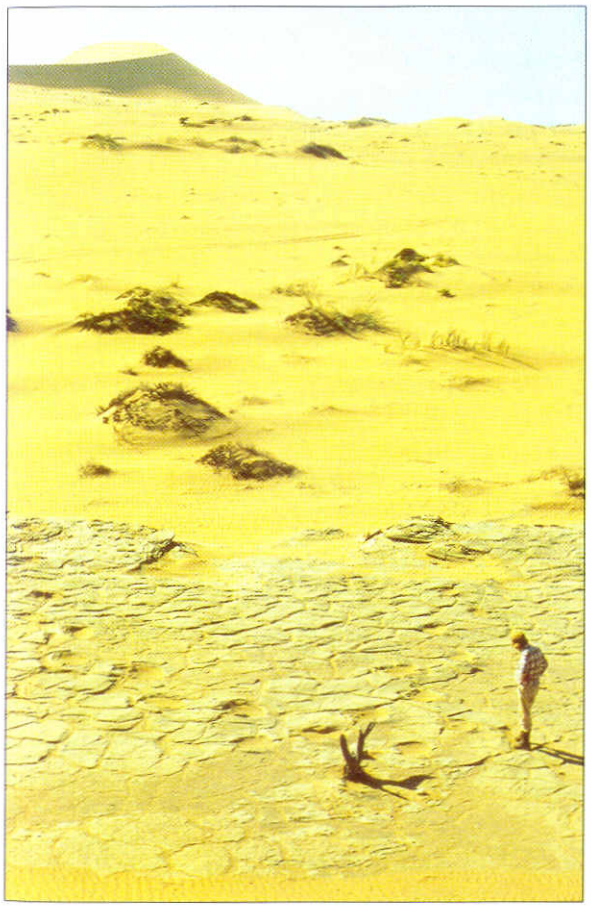
It must not be forgotten that wildlife are also dependent on plants for food. Sometimes wildlife and people compete for this resource. When swarms of locusts or army worms 'invade' an area they consume large amounts of vegetation. Similarly, people may reduce

Mopane worms are an important, protein-rich component of the diet of many people living in the western catchments.



An unusual food source derived from animals within western catchments are delicious mushrooms. These fungi are cultivated by termites which build large mounds, commonly seen in eastern sections of the larger catchments from the Swakop northward.

the carrying capacity for wildlife and livestock alike by cutting mopane for firewood. If mopane is eliminated, the rich protein source associated with mopane worms is also removed. Understanding essential links between plants and wildlife forms the basis for sustainable use of these nutritious resources. If such links are broken, through overuse, alternative sources will have to be found, which are often costly or unavailable.



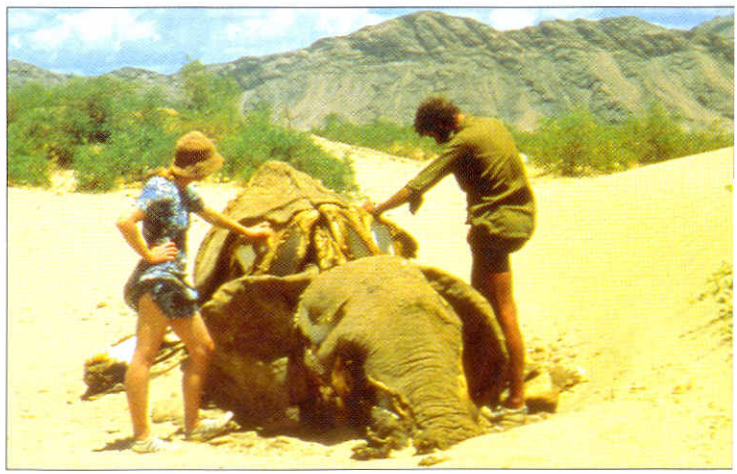
Although difficult to imagine today, less than two hundred years ago elephant may have visited the beaches near Walvis Bay. These elephant tracks, made more than three hundred years ago in the wet silts of the Kuiseb River, occur near Rooibank. (photo: J Ward)

Wildlife - a resource almost lost

Although difficult to imagine now, less than two hundred years ago elephants walked the coast near Walvis Bay and Swakopmund. Well preserved tracks in silt deposits near Rooibank, on the Kuiseb River (96), as well as the recovery of an elephant tusk near the Rooikop airport, record their presence several hundred years ago. Travel records of early explorers and missionaries from about 200 years ago tell of large numbers of game, particularly within the western rivers such as the Kuiseb and Swakop (4). These rivers provided the main paths of travel from Walvis Bay to the inland. As a result, we have a much better impression of the historical distribution of wildlife in these rivers than those further north. At the same time, however, rivers that people used for travel were also first to lose their wildlife resources through indiscriminate shooting. Elephant, rhino, lion and wildebeest have long been absent from these southern rivers.

Travels of these earlier explorers marked the beginning of a sharp decline in much of the region's wildlife. As the wetter headwaters of catchments were settled and developed as farms, conflicts arose between wildlife and the new inhabitants. Hunting, fencing, and destruction of springs helped further commercial livestock production which was generally intolerant of all predators, rhino, elephant, vultures and many birds of prey. In the 1950s a reward was offered by the government for killing wild dog and other 'vermin' in the region (99). Rifles issued in the Otjohorongo Reserve, and strychnine poison issued to headman throughout the region (152), facilitated a widespread and effective effort at 'predator control'. At the same time, however, the State's granting of use rights of wildlife to the farmers on private lands in 1967 did ensure maintenance of populations of huntable and sellable ungulates. These rights did not extend to people in communal areas, however, where a new phase of wildlife decimation was about to begin.

Whale bone huts near the Ugab River mouth are evidence of inhabitants from centuries gone by. Wildlife, whether derived from sea or land, has long been an important component of the diet of people living within the western catchments. (photo: M Seely)



The threat of wildlife poaching within the western catchments still exists, although greatly reduced through the recent involvement of communal farmers in conservation and tourism development efforts. A far greater threat to the region's wildlife is the destruction of their habitat through the effects of unco-ordinated development. Drying springs and dying riparian vegetation are a frightening sign that we may yet lose much of this valuable resource. (photo: P Tarr)

Although headwaters of the western catchments were well developed by the early 1960s, the more arid western areas remained largely untouched by settlers. Much of the area had been proclaimed as Game Reserve No. 2 in 1927. Wildlife, although hunted for consumption by residents and occasional visitors from further inland, was reportedly abundant throughout much of the region (152). In 1970, on the recommendations of the Odendaal Commission, the Kaokoveld and parts of the Etosha National Park were deproclaimed, establishing the 'native reserves' of Damaraland and Kaokoland. Because of developing conflict along Namibia's northern border in the 70s, access to these areas was strictly controlled. As a result, little was known about activities of the South African Defence Force (SADF), the South African Police and officials of the South African government. By 1977, reports began to emerge of excessive hunting of large game by senior South African officials and SADF personnel (68). Attempts to publicise these activities were suppressed, although recent admissions have detailed the blatant destruction of wildlife, including shooting of elephant and black-faced impala from SADF helicopters (32).

Drought in the early eighties added to the severity of the situation, by causing further reductions of wildlife. At the same time, the South African government was issuing .303 rifles and ammunition to people in Kaokoland, ostensibly 'to protect themselves from SWAPO terrorists' (68). In addition to extensive poaching by the police and army, some residents also used their newly acquired weapons to hunt wildlife as the severe drought took its toll on their livestock. Illegal hunting was slowly brought under control in the early eighties through efforts of several individuals in the then Department of Nature Conservation and the newly formed Namibian Wildlife Trust (32). The first step taken by the Department of Nature Conservation in 1980, when charged with all conservation functions in the area, was to close many regions to all hunting because of the critically low numbers of many species.

Community-based approaches to wildlife management

'Community-based' has become an increasingly common term used in discussions regarding the management of natural resources such as water, vegetation and wildlife (82, 88, 100). Although the term 'community' is at best loosely defined when used in the context of natural resource management (100), it is most often used in Namibia in reference to people living on communal lands. It could also be applied to groups of farmers on private lands who share common interests in their management of adjacent farms. Community-based approaches to natural resource management involve individuals acting in concert to achieve common goals. The goal of this management can be generalised as an effort to maximise benefits from resources upon which they jointly depend or otherwise attach some value.

Consumptive versus non-consumptive use of wildlife: The use of wildlife resources is often classified as consumptive or non-consumptive. Examples of consumptive wildlife uses within the western catchments include the harvesting, trophy hunting, and sale of live game - currently practised on many farms within the private lands of the upper catchments. Non-consumptive uses include the viewing of wildlife by tourists visiting the many guest farms, campgrounds, and lodges within the catchments (15, 170). The economic benefits from wildlife use can be substantial, with estimates of annual revenues from consumptive uses alone ranging from nearly N$20 million to more than N$40 million per year on private farms in Namibia (18, 126). Tourism on private farms was estimated to have generated an additional N$10.8 million dollars (126). Although revenues from consumptive and non-consumptive uses of wildlife are clearly substantial, the opportunity to capture these benefits is not shared equally between private and communal farmers.

Ostrich farming, an example of the consumptive use of wildlife, is a lucrative industry in Namibia. The eggs, meat, skin and feathers are all used. At the same time, tourists enjoy seeing wild ostrich in arid landscapes of the western catchments, an example of their non-consumptive use. (photo: P Tarr) ▶

Rights to wildlife use on private versus communal land: Since 1967, farmers on Namibia's private lands have benefitted from their rights to consumptively use wildlife inhabiting the lands of which they are sole owners. The result has been a marked recovery of huntable wildlife on private lands. In contrast, farmers on communal lands have had no such rights of use and have therefore seen little value in wildlife as an economic resource (18, 82). In many areas wildlife populations have declined and remained low (32). Recognising that it is inequitable that communal farmers are denied rights of use of valuable wildlife resources, while private farmers enjoy these rights, the Ministry of Environment and Tourism (MET) has launched an initiative to grant such rights to communal farmers. Efforts are currently underway to grant rights of consumptive use to communal farmers through a revision of the existing Nature Conservation Ordinance (4 of 1975).

A major constraint recognised by the MET, however, is the lack of individually exclusive land tenure within the communal farmlands of the western catchments. A private farmer is the sole owner and rightful user of the natural resources within the boundaries of his or her farm. In the case of wildlife, these rights of use may be removed if the user does not abide by the regulations enforced by the MET. In contrast, a communal farmer shares the natural resources of the communal lands with all other rightful inhabitants. The Government has thus been hesitant to grant rights of use for wildlife without clear accountability for resource management (126). Given the difficulties involved in rapidly instituting appropriate and effective land reform (150), some other mechanism was deemed necessary to enable people living within communal lands to enjoy the benefits of consumptive wildlife use.

Applying the conservancy model: Recently, in an effort to more effectively manage their wildlife resources and maximise economic benefits, private farmers have adopted a type of 'community-based' management. The so-called conservancy model is being used by farmers who realise that it is advantageous to pool their land and financial resources to make available a larger unit for management (44).

> *'A conservancy on private farmland is a group of farms on which neighbouring landowners have pooled their resources for the purposes of conserving and utilising wildlife on their combined properties. By cooperative management of wildlife, farmers can enhance their productivity and increase their individual incomes' (126).*

Because of their success and increasing popularity in private farms within headwaters of some of the western catchments, conservancies are being encouraged as an appropriate model for resource management in communal areas to the west (and throughout Namibia) (44).

> *'On communal land, a conservancy would be a community or group of communities within a defined geographic area who jointly manage, conserve and utilise the wildlife and other natural resources within the defined area' (126).*

NAMIBIA'S WILDLIFE: USE RIGHTS OR OWNERSHIP?

Efforts are currently being made to grant the benefits of consumptive wildlife use, enjoyed since 1967 by private farmers, to communal farmers through revisions of the existing Nature Conservation Ordinance (4 of 1975). This legal right to harvest, hunt or capture and sell game for profit is often expressed incorrectly as 'ownership of the wildlife' or 'effective ownership' (18, 77, 126). In reality, rights which private farmers currently enjoy and which, pending legislative amendment, will be extended to communal farmers, are 'rights of consumptive use' rather than ownership. These rights of use are in fact a privilege granted by the State, and may be removed if the user does not abide by directives issued by the responsible government authority, the Ministry of Environment and Tourism. Although this distinction between rights of use and ownership may seem trivial, it is in fact an important one. The individual or community to which these rights have been granted must recognise their responsibility, along with the State's, of sustainably managing this valuable resource.

Although game farming is a profitable enterprise in the western catchments, a far greater economic value can be generated by non-consumptive wildlife use through tourism. Ultimately, a mixed economic system generating revenues from tourism, trophy hunting, live sale and sustainable harvesting will yield the greatest benefits to people living within the region. ▶

Further,

> *'a conservancy must have clearly defined physical boundaries and contain viable resources, and must be a legally constituted body. A conservancy would gain the rights to utilise wildlife within the bounds of the conservancy to the benefit of the community. The MET would set a quota for each available species and the conservancy would decide how to use these numbers in terms of, for instance, hunting, culling, or the sale of live game. A conservancy would have the right to enter into a business arrangement with private companies, and would have the right to establish tourism facilities within its boundaries' (125).*

While at first glance this approach appears to be a potentially effective mechanism for granting rights of consumptive wildlife use to communities on communal lands, several key points must be considered further before success of such endeavours can be ensured. First, the existence of 'viable' resources is essential, as noted in the policy statement above. In the arid western regions of the catchments, the availability of such resources varies widely in response to rainfall and associated river flow, groundwater recharge and primary production (plant growth). Secondly, in the context of the policy, wildlife is identified as the key resource within the conservancy and is the only resource over which the legally constituted members would have exclusive rights of use. The issue of land tenure is unresolved. Expanding human populations and the lack of legally defendable and exclusive land tenure, coupled with the relatively unproductive and variable environments of the arid west, must be given serious consideration if community-based programs are to be economically sustainable or otherwise successful. If the members of the conservancy are unable to restrict the access of nonmembers wishing to use other resources such as water and vegetation for stock farming, the 'viability' of the wildlife resource will be severely limited in times of grazing or water shortages. For these reasons recommendations for conservancies should be cautiously evaluated in the arid areas of the western catchments.

These two major differences between the private and communal farmlands of the western catchments, climate and land tenure, have great relevance to the success of any natural resource management plan. Although the conservancy model is seen as an effective approach to dealing with both constraints (126), the effect of the marked difference in climate upon the success of an individual conservancy must not be under-estimated. As has been discussed earlier in this book in more detail, there is a strong climatic gradient across the catchments. Rainfall decreases sharply from east to west with a sharp increase in variability. The result is that primary production (vegetation growth for grazing and browsing) is low in the arid communal farmlands of the western catchments and varies widely from year to year.

The result for conservancies, with defined boundaries as mandated by the MET policy, is that risks associated with stock farming are high while wildlife populations move nomadically with no regard for conservancy boundaries. The challenge for any conservancy within the arid western reaches of the catchments will be to develop management systems capable of responding to this highly variable environment. Although the option of consumptive wildlife use may help to minimise risks by diversifying local economies in other areas, this remains to be tested in the arid west. Given the climatic constraints, dependence upon consumptive uses of wildlife from within fixed-size conservancies may indeed increase risk because of the nomadic movements of wildlife.

Proponents of conservancies argue that sole reliance on either wildlife resources or livestock yield fewer benefits than a judicious mix of the two. It is often stated that wildlife use and livestock farming are compatible, having the benefits of increasing incomes and reducing vulnerability to drought. Further, it has been suggested that combining game and livestock increases the physical 'carrying capacity' of the land and reduces the risk of environmental degradation, due to the different feeding and watering behaviour of livestock and wildlife (18). Although such generalisations may be supportable in the more climatically stable regions of central and eastern Namibia, there is no published evidence to support such assertions in the arid rangelands of the western catchments. In fact, evidence suggests that if vegetation is limited, livestock may outcompete wildlife (such as rhino) for available forage, with fatal results during drought years (108, 135). Co-ordinated ecological and economic research is urgently needed to clarify these issues.

Given the climatic variability typical in the western catchments and the associated variability in wildlife numbers within a given area, conservancies may benefit much more from non-consumptive uses such as tourism. Because of low agricultural productivity and spectacular scenery and wildlife, tourism is being increasingly promoted as an option, in addition to consumptive wildlife use, for increasing and diversifying the economy of the western catchments (73). Evidence suggests that there are far more people who are willing to pay to see wildlife in such scenic settings than there are people willing to shoot them (106). Ultimately, the interests of the region's inhabitants and Namibia as a whole may be best served by a diverse and well managed industry which captures revenues from both forms of use.

COMMUNITIES IN ACTION: PROTECTING WILDLIFE RESOURCES

In 1982, recognising local communities as stewards of the resource base upon which they depend, the newly formed Namibian Wildlife Trust initiated the 'community' game guard system (at that time known as the auxilliary game guard system). The aim of this system was to establish a network of individuals, selected by and from the local communities, to monitor the region's wildlife populations and to act as a deterrent to poaching. Today the Kunene and northern Erongo regions can boast one of the most successful examples of such community-based conservation efforts in the world. Local residents in these regions, employed by the Integrated Rural Development and Nature Conservation (IRDNC) and the Save the Rhino Trust (SRT), both non-governmental organisations, continue to monitor wildlife populations in association with officials of the Ministry of Environment and Tourism.

The success of this approach was shown by a recent survey which covered a large section of the western catchments (32). The main aim of this survey was to provide a baseline inventory of wildlife, to facilitate development of an informed approach to land use planning and management, particularly in regard to conservation and tourism. The survey found that populations of many species decimated in the 70s and early 80s, including mountain zebra, elephant and rhino, had recovered well. These recoveries are attributable to the combined efforts of people living in the region, non-governmental organisations and local officials of the Ministry of Environment and Tourism.

Ensuring the sustainability of natural resource use, including water, soil, vegetation and wildlife, is a difficult challenge for the 'communities' of the arid western reaches of the catchments.

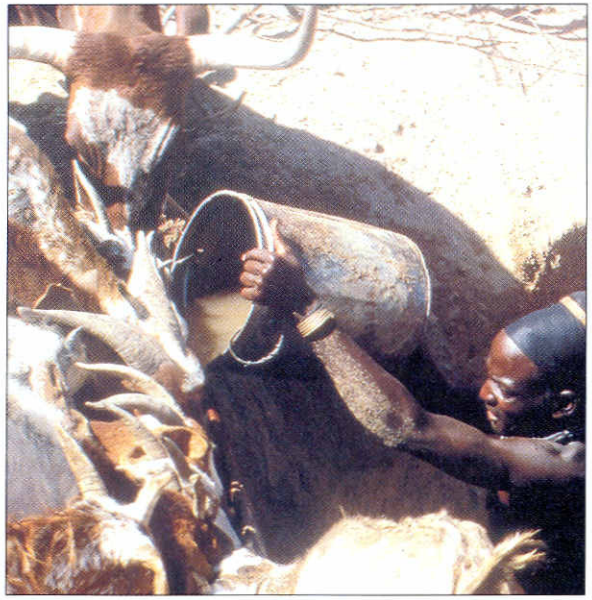
Local residents hired to protect wildlife have played an important role in generating an awareness of the economic value of wildlife, as well as preventing poaching.

THE CHALLENGES FOR COMMUNITY-BASED PROGRAMMES

Although community-based natural resource management (CBNRM) programmes hold much promise, their long-term benefits may be limited if not carefully implemented. These programmes are based on the belief that sustainable resource management improves an individual's livelihood. While this may be the case, individuals and communities often act out of necessity for their short-term interests, leading to unsustainable land use in efforts to maximize yields. While CBNRM programmes may achieve some objectives, such as contributing to a reduction in wildlife poaching, they will be unsuccessful in maintaining the habitat on which the wildlife depends unless the programme specifically adopts habitat protection as a goal.

An important consideration, which is often overlooked, is the aspiration of the resource user. Farmers struggling for basic survival or eager to break economic barriers preventing them from acquiring a higher standard of living may not give thoughtful consideration to the long-term sustainability of their actions. Unsustainable land use is, in many cases, a means to an end - a way of achieving short-term economic goals or satisfying certain basic needs. Examples abound throughout the world of short-sighted management which has led to a recent backlash against community-based conservation programmes, in which neither the goals for conservation nor long-term community benefit have been achieved (62, 71, 157, 160, 168).

The economic viability of conservancies: A principal goal for conservancies is that they should become self-funding. Although there is certainly potential, it is unclear whether self-sufficiency is attainable because no thorough economic analyses of the available resources have yet been done in the region. The main example which has been used to justify the assumed future success of conservancies in western Namibia has been the rapid recovery of wildlife populations on private farms following the State's granting of usage rights for game to the landholders in the late 1960s. However, the validity of such a comparison is questionable given the differences in the quantity of resources accessible to a private farmer and a communal farmer in the western catchments. The family of a private farmer has rights of use of wildlife on an area averaging between 5 000 to 10 000 hectares. In contrast, the family of a communal farmer in the western regions has access to resources on approximately 500 hectares, if the area is shared equally amongst every family. In addition, inland areas where the private farms lie have the potential to carry significantly higher populations of wildlife than the arid west. If consumptive uses are to be sustainable in the west, the number of animals harvested will be lower and more variable from year to year in comparison to areas with higher rainfall and more evenly distributed vegetation.



As the human population of the western catchments increases, the challenge of maintaining equitable access to the region's resources will become even greater. As one resident remarked, 'the more people, the more problems'. (photo: R Swart)

In addition to the above constraints, consumptive wildlife use within the western regions will not greatly enhance livelihoods of the area's thousands of inhabitants (33 000 in the case of former Damaraland) if shared equally amongst them, because the area simply cannot support enough game. The conservancy policy requires that a conservancy occupy a 'defined geographic area', in which the members will have rights of use to the wildlife. However, people living in areas adjacent to such conservancies who do not share such rights will have no incentives to act as responsible stewards of their neighbors' resource. If the entire region functioned as a conservancy this problem would be resolved although individual benefits would be very low. This problem has been observed in recent reviews of community-based natural resource management programmes in Zimbabwe, where dividends returned from community-based natural resource programmes have been substantially less than household incomes derived from agricultural practice (140). As a result, dividends are re-invested in the economic mainstay of the household, namely cattle. The result has been continued and increased pressure on the region's natural resource base.

There is currently an urgent need for economic analyses of the benefits of alternative land uses within the arid western regions of the catchments. Particular emphasis on agriculture and the consumptive and non-consumptive uses of wildlife, within the environmental constraints of the area, is needed. At present no detailed economic analyses have been done to estimate potential revenues from either consumptive or non-consumptive uses of wildlife in the arid communal lands of the western catchments (45). Assumptions that wildlife-based enterprises can play a role in developing rural economies are based upon comparisons with Botswana and Caprivi (18). Such comparisons are of little relevance, however, because of both the unique resource base and the environmental constraints associated with the western catchments. The catchments have spectacular desert scenery and wildlife, unrivalled anywhere on the continent. But, because of the aridity of the region, the distribution and abundance of natural resources, such as water, vegetation and wildlife, are much more limited than in wetter areas such as the Caprivi and Botswana.

Lions, such as this wary individual hiding behind a mopane tree in the Uniab River, may soon vanish from the western catchments. Although their passing may please the region's farmers, it will represent a great loss to the tourism and conservation value of the area.

▶ ***What's important about the use and management of wildlife resources in the western catchments?***

- *Rights of consumptive use must be granted to communal farmers in the western catchments, rectifying the current inequity between communal farmers and private farmers who currently enjoy such rights. The existing Nature Conservation Ordinance (4 of 1975) must be appropriately amended.*

- *Given the low and highly variable rainfall in communal areas of the western catchments, thorough environmental and economic analyses of the benefits of potential land uses should be undertaken, with particular emphasis on agriculture, tourism and consumptive and non-consumptive use of wildlife.*

- *The effects of a dry and variable climate on resource availability in the area must be considered when evaluating the effectiveness of current policies, legislation and regulations for supporting various land uses.*

- *The current focus on protecting wildlife from poaching, and involving rural communities in wildlife conservation must be expanded to include an emphasis upon wildlife habitat protection and involvement of local communities in such efforts.*

The Future: Reaping the Greatest Benefits Through Tourism

The Unique West

Western Namibia is unique, from both national and international perspectives. Although much has been said regarding wildlife within the arid western sections of the catchments, not enough emphasis is placed on the value of these animals, in this particular setting, to the nation as a whole. In addition to all the other wildlife, the African continent's last populations of desert elephant and rhino still wander unrestricted through this ancient landscape of spectacular and varied topography. Expansive landscapes stretch from high mountains, across wide plains and along beautiful beaches. The uninhabited western reaches of the catchments are still largely a wilderness and, as such, have tremendous value to Namibia through their capacity to generate tourism revenue. In short, what the western catchments offer is what people living in other corners of the world pay to see because their own open spaces are gone or diminishing rapidly. They are a critical resource to the country, a resource which must be carefully developed and well managed to benefit all Namibians.

◀ *Many tourists travelling through the arid west, such as these seen here in the Hoanib River below Sesfontein, leave little behind other than vehicle tracks. These areas are popular destinations for tourists and are unused by the region's farmers because of the harsh climate. The lack of an official proclamation declaring them as conservation and tourism areas, however, complicates efforts to collect revenues for their use.*

A Growing Industry

It is estimated that 213 000 tourists from around the world visited Namibia in 1991. These visitors contributed approximately 360 million Namibian dollars to the national economy (73). Tourism is the largest and fastest growing industry in the world. In the Namibian economy, tourism currently occupies fourth place, behind mining, agriculture and fisheries but has potential to be the second most important sector of the economy behind mining by 2002 (73). At present tourism formally employs some 10 000 people, making it one of the most important employers in the country. In spite of all this, Namibia's tourism industry is underdeveloped and nowhere is this more obvious than in the western catchments.

Since 1990 there has been a tremendous influx of tourists into the western catchments, particularly in communal areas of the northwestern rivers, such as the Khumib, Hoarusib, Hoanib and Uniab, lying within the Kunene region. Sales of petrol at the Palmwag pump, which is the logistical gateway to this region, average nearly 50 000 litres per month, climbing to 100 000 in some months. This reflects the increasing numbers of tourists who are entering the region to see its unique resources. In Australian drylands, revenue from tourism is now higher than from livestock. In a similar way, in arid western Namibia, sustainable revenue generation from tourism has a much greater potential than that from agriculture (28).

Sales of petrol at the Palmwag petrol pump, as high as 100 000 litres a month, reflect the high tourism value of the arid western catchments.

Who Benefits?

Is the region's popularity with tourists good news? At the moment probably not, as activities of many of these individuals are completely uncontrolled, resulting in damage to the region's resource base. Unregulated tourism results in excessive wear to poorly maintained tracks, which only encourages people to drive off the roads, making unsightly new tracks. Increasing numbers of tourists collect and burn large amounts of wood. Wildlife in many areas, particularly within the western rivers, is put under stress as tourists attempt to get a closer look or camp overnight at the region's springs. As a result, the quality of future visitors' experiences is degraded. But surely these visitors are contributing their fair share to Namibia's economy? Again, probably not. A large number of tourists entering the more remote western areas come to Namibia from throughout southern Africa, fully equipped for their travel, contributing little revenue to the region or the nation, other than that paid for petrol. In return they receive the privilege of seeing some of Africa's most unique scenery, and all largely for free. Other visitors, travelling with registered tour companies and concession owners, pay N$500 or more per day for the same experience, making a substantial contribution to the Namibian economy. Because the area has no official conservation status and residents of communal lands have no right to restrict access to these areas, no fees can be levied for the privilege to visit this unique region.

While private landowners in the headwaters of many catchments profit from operation of game and hunting farms, guest farms, and wildlife conservancies, similar developments have lagged behind in communal areas. This is, in part, due to the lack of use rights for wildlife in these areas. Although this is certainly part of the problem, in reality lack of use rights is not an obstacle to the most lucrative economic activity associated with wildlife, namely non-consumptive use through tourism. Rather, what is essential to achieving this aim is resolution of land tenure, giving a community or individual the ability to protect resources which support the wildlife itself. In the absence of legal rights, a community encouraging tourist development within a region cannot prevent someone else from moving into the area and settling livestock on a picturesque spring, which is critical to the region's wildlife. A legally defendable basis for controlling such activity is urgently needed.

Private tour operators, such as these showing clients the "Clay Castles" in the lower Hoarusib River, make an important contribution to both the local and national economy through the provision of jobs and the payment of fees and taxes. (photo: D Heinrich)

Spectacular geological features, such as this folded rock in the lower Ugab River, are an important asset for tourism within the western catchments. (photo: P Tarr)

■ *GEOLOGICAL TOURISM: DOES ANYBODY HAVE A MAP?*

Although the western catchments contain some of the most appealing geological features in the world, no interpretive guides exist to encourage geologically-orientated tourism. Guidebooks could greatly enhance the experience of the large numbers of tourists seeking stimulating experiences. A further constraint is the lack of topographic maps of the region. Although high-quality 1:250 000 topographic maps have been produced for the region encompassing the western catchments, some of these maps are out of print and often out of date. Low quality copies of old sheets are available but in no way compare to original colour sheets. Such seemingly insignificant inconveniences can cause great annoyance to tourists. Although the 1:250 000 topographic maps could easily and cheaply be reprinted, this has not been made a priority and no budget allocation has been granted to the Surveyor General. For tourism to return the revenues to Namibia of which it is capable, investments will have to be made to meet such specialised needs of tourists.

The Role of Parks: Use or Preservation?

A common observation of tourists in Namibia, both local and overseas, is that parks are inaccessible (73). Although dangerous wildlife in Etosha requires visitors to remain in their vehicles, other conservation areas such as the Skeleton Coast and Namib-Naukluft Parks can be explored on foot. By and large, however, points of interest often go unnoticed, due to lack of interpretive materials such as maps and guides.

Although a few hiking trails exist in the western parks, there could be many more. Numerous sites of interest could be developed for day hiking from roadside parking spots. In conjunction with such trails, brochures and maps which discuss features of interest along the route are needed. This model has been used in parks throughout the world and is well known to many tourists coming to Namibia, hoping to encounter similar interpretive aids. While a tremendous amount of research has been conducted on the environment in this country, very little has been translated into a form digestible for tourists (39, 40, 174). The recent development of the interpretive centre and brochures at the Twyfelfontein rock engravings is a notable and beautiful exception.

Much interpretive information could be made available for the two main tourism areas within the western catchments, the Skeleton Coast and the Namib-Naukluft Parks. A tourist entering the Skeleton Coast Park and driving northward is unaware that the Ugab River, which they cross just north of the gate, may have served as a pathway for pre-historic people and wildlife moving between the inland and the coast. They are probably unaware that just off the road lies an ancient village, with huts made of whale bones. Further north, tourists cross the normally dry channel of the Huab River, probably unaware that upriver live many of Namibia's desert elephant. Still further along, they drive straight past one of the most interesting features of all, the multiple channels of the Uniab River where it drains into the sea. Here a rich story could be told of springs and wildlife, of massive floods that come in the night, rolling rocks the size of cars down towards the ocean. A walk in the vicinity would reveal agates and silts, washed out of the catchment, along with ancient beaches raised high above the ocean and numerous springs (226). The fact that the water of the spring which flows over a beautiful waterfall is derived from a catchment some 50 to 100 km inland is unknown to the tourist who happens to stop there today.

Within the Namib-Naukluft Park, unique sites also abound which could offer interesting hikes for the more energetic tourist. Recent developments of trails, maps and brochures for the Naukluft section provide an example that should be expanded into other regions of the Park. For example, the summit of the Swartbank Mountain along the Kuiseb River provides one of the most spectacular views in the Park as the late afternoon sun lights up the massive dunes to the south of the river. Along the way to the top one passes striking formations of white marble and black volcanic rocks, many covered in thick coats of orange and black lichens. Regrettably, this feature will not attract tourists to the Park, along with many other interesting sites, as there is no road, no interpretive map, and no plan for such areas to be used. Having access to interpretive information and then visiting an area for oneself is what most tourists desire from environmentally related tourism, or ecotourism. Those who are uninterested will pass by, while those who are intrigued will linger, enriched by the experience.

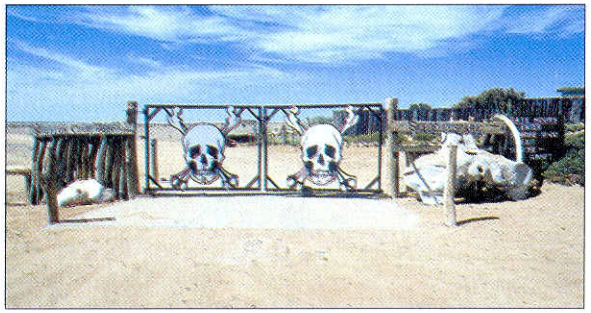
Most people today, interested or not, are unaware of the western parks' unique resources and their stories. Those in favour of preservation say that this limits the impact that humans would otherwise have on such sites. At the same time, however, it encourages use of such resources in other ways. In the case of Swartbank Mountain, there have been suggestions that the marble should be mined. Namibians and visitors must be given the opportunity to use and appreciate the nation's treasures as they are. In the absence of such interest, however, these scenic resources will have little value to Namibia - leaving their future insecure. Namibia must use its resources to the economic advantage of its citizens. The government agencies currently charged with maintenance of the Park's environment must try to guide that use now, increasing the value of such areas to the nation and providing a greater incentive for their protection. Sites such as these will be developed, sooner or later, either as an attractive feature providing a sustainable source of revenues through tourism or, in the case of the Swartbank Mountain, as a marble quarry, the benefits of which will be short-lived.

Although there is tremendous potential to generate revenues through various forms of tourism, little development has actually occurred. As an example, only two official hiking trails exist within the whole of western Namibia, one in the Naukluft Mountains within the Tsondab catchment and the other seen here, within the lower Ugab River. (photo: R Loutit)

THE SKELETON COAST PARK AND THE NAMIB-NAUKLUFT PARK

The Skeleton Coast Park and the Namib-Naukluft Park together encompass a major part of the lower reaches of the western catchments. The Skeleton Coast Park extends from the Kunene River in the north to the Ugab River in the south. Toward the north it is 25 km wide, while in the south it stretches some 40 km inland. The Skeleton Coast Park was proclaimed in 1971. Since that time it has developed to encompass a camping site at Torra Bay, open over the Christmas holidays, and a number of bungalows at Terrace Bay - an old diamond mining camp - open throughout the year. The major focus of the park is to provide access and accommodation for line fishermen enjoying Atlantic surf fishing. In addition, a major tourism concession to use the area in the northern part of the park is allocated out at ten-year intervals. Currently foreign interests hold the concession.

Despite its current focus on coastal fishing, the tourist potential of the Skeleton Coast Park is tremendous. With provision of field guides, maps, interpretive materials, self-guiding walking trails and other low-cost development, the unique landscape, fauna and flora could bring tangible benefits to Namibia. White beetles, sand-diving herbivorous lizards, rich lichen fields, antelope, agates, moving sand dunes, springs, rivers and many other attractions would intrigue discerning tourists if properly presented.



The Skeleton Coast Park stretches along the Namibian coastline from its southern entry point, seen here just south of the Ugab River mouth, all the way north to the Kunene River at the border with Angola. Along the way, it is crossed by the Ugab, Huab, Koigab, Uniab, Hoanib, Hoarusib and Khumib Rivers, as well as several smaller rivers further north. The water and vegetation resources within these rivers are essential for the ecological and economic viability of the park.

A second conservation area, encompassing part of the lower catchments of the Swakop, Kuiseb, Tsondab and Tsauchab Rivers, is the Namib-Naukluft Park. Originally proclaimed by the Germans in 1907 as Game Reserve 3, it was known as the Namib Desert Park until the Naukluft Mountain farms were purchased from their private owners and incorporated into the park in 1979. At the same time, Diamond Area 2 was also incorporated into the Namib-Naukluft Park. By 1986, further additions resulted in one of the largest parks in the world and the largest park in Africa at 49 768 square kilometres. The Namib-Naukluft Park encompasses Sandwich Harbour and places further south along the coast; the Welwitschia Flats north of the Swakop River; Sossus Vlei at the dune extremities of the Tsauchab River; and a host of landscapes in between.

The Uniab River mouth within the Skeleton Coast Park is a site of international significance. With its unique geological features, springs, waterfall and wildlife, the site deserves special protection for tourism development. Plans laid out in the Skeleton Coast Park Master Plan, to establish hiking trails and interpretive materials, should be implemented immediately. Such efforts are needed if Namibia's tourist industry is to achieve its full economic potential.

Many unique sites within the Namib-Naukluft and Skeleton Coast Parks, such as the Swartbank Mountain seen here within the Namib-Naukluft Park, are inaccessible to tourists. Although some people argue they are better protected in this way, appropriate and sustainable development as tourist venues is ultimately the best protection.

Within the Namib-Naukluft Park a number of campsites have been laid out at inselbergs, along ephemeral river courses, and on the Naukluft Mountain. Walking trails have been established in the Naukluft. Still, the tourism potential has been largely neglected and little information is available (39, 40, 174), although the potential for further development is enormous. As an underdeveloped benefit to the nation, the Namib-Naukluft Park is equalled only by the unprotected western regions of Erongo and Kunene Regions.

The Omaruru River is the one major western ephemeral river that is not encompassed in or bordering on a park. Its mouth at Henties Bay does, however, lie within the West Coast Recreation Area, another area proclaimed and maintained for the benefit of coastal fishermen. As with other west coast conservation areas, it has tremendous potential for further development for discerning tourists. Field-guides, maps and other information-based materials should be accessible to help tourists experience and appreciate the unusual plants, animals and landscape of the western catchments.

Maintaining Our Resources for Sustainable Use

How do we evaluate the most appropriate use of land? This is a difficult question, and as Namibia struggles to develop its economy for the benefit of its citizens present and future, economics must help guide such decisions. In the case of the western catchments, two main land uses predominate - agriculture and tourism. As has already been reviewed, the eastern halves of the catchments are extensively used for private and communal farming operations with scattered tourism enterprises, while the western and southern regions lie within proclaimed conservation and tourism areas. What is not so obvious is that between the actively-farmed communal areas to the east and the Skeleton Coast Park in the west, there is a broad strip of land: a no man's land. With minimal rainfall and no value for livestock farming. No one lives in this area permanently. It does, however, have tremendous potential for conservation and tourism and could enrich the livelihoods of people living adjacent to this area.

Large sections of this area are already being used for tourism and as de facto conservation areas. The Palmwag, Ombonde and Doros Crater Concession areas lie within this region, encompassing a large percentage of it. Despite designation as tourist concession areas, this affords little long-term security in the absence of any enforceable proclamations protected by law. Even though these areas are the main range of desert rhino and elephant, there is no official conservation status which grants protection to this critical habitat. Recognising the value of these areas, local communities, non-governmental organisations as well as local government officials recently called for a proclamation of these areas as legally protected conservation and tourism areas (32, 73).

Namibia has been quick to secure adequate protection for its marine resources which have great value to the national economy (12, 145). Through the declaration of an economic exclusion zone, construction of a new research building and purchase of patrol boats and helicopters, Namibia is clearly very serious about maintaining the economic output of its fisheries. One hesitates to draw the same conclusion, however, about its commitment to protecting the terrestrial environment upon which the tourism industry and so many communal farmers depend. Although tourism is thought to have potential to generate revenues in excess of those from agriculture and fisheries, efforts to secure protection of these resources has been much slower in coming.

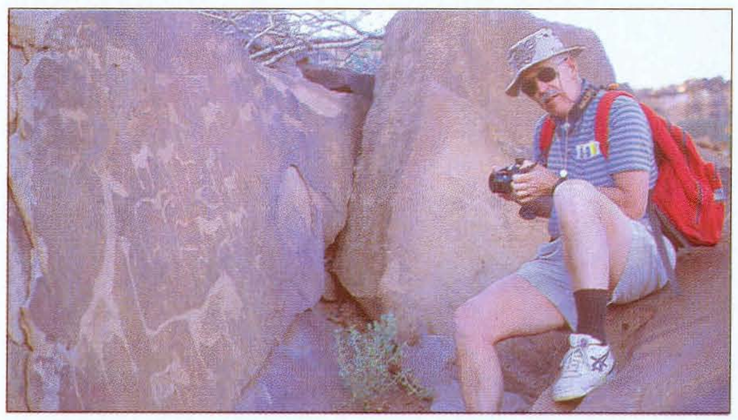
The most serious constraint to development of tourism in the western catchments is lack of land use planning. There is an urgent need to decide how the region's land will be used, recognising that some forms of land use may be conflicting, or may be inappropriate. Lack of planning is reflected in the fact that no land use zones have yet been established within the region, which would provide the necessary guidance for the development of diversified forms of resource use. Instead, unco-ordinated development goes on. Farmers on private lands within the upper reaches of the catchments, such as the Huab, have built ground dams. These dams are reducing flow, endangering livelihoods of downstream private and communal farmers, as well as degrading the natural resource base upon which the region's wildlife depend. Holders of tourism concession areas in the Hoanib and Uniab catchments have found that their resources, including grazing and springs, are under constant threat from neighbouring farmers, who are not interested in the region's significance to tourism development and the Namibian economy. Balancing such conflicting demands will require a realistic evaluation of both the national interests and those of local people directly involved.

Livestock, here in the Opdraend wetland in the Huab River, can outcompete wildlife for forage. A rhino recently died off starvation in the lower Ugab River after cattle ate the available forage.

Given the significance of tourism to the Namibian economy and the livelihood of its citizens, it is imperative that resources upon which this sector depends be given appropriate attention and protection. A conservation status for the western sections of the catchments, which recognises and legally mandates their use as conservation and tourism areas, is urgently needed. By providing this recognition of the region, the State, local people and the private sector can benefit from the unique natural resources of the area. Finally, unless a regionally-specific land use plan is made, which takes into account the inherently low production in drylands, there is little future for the region, its people and its unique natural resources.

The west coast is a popular spot for fishing, bringing large numbers of tourists into lower reaches of the western rivers. These tourists often travel inland to visit various sites within the catchments. (photo: P Tarr)

The new interpretive center for the rock engravings at Twyfelfontein is an excellent example of the efforts needed to develop Namibia's unique tourist sites, making them more interesting and accessible to everyone who visits.



Visitors from around the world are eager to see the many unique features found within western Namibia, including the rock engravings seen here at Twyfelfontein in the Huab catchment. Archaeological sites throughout the western catchments are an important record of past environments. As such, they warrant a high conservation priority and further study.

▶ *How can we use the unique resources of western catchments most sustainably?*

- *Possibilities for further development in the western catchments focus mainly on agriculture and tourism. Therefore all Ministries involved with managing wildlife, soil, water and rangeland resources must be involved in making decisions about development of the region's resources. Ministries involved with economics, finance, trade, and industry should examine economic sustainability of developments, given available resources, and Ministries involved with human development, lands and resettlement, health, education and culture must ensure that goals of social sustainability are met.*

- *Land use planning and resolution of land tenure and wildlife ownership issues are desperately needed to support informed decision making at all levels and facilitate continued economic development. The most serious constraint to development in the western catchments is the lack of land use planning. There is an urgent need to decide how the region's land and water resources will be used, recognising that some forms of use may be conflicting, or may be inappropriate. Lack of planning is currently reflected in the fact that no land use zones have yet been established within the region, and as a result development in the region is unco-ordinated. Conflicts have arisen over rights to water resources, as well as grazing rights of individuals interested in agriculture or tourism. These examples illustrate the desperate need for land and water use planning, particularly in communal areas of the western catchments.*

- *Tourism has been identified as a major growth sector in the Namibian economy. Given the outstanding tourism potential of the western catchments, development of the tourism industry in this region should feature strongly in land use planning.*

- *Use of the region and its resources by tourists is currently unregulated and in some areas of the Kunene and Erongo regions, is resulting in damage to the natural resource base. If allowed to continue, this could reduce the value of the region for tourism development. This is happening because the region currently has no conservation status and because people living in communal areas have no right to restrict access to communal lands, nor to receive benefits from their use by visitors.*

- *Given the high potential for tourism as a development strategy in the western catchments, policies and laws must be drafted that ensure sustainable use of resources that support tourism - namely water, soil and vegetation, and wildlife.*

- *The Ministries charged with care and maintenance of these resources (Ministry of Agriculture, Water and Rural Development and Ministry of Environment and Tourism), should work in close co-operation with other ministries involved with land use planning and rural development in drafting policies to ensure that development of tourism as an industry supports both the local as well as the national economy.*

- *Interpretive materials such as maps and brochures are desperately needed for the entire region within the western catchments, including the Skeleton Coast and Namib Naukluft Parks. Even those tourists who would otherwise be interested are usually unaware of the desert's unique natural features because of this lack of interpretive materials.*

IV: THE NATIONAL PERSPECTIVE

Law and the Environment

Virtually any recently published report relating to any aspect of the Namibian environment will either begin or end with reference to Article 95 of the Constitution of the Republic of Namibia (17), which states that:

> *'the State shall actively promote and maintain the welfare of the people by adopting . . . policies aimed at . . . maintenance of ecosystems, essential ecological processes and biological diversity of Namibia and utilisation of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future . . .'*

This article is a guiding principle but is not enforceable by law. Rather, effective legislation and incentives must be in place so that principles of state policy are adhered to.

Water Law

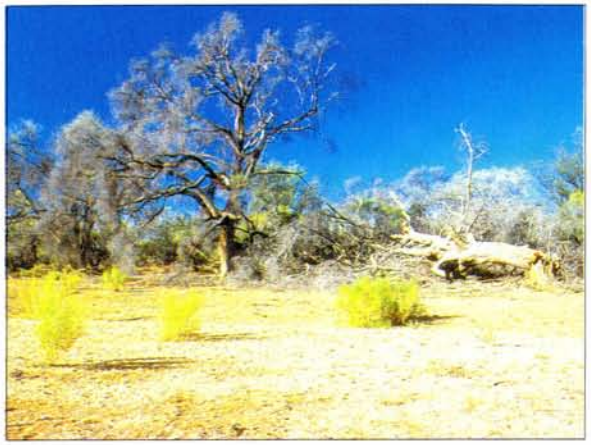
The greatest challenge Namibia faces as it attempts to manage its natural resource base is to balance the conflicting needs of all resource users. This is particularly true in the western catchments where competition for water is especially severe. The simple fact that water flows downhill forms not only the basis for the rivers' ecology but also gives rise to many of the challenges in managing these systems and their resources. Water flow may be captured to benefit riparian users and these users, whether a town, a farmer, a tree or a wetland within a proclaimed park, are all dependent upon the flow from upstream. Consequences of reducing or stopping this flow can be severe - a crisis in the town, a decline or collapse in productivity of the farm, loss of a tree or its fruits, or destruction of the ecological and economic well-being of the park.

Although it seems obvious to include the town and the farmer as downstream users, many may not have considered the tree or park as a downstream user. Yet, their welfare is as dependant upon access to water as is the town or farmer. The downstream environment is often ignored when decisions must be made about equitable water distribution. This occurs in spite of the tremendous economic value of these environments. Without ana trees in the river, farmers in communal areas will have difficulty feeding their stock, and without riparian resources in both communal farmlands and parks, wildlife- and tourism-based revenues will be reduced or disappear. Such losses, although seemingly of little immediate significance to upstream users who have captured the water, impoverish Namibia as a whole. Such losses, therefore, must be factored into decisions regarding use of water upstream.

The Water Act

Namibia's water resources are currently protected by legislation that was in place at independence, chief of which is the Water Act No. 54 of 1956. The Act covers a wide range of issues relating to protection of surface and subsurface waters from pollution and misappropriation, clearly defining interests of the State in protecting this resource. A major limitation of the Act, however, is that it does not identify the need to recognise the downstream environment as a user. In the context of the Act, provision is made for protecting the riparian user, but only in the context of a land owner, not in regard to the natural environment on which Namibians depend.

◀ *While farmers living along the rivers of western Namibia are recognised by the Water Act as 'users' of water, the environment upon which they depend is not considered a user. No provision is made within the Act to meet and protect the water needs of riparian forests, such as the one seen here along the lower Kuiseb River. Recognising the environment as a 'user' of water is essential, given the dependence of agriculture and tourism on environmental resources such as these riparian forests.*



The frequency and volume of floods on the upper Huab River has shown a marked decline in the past twenty years. This appears to be due to the combined effects of increasing numbers of farm dams (49 dams in 1974 to 91 dams in 1989) and a general decrease in rainfall over the catchment. The result, seen here, has been the die-off of large numbers of ana trees of all ages. Springs and wetlands have also disappeared as the water table within the river's alluvium has dropped.

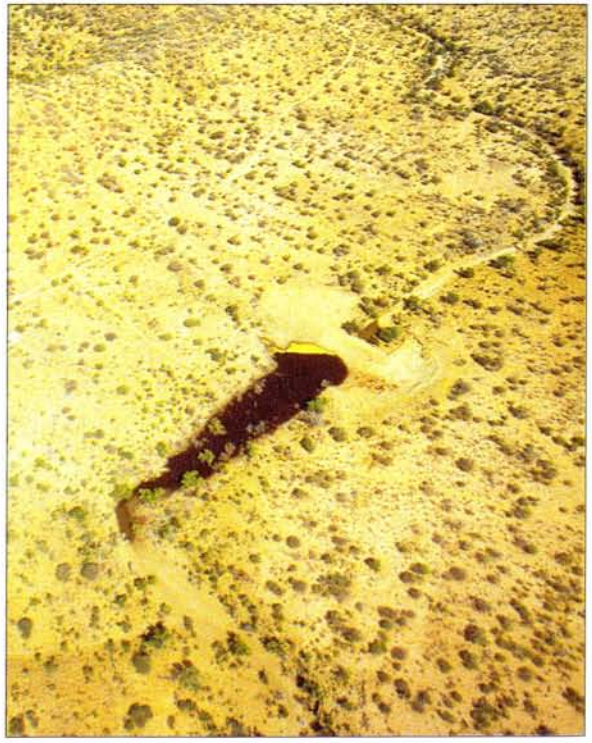
Water: public or private? The foundation of the Water Act is the distinction between public and private water. Public water is defined as water flowing in a natural stream, in a known and defined channel (even if it is dry for most of the year as in an ephemeral river), if this water is capable of being used for irrigation on at least two separately owned pieces of riparian land. In contrast, private water is water originating and naturally remaining on land of the owner (such as a spring) and as such can be used exclusively by the land owner. The Act states that in the case of a public stream, all riparian owners are subject to 'reasonable rights of common use' for urban and agricultural purposes, although irrigation of land in excess of one hectare is not allowed without special permission. The Act also allows special regulations governing use of public water to be declared in times of water shortage, as well as regulations to prevent its wastage and pollution.

Groundwater: Regarding groundwater, the Act defines 'subterranean water' as water which exists naturally underground or is derived in any way from natural underground water. Such water is regarded as private, permitting a landowner to make use of subterranean water under his or her own land. Such use may be restricted, however, if deemed in the interests of the State, by proclaiming 'subterranean water control areas'. The Act also protects springs from destruction or 'cleaning and deepening' without prior approval of the Department of Water Affairs (195).

Drilling of boreholes is tightly regulated under the Act. Any person drilling a borehole on any land must notify the Department of Water Affairs and keep a journal with details relating to date of drilling, final depth, geology, water strikes, pump test data, and any other information about the borehole. The journal must be submitted to the government upon completion of drilling work (196). This applies to any contractor hired by the landowner or the government to carry out the work. Although this regulation is very important, because it facilitates creation and maintenance of a database providing essential information for future evaluation of the region's water resources, it is not enforced.

Water, even more than petroleum, is a precious resource and as such its exploration and exploitation must be tightly regulated. The Petroleum (Exploration and Production) Act of 1991 sets stringent guidelines, some of which provide examples for how we should regulate our use of water. For example, on a biannual basis the holder of a licence for petroleum exploration must submit detailed reports of any sampling or drilling conducted in the previous six months. Failure to make such submissions, within 30 days after the end of each six month period, is punishable by a fine of $N 100 000 or imprisonment of five years. Although the Water Act stipulates that similar reports must be filed, the penalty prescribed in the Act is a fine of only N$ 500 or three months imprisonment. Penalties should be increased to reflect the value of water in Namibia.

Finally, the State may act to ensure equitable distribution of water in the public interest by requiring measurement and regulation of the quantity of water abstracted or, if necessary, the sealing of boreholes. Although no specific recognition is given to protection of environmental water needs, the State may '. . . limit or prohibit the abstraction and use of subterranean water for any purpose . . .' (197).



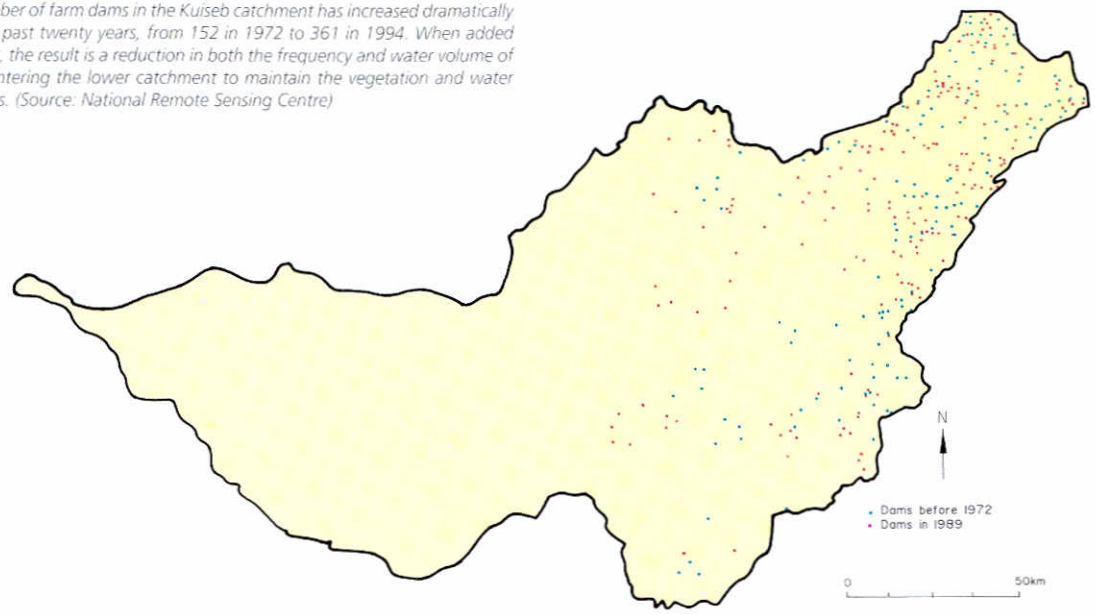
▲ *Farm dams within the western catchments can be built without permission if they do not exceed a storage capacity of 20 000 cubic metres. The dam seen here in the upper Kuiseb catchment is typical of such structures, built to intercept and store the downstream flow of floodwater.*

Dams and the public stream: The Water Act and its regulations specify that a person may construct a dam, with storage capacity less than 20 000 cubic metres, in a public stream and use water therein for domestic purposes and stock-watering (199). It allows for any person 'aggrieved by this storage' to apply to the State for alterations of these storage works, and permits the State to ensure 'equitable division of water in the public interest' by allowing for payment of compensation from the owner of the storage work to the affected person (200). Finally, the Act allows the State to order removal of such works if it is found to be 'necessary for an equitable division of water in the public interest ...' (201).

The Act also allows for collection of charges from any person entitled to and using 'water abstracted, supplied or distributed from a public stream or a borehole in the bed of a public stream . . . '(202). In regard to larger storage works, the Water Amendment Act No. 22 of 1985 prohibits impounding and storage of more than 20 000 cubic metres of either private or public water without permission from the Department of Water Affairs.

Maintaining the flow: When deemed necessary, the State can declare 'catchment control areas' under the Water Act where rights of landowners can be suspended to maintain flow in public streams. The Act also gives the State discretion to declare control areas where water rights may be restricted or suspended and then re-allocated in the public interest. The power vested in the State to proclaim 'catchment control areas' and 'subterranean water control areas', as well as levy fees for use of public water, has tremendous implications for management of water and protection of the natural resources water supports in Namibia's western catchments. If applied, the law could in principle be used to maintain downstream flow for environmental needs.

The number of farm dams in the Kuiseb catchment has increased dramatically over the past twenty years, from 152 in 1972 to 361 in 1994. When added together, the result is a reduction in both the frequency and water volume of floods entering the lower catchment to maintain the vegetation and water resources. (Source: National Remote Sensing Centre)



PARKS: THE LAST IN LINE FOR WATER!

The process of settlement within the western catchments, and the associated division of land, has resulted in creation of conservation areas which lie only at the downstream end of the catchments. The only exceptions to this rule are the Hoanib and Tsondab catchments where, respectively, small sections of Etosha National Park and Namib-Naukluft Park fall within their upper reaches. For the most part, however, many of Namibia's most important conservation and tourism areas are last in line for water. This fact has great significance given the importance of successful conservation efforts to continued generation of tourism revenues and the ecological importance of these linear oases in the arid western environment. Much of the wildlife within these parks is dependant upon riparian resources, either as a dry season refuge or throughout the year.

Drying up the lower reaches of Namibia's western-flowing ephemeral rivers would be a disaster - for parks, for tourism development and for Namibia's economy. It is therefore essential that any upstream development which would reduce downstream flow be restricted. Such developments should only proceed if their significance, economic or otherwise, outweighs the value of these unique downstream areas to the nation.

The Mountain Catchment Areas Act recognises the need to protect mountainous regions, such as the Kuiseb catchment seen here near the Gamsberg. The main aim of the Act is to ensure the delivery of the highest possible quality and quantity of water from proclaimed catchments, thereby protecting public water supplies. It could also play an important role however, in maintaining downstream flow essential for the environment upon which many people depend in the lower reaches of the western rivers.

At the same time, however, the Act again does not specifically recognise water needs of the natural environment. Strictly interpreted, the law implies that flow of public rivers can be appropriated in its entirety by riparian owners, without consideration of water needs of the downstream natural environment. In an arid country like Namibia, where water is increasingly scarce, laws must provide the necessary protection to downstream environments on which so many people depend, particularly in the western catchments.

Although applicable throughout the western catchments but never applied, the Mountain Catchment Areas Act 63 of 1970 directly identifies the need to grant special protection to mountainous regions and their river catchments. As stated in the Act, it is 'to provide for the conservation, use, management and control of land situated in mountain catchment areas, and to provide for matters incidental thereto'. The State may, by notice in the Gazette, declare any mountainous area to be a mountain catchment area. Directions may then be issued with reference to such land relating to:

> *'. . . the conservation, use, management and control of such land; the prevention of soil erosion, the protection and treatment of the natural vegetation and the destruction of vegetation which is, in the opinion of the Minister, intruding vegetation; and any other matters he considers necessary or expedient for the achievement of the objects of this Act in respect of such land . . .(Section 3)'*

The main aim of the Act is to yield the highest possible quality and quantity of water on a dependable basis from proclaimed catchments, while retaining optimal plant cover and variety of species (6). In the Republic of South Africa, where the Act was drafted, proclamations are made when and where the water yield from a mountain catchment is of great importance. It is in part based upon the observation that runoff from catchments with carefully managed forest resources contains substantially less sediment than runoff from adjacent unmanaged areas. This has obvious affects on reservoir life and water quality. It could well be applied to rivers such as the Omaruru. Inappropriate farming practices in the headwaters of the Omaruru have caused erosion into the river of sediments that are thought to be reducing recharge of the lower aquifer (41). Although the Act's chief aim has been to protect public water resources, it can also play an important role in recognising and protecting water needs of downstream environments and their users.

WATCOM, WASP AND THE WATER ACT

A Cabinet decision in March 1993 mandated that the Ministry of Agriculture, Water and Rural Development initiate a project (WATCOM) to investigate commercialisation of its bulk water supply function (3). Commercialisation is defined as a process whereby a directly controlled State activity is transformed so that corporate values and financial motives are developed, related to the needs of a demand-led market. Ownership of the commercialized entity is still retained by the government, as it will be the majority shareholder. (In contrast, privatisation is defined as transfer of ownership or control over assets or activities from the public sector (State) to the private sector.)

In this context, it was proposed that bulk water services be separated from the DWA and transferred to a commercialised entity, creating a State-owned bulk water supply company. On the other hand, commercialisation of rural water supply was viewed as economically unviable. In addition, provision of rural water was recognised as a social responsibility of the State. It was thus recommended that the Directorate of Rural Water Supply remain within the DWA. The principle objective of rural water supply is to make the transition from the State's role as a provider to that of facilitator on the basis of community participation though water committees. In addition, it was decided that, as water in Namibia is a scarce and valuable resource, overall responsibility for conservation, control and allocation of these resources should remain with the State.

Major problems identified in the report included serious financial constraints, an inability to attract and retain qualified staff, tariffs that are not set at cost recovery levels resulting in Government subsidisation, and inadequate legislation and insufficient co-ordination of all actors in the water sector (all Namibians). A major concern was that the water company will be operated in a monopolistic fashion, and will thus be subject to abuse. It was recommended that a public utilities commission be established to ensure the economic regulation of all utility organisations. The Company is scheduled to commence operations in September 1995.

Namibia is also revising the existing Water Act of 1956. This revision is aimed at ensuring the appropriateness of the Act with respect to the Namibian Constitution as well as the Government's National Water Supply and Sanitation Sector Policy (WASP) (51). The WASP document explicitly states that private landowners are to assume full responsibility (cost included) for their water and sanitation installations. Farmers on State land are also expected to assume responsibility for their water and sanitation facilities, as far as possible, either as individuals or communities. In redrafting the Act, attention needs to be explicitly given to environmental implications of these new policies and the Act itself. The following issues are relevant to the western ephemeral rivers and their catchments:

- *The environment must be specifically recognised in the Act as a user with defendable rights to water, particularly in the case of public streams and the downstream environment. It is essential that all Namibians understand that in calling for the protection of the environment we are acting in our own self-interest. Calls for environmental protection must not be seen as elitism but rather as an issue of great significance to the nation, given that more than 90 per cent of Namibia's people depend directly upon the environment for their livelihood. Therefore, the water needs of the environment must not be regarded as a low priority, as are recreational uses. Rather, they must be given top priority, alongside water for domestic, industrial and stock watering demands.*

- *Sustainability of water supply should only be defined as pumping not exceeding the rate of recharge - meaning no net change in groundwater table over time. Mining of groundwater supplies should be allowed only with approval from Parliament.*

- *Specific provision must be made for maintenance of downstream flow to proclaimed conservation and tourism areas within downstream reaches of the western catchments.*

- *The implications to wildlife of altering water provision policies in communal farmlands must be considered. If the Government expects rural farmers to assume logistic and financial responsibility for their own water supply, they are likely to be far less tolerant of elephant damage to water installations, such as in the Huab catchment. Given the importance of elephant to tourism revenues, both realised and potential, serious consideration must be given to resolving this issue.*

- *Provision needs to be made for declaring 'catchment control areas' and 'groundwater control areas,' not just for water supply protection, but also for environmental protection.*

- *Specific provisions need to be made to enforce data archiving within the Department of Water Affairs regarding all aspects of water exploration and development. Severe penalties should be levied against individuals, and private and public sector entities violating provisions relating to data logging in archives.*

- *The public utilities commission must be established to ensure that 'corporate values and financial motives' associated with a cost recovery and profit-driven enterprise do not override protection of the environment, its economic value and rights of those dependant upon it.*

- *The water company should investigate and implement demand management strategies compatible with its objectives, namely providing a sustainable water supply to all Namibians. Strict adherence to supplying the needs of a demand-led market is neither possible nor desirable in a country such as Namibia with limited water resources. The public utilities commission must ensure that 'corporate values and financial motives' do not focus only on profit making, leading to the short-sighted and unsustainable use and development of Namibia's water resources.*

Animals, Plants and the Law

The Nature Conservation Ordinance (No. 4 of 1975) protects various categories of wild animals and plants, and provides various enforcement mechanisms. It also stipulates rules of conduct within declared conservation areas. The Ordinance and its amendments are focused primarily on control of consumptive uses, however, and make few provisions for protection of wildlife habitat outside of proclaimed reserves. As an example, although the Ordinance protects elephant in the Huab catchment from illegal hunting, it offers no protection to the riparian ana trees on which the elephants feed. Integrating existing legislation to recognise these links between various resources is greatly needed to ensure adequate protection to all natural resources of the western catchments.

The Nature Conservation General Amendment Act No. 100 of 1990 amends the Ordinance of 1975, increasing the penalty for the poaching of an elephant or rhino to '... a fine not exceeding R200 000 or to imprisonment for a period not exceeding twenty years or to both such fine and such imprisonment . . .' Although this fine may seem excessive, it reflects the tremendous value such animals have to Namibia's economy through tourism.

Plants protected by the Nature Conservation Ordinance include a number of species of small succulents, favoured among plant collectors, such as *Lithops* and *Hoodia*. Other unusual or ornamental trees, which people like to transplant, are also protected, including species of *Pachypodium, Aloe, Moringa* and *Cyphostemma*. Finally, *Welwitschia,* most famous of Namibia's plants and only found within the western catchments, is also protected.

The Forest Act No. 72 of 1968 provides for protection and management of forests within Namibia. It empowers the State to protect any tree or species of tree on any land whenever deemed necessary in the public interest. Of particular relevance to the western catchments is the declaration, under the Act, of the ana tree as protected throughout its range in Namibia. As such, 'nobody shall ... cut, injure or destroy any of the said trees ...' (198). Camelthorn, leadwood, mopane, *Euclea, Tamarix, Boscia* and !nara are all similarly protected under the Act or the Preservation of Trees and Forests Ordinance No. 37 of 1952.

This Act does, however, make allowances for collection of wood and other tree produce of protected species for domestic purposes, including firewood or construction material. This permission only extends to the rightful inhabitant or owner of the land. As such, collection of ana tree pods within the communal areas of the western catchments by private farmers is illegal under the Ordinance. It is also illegal for pods or wood to be sold by the rightful inhabitants or the owner of an area without a permit to do so, issued by the Department of Forestry. It is worth noting, however, that it is for lawful 'domestic use' that most trees in the western catchments are presently being cut down at unsustainable rates (Section 13 (2), Ordinance).

This elephant, reaching for an ana tree branch in the Hoanib River, is well protected from poaching by a recent amendment of the law. The riparian forests upon which it feeds, however, are inadequately protected under existing Namibian law, leaving the future of these animals uncertain.

Many of the unusual plants found within the western catchments are protected by law, such as the well known Welwitschia and this Hoodia species, flowering near the Uniab River.

Soils, Minerals and the Law

The Soil Conservation Act No. 76 of 1969 makes provisions for controlling and preventing soil erosion and for conservation, protection and improvement of the soil, vegetation and sources and resources of the nation's water supplies. The Act has particular relevance to protection of soils in the western catchments. It allows the State to make declarations for the

> *'. . . temporary withdrawal from grazing and stabilising of any soil surface including mountain slopes and natural water courses which are or may become subject to erosion or denudation of vegetation; . . . the use of areas reserved as water catchment areas under a provision of any law; . . . the resting and utilisation of pasturage; . . . the number of large stock as well as small stock which may be kept on the land'*

and

> *'. . . any other disturbance of the soil which . . . may cause any form of erosion or pollution of water by silt ...' (Section 3).*

Although the Act gives broad powers to the State in protecting soils and associated vegetation, it is not applicable in communal lands. In order to fully protect the soil and vegetation resources throughout the western catchments, the Act should be amended to be applicable in Namibia's communal farmlands.

The Soil Conservation Act aims to control and prevent soil erosion, such as the spectacular example seen here to the east of the Khowarib Schlucht in the Hoanib catchment.

The Minerals (Prospecting and Mining) Act No. 33 of 1992 also has great significance to the environment within the western catchments of Namibia. Most types of mining operations require large volumes of water. Because large diversions of water are cause for concern in the western catchments, mining developments need to be carefully evaluated. Mining activities can also greatly increase vehicle traffic in an area, resulting in severe damage to the local environment. In addition, the mine itself often severely disrupts the local landscape. As such, mining can negatively affect the conservation and tourism potential of an area. If carefully managed, however, mining could also enhance and diversify tourism potential of a region. Mines, both closed and active, offer interesting sites for tourists, providing an opportunity to learn about a region's geology and economic history.

In the case of abandonment of a mining claim or a mineral license, the Act specifies that the holder of the claim or licence shall

> *'take all steps as may be necessary to remedy to the reasonable satisfaction of the Minister any damage caused by any prospecting operations and mining operations carried on by such holder to the surface of, and the environment on, the land in the area in question' (Section 43 and 54).*

The Act also allows the Minister to refuse an application for a mining licence until satisfied that

> *'the proposed programme of mining operations to be carried out and the expenditure to be expended in respect of such operations will ensure . . . adequate protection of the environment; . . .' (Section 92 (2)).*

The Minerals (Prospecting and Mining) Act of 1992 gives the Minister of Mines and Energy the authority to order mining sites to be cleaned up or rehabilitated, where necessary. The Brandberg West mine, seen here in the Ugab catchment, was abandoned without being cleaned up when the price of tin dropped sharply in the 1980s.

The Minister may also reserve land from prospecting and mining operations if deemed to be in the national interest and if necessary for

> *'. . . protection of the environment or the natural resources of Namibia . . .' (Section 122).*

In the context of this Act 'Minister' refers to the Minister of Mines and Energy. The Act does not specifically call, however, for approval of the Minister of Environment and Tourism. Although there might be consultations between the two ministries on environmental issues, they are not mandated by law in the Act. This oversight should be amended, given the impact which mining operations may have upon the environment and revenues derived from its use, especially tourism.

THE ENVIRONMENTAL ASSESSMENT ACT

The Environmental Assessment Policy for Namibia was approved by Cabinet in 1994 and plans are under way to draft an Environmental Assessment Act or to incorporate environmental assessment provisions in a broader Environmental Conservation Act. Such an Act would provide for appointment of an environmental commissioner housed within the office of the National Planning Commission. This commissioner will be responsible for administering the environmental assessment policy of Namibia and will report to an environmental board, composed of senior representatives from various government ministries. This structure has potential for greatly facilitating co-ordinated planning and decision making regarding the suitability of proposed development projects (both public and private) within the western catchments. As with any new policy, however, an independent assessment should be done on the Environmental Assessment Act, helping to ensure its effectiveness in accomplishing its objectives.

RESEARCH: WHAT IS IT AND DO WE REALLY NEED IT?

The Water Research Act No. 34 of 1971 provides for promotion of research in connection with 'water affairs' through establishment of a water research commission and a water research fund. The Act specifically encourages research in respect of the 'occurrence, preservation, conservation, utilization, control, supply, distribution, purification, pollution or reclamation of water supplies and water.' It encourages collaboration with other Ministries as well as non-government organisations, allowing grants to be made in the interests of facilitating research. The fund is to be maintained through rates levied on irrigated land and charges levied for water supplied throughout the State. Unfortunately, no such commission or fund is currently in existence. In a similar way, the recently enacted Petroleum Products and Energy Act No. 13 of 1990 provides measures for establishment of a National Energy Council and creation of a National Energy Fund. One of the uses of the fund is to make monies available to

> '. . . any competent institution of the State, or any person or body, which in the opinion of the Minister undertakes research in connection with and the development of any other form of energy ...' (Article 11).

Why do these acts call for creation of funds in support of research relating to water and energy resources?

Water and energy resources are of obvious importance to all Namibians, present and future, and thus their sustainable use is essential. The call for research in acts such as those mentioned above reflects the need for accurate and up-to-date information in order to effectively manage Namibia's natural resources. Only through research, the systematic search for answers to specific questions, will Namibia have the information needed to ensure sustainable resource use. If we do not understand the dynamics of resources we are using, whether they be an aquifer, a river, an oil field or a solar panel, we cannot hope to achieve sustainable use. The Environmental Assessment Act, currently being drafted, should include a mechanism to create an environmental research fund. This fund should be used to support both government and non-government organisations engaged in applied research relevant to the appropriate development of Namibia's natural resources.

Enforcing the Law

> *'The idea which prevailed in the past that ownership of land conferred the right on the owner to use his land as he pleased is rapidly giving way in the modern world to the more responsible conception that an owner must not use his land in a way which may prejudice his neighbours or the community in which he lives, and that he holds his land in trust for future generations' (98).*

A law is only as good as the quality of its application and enforcement. A classic example is the proliferation of dams in the headwaters of many of the western catchments. Although the law specifically states that such structures, in excess of 20 000 cubic metres, must be registered and approved by the Department of Water Affairs, enforcement often does not occur. At the same time, although dams holding less than 20 000 cubic metres of water are allowed by law, their proliferation, in combination with larger dams, is reducing downstream runoff in several western catchments. Official records in the Ministry of Agriculture, Water and Rural Development may indicate that a farm has few dams but a flight over the farm will reveal otherwise. These illegal and unregistered dams, which confer benefits to the individual landowner in the form of increased water availability, can affect resources downstream. The State must act in such cases, enforcing appropriate legislation, to ensure that a balance is achieved between the needs of all users. The need to recognise the environment as a user with its own rights must not be overlooked. This is essential, given the large numbers of people and wildlife that depend on downstream riparian resources.

At the same time, the Water Act clearly prohibits the waste of water, allowing the levying of a N$500 fine

for such violations. Throughout the western catchments water is wasted when brakes on windmills are removed or disabled and water is pumped for days, overflowing the reservoir. Diesel pumps are left unattended, also causing holding reservoirs to overflow and wasting large volumes of water. Throughout Khorixas and Windhoek suburbs, taps are left on and lawns are over-watered; small streams of water commonly can be seen flowing down sidewalks and streets. A 'water cop,' issuing fines for such obvious examples of waste, would earn his or her salary for the year in one week virtually anywhere in Namibia. It's time to start enforcing the law!

Although the Water Act allows a fine of N$ 500 to be levied when water is wasted, for example when lawns are over-watered as seen here in Windhoek, the law is not enforced .

▶ *What's important about the Law and Namibia's Natural Resources?*

- *Article 95 of the Constitution of the Republic of Namibia states that the government will ensure the sustainable use of natural resources for the benefit of all Namibians present and future. While this article is a guiding principle, it is not enforceable by law. Effective legislation must therefore be in place so that this principle of state policy is adhered to.*
- *The downstream environment is often ignored when decisions are made about equitable water distribution. Degradation or loss of the downstream environment resulting from reduced or eliminated river flow will deprive communal farmers of the resources upon which they depend. Ana trees, an essential source of fodder for livestock and wildlife, are such an example. Without riparian resources in both communal and park areas, wildlife and tourist revenues will decrease and probably disappear. Such economic losses impoverish the nation and must be factored into decisions regarding catchment water use.*
- *The greatest challenge facing Namibia as it attempts to manage its natural resources is to balance the conflicting needs of all resource users. This is particularly true in the western catchments where competition for water is especially severe.*
- *Namibia's water resources are currently protected by the Water Act (No. 54 of 1956). The Act covers a wide range of issues relating to protection of surface and subsurface waters from pollution and misappropriation, clearly defining interests of the State in protecting this resource. A major limitation of the Act, however, is that it does not address the need to specifically recognise the downstream environments, upon which many Namibian's livelihoods depend, as high-priority users of water.*
- *When deemed necessary, however, the State can declare 'catchment control areas' under the Water Act, where rights of landowners can be suspended to maintain flow in public streams. If applied, the law could in principle be used to maintain downstream flow for environmental needs.*
- *Drying up the lower reaches of Namibia's western-flowing ephemeral rivers would be a disaster - for parks, for tourism development and for the nation's economy. It is therefore essential that any upstream development which would reduce downstream flow be restricted. Such developments should only proceed if their significance outweighs the value of these unique downstream areas to Namibia as a whole.*
- *The Nature Conservation Ordinance (No. 4 of 1975) protects various categories of wild animals and plants. The Ordinance and its amendments are primarily focused on control of consumptive uses, however, and make few provisions for protection of wildlife habitat.*
- *The Soil Conservation Act No. 76 of 1969 makes provisions for controlling and preventing soil erosion and for conservation, protection and improvement of the soil, vegetation and sources and resources of the nation's water supplies. The Act has particular relevance to protection of soils in the western catchments.*
- *The Minerals (Prospecting and Mining) Act No. 33 of 1992 also has great significance to the environment within the western catchments of Namibia. The Act allows the Minister to refuse an application for a mining license until satisfied that 'the proposed programme of mining operations to be carried out and the expenditure to be expended in respect of such operations will ensure . . . adequate protection of the environment; . . .'*
- *A law is only as good as the quality of its application and enforcement. No matter how well drafted, relevant and acceptable by society Namibia's laws may be, they will have no impact upon ensuring the sustainable use of the resources within the western catchments unless they are applied and enforced.*

Economics and the Western Catchments

The Impact of World Markets

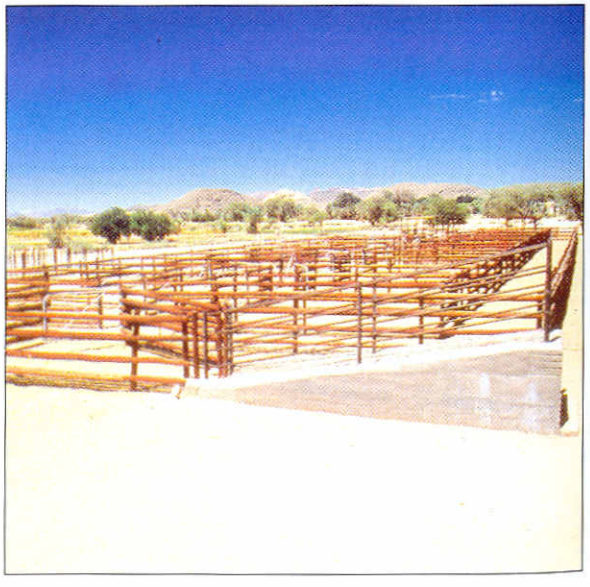
At present the four largest sectors of the Namibian economy are mining, fisheries, agriculture and tourism. Although mining, fisheries and agriculture are critical sources of revenue, each has its own limitations which may affect future earnings. Earnings from mining in Namibia have a finite lifespan as they are derived from non-renewable resources. Continued maintenance and growth of earnings from this sector depend on discovery of new and viable deposits. In contrast, the fishing industry depends on a renewable resource and should, if properly managed, provide a sustainable source of revenue. The fishing industry is one of the bright lights in the Namibian economy and is expanding rapidly. Of concern, however, is the fact that sustainable management of marine fisheries, while attempting to maximise production, is difficult. This has been demonstrated by collapse of similar fisheries around the world during the last 20 years (118).

Agriculture has its own limitations for continued or expanded production. Similar to fisheries, agriculture should, in principle, be a reliable source of continued earnings because it is dependent on renewable natural resources. This industry cannot realistically sustain any major expansions in the western catchments, however, given that the most suitable rangelands, in the upper reaches, are already fully developed for this purpose (2). Further expansion of commercial crop production is also severely limited by inadequate soils, high evaporation and limited water availability. Inability to predict the effects of international influences on mining, fisheries and agriculture is also problematic. Recent depression of the global minerals market and its effects on Rössing Uranium is one example (33). Also of great significance are potential impacts of changing foreign economic policies, particularly with regard to Namibia's largest agricultural export, beef. Changes in foreign trade policies, through revisions to existing agreements such as the Lomé Convention, the General Agreement on Tariffs and Trade (GATT), and the Southern Africa Customs Union (SACU,) could have major effects on this industry (54).

Under the Common Agricultural Policy of the European Union (EU), prices of European-grown beef are artificially maintained at levels well above their value on the open world market. This subsidy is intended to support cattle farmers in Europe. In order to maintain these prices the EU charges a levy, effectively an additional import duty, on imported meat. Under Lomé IV and the beef protocol, Namibia receives a 90 per cent rebate on this levy, thereby receiving a beef price only 10 per cent below that received by farmers in Europe. This enormous subsidy for Namibia's beef producers could soon be reduced, however, as the international community continues to move away from the high cost of subsidising agricultural producers. The General Agreement on Tariffs and Trade (GATT) will force the EU to reduce subsidies presently offered to farmers under its common agricultural policy (131). Although Namibia's quotas are guaranteed under the Beef Protocol of Lomé IV, prices paid are not. As a result of the GATT, prices in the livestock sector will fall (54, 131). Given that in 1990, 82 per cent of Namibia's beef was exported, these changes will have a marked effect on Namibia's beef producers. Further losses to beef producers will likely result due to changes in the South African markets. Although this outlook is bleak, there are indications that losses to Namibian beef producers may be offset, to a small degree, by an expansion of the world market for beef (131).

Cash or Cattle?

Increased market access for communal farmers is currently being developed as a part of governmental policy to integrate communal and commercial livestock farming (54). It has been assumed that this will encourage appropriate rangeland management by providing mechanisms for livestock sale during dry periods (54). But will increased access to markets in communal areas really encourage farmers to sell their stock, generating cash incomes? The success of such efforts ultimately depends upon accessibility and understanding of suitable financial institutions and, more significantly, ability of the government to control inflation. Even with increased access to markets and financial institutions, if inflation exceeds interest earnings, farmers may be financially rewarded by keeping their cash on the hoof (71). These issues clearly require a thorough and thoughtful analysis of the economic



Increased access to markets for communal farmers is part of government policy to integrate communal and commercial livestock farming. New auction kraals at Sesfontein have been installed as a first step to implementing this policy.

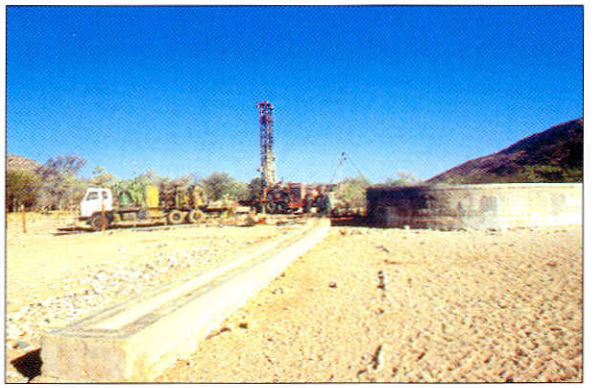
incentives influencing resource users, as consequences of increasing stock numbers in the arid western catchments, with high climatic uncertainty, could be severe. The Government's recently announced policy to promote the 'development of rural savings and investment opportunities as an alternative to investing in livestock . . .' is an important step in efforts to foster appropriate rangeland management (124).

Why Move?

Economic considerations are obviously critical to the debate over how to address inequalities in distribution of and access to private agricultural land. A major consideration in the debate surrounding land reform in communal areas of Namibia has been how to deal with the few individuals who own a large percentage of livestock within these areas (2, 166).

As has been discussed earlier, loan schemes have been put forward as one solution, with limited success in the western catchments (166). Current strategies, of providing loans to communal farmers to encourage purchase of private property while at the same time increasing taxes and removing subsidies to current private farmers (54) in order to bring more private land on the market, are contradictory. It is unclear how reducing economic incentives for commercial farming on private land through higher taxes and fewer subsidies will encourage commercial farmers on communal lands to purchase private land, even if the land is available.

At present, commercial farmers on communal lands pay nothing for use of land - no income tax, no land tax, very little for labour and nothing towards agricultural infrastructure - while at the same time they receive subsidised water provision and veterinary services. Moving to private land would therefore entail a range of new costs. At present such a move would be financially unwise for these farmers, regardless of how beneficial it may be to small-scale livestock farmers sharing the same communal lands. Current plans to reduce subsidies and to introduce 'a natural resource user fee system' in the communal lands may encourage large-scale communal farmers to purchase private farmland, thereby reducing the load on the communal rangelands (124).



Wealthy farmers on communal lands who might consider purchasing and moving to private farmlands have little financial incentive to do so, given the high costs associated with such a move. While stock watering points on communal lands are maintained by the government at no charge, farmers on private lands assume full financial responsibility for the purchase, installation and maintenance of such infrastructure.

Tourism as a Development Strategy

It has been observed that, in order to raise incomes of the majority of Namibians, the main thrust of the government should be on agricultural development in communal areas (54). Current efforts to increase market access will certainly be beneficial but, given constraints of low and variable productivity in western communal areas, potential is limited for expansion of the agricultural sector. What is clear, however, is that there is great potential for expanding incomes based upon revenues from various types of low impact tourism.

Tourism is set to become a major, if not the major, source of foreign exchange earnings in Namibia. Recognising this, in 1991 the Namibian Cabinet declared tourism a priority sector for economic development of the country (127). In the same year, 213 000 tourists visited Namibia, providing full-time jobs for 10 000 people. This doesn't include benefits to those sectors which indirectly support tourism, for example, petrol sales, car hire and curio and book stores. If these are included, total employment related to tourism in Namibia in 1991 stood at 20 000 jobs. Total financial turnover for tourism in 1991 was estimated to be N$ 320 million, of which N$ 270 million was foreign exchange earnings from international tourism (excluding international air travel). Direct government revenue through taxation and levies was estimated at N$ 123 million.

Tourists are attracted to Namibia because of the wildlife and pristine beauty of wide-open, unspoilt landscapes. These resources will become more and more valuable as the rest of the globe becomes increasingly urbanised and overcrowded. Based on trends since 1990, the tourism industry is expected to grow by 8.5 per cent annually, so that by 2002, 635 000 tourists are expected to visit Namibia per year. Although speculative, such figures are indeed encouraging for Namibia's economic future, and suggest that major investments and planning will be required to ensure sustainable returns from tourism. Hoff and Overgaard, consultants hired by the Ministry of Environment and Tourism to conduct a tourist development study, estimate that about N$ 500 million will have to be invested to meet this growth in the coming years. The White Paper on Tourism, approved by Cabinet in 1994, states that returns on this investment will be 26 000 tourism-related jobs (plus 55 000 indirectly related jobs), N$ 1 530 million in gross foreign exchange earnings, and a national income generation of N$ 1 180 million in the year 2002.

To acquire the necessary investment, the White Paper lays out a plan for development of the tourism industry, including a parastatal institution, with 64 per cent of needed investment coming from the private sector. The government can facilitate attraction of local and foreign investment funds 'through the creation of a generally favourable investment climate and more specifically, by instituting a series of specific fiscal, financial and other investment incentives' (73).

Namibia must ensure that achieving this aim does not allow foreign investment to dictate development of its tourism potential, as has frequently happened in other developing countries. If foreign tourism industries define policies and strategies which guide tourism, they frequently do so to suit their own short-term financial goals (62). Based on the sound recommendations of the White Paper on Tourism, it is therefore imperative that Namibia establish and carry out a well co-ordinated tourism plan that guides and facilitates sustainable development of the industry at all levels: national, local and individual. This plan must ensure that tourism development is economically, socially and environmentally sustainable for the nation. To achieve this goal tourism must be based on sustainable yields of the required resources. Particular efforts must therefore be made to facilitate local development of the industry in the western catchments. If local people are not involved in and benefitting from tourism development, there will be no incentive to maintain resources which are critical to such development, namely: the pristine, unspoilt expanses, unique and spectacular desert scenery and the opportunity to view wildlife in such a unique setting.

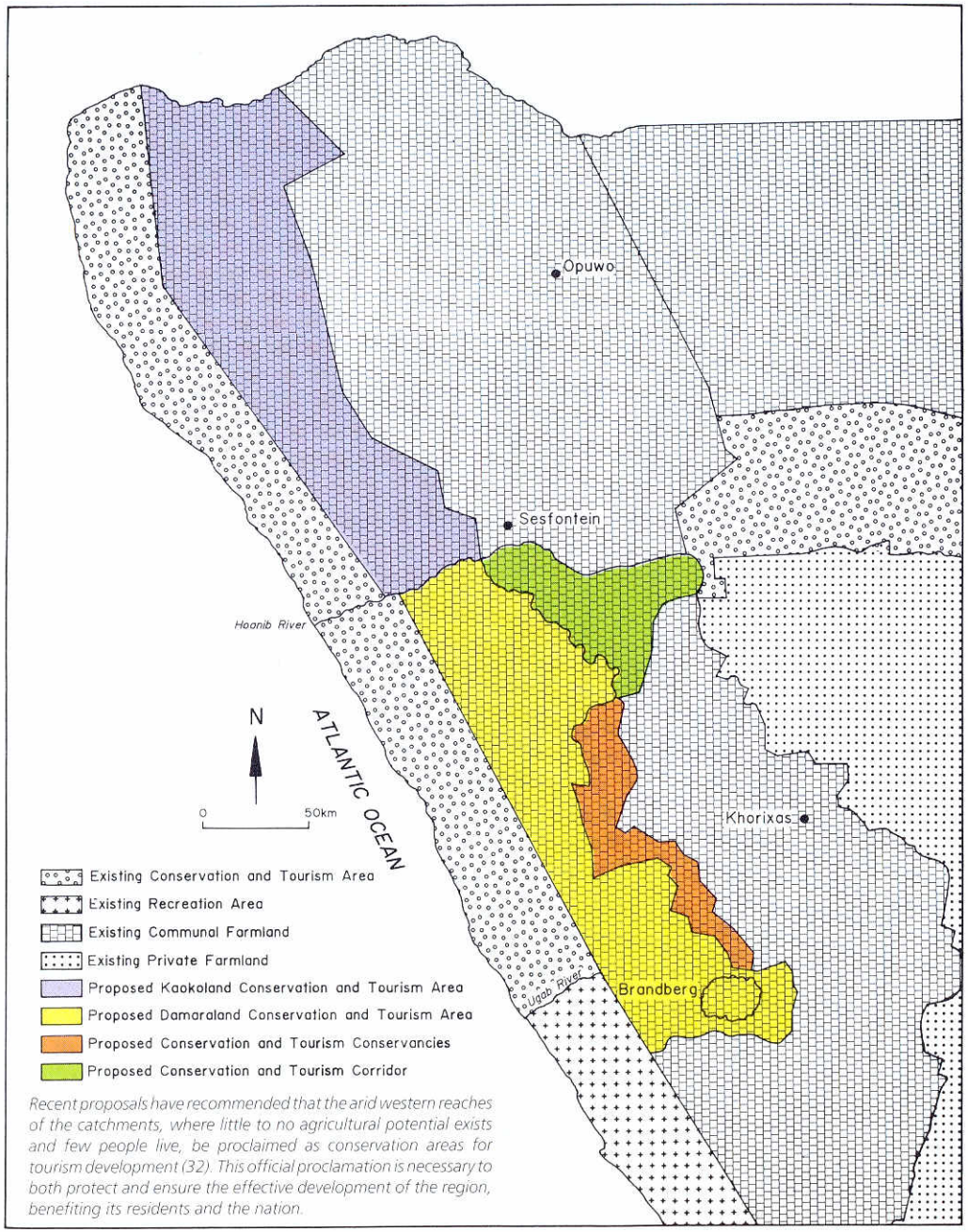
REAPING THE GREATEST BENEFITS: A LAND USE PLAN FOR THE WEST

A portion of the arid western lands, from the Ugab northwards to the Kunene, remains largely unused today. To the west lies the Skeleton Coast Park, a strip of land approximately 25 to 40 km wide, which is used for tourism and conservation. In the east, where rainfall is higher and more regular, communal farmers use the land for livestock farming. The area between these two regions, stretching from the Kunene River southward to the Brandberg, receives less than 100 mm rainfall each year. Although occasional rains may bring communal farmers westward to use the rare annual pastures, very few people live here permanently.

This area is visited by thousands of tourists every year. These visitors come to see the unique combinations of spectacular arid landscapes and the wildlife that roam through them. Despite the fact that the area receives increasingly large numbers of visitors, it has no official status as a tourism and conservation area. Rather, the entire area lies within the State-owned communal farmlands of the Kunene and Erongo regions. As a result, few financial benefits are conferred to the people in the region, or to the government itself, from the tourists that visit. In addition, this unregulated movement of tourists is resulting in the degradation of many sites in the fragile arid landscapes which, if protected and appropriately developed, could yield great financial returns.

The value of these areas, and the need to protect and develop them appropriately, has long been recognised. As early as 1971 attention was drawn to the unique value of the region for conservation and tourism (152). Recognising the significance of the region, a symposium was held in 1986 to develop guidelines for its development (7). Most recently, a tourism development study identified the resources of this region as critical to the successful development of Namibia's tourism industry (73). Despite these preliminary efforts, however, little co-ordinated development has occurred in the area. Today, an urgent need exists for a land use plan in the region, guiding its sustainable development and maximising benefits from tourism and conservation to the people living adjacent to these areas.

Recent reports (32, 73) have taken the first steps towards developing a land use plan, recognising the value of the region's resource base and highlighting the need for its protection. These reports suggest that the northwestern area of the Kunene Region be proclaimed a conservation and tourism area, the so-called 'Kaokoland Park'. A similar proposal has been made to protect the region stretching from the Hoanib River southward to the Brandberg Mountain. These areas have tremendous significance to Namibia's developing tourism industry and such proclamations are needed to ensure their sustainable development for the benefit of all Namibians.



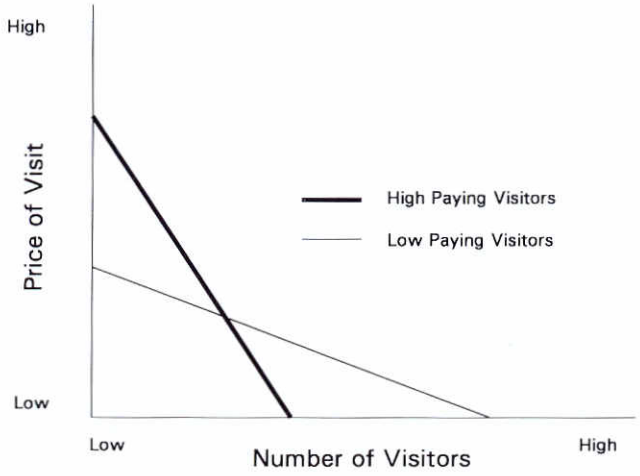
Recent proposals have recommended that the arid western reaches of the catchments, where little to no agricultural potential exists and few people live, be proclaimed as conservation areas for tourism development (32). This official proclamation is necessary to both protect and ensure the effective development of the region, benefiting its residents and the nation.

The Namibian Cabinet has declared tourism a priority sector for the economic development of the country. The unique landscapes of western Namibia, seen here in the Ugab, Kuiseb and Uniab catchments, have much to offer this developing industry.

As the sign says, the ephemeral rivers of western Namibia offer some of the 'best camping' in the country. Local initiatives, such as this tourist camp in the Hoanib River, provide an example of how tourism developments can diversify local economies and improve the livelihoods of the people they employ.

The Palmwag Lodge in the Uniab catchment is a popular destination for tourists in the western catchments.

Arid landscapes, such as those found within the western catchments, can be easily damaged by large numbers of visitors. In planning the sustainable development of the region, an approach emphasising lower numbers of visitors paying higher prices will be the best compromise. This approach will help to ensure maximum revenues while protecting the resource upon which their generation depends. As the plot shows, the same amount of revenue can be derived from a small number of tourists paying high prices as can be generated from a large number paying low prices. Foreign tourists will typically pay much higher prices to visit an area than local tourists. Ideally, differential pricing - foreign tourists paying more than local tourists - should be used so as not to restrict Namibians' access to their natural heritage.



What economic issues are currently important in the western catchments?

- *While the agricultural sector within the western catchments has limited potential for expansion, it should remain a reliable source of continued earnings if water and rangeland resources are used sustainably.*
- *Foreign markets, where most Namibian beef is sold, can have profound effects on the economic sustainability of agricultural production in the western catchments and throughout Namibia. Although Namibia's quotas are guaranteed under the Beef Protocol of Lomé IV, prices are not. Prices will drop substantially with changes to European policies on beef imports, although an expanding world market for beef may reduce the scale of these losses.*
- *Current efforts to improve communal rangeland management practices through livestock marketing, and loan schemes to encourage wealthy communal farmers to purchase private farms, are not achieving their desired goals. Thorough and thoughtful analyses of short and long-term economic benefits to resource users in communal areas are desperately needed to guide the development of appropriate incentives for effective rangeland management.*
- *While the agricultural sector has little capacity to expand individual incomes in the rural regions of the western catchments, revenues based on a variety of low-impact tourism options are predicted to have significant effects on local income generation.*
- *The newly approved White Paper on Tourism lays out a plan for development of the tourism industry, including the creation of a parastatal institution. The government plans to attract both local and foreign investors to provide the majority of the needed investment. In so doing, however, it must first define policies and strategies which will guide the sustainable development of the tourism industry at all levels: national, local and individual. To achieve this goal, tourism must be based on sustainable yields of the natural resources, and must make special efforts to facilitate local developments involving rural people.*

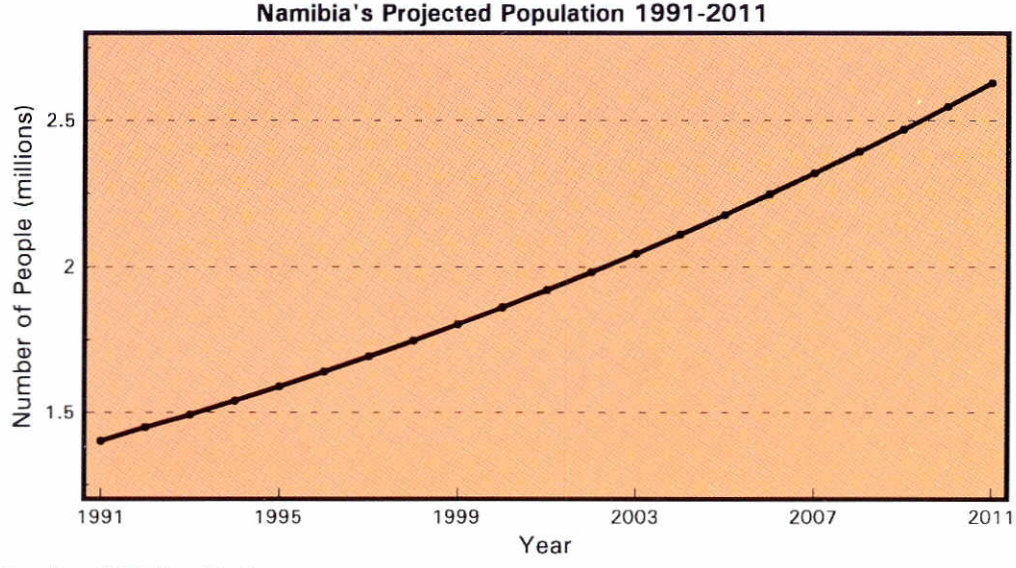
Population

The 1991 census revealed a total population of 1 401 711 people in Namibia, of which 382 680 lived in urban centres and 1 027 240 lived in rural areas. Forty-two percent of Namibians are between the ages of 0-14 years. This is in large part a reflection of the high fertility rate. Every Namibian woman will, on average, have approximately six children during her reproductive years. This is one of the highest fertility rates in the world and, combined with a declining death rate (due to improved living conditions and health care services), the annual population growth in Namibia is very high, estimated at slightly over 3.3 per cent (16). At the same time, the growth rate of the real gross national product, GNP, has averaged less than 0.3 per cent annually (16).

Because economic growth is not keeping pace with population growth, most people have experienced a decline in their personal income. Although certainly not the only indicator of 'quality of life' for Namibians, such figures do provide an indication of worrisome trends regarding the State's ability to provide basic support for its citizens (16). Continued population growth will only cause this situation to deteriorate further. In the long-term, as population continues to increase, Namibians who depend on land for their livelihoods, will simply have to live with less. Wood, water and grazing are already becoming limited in many areas of the western catchment, making day-to-day life more difficult than before. Ultimately, if the population continues to grow, resources will continue to decrease, and the probability of famine during dry years, such as those frequently experienced in the Sahel region, will only increase (186).

An alternative to living off minimal resources from the western lands is to move into towns and cities. Urbanisation is causing high growth rates in many urban centres in Namibia. The population of Khorixas swelled in the early eighties when drought forced large numbers of people from the marginal drylands to look for better opportunities in town. From 1981-1984, the population of the town grew annually at an estimated rate of 15 per cent per year (104). Unplanned and uncontrolled urbanisation puts tremendous strain on the capacity of town authorities to meet basic needs of residents. Providing water is one of the greatest challenges which applies to all urban centres in the western catchments. A national plan which addresses local, regional and national limitations to development, with respect to water supply, is desperately needed. In many urban centres water availability is limited (190). Future access will require long-distance transfers which entail very high capital costs. A national development plan which recognises water as the fundamental constraint for our expanding population is urgently needed.

Namibia's urban areas are growing rapidly, some at a rate estimated as high as 15 % a year. Katutura has expanded since Namibian independence as people move to the city looking for employment and a better life.



Namibia's population is expected to double in approximately twenty years. With the current high rates of unemployment and scarce natural resources, especially water, it is unclear how twice as many Namibians in twenty years will live as their parents are living today.

POPULATION GROWTH AND WATER DEMAND - WHEN WILL THE WELL RUN DRY?

As can be seen in the graphs detailing growth in population and water consumption for Khorixas and Windhoek in section III, there is a strong link between population and demand. In addition, although implementation of water use restrictions in Khorixas caused a reduction in total consumption, it was only temporary due to a continual increase in population numbers. Can increases such as these continue indefinitely? Given Namibia's limited water supply and its unequal distribution they obviously cannot. So when will the well run dry? In some areas of Nambia it already has. Numerous abandoned farm posts in the western catchments speak of local declines in the water table. This may have been caused by a combination of factors, including low rainfall and inappropriate land and water management, all contributing to unsustainable water use.

On a larger scale, various state-operated bulk water supply schemes also have been unable to meet demand. The schemes at Anixab, Fransfontein, Okombahe, Tubusis and Usakos were all unable to supply sufficient water to meet the demand in 1991, although recent expansions in some cases have temporarily alleviated supply challenges (192). Khorixas and Kamanjab are currently experiencing difficulties in meeting the high demands for water. The ongoing Central Area Water Master Plan study currently under way identifies water shortage on an even larger scale (190). As the example of Khorixas demonstrates, water restrictions and conservation campaigns can reduce demand but ultimately such reductions will be cancelled by the needs and basic demands of more people. In the future, the only solution will be to limit the number of Namibians through family planning efforts or all Namibians will have to make do with less - less water, less money, and a lower quality of life.

▶ What's important about demographics in the western catchments?

- Annual population growth in Namibia is estimated at 3.3 per cent, but the growth rate of the real gross national product, GNP, has averaged less than 0.3 per cent annually. If such discrepancies persist in the long-term, Namibians will simply have to live with less.
- An alternative for rural communities struggling to survive while living off minimal resources from the western lands is urbanisation. Providing basic needs, such as water, is one of the great challenges resulting from high rates of urbanisation in towns and cities throughout the western catchments.
- A national development plan which recognises water as a fundamental constraint for Namibia's expanding population is urgently needed. Water restrictions and conservation campaigns can reduce demand, but ultimately these reductions will be cancelled out by the basic demands of more and more people. In the future, the only solution will be to limit the number of Namibians through family planning efforts. Otherwise all Namibians will have to make do with less - less water, less money and a lower quality of life.

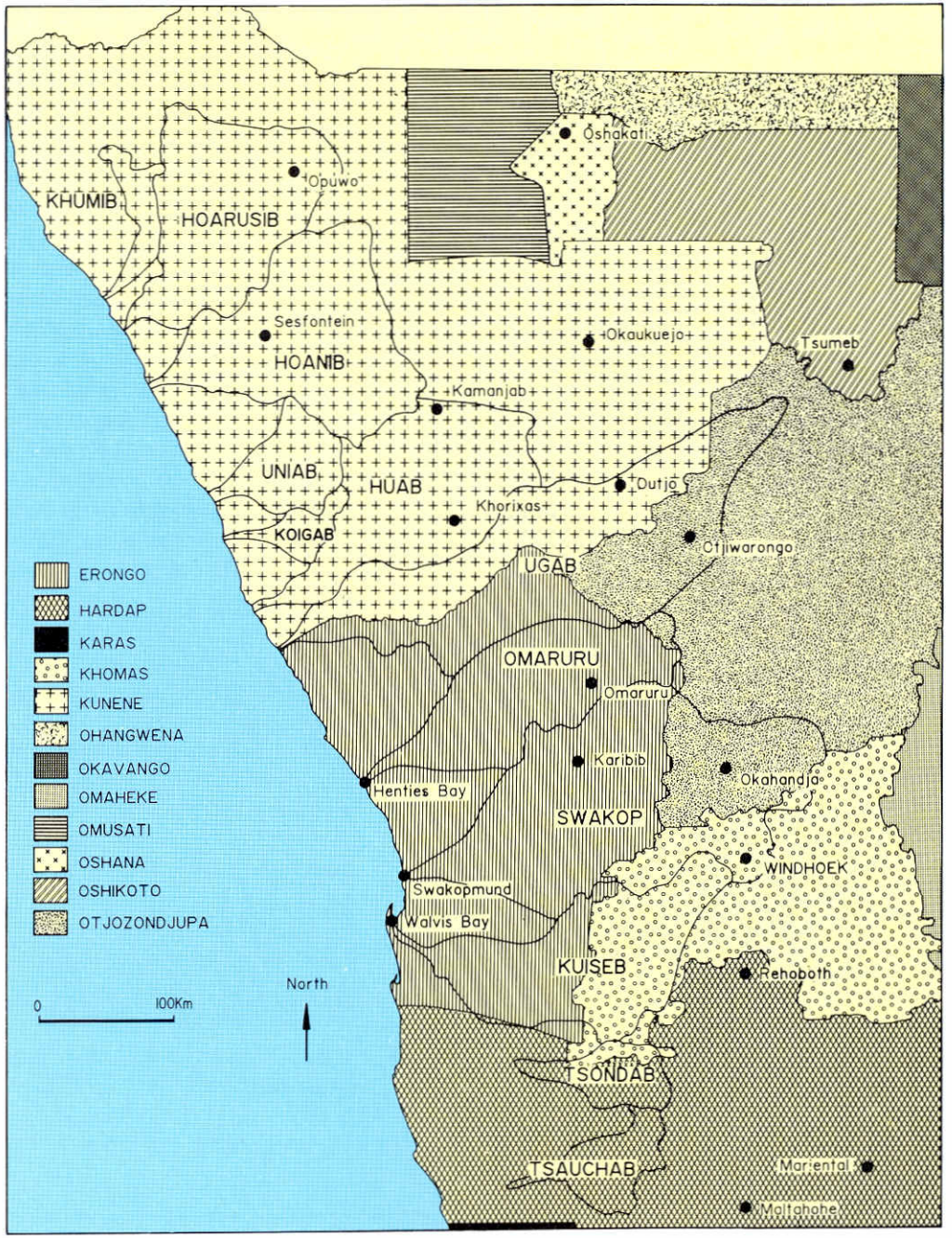
In the 1991 Census, the total population living in the western catchments was estimated at 290 631 - about one fifth of all Namibians.

WHO'S TUNED IN?

Attempts at generating public awareness often rely on newspaper and radio as the most effective means of getting information to the greatest number of people. While such approaches may be effective, they suffer from several important limitations. The 1991 Namibian Population and Housing Census revealed that many households, particularly in the western catchments, have neither a radio nor access to a newspaper. Another complication is that FM transmitting stations are not evenly distributed across the catchments. As a result, large areas within the west are out of range for FM radio. Although shortwave radio transmissions can be received throughout the catchments, receivers are substantially more expensive than FM sets. This uneven access to information must be considered in any attempts to distribute information to the public within the region. Efforts are currently underway to expand the transmitter network within the regions of the western catchments.

Catchment	% of Households with a Radio	% of Households Reading a Newpaper once a week
Khumib	0	0
Hoarusib	18	5
Hoanib	21	3
Uniab	41	0
Huab	61	11
Ugab	69	29
Omaruru	69	23
Swakop	79	64
Kuiseb	71	19
Tsondab	44	2
Tsauchab	52	7

Based on the 1991 Namibian Census



Namibia's regional boundaries have little relation to the boundaries of the western catchments. Although these divisions could complicate efforts to sustainably manage the region's natural resources, they need not. Planners, policy makers and decision makers must only consider the effects of their actions on the catchment as a whole.

Catchment Awareness: Essential for Sustainable Development!

Achieving sustainable development in the western catchments is no easy task, requiring a great deal of co-ordinated planning and management. One of the fundamental guides for such planning should be the river catchment (32, 34, 42, 111). Downward-flowing water not only forms catchments but also provides resources essential for people. Soils, aquifers, rangelands, wildlife and riparian forests - critical to development in the region - are all dependant upon water. Any development within a catchment which alters water's availability, distribution or movement, in turn affects other resources.

If water moves too rapidly off land, it carries soil and seeds with it, grasses don't grow, and aquifer recharge is reduced. Alternatively, if water does not flow at all or in large enough volumes, riparian forests collapse

The fact to be remembered in regard to the westward-flowing ephemeral rivers is the importance of uninterrupted flooding. Any development within a catchment which alters runoff patterns can affect the environment and it users downstream. It is essential that all Namibians dependant upon the natural resources of the catchments are as aware of this fact as are these students, running from a flood in the Kuiseb River.

(233), and downstream aquifers are not recharged (49). If springs dry up, wildlife move away or perish. Changes in rangeland management, construction of dams and roads, installation of boreholes and pumps -these are all developments that change water distribution and, in turn, affect water-dependant resources.

A review of various government departments reveals a wide range of planning regions and jurisdictional boundaries crossing catchment boundaries. Such disregard for catchment boundaries means that development decisions are often made without sufficient consideration of their impacts throughout an affected catchment. Changing these jurisdictional boundaries to match catchment boundaries would be difficult and expensive. A wiser decision is to ensure that planners, policy makers and decision makers are aware of the catchments for which they are responsible, and actively consider how their actions in one region of a catchment affect the catchment as a whole (138).

▶ *Why is catchment awareness necessary for sustainable development?*

- *Because planning regions and jurisdictional boundaries cross catchment boundaries, development decisions affecting water and rangeland resources are often made without consideration of their impacts throughout the catchment. In order to ensure sustainable use of these critical resources, planners, policy makers and decision makers must be aware of the boundaries of the catchments for which they are responsible, and actively consider how their actions in one area affect the catchment as a whole.*

■ *BIODIVERSITY, SUSTAINABLE DEVELOPMENT AND CO-ORDINATED DECISION MAKING*

If an area is to be used for conservation and tourism, emphasis should be placed upon protecting all ecological processes and all components of biodiversity. But what if an area is to be used agriculturally? Should we protect all ecological processes and all components of biodiversity? Following a recent 'socio-ecological' survey in the Huab catchment, the Ministry of Environment and Tourism defined the following goal as a broad conservation strategy for the entire region: 'Maintenance of essential ecological processes and biodiversity for the sustainable development of the region and the nation' (87). It is unclear, however, how this statement should be interpreted.

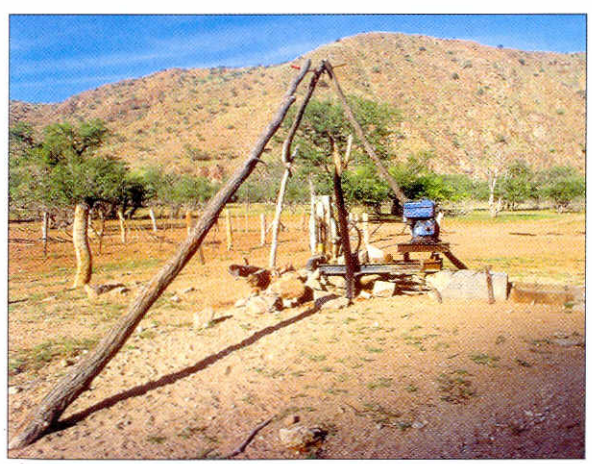
'Essential ecological processes' should, indeed, be maintained whether an area is to be used for agriculture or conservation. But what are essential processes? If groundwater levels must be maintained to support the growth of trees providing browse and firewood, recharge is an essential process. Given that recharge of alluvial aquifers is important for people, livestock and wildlife in the lower rivers, should we reduce the number of ground dams in the upper catchments? Such decisions obviously relate to the management objectives of an area as well as perceived benefits of the essential ecological processes.

In a similar manner, 'maintenance of biodiversity' must reflect the management objectives of an area. If livestock farming is to be the primary land use in an area, maintenance of biodiversity - in the form of elephants or in the form of the organisms that cause lumpy skin disease - could be considered inappropriate. On the other hand, if tourism is to be the primary land use, maintenance of biodiversity - in the form of large herds of livestock or in the form of bedbugs - could be considered inappropriate. Such differences obviously relate to perceptions regarding benefits conferred by various components of biodiversity. So how should Namibia invest its resources? Which components and processes should be maintained and protected in the face of limited manpower and financial resources?

First, we need definition of the types of development desired for the region. Ideally, this should be by a consensus of all Namibians with particular attention paid to desires of local people. With this consensus in mind, the Government must determine whether these types of development are sustainable, given resources available in the region. The Government should determine which resources will be used as well as the sustainable yield of these resources. If they do not possess this information, then government should acquire a best estimate and, in the meantime, set conservative yields and require effective management of existing resources (no wastage or degradation, for example). Which government Ministries are involved in determining sustainability in the western catchments? Because possible development in the region includes livestock farming, game farming, mining and tourism, all Ministries involved with managing vegetation, wildlife, soil, and water must be involved in making decisions concerning resource sustainability for development. Ministries involved with finance, trade and industry should examine economic sustainability of developments given available resources. Finally it is the job of Ministries involved with human development, land rehabilitation and resettlement, health, education and culture, to ensure that goals of social sustainability are being met.

WATER SUPPLY AND DROUGHT RELIEF: MYTHS AND REALITIES

Recent efforts at providing assistance to drought-stricken communities within the western catchments have revealed that politicians and donors confuse relief and development. Relief implies something given to relieve a temporarily poor situation which has a chance of recovering naturally to its original state in the not too distant future. As such, it is a very good thing. However, in many instances within the western catchments 'relief,' as currently viewed, is essential on a long-term basis. Such 'relief' should therefore be recognised as development. Some claim that if an area has been neglected in the past, relief can be used to 'kick-start' development in the area. But if relief is accepted as development, should it be done hastily? Should it be done without benefit of land use planning or in the absence of consideration of alternative options for either relief or for development of the area?



The communal farmer using this borehole demonstrated his technical know-how by installing this engine without any outside assistance.

Provision of water supplied from boreholes sets the development agenda of a specific area, mainly directed at livestock farming and permanent settlement. The viability of other options, perhaps more economically beneficial and sustainable, such as the use of an area for wildlife or tourism, may be reduced. Planning for movement of livestock between posts to manage grazing may also be precluded, if 'drought relief' boreholes have been placed too close together in response to the community's demands. What is the long-term availability of grazing in the surroundings of a hastily established borehole? Application of land use planning, which should address the most appropriate and sustainable uses of resources in a particular area, has been pre-empted. Is this best for Namibia as a whole? Does it serve the long-term interests of the communities?

Some of this relief has been directed toward an area in the western catchments (105) which has been described as 'barren Namib Desert, where there are no prospects for dryland cropping and livestock farming is of negligible potential' (137). Although the limited potential for agricultural development in the western reaches of the catchments has long been recognised (114), no effort has been made to evaluate the region's potential for other land uses. Does this limited agricultural potential mean that the area is not an asset to Namibia which must be thoughtfully developed? Certainly not, but only land use planning will provide the necessary answers.

Some relief has been based on an assumed lack of technical knowledge within the local community. Such knowledge is, in fact, often underestimated by outsiders, as demonstrated by communal farmers who remove pump heads and engines, transporting them to and reinstalling them at sites to which they have moved their stock.

When politicians instruct the Department of Water Affairs to immediately install relief boreholes, it is impossible to assess their potential effects on the regional groundwater situation, and hence on springs and other natural water points and the livestock and wildlife dependant upon them. In such cases, one person's relief may take away someone else's livelihood, in the absence of land use planning and appropriate geohydrological investigations.

Long before the next dry period, which could happen any time, regional land use planning should be implemented. Only results of such a process can help assure that drought relief really is a positive contribution to Namibians living in the western catchments.

Boreholes, such as this one in the Uniab catchment, should only be installed after land use planning has identified the most suitable types of development for an area. The absence of land use planning for the Uniab catchment is responsible for the current conflicts between agricultural and tourism developments.

Planning, Co-ordinated Development and Water Supply

The Namibian government is trying very hard to revive and sustain economic growth, create employment opportunities, alleviate poverty and reduce income inequality (146). These efforts are essential, but they will not be sustainable in the long run without a realistic assessment of the available natural resource base which must support such development. A major oversight in most national development plans has been the limitations to development imposed by the scarcity of water in an arid country (158). As an example, the recent sectoral issue paper of the Ministry of Trade and Industry, which discusses planning of continued economic growth in the private sector, makes no mention of the water needs for such growth (130). This is problematic given that manufacturing, fish processing, mining and large-scale agricultural production generally consume large amounts of water. In a similar way, the revised keynote issues paper of the National Planning Commission, which sets out the framework for the Government's proposed 1995-2000 National Development Plan, also makes no specific reference to the challenge Namibia faces in attempting to provide water to its rapidly growing population and their associated centres of economic activity (146).

It is essential that we consider water as the ultimate constraint to economic growth because of the high costs associated with its provision. At present Namibia is facing enormous capital costs to meet the most basic short-term water demands of its current population (190). In the case of the arid western catchments, these costs must not be underestimated. The cost of securing reliable water supplies over the next 20 years, for Windhoek and the West Coast alone, has been estimated at more than 2 000 million Namibian dollars (190). Such estimates are undoubtedly low as they do not account for the economic costs associated with environmental effects of meeting this demand. It is imperative that the Government ensure that capital is available to invest in sustainable water supplies for current and future Namibians.

Having sufficient capital will not solve the entire problem, however. Wise choices will still be needed about how to make the best use of this money. Co-ordinated regional and national development plans are essential to guide appropriate development of such infrastructure. In particular, planning industrial development, critical to the long-term viability of Namibia's economy, will be hampered if sufficient water is not available. It is therefore essential that Namibia identify suitable industrial investors in part based upon their water needs and water use efficiency.

At present, few long-term development plans exist for areas within the western catchments, particularly communal areas. Perhaps the greatest deficiency is the lack of a national structural and industrial development plan which considers existing and planned future growth points in respect of their water supply limitations. Decisions must be made as to where government should invest its limited capital to provide the maximum return for the greatest number of its citizens. Such decisions must not and cannot be taken in the absence of sound analysis and planning.

■ *DEVELOPMENT WITHOUT PLANNING IN THE WESTERN CATCHMENTS*

As a result of the lack of regional and national land use and development plans, numerous independent projects have been, and are being, investigated, planned and implemented in an unco-ordinated way in the western catchments. Dams (for example, at Sebraskop on the Ugab), small-scale irrigation schemes (for example, at Sesfontein on the Hoanib), small-scale water development (boreholes throughout the Kunene and Erongo regions), and residential and industrial development are all proceeding. Such developments often establish fixed patterns of land use, whether intended or not. These patterns may or may not be in Namibia's best interest. The fundamental unanswered question is what is the best use for land in the arid regions of the western catchments. Exploring this single question will take the nation a long way forward in its attempts to find sustainable development options.

▶ *What's important about planning, co-ordinated development and water supply?*

- *While not recognised in current development plans, water is the ultimate constraint to economic growth because of the high costs associated with its provision in an arid country. Government must ensure that capital is available to invest in sustainable water supplies for current and future Namibians, and that co-ordinated regional and national development plans guide appropriate development of associated infrastructure.*
- *Development critical to the long-term viability of Namibia's economy will be hampered if sufficient water is not available. Government should therefore identify suitable investors based upon their water needs and water use efficiency.*

7: A VIEW TO THE FUTURE: SUSTAINABLE DEVELOPMENT AND THE WESTERN CATCHMENTS

Sustainable Development: What's Stopping Us?

> *'Sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.' (80)*

Sustainable development is a guiding principle to which we all agree, but how do we achieve it? This document takes the initial step of reviewing existing information about resources of the western catchments, their use, and the national framework in which future development will proceed. But what happens next?

In focussing on how to proceed with an integrated approach to sustainable development, it is helpful to give serious consideration to three components of sustainable development: economic, environmental, and social sustainability. In our review of the western catchments we identified six factors that are hindering the achievement of sustainability within these three spheres. They require urgent attention if sustainable development in the western catchments is to be successful.

The current lack of resolution on land tenure within the communal rangelands of the western catchments hinders establishment of long-term development plans. As a result, natural resource use is often short-sighted and potentially unsustainable.

1. *Economic Sustainability*
   - Lack of resolution relating to land tenure in communal areas.
   - Absence of any approved development and land use plan for the western catchments.

2. *Environmental Sustainability*
   - Limited knowledge of sustainable yields of natural resources within the region as a whole.
   - Inappropriate, excessive and unsustainable use of the region's most critical resource: water.

3. *Social Sustainability*
   - A rapidly expanding human population within the region and the nation.
   - Confusion over relationships between various authorities, including traditional, local, regional and national leadership.

Where Do We Go From Here?

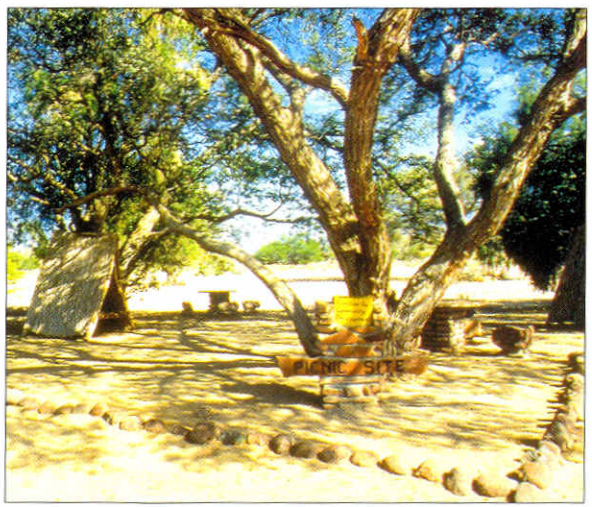
Economic Sustainability

Lack of resolution of land tenure in communal areas results in conflicts amongst livestock farmers over rangeland and water use. Conflicts also arise over who pays for property and livestock losses caused by wildlife. Settlements in both cases are complicated by lack of tenure to both the land and its resources, including wildlife. The result has been a complete inability for people in the region to establish long-term development plans based on sustainable resource use.

Successful planning requires a balance between short-term and long-term interests. Attempts to simply maximise profits in the short-term most often lead to

unsustainable use of resources (20). Planning resource development and use requires an awareness of incentives which may drive unsustainable use and then the creation and enforcement of appropriate controls to prevent it.

In planning future land use patterns, as well as evaluating existing patterns, it will not be possible to please all interested parties who may wish to pursue different forms of development in a single region (8, 87). Conservation and tourism developments are often incompatible with sedentary stock farming operations and large-scale irrigation projects. Although a few individuals or a community may profit from agricultural development of a region, resources in the area may hold far greater promise for broader local employment and income generation if developed for conservation and tourism. It is essential that interests of the individual, community and nation are considered and carefully evaluated when developing future land use plans.



Near Twyfelfontein, site of the famous rock engravings, a popular campground on the banks of the Aba-Huab River exemplifies the local development initiative that should be encouraged in the western catchments through effective land use planning.

Environmental Sustainability

Future success in achieving sustainable development within the western catchments will ultimately depend upon our integrated understanding of economic, ecological and social issues relevant to the region. In the western catchments, the bases for economic and social sustainability are, and will continue to be, environmental resources and their sustainability. An overall development plan based on the region's natural resource base, and recognising its limitations, is urgently needed. Objectives for resource use must be defined and evaluated. At the same time, resources themselves must be defined - what and where are they, what is their availability and how do we wish to use them? If a resource is non-renewable, for example a mineral resource, society must evaluate if this is really the best time, or the best way, to use it. Will future generations benefit from the products of such use? Can we replace the resource through human ingenuity? For renewable resources, such as water, rangelands and wildlife, management plans must ensure that future generations will enjoy the same access to the resource as we have.

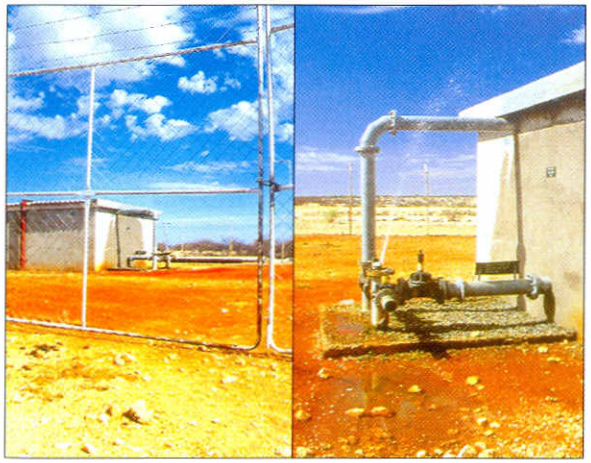
Achieving sustainable development within the western catchments is dependant upon a thorough understanding of the sustainable yields of essential resources, such as water, soil, vegetation and wildlife. We must not consume these resources faster than they are replaced by natural processes if our use is to be sustainable in the long-term.

The government body 'responsible for the environment' (87), the Ministry of Environment and Tourism (MET), must know the sustainable yields of resources in the region. All too often sustainable development is equated with 'maintenance of biodiversity and essential ecological processes' (31). An assessment of how important various components of the region's biodiversity are to successful sustainable use of the region's natural resources is desperately needed, as is a clear understanding of which 'essential ecological processes' must be preserved. Without this baseline information, the MET will not be able to perform its function of assisting the nation to achieve environmentally and economically sustainable development. An effective plan for the management of the natural resource base in the western catchments has yet to be devised.

Action must be taken immediately to determine sustainable yields of important resources: water, vegetation, soil and wildlife. This will be achieved only through a well co-ordinated research effort which focuses on natural climatic variability and its influence on resource availability in drylands. Given that livestock farming, game farming, and various forms of low-impact tourism have been identified as desirable development trajectories (8, 73, 87), the goal of research should be to determine the sustainable yields of resources with these activities in mind. Ultimately, research must provide an effective framework for determining and managing sustainable resource yields. An appropriate management plan must then be established which ensures equitable resource use.

Undoubtedly the greatest challenge ahead will be managing the water resources of the western catchments. Availability of this resource must be an essential consideration in all land use planning in the western catchments. Thorough consideration must be given to implications of altering water flow and distribution patterns prior to undertaking development in any catchment. In such linear systems, downstream users bear the costs of upstream developers. There is an urgent need to prioritise the use of water within the catchments. If downstream areas are important for farming, conservation or tourism, then the extent of upstream development must be limited when it involves altering downstream water flow patterns.

Namibians are going to have to make hard choices; the resources of the western catchments are finite. Ultimately, if a resolution cannot be found to any issue relating to natural resource management, the government - charged with sustainable development for all Namibians present and future - will have to make decisions in a timely fashion. Continued lack of resolution on environmental resource management will only perpetuate current resource abuse, preventing us from ever achieving our goal of long-term sustainability.



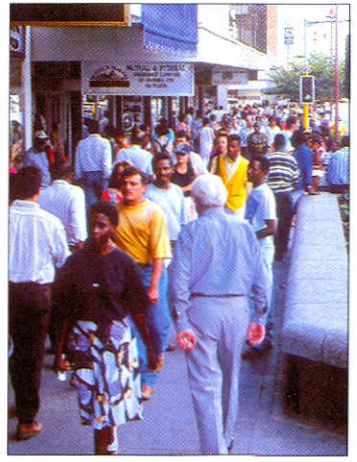
Social Sustainability

Ensuring social sustainability requires development of a social framework which creates empowerment or self-control over the resource base, both at the individual and national level. This involves an appropriate legal and economic framework, defining and ensuring rights to land and associated resources, such as water, grazing and wildlife. A major challenge to Namibia's attempts to achieve social sustainability is its rapidly expanding population. Unless the current growth rate is reduced, twice as many people will be using the resources that we are currently using, assuming that our efforts at sustainable use are successful. If development and implementation of plans challenge us now, how much more difficult will they be in 20 years?

Currently, Namibians are committed to effecting positive change in the western catchments. Many local and regional leaders as well as government and non-government organisations and communities are playing essential roles in developing plans for sustainable use of the region's natural resource base. However, their efforts must be more effectively co-ordinated, each recognising his or her capacity to assist with such a difficult task. The Government should continue to provide a framework for leadership, assist in assessing resource availability, and ensure sustainable use. At the same time the government must not act as a provider, continually meeting demands of an ever-enlarging population. Rather, it must be a facilitator, assisting individuals and communities to identify and quantify local resources and options for their use. It must also ensure equitable resource use - local inhabitants may have priority for resource use but exploitation must not occur at the expense of the nation. In the end, no development will be sustainable if it does not recognise and meet the short-term needs as well as the long-term goals and aspirations of the individual (20). If individual or regional land use is unsustainable, the nation as a whole pays the price.

◀ *Managing the scarce water and rangeland resources of the western catchments is a great challenge in the face of a rapidly expanding and needy population. This reservoir station near Khorixas was damaged when a farmer cut a hole in the fence, allowing livestock to enter, and then broke off a monitoring gauge to create an instant fountain. Although such vandalism enables a farmer to meet short-term needs, it undermines efforts to achieve sustainable resource use for the benefit of all the region's residents.*

Individuals and communities have a major role to play in identifying local resources and options for their use. The government can act as a facilitator, helping to assess resource availability and establish guidelines for management. However, achieving sustainable resource use is ultimately dependant upon effective decisions made at the local level by individual resource users.



The single greatest threat to efforts at achieving sustainable resource use and a better quality of life for all Namibians is the rapid expansion of Namibia's population. In less than twenty years twice as many Namibians will have to make their living off the same finite natural resources we are using today, unless population growth is rapidly reduced.

THE RAINS AND FLOODS OF 1995: A POSTSCRIPT

2

As this book was nearing completion in early February of 1995, heavy rains began to fall in the north-western catchments. The rains continued throughout February, March and early April, often falling in massive late afternoon and evening thunderstorms. As a result, residents of the Huab, Koigab, Uniab, Hoanib and Hoarusib catchments will remember 1995 as a year of exceptionally high rainfall. They will also remember the effects of the rains on the catchments themselves: rocky desert landscapes were transformed into lush grasslands and lily fields, and bare savannas were covered by showy displays of flowers set amongst bright green grass.

The effects of this rainfall on the ephemeral rivers were equally spectacular. In some rivers the 1995 floods were far larger than any seen in the past several decades or, in the case of the Koigab and the Hunkab floods, perhaps several centuries or more. River channels were broadened and deepened, large boulders tumbled downstream, old trees and wetlands disappeared, rivers cut through dunefields, and large reddish-brown plumes of silty water spewed into the ocean. While some floods were destructive, they also brought new life to the rivers. Aquifers and springs recharged, floodplain soils were enriched with nutrients, and seeds of riparian trees germinated and began to grow. These seedlings will mature to become the riparian forests of the future, yielding valuable forage for stock and wildlife.

True to the nature of an arid climate, however, the 1995 rains were patchy. While the late rains came as a welcome surprise to much of the Erongo and Kunene regions, many areas of Namibia, particularly the east and the south, received below average rainfall. The purpose of this postscript is to provide a brief documentation of what the 1995 rains meant to north-western Namibia and its rivers, for us all to savour in the dry years ahead . . .

1

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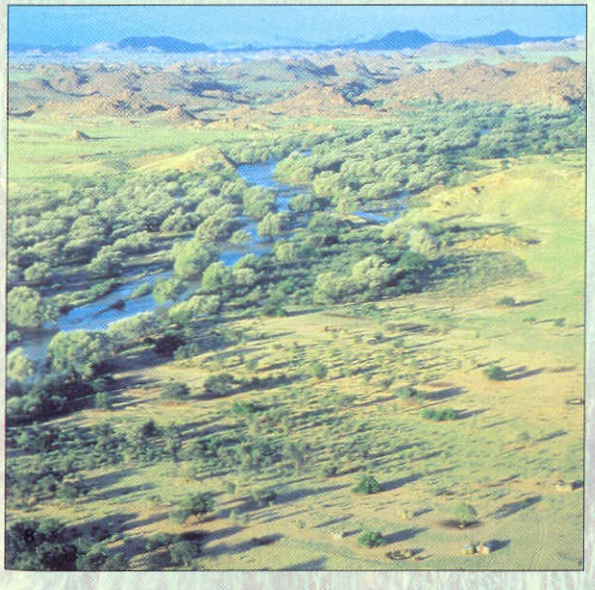


FACING PAGE:

1 *Clouds such as these produced torrential rains during late afternoon and evening storms - 60 mm fell in less than an hour in one storm in the Khorixas area.*

2 *In some cases, new river channels were cut open. Today's maps show the Hunkab River (a small desert catchment between the Uniab and Hoanib) ending in the eastern edge of the Northern Namib Sand Sea. A powerful storm dropped as much as 55 mm of rain throughout the small catchment, (which usually receives less than 25 mm per annum), during the late afternoon of 2 April. The resulting flood pushed the river through 15 kilometres of high sand dunes, cut a new canyon near the coast, and went into the sea.*

3 *The Hoanib River broke through the dunes of the Skeleton Coast Park on 26 February 1995 and flowed into the sea for the first time since 1984.*

THIS PAGE:

4 *The Uniab River also broke through dunes which had blocked its path to the sea since 1982.*

5 *The Koigab River flood on 25 and 26 February was of a magnitude probably not seen for a century or more. The Gui-Tsawisib, a large tributary of the Koigab, was 600 metres wide where it flowed across the road near Springbokwasser.*

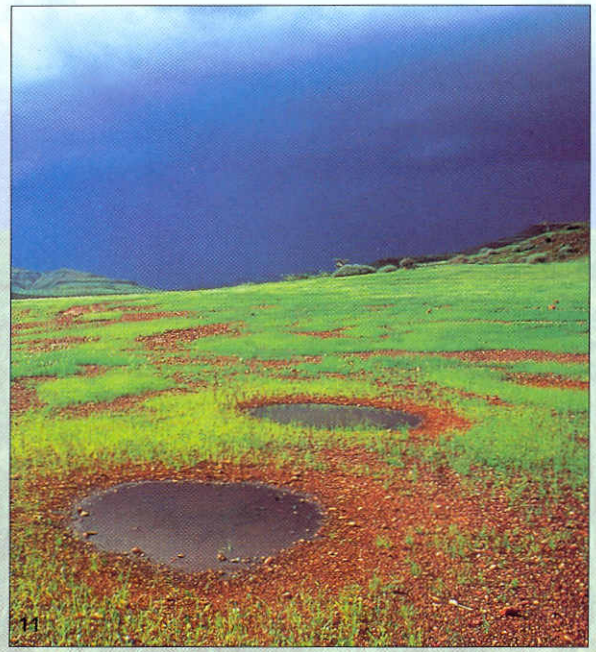
6 *Heavy runoff resulting from intense storms gave rise to floods that roared through the rivers, scouring channels and banks and sweeping away riparian vegetation, as seen here at Peter's Pool on the Huab River.*

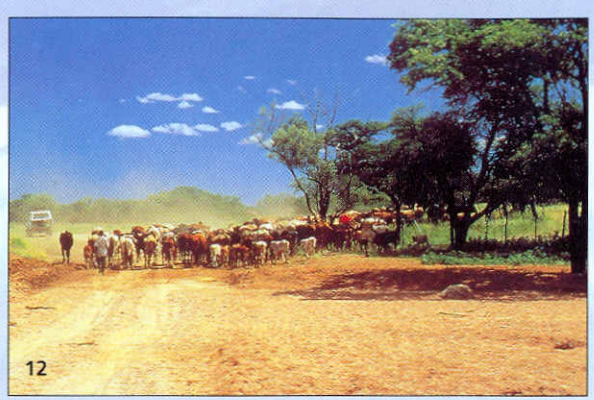
7 *These large floods maintain riparian ecosystems for years and decades to come. Groundwater recharge is substantial, replenishing depleted aquifers and rejuvenating springs.*

8 *The Ugab River floods, while not as large as those in the more northerly rivers, will still ensure a large crop of ana tree seed pods next year - feeding the region's livestock and wildlife.*

9 *The floods of the Huab River were of a magnitude not seen for more than 30 years. These waves at the Jack Scott bridge were more than 2 metres high.*

10 *The upper Huab River, draining from the private farms, flowed strongly and repeatedly during February and March, for the first time in nearly 20 years.*





11 *With abundant surface water available, wildlife could move wherever they pleased in search of grazing.*

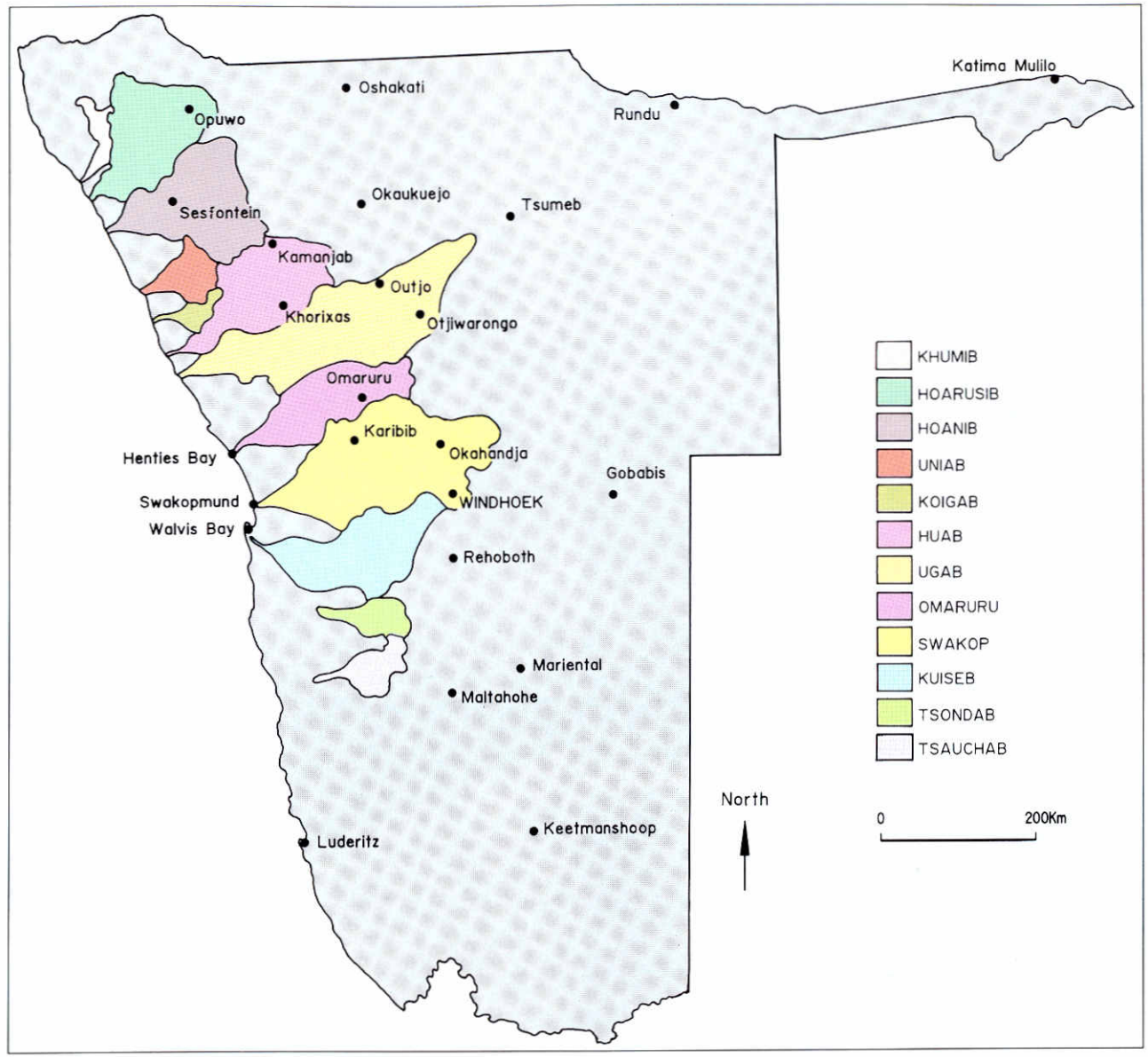
12 *The same was true for livestock. Making use of rain pools and grazing along the road, these farmers moved their stock from the Ugab River back to the Grootberg farms in the Huab catchment. They had moved their stock more than 100 km to the south last year in search of better grazing after below average rains fell in the Grootberg area.*

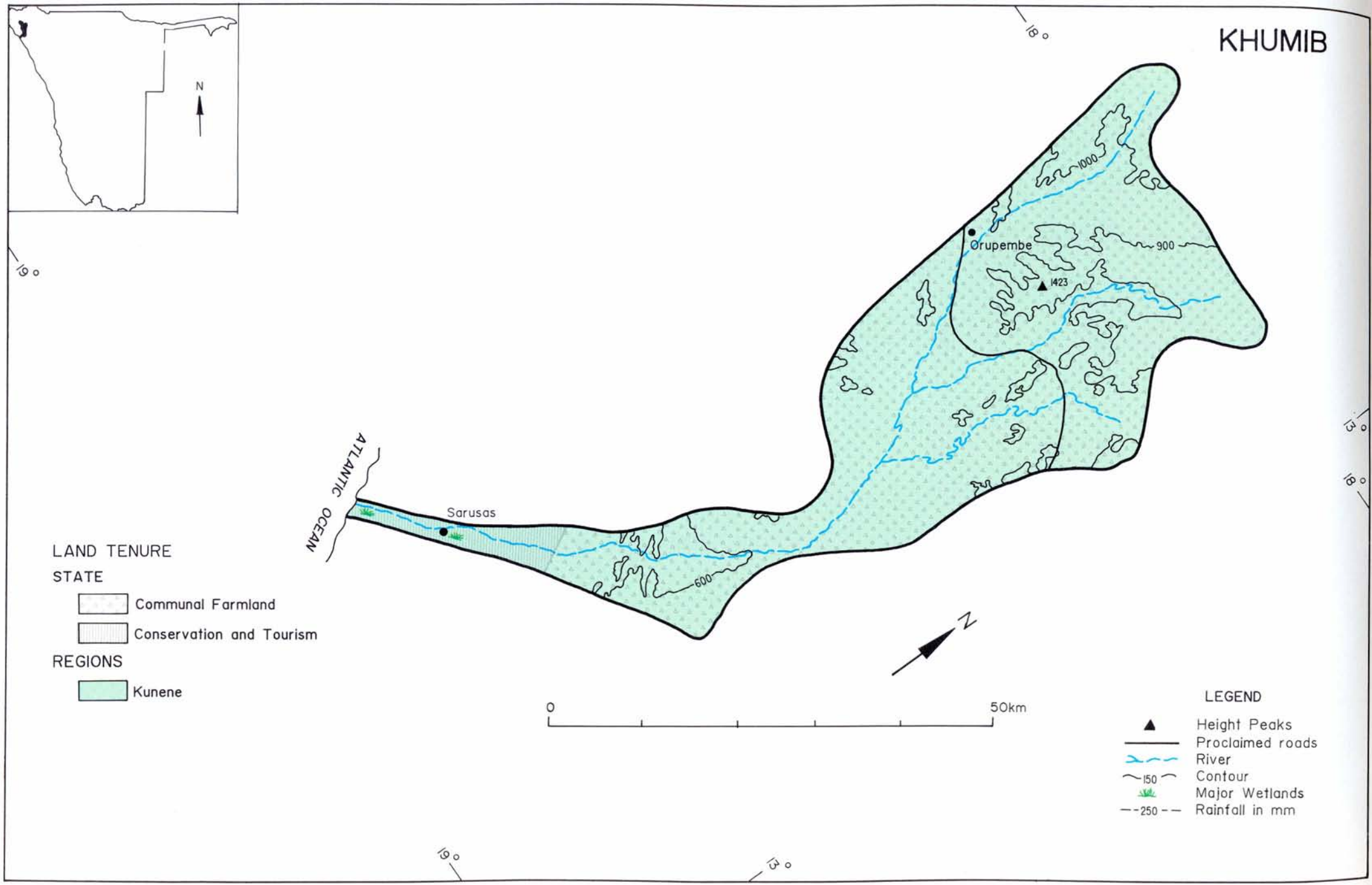
13 *The residents and guests at the Aba-Huab Camp near Twyfelfontein will never forget the floods which swept through in the night.*

14 *The Hoarusib River flood, seen here flowing into the ocean on 27 February, resulted from more than 200 mm of rain falling within 48 hours over sections of its catchment.*

15 *Many areas in the Kunene and Erongo regions, which were barren when the rains began to fall in early February, had extensive perennial grass cover by mid-April.*

CATCHMENT SUMMARIES




KHUMIB
N
18°
19°
13°
18°
19°
13°
Orupembe
1423
1000
900
600
Sarusas
ATLANTIC OCEAN
LAND TENURE
STATE
Communal Farmland
Conservation and Tourism
REGIONS
Kunene
0
50km
LEGEND
Height Peaks
Proclaimed roads
River
150
Contour
Major Wetlands
250
Rainfall in mm

Khumib Catchment

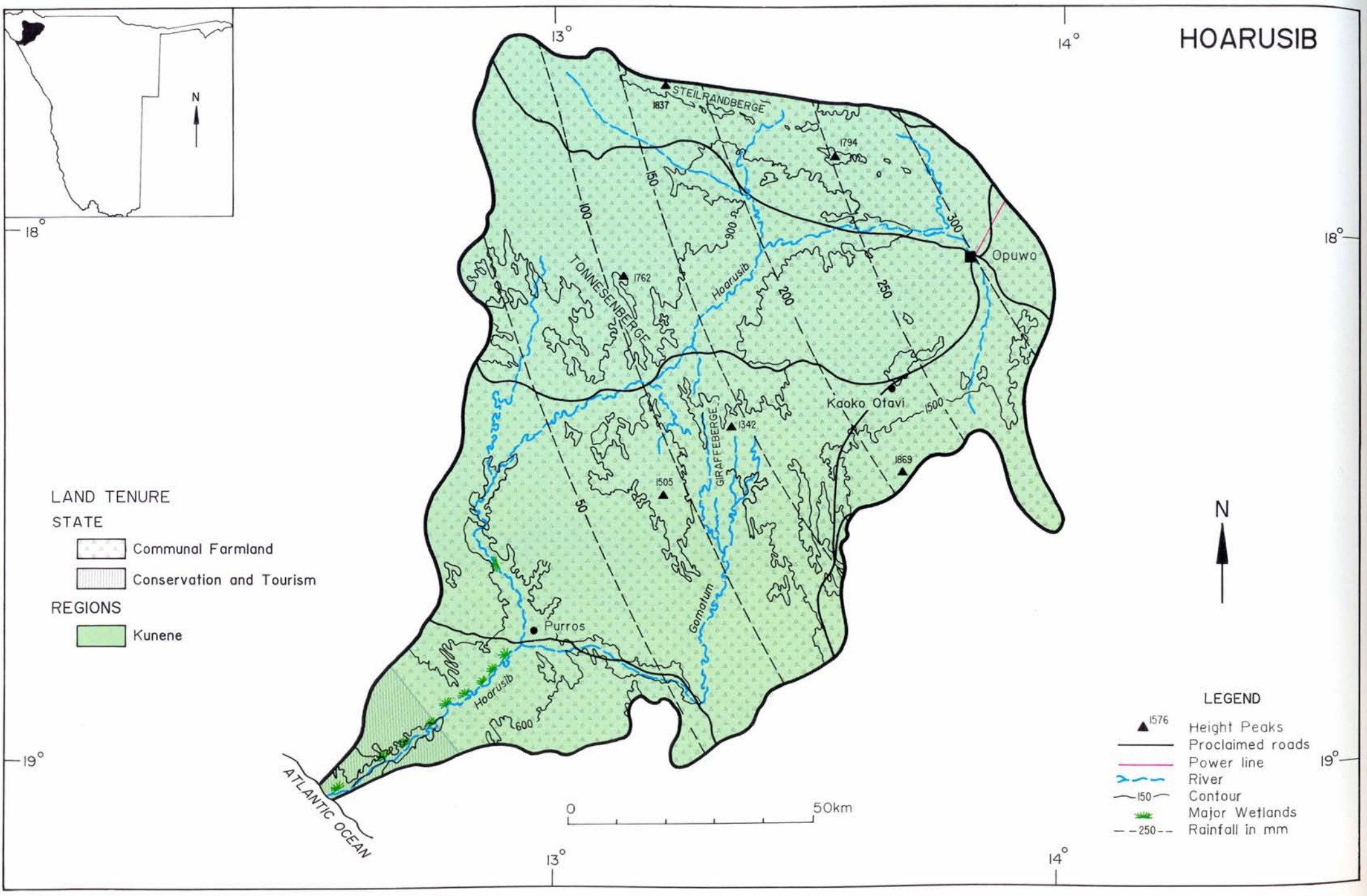
Catchment Area		2 200 km²
Elevation Range		0 - 1542 m
River Length		80 km
Gauging Points on River		None
Common Riparian Vegetation		leadwood, mopane, *Salvadora, Euclea*
Precipitation Range		0 - 25 mm
Area With Rainfall >100mm		0 %
Area With Rainfall >300mm		0 %
Active Rainfall Stations		None
Catchment Vegetation Types	Northern Namib	23 %
	Mopane Savanna	77 %
Total Population		< 100
Percentage of Population Under 16		48 %
Percentage of Households Cooking With Wood		100 %
Percentage of Households With a Radio		0 %
Percentage of Households Reading a Newspaper Weekly		0 %
Percentage of People Who Have Never Attended School		48 %
Percentage of Population Living in Rural Areas		100 %
Local Authorities		None
State Water Schemes		None
Proclaimed Road		60 km
Catchment Area (km²) / km road		37 km²
Land Tenure	Private	0 %
	Communal	93 %
	Park	7 %
Private Farms		0

This small remote catchment, located in a very arid region with limited agricultural potential, is currently used by a small number of nomadic pastoralists and tourists. Of the small desert rivers north of the Hoarusib, the Khumib has the strongest and most regular flow, occasionally reaching the sea. Stranded driftwood along the river course provides evidence of brief but strong floods from time to time. Draining into the Skeleton Coast Park and concession area, the catchment contains several springs of importance to nomadic wildlife. Plans to develop the Kaokoland Conservation and Tourism Area, which would encompass the entire catchment, should be vigorously supported in the interest of all.

Sarusas spring, only 10 km from the sea, is an important stopping point - both for wildlife and the tourists who come on guided trips to the Skeleton Coast Park. (photo: D Heinrich)

The Khumib River, here some thirty kilometers above Sarusas, contains an interesting mix of riparian vegetation supported by its occasional flows.

In its headwaters near Orupembe, nomadic pastoralists make use of the annual grasses which are periodically found after rains have fallen in this arid region. (photo: D Heinrich)


HOARUSIB
13°
14°
18°
19°
N
STEILRANDBERGE
1837
1794
1762
TONNIESENBERGE
1342
GIRAFFEBERGE
1505
1869
Opuwo
Kaoko Otavi
Purros
Hoarusib
Gomatum
ATLANTIC OCEAN
50
100
150
200
250
300
500
600
900
1500
0
50km
LAND TENURE
STATE
Communal Farmland
Conservation and Tourism
REGIONS
Kunene
LEGEND
Height Peaks
Proclaimed roads
Power line
River
Contour
Major Wetlands
Rainfall in mm

Hoarusib Catchment

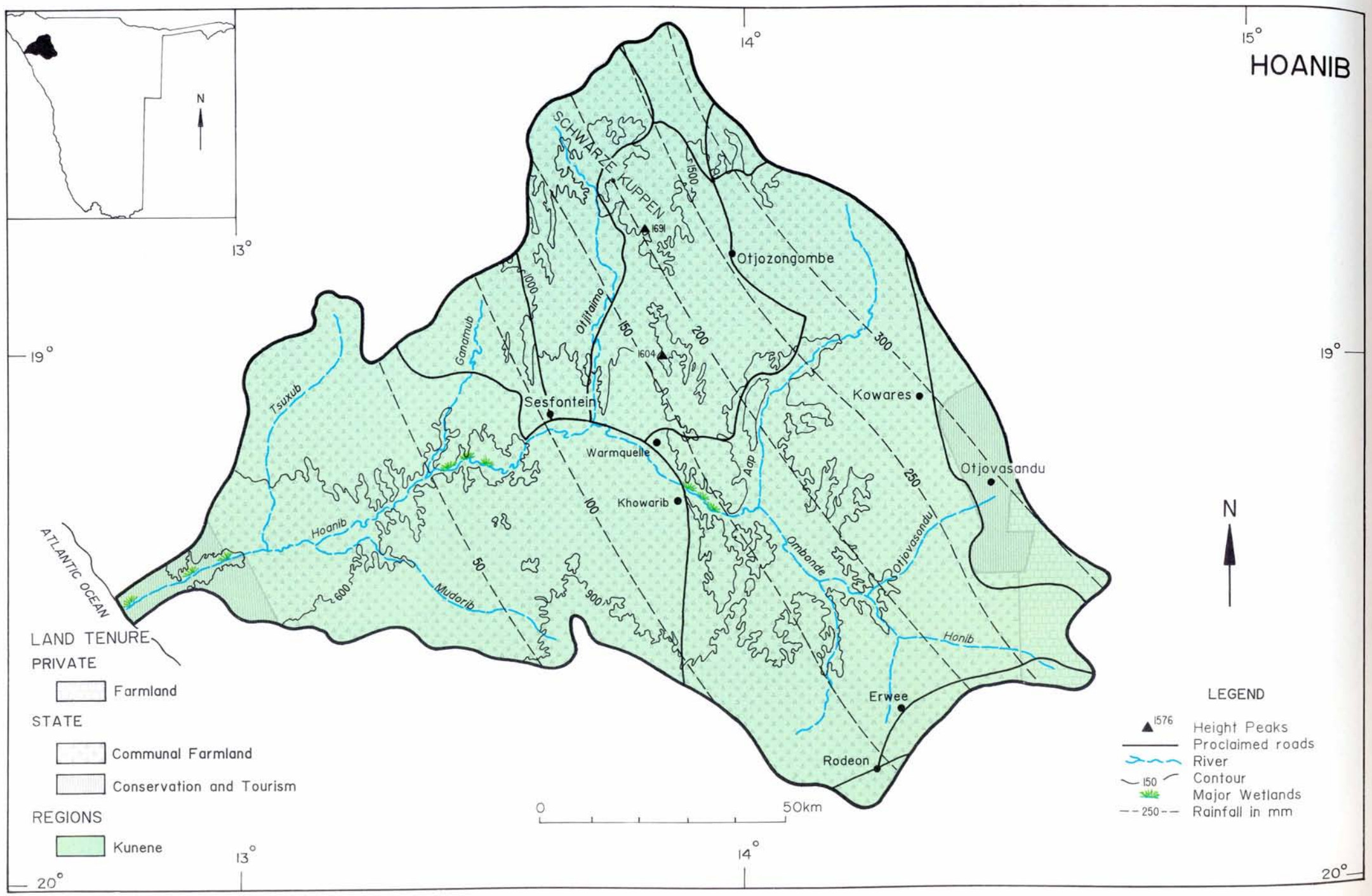
Catchment Area		15 100 km²
Elevation Range		0 - 1964 m
River Length		300 km
Gauging Points on the River		5
Common Riparian Vegetation		*Tamarix*, palm, leadwood, ana tree, mopane, camelthorn, *Euclea*, *Phragmites*
Precipitation Range		0 - 325 mm
Area With Rainfall >100mm		40 %
Area With Rainfall >300mm		8 %
Active Rainfall Stations		None
Catchment Vegetation Types	Northern Namib	6 %
	Mopane Savanna	94 %
Total Population		12 653
Percentage of Population Under 16		47 %
Percentage of Population Cooking With Wood		90 %
Percentage of Households With a Radio		18 %
Percentage of Households Reading a Newspaper Weekly		5 %
Percentage of People Who Have Never Attended School		35 %
Percentage of Population Living in Rural Areas		66 %
Local Authorities		Opuwo
State Water Schemes		Opuwo
Proclaimed Road		600 km
Catchment Area (km²) / km road		25 km²
Land Tenure	Private	0 %
	Communal	98 %
	Park	2 %
Private Farms		0

The Hoarusib River flows regularly, reaching the sea nearly every year. As a result it supports several large wetlands, a riparian forest along its banks and a rich assemblage of wildlife. This large mountainous and remote catchment is currently visited by growing numbers of tourists, despite the fact that the region has no official conservation status. A rapidly expanding population at Opuwo, the capital of the Kunene region, places increasing pressure on the region's natural resource base, particularly its finite water supply. Ongoing tourism developments in the lower reaches of the catchment may, in the future, have to contend with plans for irrigation schemes and a large dam in the vicinity of Purros. The development of the Möwe Bay harbour near the mouth of the river could lead to a dramatic increase of uncontrolled traffic in this sensitive region, and would necessitate the damming of the river for water supply below Purros, unless desalination is used to supply water.

The Hoarusib, like many of the western catchments, has large silt deposits within its lower reaches - evidence of climatic changes that have occurred in the region within the past 100 000 years.

The Hoarusib is one of the more active rivers, flowing into the sea nearly every year. The steep, rocky slopes found throughout its catchment - here east of Purros - rapidly shed rainwater into the river, giving rise to large and frequent floods.

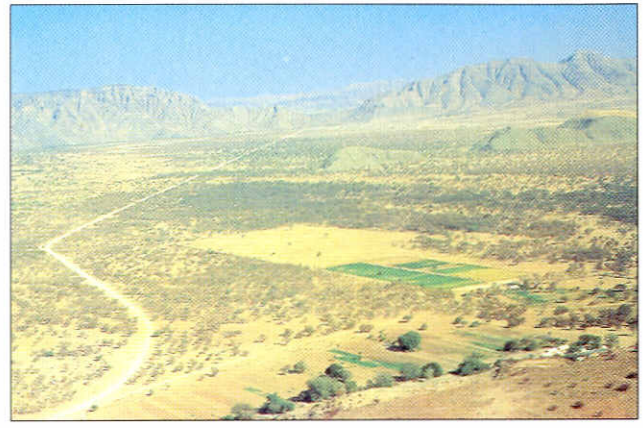
Vegetationless circles, seen here southeast of Purros, are found in the arid reaches of many of the catchments. Their origins have yet to be explained, although many unproven theories exist about termites, poisoned soil, fairies and landing sites for space aliens!


HOANIB
14°
15°
13°
19°
20°
N
SCHWARZE KUPPEN
1691
1604
Otjozongombe
Sesfontein
Warmquelle
Khowarib
Kowares
Otjovasandu
Erwee
Rodeon
Tsuxub
Ganamub
Otjitaimo
Hoanib
Mudorib
Aop
Omboande
Otjovasandu
Honib
ATLANTIC OCEAN
1500
1000
150
200
300
250
100
50
600
900
0
50km
LAND TENURE
PRIVATE
Farmland
STATE
Communal Farmland
Conservation and Tourism
REGIONS
Kunene
LEGEND
1576 Height Peaks
Proclaimed roads
River
150 Contour
Major Wetlands
250 Rainfall in mm

Hoanib Catchment

Catchment Area		17 200 km²
Elevation Range		0 - 1821 m
River Length		270 km
Gauging Points on the River		2
Common Riparian Vegetation		ana tree, leadwood, mopane, *Salvadora, Tamarix,* camelthorn, *Euclea*
Precipitation Range		0 - 325 mm
Area With Rainfall >100mm		72 %
Area With Rainfall >300mm		12 %
Active Rainfall Stations		2
Catchment Vegetation Types	Northern Namib	13 %
	Mopane Savanna	87 %
Total Population		7 866
Percentage of Population Under 16		50 %
Percentage of Population Cooking With Wood		97 %
Percentage of Households With a Radio		21 %
Percentage of Households Reading a Newspaper Weekly		3 %
Percentage of People Who Have Never Attended School		33 %
Percentage of Population Living in Rural Areas		100 %
Local Authorities		None
State Water Schemes		Erwee, Otjovasandu, Sesfontein
Proclaimed Road		700 km
Catchment Area (km²) / km road		25 km²
Land Tenure	Private	3 %
	Communal	91 %
	Park	6 %
Private Farms		12

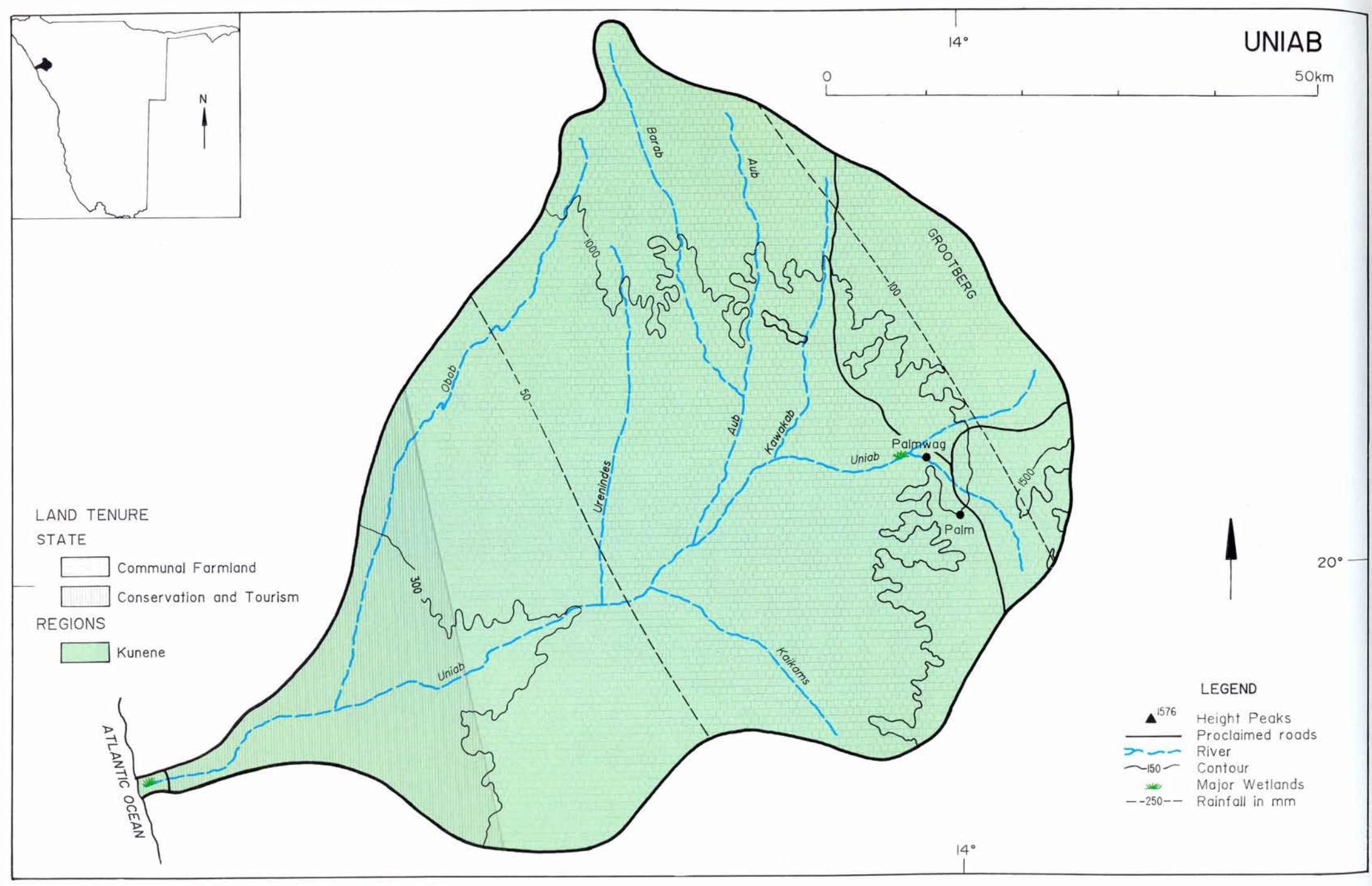
With prospects for increased development in agricultural, mining and tourism sectors, this catchment faces the challenge of managing these potentially conflicting development trajectories. The population centre, the Sesfontein region, is well-known for its numerous springs, associated gardens, and large herds of livestock. The springs, wetlands and a large floodplain near the coast, provide essential resources for a rich flora and fauna, including elephant and rhino. Draining two parks, three concession areas and several campgrounds, the catchment is of great conservation and tourism significance in north-western Namibia.



The Hoanib catchment is well known for its abundance of mountain springs, some of which support rural communities and irrigated gardens. Warmquelle, seen here, is the site of a large hot spring, the warm water emerging from fissures in the side of the mountain.

The Hoanib floodplain, formed where the river enters the sand dunes close to the coast, is a popular spot for elephant with its abundant vegetation and large wetlands. Although elephant are a valuable and unique resource within the western catchments, the absence of a land use plan for the region leaves these animals walking away into an uncertain future.

The Khowarib Schlucht, a deep and spectacular canyon formed where the Hoanib River cuts through the mountains east of Khowarib, is a popular spot with visiting tourists. A large wetland provides a unique setting for a popular campsite, as well as water for the gardens of the Khowarib community at the western mouth of the canyon.


UNIAB
14°
0
50km
N
Barab
Aub
1000
GROOTBERG
100
Obob
50
Aub
Kawakab
Uniab
Palmwag
Palm
1500
Urenindes
300
Uniab
Kaikams
ATLANTIC OCEAN
20°
14°
LAND TENURE
STATE
Communal Farmland
Conservation and Tourism
REGIONS
Kunene
LEGEND
1576 Height Peaks
Proclaimed roads
River
150 Contour
Major Wetlands
250 Rainfall in mm

Uniab Catchment

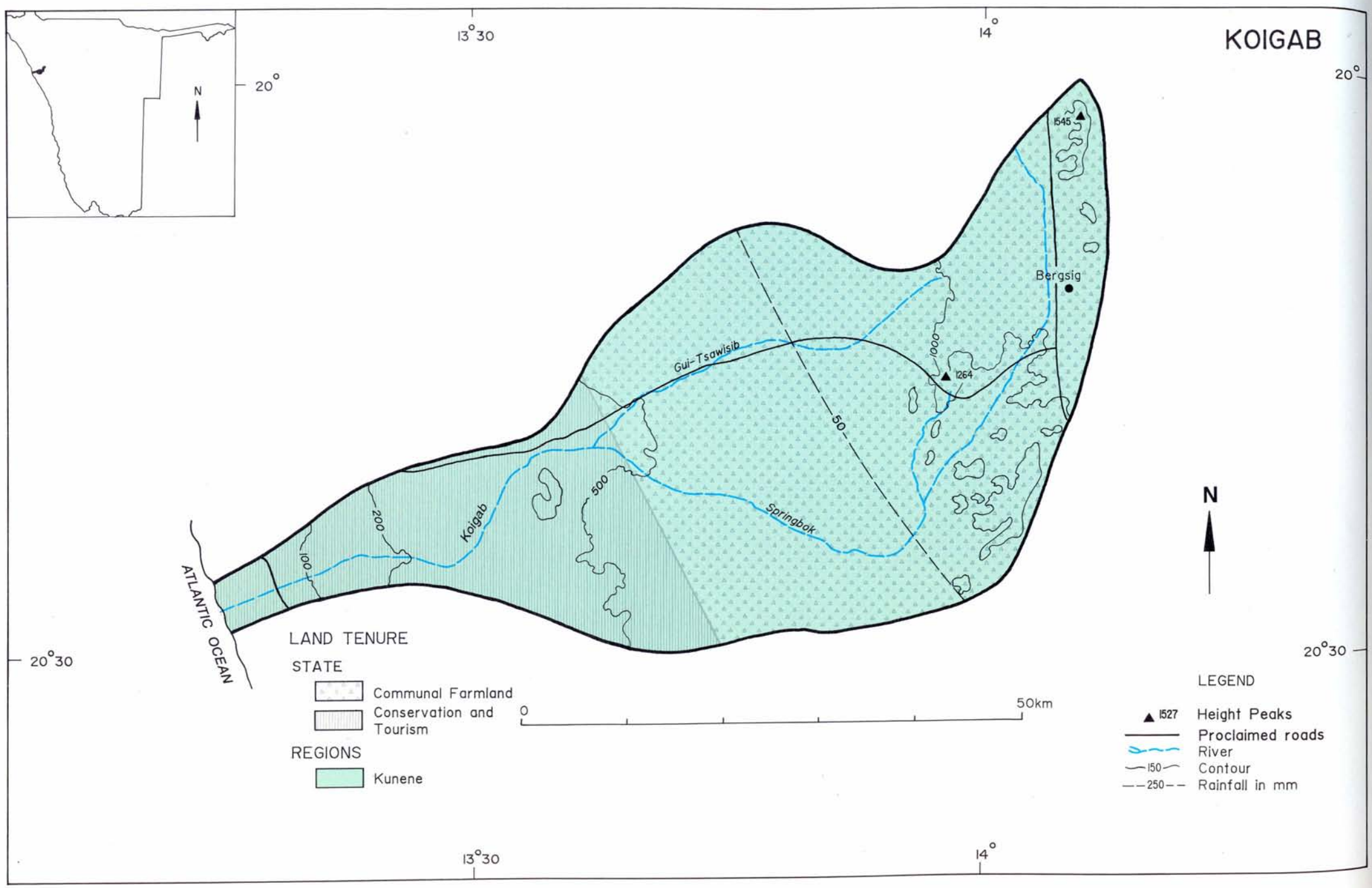
Catchment Area		4 500 km²
Elevation Range		0 - 1635 m
River Length		110 km
Gauging Points on River		None
Common Riparian Vegetation		mopane, *Salvadora, Tamarix,* palm, *Cyperus, Phragmites*
Precipitation Range		0 - 125 mm
Area with Rainfall >100mm		2.3 %
Area with Rainfall >300mm		0.0 %
Active Rainfall Stations		1
Catchment Vegetation Types	Northern Namib	26 %
	Mopane Savanna	74 %
Total Population		< 100
Percentage of Population Under 16		36 %
Population Cooking With Wood		93 %
Percentage of Households With a Radio		41 %
Percentage of Households Reading a Newspaper Daily		0 %
Percentage of People Who Have Never Attended School		29 %
Percentage of Population Living in Rural Areas		100 %
Local Authorities		None
State Water Schemes		Terrace Bay
Proclaimed Road		90 km
Catchment Area (km²) / km road		49 km²
Land Tenure	Private	0 %
	Communal	89 %
	Park	11 %
Private Farms		0

This small catchment drains the red volcanic rocks of the Grootberg Mountains, flows through a rocky desert dotted with Euphorbia, *and traverses a narrow strip of low dunes before passing through a spectacular canyon and over a waterfall at the coast. Because of low rainfall, the catchment has no significant agricultural potential. Rather, numerous springs support migratory wildlife, including a large proportion of Namibia's western elephant and rhino populations. As a result, the catchment is home to two of Namibia's largest and most successful tourism concessions. In recognition of its great value, the entire catchment should be granted status as a conservation and tourism area to ensure the protection and appropriate use of the valuable resources.*

The Uniab River supports a dense stand of mopane, Tamarix and Salvadora in its middle reaches. Combined with an abundance of small springs, the catchment provides an important refuge for a large amount of wildlife.

Although the Uniab does not flow often, when it does the reddish-brown water draining over the ancient lavas creates a striking image. Such floods are essential to maintain downstream springs and the wildlife that depend upon them.

One of the most interesting points along the entire western coast of Namibia is where the Uniab River drains into the sea. The combination of its canyon, wetlands and wildlife are a unique asset to the value of the Skeleton Coast Park.


KOIGAB
13°30
14°
20°
20°30
N
1545
Bergsig
1264
Gui-Tsawisib
1000
50
500
200
100
Koigab
Springbok
ATLANTIC OCEAN
LAND TENURE
STATE
Communal Farmland
Conservation and Tourism
REGIONS
Kunene
0
50km
LEGEND
1527 Height Peaks
Proclaimed roads
River
150 Contour
250 Rainfall in mm

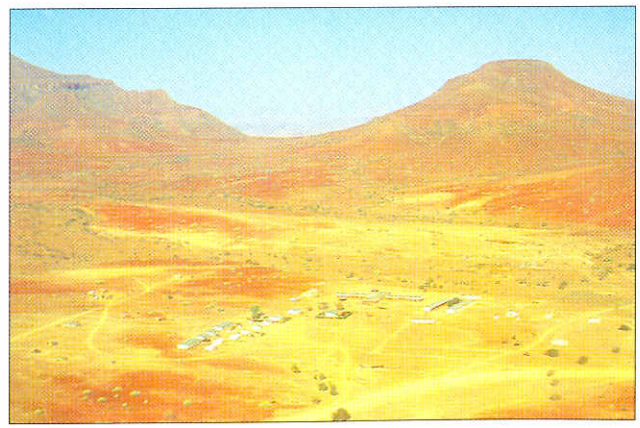
Koigab Catchment

Catchment Area		2 400 km²
Elevation Range		0 - 1571 m
River Length		130 km
Gauging Points on the River		0
Common Riparian Vegetation		mopane, *Euclea, Tamarix, Salvadora, Salsola*
Precipitation Range		0 - 100 mm
Area with Rainfall >100mm		2 %
Area with Rainfall >300mm		0 %
Active Rainfall Stations		1
Catchment Vegetation Types	Northern Namib	50 %
	Mopane Savanna	50 %
Total Population		< 100
Local Authorities		None
State Water Schemes		Bergsig
Proclaimed Road		130 km
Catchment Area (km²) / km road		18 km²
Land Tenure	Private	0 %
	Communal	80 %
	Park	20 %
Private Farms		0

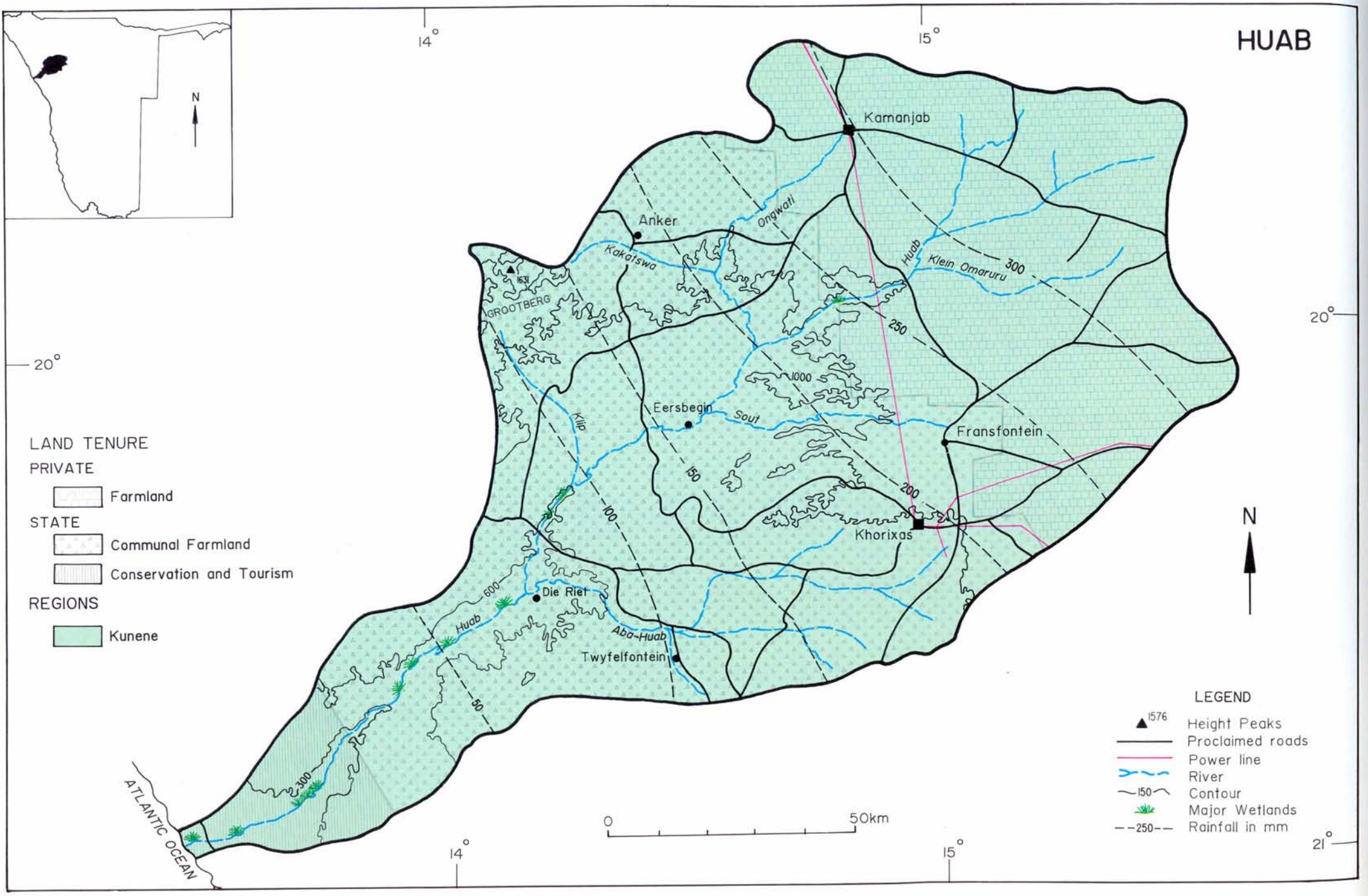
This small, arid and mountainous catchment bears a strong resemblance to the Uniab. With its canyon, springs, wetlands and wildlife it has high significance for tourism and conservation. The springs and wetlands are a critical resource to wildlife of the Skeleton Coast Park, including Namibia's desert rhino. With limited agriculture resources, future development should be tourism-based. Currently, plans are being considered to develop a tourism area and lodge within the headwaters of the catchment.

The Koigab River, like the Uniab, its northern neighbour, drains from the red and brown lavas of the Grootberg Mountains. It contains a number of small springs, critical for the rhino and other wildlife found within the region.

The middle reaches of the Koigab River, within the Skeleton Coast Park, support dense stands of Salsola. *Several important springs are also found in this reach, including Springbokwasser at the eastern entry point to the Skeleton Coast Park.*



Bergsig, sitting at the base of the Grootberg Mountains near the headwater of the Koigab River, is home to a small community of farmers who use the scarce water and vegetation resources in the region for livestock farming.


HUAB
N
14°
15°
20°
21°
Kamanjab
Anker
Ongwati
Kakatswa
Huab
Klein Omaruru
GROOTBERG
1631
300
250
1000
Eersbegin
Sout
Klip
150
200
100
Fransfontein
Khorixas
Die Riet
600
Huab
Aba-Huab
Twyfelfontein
50
300
ATLANTIC OCEAN
0
50km
LAND TENURE
PRIVATE
Farmland
STATE
Communal Farmland
Conservation and Tourism
REGIONS
Kunene
LEGEND
1576
Height Peaks
Proclaimed roads
Power line
River
150
Contour
Major Wetlands
250
Rainfall in mm

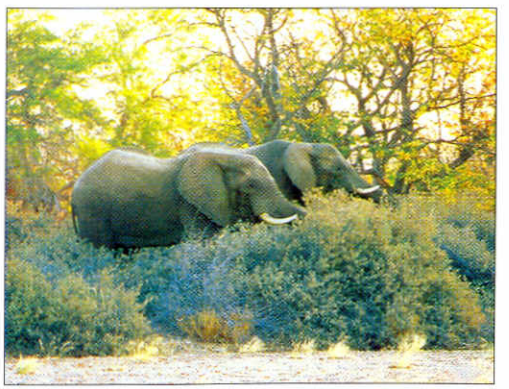
Huab Catchment

Catchment Area		14 800 km²
Elevation Range		0 - 1597 m
River Length		300 km
Gauging Points on the River		6
Common Riparian Vegetation		ana tree, *Tamarix*, camelthorn, *Salvadora*, mopane, leadwood, *Cyperus*, *Phragmites*, *Euclea*
Precipitation Range		0 - 345 mm
Area with Rainfall >100mm		80 %
Area with Rainfall >300mm		13 %
Active Rainfall Stations		7
Catchment Vegetation Types	Central Namib	20 %
	Mopane Savanna	80 %
Total Population		14 762
Percentage of Population under 16		42 %
Percentage of Population Cooking with Wood		80 %
Percentage of Households With a Radio		61 %
Percentage of Households Reading a Newspaper Weekly		11 %
Percentage of People Who Have Never Attended School		15 %
Percentage of Population Living in Rural Areas		44 %
Local Authorities		Kamanjab, Khorixas
State Water Schemes		Anker, Fransfontein, Kamanjab, Khorixas
Proclaimed Road		1 100 km
Catchment Area (km²) / km road		13 km²
Land Tenure	Private	36 %
	Communal	62 %
	Park	2 %
Private Farms		95

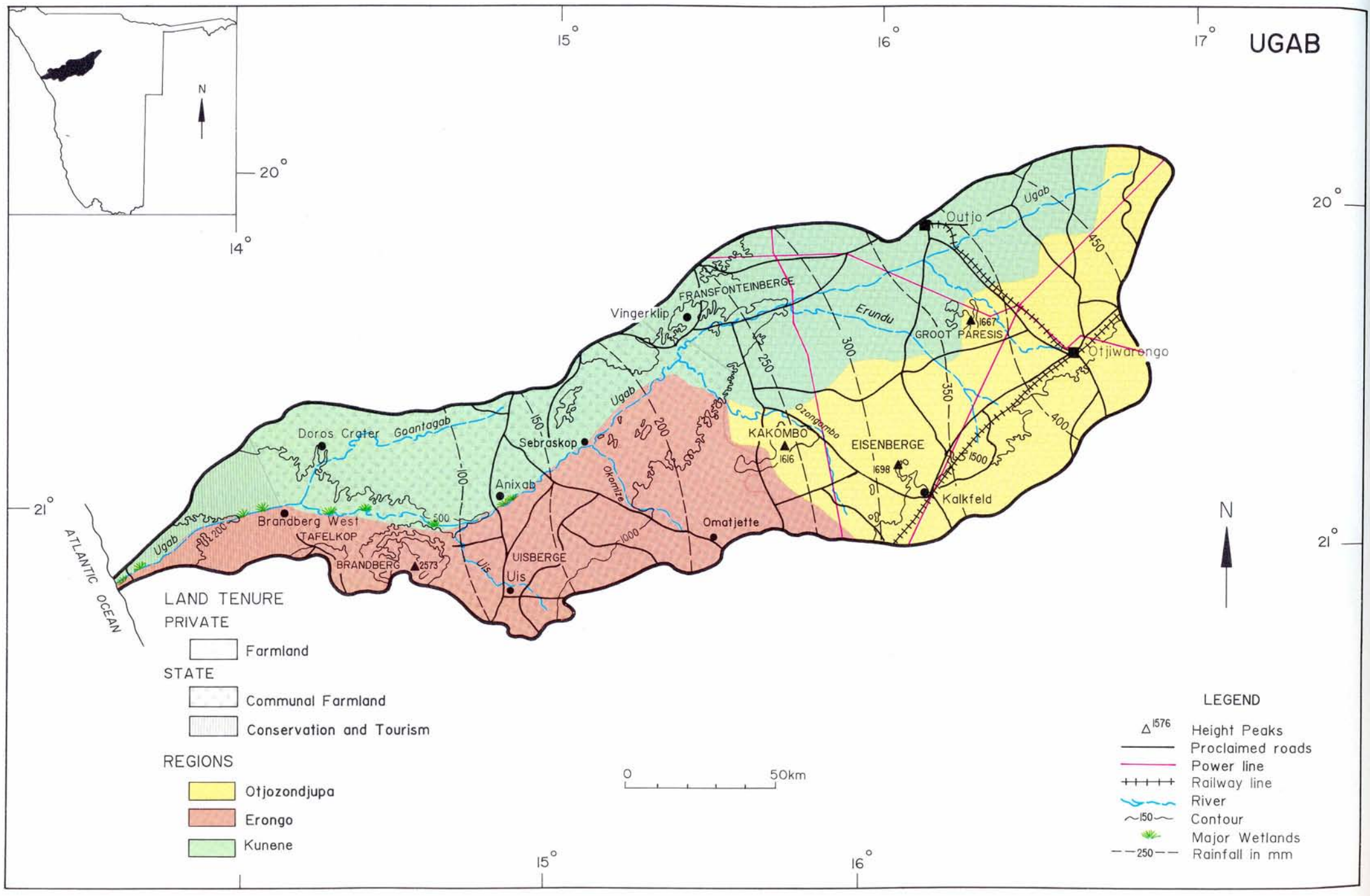
There is an urgent need for land use planning to resolve an increasing number of conflicts amongst resource users in the Huab catchment. Khorixas, the largest population centre in the catchment, is grossly over-using its water supply. A reduction in runoff from the river's headwaters on private farms over the past 15 years, due to an increase in dam numbers and low rainfall, has resulted in the loss of many springs and large numbers of ana trees downstream. Fair agricultural potential exists in the eastern half of the catchment, but the arid climate in the lower half requires flexible farming strategies, such as the large-scale livestock movement to the Ugab catchment in 1994, which led to conflicts between resource users. In addition to being used by livestock, the water and vegetation resources of the Huab catchment are key to the survival of western Namibia's elephant. The catchment has great potential for tourism development, as witnessed by the recent creation of game farms and lodges on private farms and a campground in the communal area. However, the absence of land use planning frustrates all efforts to achieve co-ordinated resource management.

The Huab River supports a number of important wetlands, such as this one in its lower reaches, close to the Skeleton Coast Park.

The Aba-Huab, a large tributary of the Huab River, is home to a number of farmers west of Khorixas. Near Twyfelfontein, site of the famous rock engravings, a popular campground on the banks of the river exemplifies the type of local development initiative that must be encouraged in the western catchments through effective land use planning.



Elephant are a source of both hope and frustration in the Huab catchment. Home to the majority of elephant in western Namibia, the catchment is a focal point for efforts to increase revenues through tourism in the region. Although many local residents see the elephant as a potential financial asset (through tourism), others feel they are a hindrance to their efforts to maintain successful agricultural enterprises.


UGAB
15°
16°
17°
20°
14°
21°
N
Outjo
Ugab
450
FRANSFONTEINBERGE
Vingerklip
Erundu
1667
GROOT PARESIS
Otjiwarongo
300
250
350
400
1500
Doros Crater
Gaantagab
150
Sebraskop
Ugab
200
100
Anixab
Okomitze
Ozongombo
KAKOMBO
1616
EISENBERGE
1698
Kalkfeld
Brandberg West
500
TAFELKOP
BRANDBERG
2573
UISBERGE
Uis
Omatjette
1000
ATLANTIC OCEAN
LAND TENURE
PRIVATE
Farmland
STATE
Communal Farmland
Conservation and Tourism
REGIONS
Otjozondjupa
Erongo
Kunene
0
50km
LEGEND
Height Peaks
Proclaimed roads
Power line
Railway line
River
Contour
Major Wetlands
Rainfall in mm

Ugab Catchment

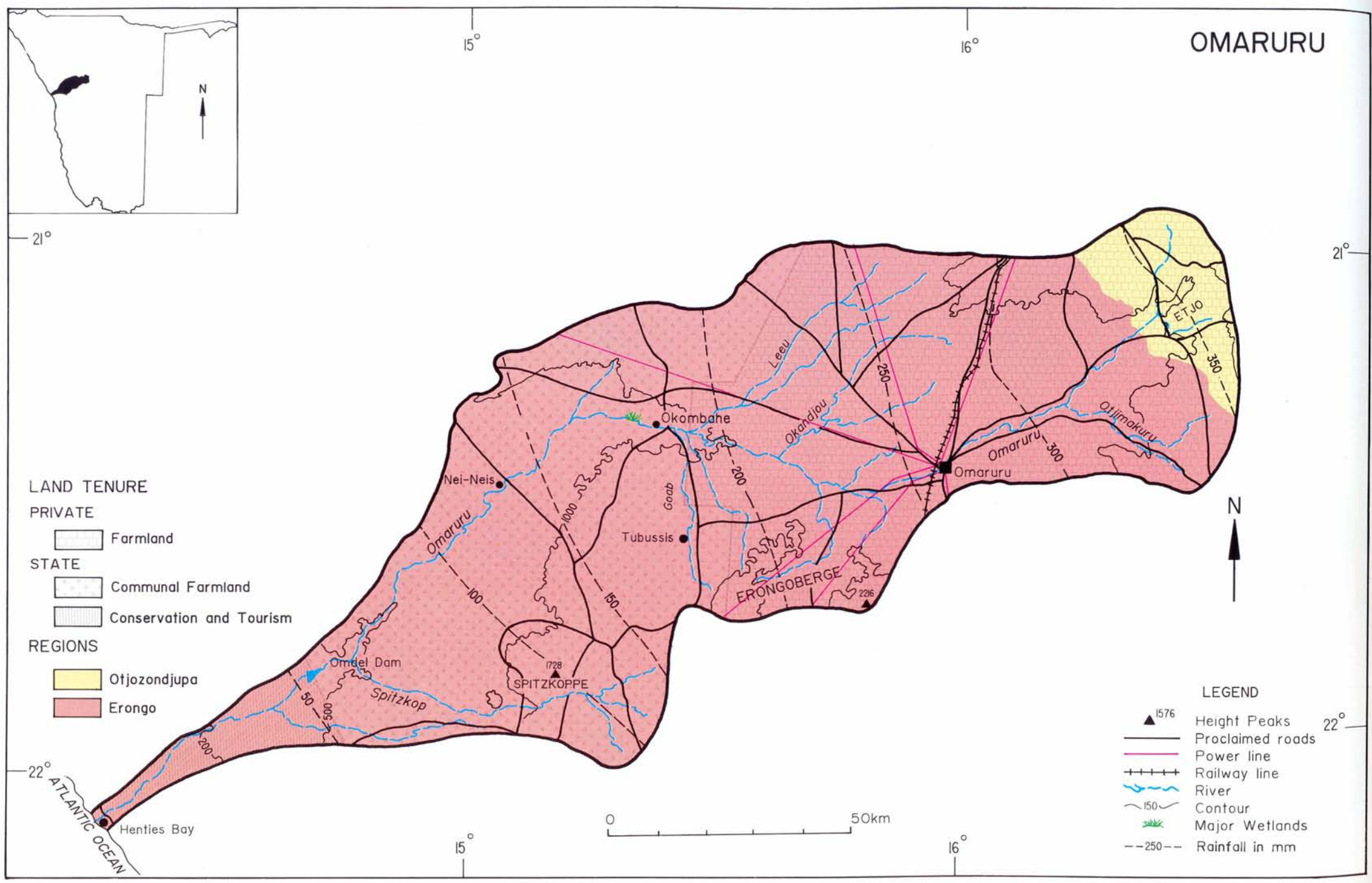
Catchment Area		28 400 km²
Elevation Range		0 - 1865 m
River Length		450 km
Gauging Points on the River		7
Common Riparian Vegetation		ana tree, *Tamarix*, camelthorn, *Salvadora*, mopane, leadwood, *Euclea, Cyperus, Phragmites*
Precipitation Range		0 - 535 mm
Area with Rainfall >100mm		85 %
Area with Rainfall >300mm		49 %
Active Rainfall Stations		16
Catchment Vegetation Types	Northern Namib	3 %
	Semi-desert / Savanna Transition	17 %
	Mopane Savanna	37 %
	Thornbrush Savanna	9 %
	Mountainous Savanna and Karstveld	34 %
Total Population		34 460
Percentage of Population Under 16		39 %
Percentage of Population Cooking With Wood		60 %
Percentage of Households With a Radio		69 %
Percentage of Households Reading a Newspaper Weekly		29 %
Percentage of People Who Have Never Attended School		18 %
Percentage of Population Living in Rural Areas		33 %
Local Authorities		Kalkveld, Otjiwarongo, Outjo, Uis
State Water Schemes		Anixab, Kalkveld, Otjiwarongo, Uis
Proclaimed Road		1 800 km
Catchment Area (km²) / km road		16 km²
Land Tenure	Private	60 %
	Communal	38 %
	Park	2 %
Private Farms		292

This long catchment, extending inland to near Otavi, supports a wide range of land uses including mining, tourism and agriculture. The high agricultural potential of the upstream reaches can be seen in the farming centres of Outjo and Otjiwarongo. In the west, prehistoric settlements at the river mouth and the Brandberg Mountain reflect the nomadic land use most appropriate for the arid regions of western Namibia. The catchment's tourism potential lies primarily in the western areas, with incredible geological features including the Brandberg Mountain, Doros Crater and the Vingerklip. The tourism value has recently been enhanced by elephant, which have re-colonised the river after an absence of more than forty years. Current plans to construct a large dam to supply water to Khorixas threaten to eliminate the tourism, conservation and agricultural value of the lower half of the river where approximately 1000 people live.

The Ugab River, flowing past the base of the Brandberg, has an enormous potential for tourism development that has been little realised. Key to this potential is the spectacular geology of the region combined with the riparian forest, wetlands and wildlife.

The "Mitten Fold", a mountainous formation in the middle reaches of the Ugab River, is the site of the proposed Sebraskop Dam intended to supply water to Khorixas. The mountains are another of the unique geological assets of the Ugab catchment.

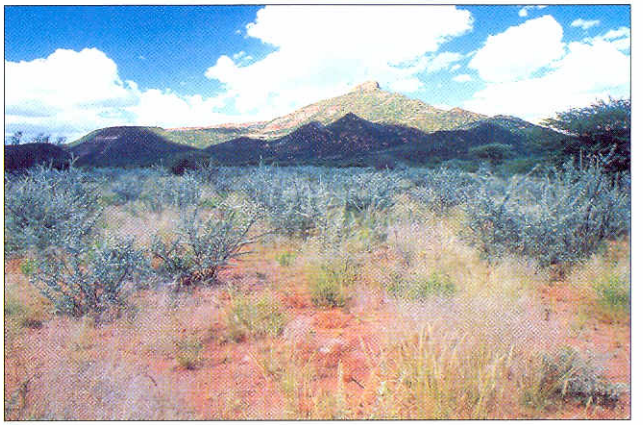
Anixab is home to many of the people living downstream of the proposed Sebraskop Dam. Such communities are totally dependent upon water and vegetation found in association with the riparian forests of ephemeral rivers. If the dam is built, alternative livelihoods must be found for people who depend, directly or indirectly, on the downstream environment.


OMARURU
15°
16°
21°
22°
N
LAND TENURE
PRIVATE
Farmland
STATE
Communal Farmland
Conservation and Tourism
REGIONS
Otjozondjupa
Erongo
Okombahe
Nei-Neis
Tubussis
Omaruru
Leeu
Okandjou
Goab
Otjimakuru
ETJO
ERONGOBERGE
2216
1728
SPITZKOPPE
Omdel Dam
Spitzkop
Henties Bay
ATLANTIC OCEAN
50
100
150
200
250
300
350
500
1000
0
50km
LEGEND
Height Peaks
Proclaimed roads
Power line
Railway line
River
Contour
Major Wetlands
Rainfall in mm

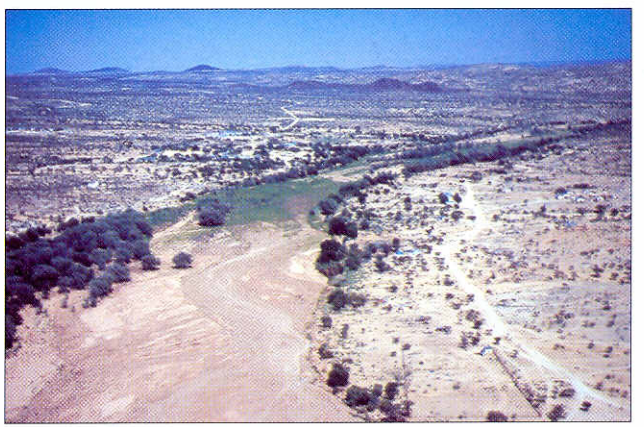
Omaruru Catchment

Catchment Area		13 100 km^2
Elevation Range		0 - 2082 m
River Length		330 km
Gauging Points on the River		5
Common Riparian Vegetation		ana tree, *Tamarix*, camelthorn, *Salvadora*, leadwood, *Euclea*, fig
Precipitation Range		0 - 375 mm
Area with Rainfall >100mm		78 %
Area with Rainfall >300mm		20 %
Active Rainfall Stations		7
Catchment Vegetation Types	Central Namib	7 %
	Semi-desert / Savanna Transition	62 %
	Thornbrush Savanna	31 %
Total Population		11 990
Percentage of Population Under 16		39 %
Percentage of Population Cooking With Wood		75 %
Percentage of Households With a Radio		69 %
Percentage of Households Reading a Newspaper Weekly		23 %
Percentage of People Who Have Never Attended School		15 %
Percentage of Population Living in Rural Areas		59 %
Local Authorities		Omaruru, Henties Bay
State Water Schemes		Central Namib, Henties Bay, Nei-Neis, Okombahe, Spitzkoppe, Tubussis
Proclaimed Road		1 800 km
Catchment Area (km^2) / km road		16 km^2
Land Tenure	Private	46 %
	Communal	52 %
	Park	2 %
Private Farms		102

Draining from the Etjo Mountain and private farms in the east, through communal area settlements such as Okombahe, this catchment has a long history of supporting agricultural development. Recently game farms and guest farms, as well as the coastal town of Henties Bay have provided important contributions to diversified tourism in Namibia. Future development must account for the limited water resources of western Namibia, however, as evidenced by mining of the alluvial aquifer at the river's mouth, to meet water needs for coastal development. This excessive demand has necessitated the recent construction of the Omdel Dam to try and enhance groundwater recharge of the aquifer.

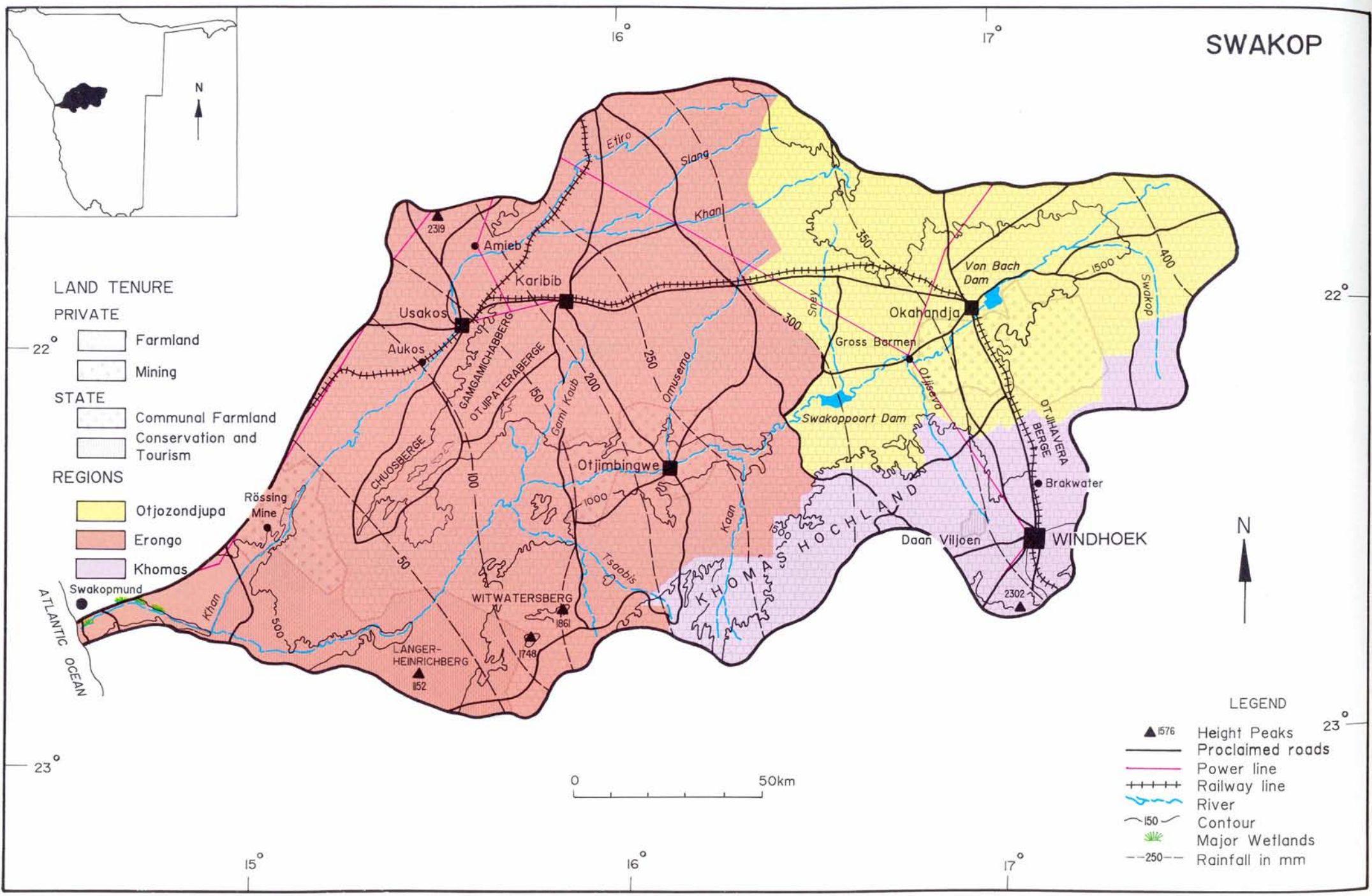


The Etjo Mountain in the upper Omaruru catchment is well known for nearby guest farms and lodges, as well as the dinosaur footprints which occur in the Etjo sandstone nearby. Perhaps less known is the fact that the farms in the area are the source of silt, derived from purple and pink mudstones and shales, which is thought to be sealing the alluvial aquifers in the lower river, thus preventing groundwater recharge during floods.



The Omaruru River at Okombahe has supported crops such as wheat and mealies from before the turn of the century. Groundwater rising to the surface also provides water for livestock in the region and supports a dense forest of ana trees on which the livestock depend.

The Omdel Dam has recently been built in the lower Omaruru River, approximately 40 kilometers upstream of Henties Bay. Its purpose is to impound silt-laden flood waters, allowing the silt to settle. Silt-free water is then to be drained into sandy basins downstream, in an effort to substantially enhance the rate of recharge over that of previous natural floods.


SWAKOP
N
LAND TENURE
PRIVATE
Farmland
Mining
STATE
Communal Farmland
Conservation and Tourism
REGIONS
Otjozondjupa
Erongo
Khomas
16°
17°
22°
23°
15°
Amieb
2319
Karibib
Usakos
Aukos
Okahandja
Gross Barmen
Von Bach Dam
Swakoppoort Dam
Otjimbingwe
Rössing Mine
Brakwater
Daan Viljoen
WINDHOEK
Swakopmund
ATLANTIC OCEAN
WITWATERSBERG
1861
1748
LANGER-HEINRICHBERG
1152
2302
KHOMAS HOCHLAND
GAMSAMICHABBERG
OTJIPATERABERGE
CHUOSBERGE
OTJIHAVERA BERGE
Etiro
Slang
Khan
Omusema
Garni Kaub
Tsaobis
Kaan
Swakop
Oljiseva
Snely
50
100
150
200
250
300
350
400
500
1000
1500
0
50km
LEGEND
Height Peaks
Proclaimed roads
Power line
Railway line
River
Contour
Major Wetlands
Rainfall in mm

Swakop Catchment

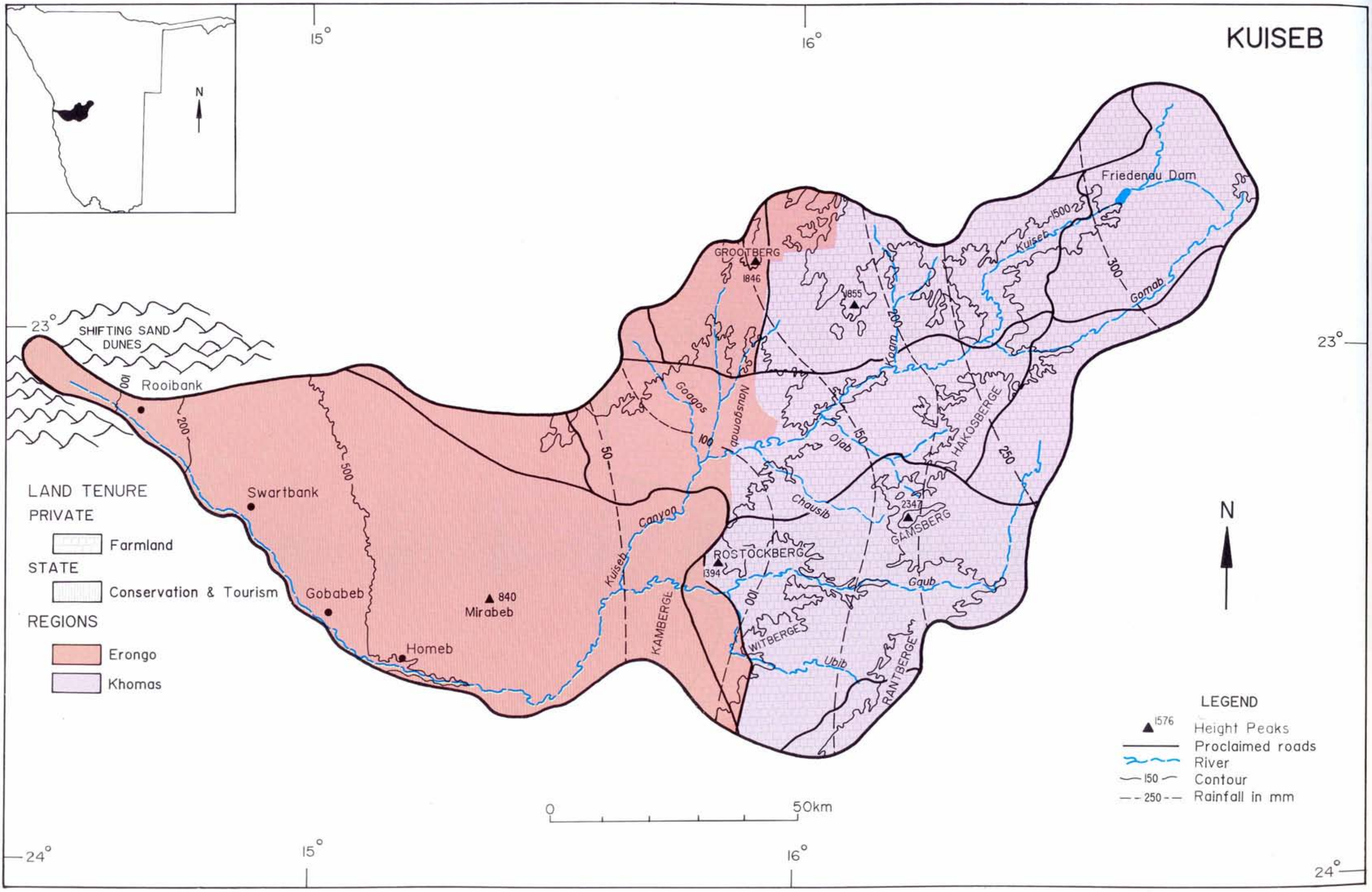
Catchment Area		30 100 km²
Elevation Range		0 - 2479 m
River Length		460 km
Gauging Points on the River		10
Common Riparian Vegetation		ana tree, *Tamarix*, camelthorn, *Salvadora*, fig, *Euclea*, mesquite
Precipitation Range		0 - 475 mm
Area with Rainfall >100mm		80 %
Area with Rainfall >300mm		39 %
Active Rainfall Stations		38
Catchment Vegetation Types	Central Namib	9 %
	Semi-desert / Savanna Transition	34 %
	Thornbush Savanna	28 %
	Highland Savanna	29 %
Total Population		183 120
Percentage of Population Under 16		32 %
Percentage of Population Cooking with Wood		17 %
Percentage of Households With a Radio		79 %
Percentage of Households Reading a Newspaper Weekly		64 %
Percentage of People Who Have Never Attended School		8 %
Percentage of Population Living in Rural Areas		9 %
Local Authorities		Karibib, Okahandja, Swakopmund, Usakos, Windhoek
State Water Schemes		Central Namib - Swakopmund, Daan Viljoen, Gross Barmen, Karibib, Okahandja, Otjimbingwe, Swakopport - Karibib, Usakos, Von Bach - Windhoek
Proclaimed Road		2 000 km
Catchment Area (km²) / km road		15 km²
Land Tenure	Private	89 %
	Communal	1 %
	Park	8 %
	Mining	2 %
Private Farms		305

As the biggest catchment, the Swakop also has the most well-developed infrastructure. Numerous towns, mines, and farms make the catchment an important centre of development in Namibia. The Von Bach and Swakopport Dams provide a large percentage of central Namibia's water supply. Rapidly expanding populations in urban centres, however, necessitate the need for careful development planning which takes into account the increasingly limited water resources of the region. Approximately 200 000 Namibians live within the Swakop catchment. This high population density is partly responsible for the rapid growth in the region's water demand. Two recreational resorts, two parks, numerous guest farms, game farms and the two dams contribute to the tourism potential of this catchment.

Windhoek, the largest urban area in Namibia, lies in the headwaters of the Swakop catchment. To meet its high and uncontrolled demand for water, plans are being considered for expansions to existing wellfields outside of the western catchments. In addition, a link to the Okavango River may soon be needed if the demand for water is not reduced.

The Khan River, the largest tributary of the Swakop, was an impressive site when it came down in flood in 1985. Such large floods, filling the river valley from wall to wall with water, happen very infrequently. (photo: D Heinrich)

The Swakopport Dam, approximately 40 km south-west of Okahandja, is an important water source for Windhoek and Karibib. Completed in 1978, it spilled water for the first time ten years later, in 1988. Although no detailed study has been done to investigate the environmental effects of the dam on the downstream environment, numerous anecdotal reports detail falling water tables, drying springs and dying ana trees.



KUISEB
15°
16°
23°
24°
N
SHIFTING SAND DUNES
Rooibank
Swartbank
Gobabeb
Homeb
840
Mirabeb
GROOTBERG
1846
1855
Friedenau Dam
Kuiseb
Gomab
Goagos
Nausgomab
Kaam
Ojab
Chausib
HAKOSBERGE
2347
GAMSBERG
ROSTOCKBERG
1394
Gaub
WITBERGE
Ubib
RANTBERGE
KAMBERGE
Kuiseb Canyon
LAND TENURE
PRIVATE
Farmland
STATE
Conservation & Tourism
REGIONS
Erongo
Khomas
LEGEND
1576
Height Peaks
Proclaimed roads
River
150 Contour
250 Rainfall in mm
0
50km

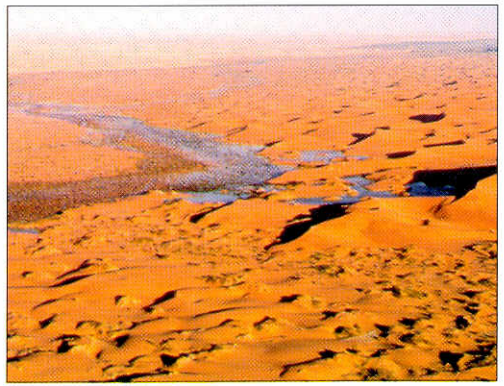
Kuiseb Catchment

Catchment Area		15 500 km²
Elevation Range		22 - 2081 m
River Length		420 km
Gauging Points on the River		14
Common Riparian Vegetation		ana tree, *Tamarix*, camelthorn, *Salvadora*, fig, *Euclea*, !nara
Precipitation Range		0 - 335 mm
Area with Rainfall >100mm		52 %
Area with Rainfall >300mm		5 %
Active Rainfall Stations		8
Catchment Vegetation Types	Central Namib	37 %
	Semi-desert / Savanna Transition	34 %
	Highland Savanna	27 %
	Dwarf Shrub Savanna	2 %
Total Population		24 935
Percentage of Population Under 16		36 %
Percentage of Population Cooking With Wood		81 %
Percentage of Households With a Radio		71 %
Percentage of Households Reading a Newspaper Weekly		19 %
Percentage of People Who Have Never Attended School		31 %
Percentage of Population Living in Rural Areas		100 %
Local Authorities		Walvis Bay
State Water Schemes		Central Namib - Walvis Bay, Friedenau, Gobabeb
Proclaimed Road		800 km
Catchment Area (km²) / km road		19 km²
Land Tenure	Private	63 %
	Communal	0 %
	Park	37 %
Private Farms		109

Draining from private farmland in the Khomas Hochland, the Kuiseb River flows through the Namib-Naukluft Park, where its vegetation and groundwater support the park's wildlife, communal farmers and the coastal towns of Walvis Bay and Swakopmund. The most thoroughly studied of the western rivers, the Kuiseb is home to the Desert Research Foundation of Namibia. With the lower catchment's unique arid environment divided by this linear oasis, the region is of great conservation and tourism significance to Namibia. The construction of ground dams on farms in the headwaters and the pumping from coastal aquifers has altered the availability of water within the catchment. Although these alterations have supported agricultural and urban development, there is concern about their effect on downstream environments, which also support agriculture and tourism.

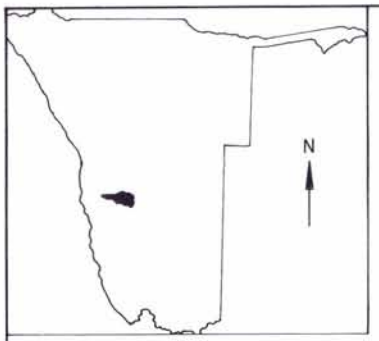
The headwaters of the Kuiseb catchment begin just to the west of Windhoek in the private farmlands of the Khomas Hochland. The highland savanna, seen here, supports commercial livestock production.

Where the Kuiseb crosses the central Namib Desert, as at Gobabeb, it creates a striking contrast between the barren gravel plains to the north and the large red sand dunes to the south. The river forms a lush green linear oasis in an otherwise harsh environment.



The lower Kuiseb River aquifer has played a crucial role in the economic development of Namibia by supporting the development of the coastal towns and the Rössing Uranium mine. The last major flood on the Kuiseb was in 1974, seen here flowing past the Rooibank water works. (photo: M Seely)

TSONDAB



16°

24°

CENTRAL NAMIB SAND SEA

Tsondabvlei

Koireb

Tsondab

Diep

Solitaire

Noab

REMHOOGTEBERGE

1853

Tsondap

NAUKLUFTBERGE

1949

50

100

150

200

900

1500

LAND TENURE

PRIVATE

Farmland

STATE

Conservation and Tourism

REGIONS

Hardap

N

0

50km

LEGEND

1576 Height Peaks

Proclaimed roads

River

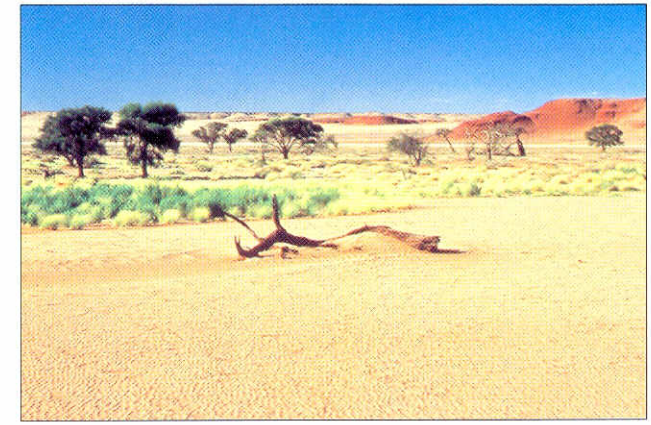
150 Contour

250 Rainfall in mm

Tsondab Catchment

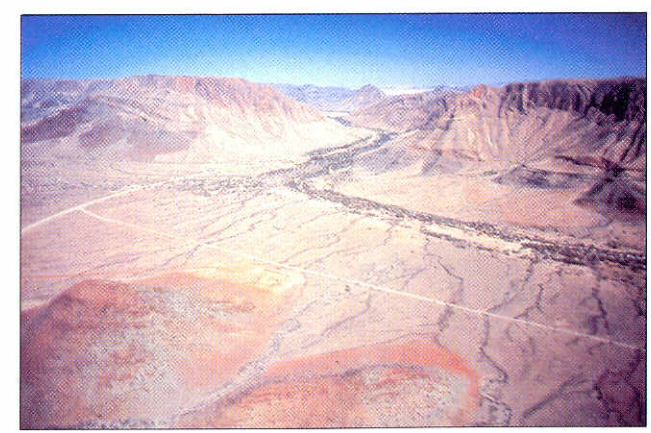
Catchment Area		3 500 km^2
Elevation Range		640 - 1927 m
River Length		150 km
Gauging Points on the River		0
Common Riparian Vegetation		camelthorn, *Acacia tortilis*, fig
Precipitation Range		0 - 205 mm
Area with Rainfall >100mm		70 %
Area with Rainfall >300mm		0 %
Active Rainfall Stations		2
Catchment Vegetation Types	Central Namib	13 %
	Semi-desert / Savanna Transition	55 %
	Dwarf Shrub Savanna	32 %
Total Population		411
Percentage of Population Under 16		36 %
Percentage of Population Cooking With Wood		88 %
Percentage of Households With Radios		44 %
Percentage of Households Reading a Newspaper Weekly		2 %
Percentage of People Who Have Never Attended School		33 %
Percentage of Population Living in Rural Areas		100 %
Local Authorities		None
State Water Schemes		None
Proclaimed Road		180 km
Catchment Area (km^2) / km road		19 km^2
Land Tenure	Private	74 %
	Communal	0 %
	Park	26 %
Private Farms		26

This small catchment drains an arid region in the Naukluft Mountains, ending in a large vlei, which supports one of the largest populations of lapped-faced vultures in Namibia. The limestone and dolomite of its headwaters are associated with unique geological formations and the presence of short perennial streams in an otherwise arid area. These features, both in the headwaters and vlei, are both well protected and well used within the Namib-Naukluft Park. Although the Tsondab River currently ends at the eastern edge of the main Namib Sand Sea, its endpoint has fluctuated over time in response to changing climates, having been considerably further west in the past.

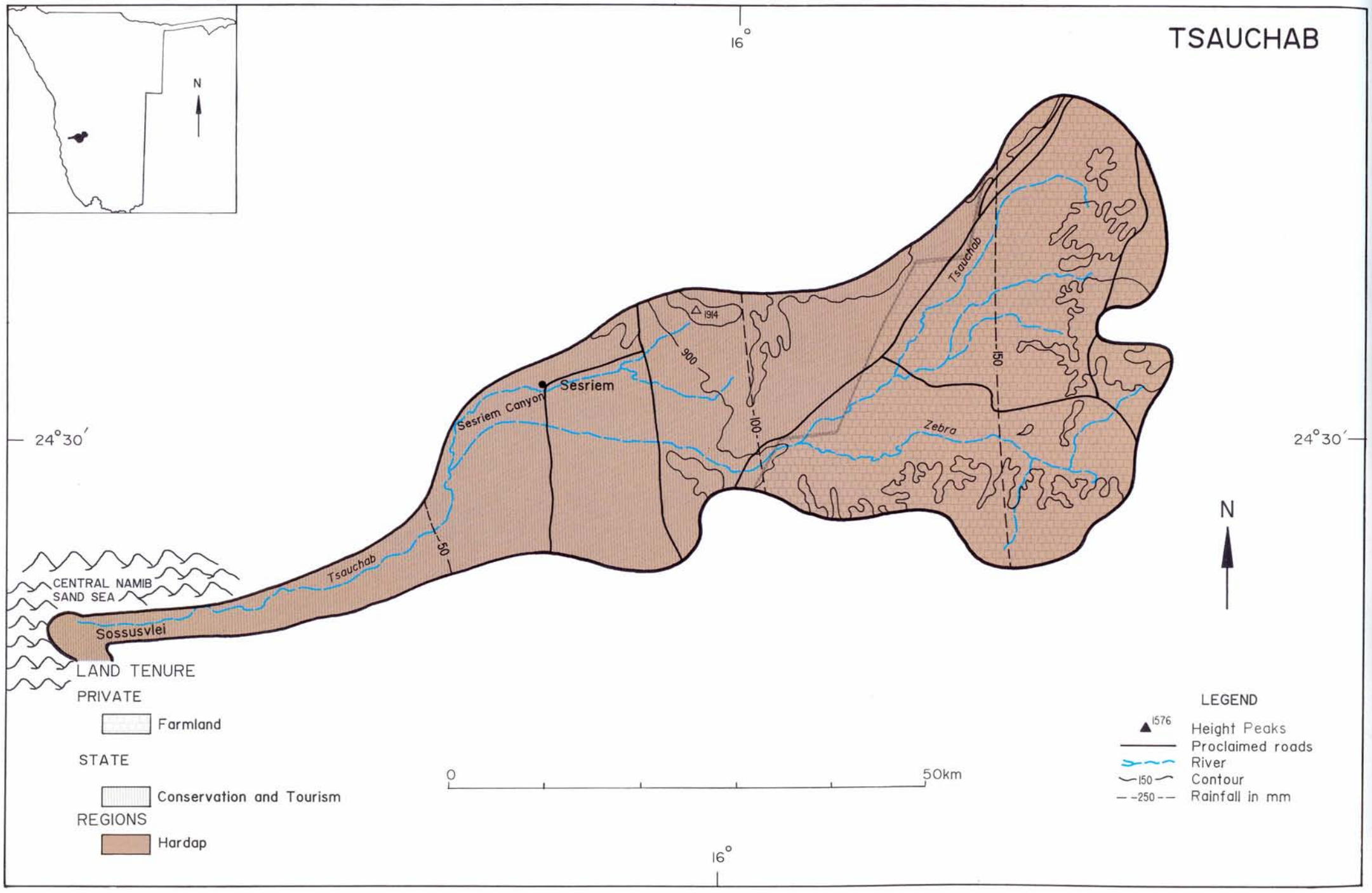


The Tsondab River ends in a large vlei on the eastern edge of the main Namib Sand Sea. Although rarely filling with floodwaters, the vlei supports a dense stand of Acacia trees in which lappet-faced vultures rest and breed.

The Naukluft Mountains are a popular destination for hikers in Namibia. Composed largely of limestone, they contain numerous springs and small streams, creating a unique setting in an otherwise arid region.



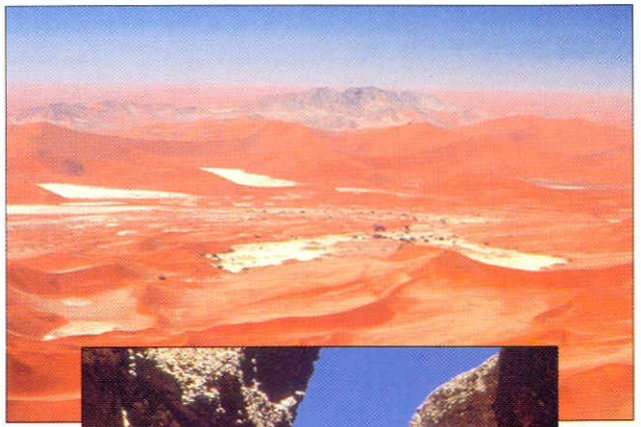
The Tsondab River, draining from its headwaters in the Naukluft Mountains, is well known for its abundant fig trees, and the large Acacia tortilis *which grow in its lower reaches.*


TSAUCHAB
16°
24°30′
24°30′
16°
N
Tsauchab
Sesriem
Sesriem Canyon
Zebra
△ 1914
900
100
150
50
CENTRAL NAMIB
SAND SEA
Sossusvlei
LAND TENURE
PRIVATE
Farmland
STATE
Conservation and Tourism
REGIONS
Hardap
0
50km
LEGEND
▲1576 Height Peaks
Proclaimed roads
River
150 Contour
--250-- Rainfall in mm

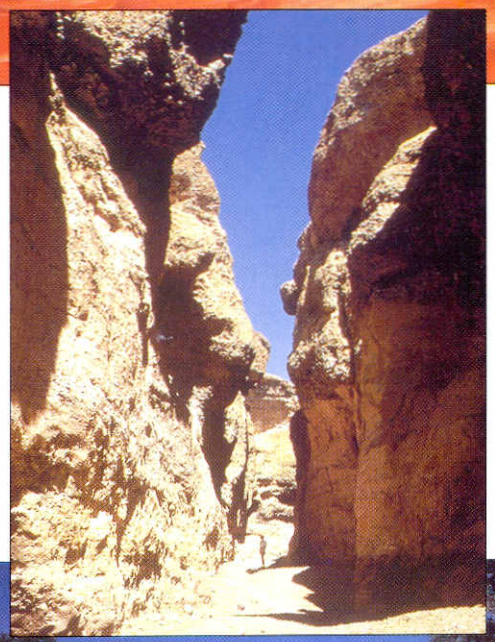
Tsauchab Catchment

Catchment Area		4 000 km²
Elevation Range		586 - 1931 m
River Length		150 km
Gauging Points on the River		1
Common Riparian Vegetation		camelthorn, *Acacia tortilis*, fig
Precipitation Range		0 - 175 mm
Area With Rainfall >100mm		60 %
Area With Rainfall >300mm		0 %
Active Rainfall Stations		3
Catchment Vegetation Types	Central Namib	9 %
	Semi-desert / Savanna Transition	68 %
	Dwarf Shrub Savanna	23 %
Total Population		230
Percentage of Population Under 16		31 %
Percentage of Population Cooking With Wood		82 %
Percentage of Households With a Radio		52 %
Percentage of Households Reading a Newspaper Weekly		7 %
Percentage of People Who Have Never Attended School		32 %
Percentage of Population Living in Rural Areas		100 %
Local Authorities		None
State Water Schemes		None
Proclaimed Road		180 km
Catchment Area (km²) / km road		22 km²
Land Tenure	Private	78 %
	Communal	0 %
	Park	22 %
Private Farms		40

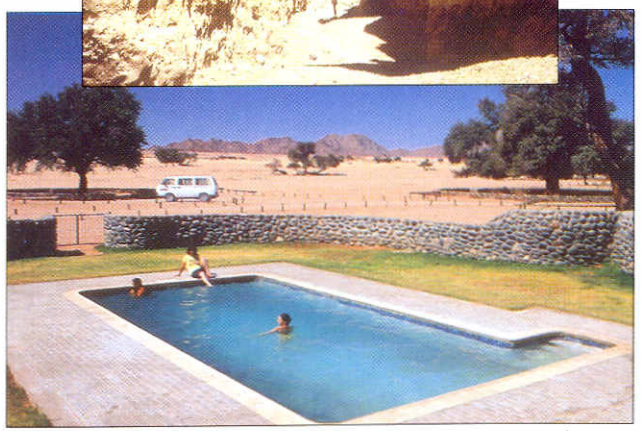
The Tsauchab River rises on the southern side of the Naukluft Mountains, flows through a deep narrow canyon carved into deposits of alluvial sediments, and ends amongst the massive dunes of the main Namib Sand Sea. Infrequent heavy rains over the escarpment push the river through the sands, filling Sossus Vlei. Other endpoints and watercourses testify to past periods of greater water flow under different climatic conditions. Park and private tourism facilities are being developed to capitalize on the diverse scenic beauty of this catchment. Such development must, however, account for the limited water resources as well as the sensitive physical and biotic features of this arid region.



Sossus Vlei is the end point of the Tsauchab River in the high dunes of the main Namib Sand Sea. This beautiful area is one of the best known tourist destinations in Namibia.



The Sesriem Canyon, just to the east of Sossus Vlei, is the result of the down-cutting of the Tsauchab River into gravelly sediments which it deposited millions of years ago. (photo: D Heinrich)



Although swimming pools in the desert, such as this one near Sossus Vlei, are an inviting sight to the hot and dusty traveller, they may also represent an unsustainable use of a precious resource. Development within all of the western catchments must be guided by the need to efficiently use water, Namibia's most valuable natural resource. (photo: D Heinrich)

Glossary

aesthetic - concerned with beauty or appreciation of beauty

agenda - a series of things to be done or items to be considered

agriculture - the practice of cultivating plants and rearing animals

aggrieve - to distress or cause harm

alien - referring to a plant that is not naturally from the region but which has become established here

alluvial deposit - soil left over from floods, especially found in a river valley or delta

alluvium - loose (unconsolidated) material deposited by flowing water

annual grass - a grass plant that can only grow from seed every rainy season (contrast with perennial grass)

apathy - lack of interest or feeling; indifference

appropriation - take possession of or be allocated for a particular use

aquifer - thick layers of sand or other porous (penetrable) material contained within non-porous (not penetrable) rock, that can hold water and serve as a source of groundwater

archaeology - the study of human history and prehistory through the excavation of sites and the analysis of physical remains, such as artifacts, rock paintings and rock engravings

arid - an area where mean annual rainfall is less than 250 mm; rainfall is seasonal, highly variable from year to year, and evaporation is high

artifacts - objects, utensils or art work made by prehistoric people

artificial water point - any man-made structure used to harvest rainwater or access groundwater

aspiration - ambition or goal

bedrock high - a place in a river where the underlying rock is close to the surface or exposed at the surface

biodiversity - biological diversity - the variety of organisms found in an area; their abundance and proportion of each type

biotic - factors (such as soil nutrients or organic matter) which reflect the influence of biological organisms, especially regarding soil and vegetation development

bore - the front edge of a flood frequently described as 'a wall of water'

borehole - a deep narrow hole made in the earth to find water

brackish - slightly salty

bulk - in large quantities

bulk water scheme - a water development engineered to provide water in large quantities

cache - a hiding place for provisions

calcareous - made of or containing calcium carbonate; chalky lime

calcified - something that has become hardened as a result of the deposition of calcium carbonate; to cement

calcrete - a (rock-like) conglomerate formed from the cementing of sand and gravel with calcium carbonate; a fossil calcareous soil (hardened)

capital - the money or other assets used to start a business (for example, a campground or hotel) or develop an infrastructure (for example, a dam)

catchment - the area from which rainfall flows into a river; catchments are separated from one another by high ground such as mountains and ridges.

channel - the deepest portion of a river through which the main volume of water flows

citizen - a member or national of a country with all related rights and responsibilities

clay - a very fine grained inorganic soil type; particle size less than 0.005 mm (contrast with sand and silt)

colluvial deposit - a mixture of loose rocks and fragments, scree (small stones) and mud which has slid down to the base of a slope

colonial era - the period in Namibia's history when it was occupied by other countries, namely Germany, Britain and South Africa

commercial - having profit as the primary aim

commercialise - to exploit for making a profit (contrast with privatise)

commission - a person or group requested (most often by a government) to perform a certain task or set of duties

communal land - land available for common use; in Namibia this land is currently owned by the State

community - all the people living in a specified area

compaction - compress, or make smaller; referring to soil surface compaction: the removal of all airspaces thus affecting soil infiltration rates and survival of soil organisms

concession - permission acquired from the Ministry of Lands, Resettlement and Rehabilitation or Ministry of Environment and Tourism by individuals who want to use a large piece of State land for a commercial enterprise such as tourism; terms are negotiated for payment, duration of agreement and boundaries as in a lease agreement

conglomerate - coarse-grained sediment composed of rock fragments cemented in a matrix (surrounding medium), often composed of calcium carbonate

conservancy - an area of land shared by multiple owners or users who jointly pool their land and/or financial resources to make available a larger unit for management

conservation - protection of natural resources and ecological processes from destruction by human misuse

consumption - the use of a resource which entails the destruction of that resource; consumption is sustainable only if the amount of consumption does not exceed the amount of replacement of the resource

consumptive wildlife use - the use of wildlife which involves its destruction, for example, hunting for meat and other animal products (contrast with non-consumptive wildlife use)

continental drift - the hypothesis that the continents are moving slowly over the surface of the earth on a deep-lying flexible substratum

dam - a structure built across a river or stream bed to hold back surface water (sand dam, ground dam, farm dam), OR a structure used to store groundwater that has been pumped to the surface (ring dam, reservoir)

degradation - to diminish the productivity of land through mismanagement

denudation - the removal of all material (that is, vegetation) covering and holding soil

desalination - the process by which salt is removed from water

desertification - land degradation in arid, semi-arid and dry sub-humid lands resulting mainly from adverse human impact (UNEP, 1992)

development - the process of achieving 'better' social and economic conditions

discharge - a measure of the amount of water transported per unit of time within a flowing river

drought - a period of more than 2 years with rainfall lower than the long-term mean; which is a normal occurrence in arid and semi-arid areas

drylands - a collective term used to describe arid and semi-arid areas

ecology - the branch of biology dealing with the relations of organisms (including humans) to one another and their physical surroundings

economic exclusion zone - in Namibia, the zone extending out 200 km from the coast set aside by the government to be used exclusively by the Namibian fishing industry.

economic sustainability - maintenance of the resource and financial base for continued use by future generations

economy - the production, management and use of the wealth and resources of a community; the national economy refers to that of the nation as a whole

ecotourism - tourism in which the natural environment is one of the main interests of the tourists

effluent - used to refer to recycled water, not purified to the level of human drinking water

empower(ment) - authorise or enable person(s) to do something

enclosure - an area fenced in so as to make it private property and inaccessible to outside users

endemic - living organisms only found in a certain area and no where else; unique to a region

enforce (the law) - force or compel people to abide by a set of rules or regulations

engineering - the application of science to the design, building and use of constructions (for example, dams) and machines

environment - the living and non-living surroundings in which we live

environmental assessment - a study undertaken to determine the effect of some planned action on the environment

environmental sustainability - the non-wasteful use of natural resources for appropriate reasons that does not jeopardise the availability of these resources for use by future generations

ephemeral - lasting only a few days; when applied to rivers, describing a river that only flows for a few days each year after localised rainfall

episodic - occuring at widely separated and unpredictable times

equality - the state of being equal; having the same in quantity, quality, size or degree

equity - fairness; application of principles of justice

erf - a surveyed plot within the jurisdiction of an urban authority (plural: erven)

erosion - wearing away of the earth's surface by the action of water and wind; frequently used to refer to removal of top soil following denudation (made bare)

evaporation - water loss to vapour that takes place from open surface water

evapotranspiration - evaporation plus transpiration

exploitation - to use or take advantage of a resource for one's own benefit without regard for the needs of others, present or future

exorbitant - excessive

extinct - used to describe a type of living organism that once lived on earth but has died out or been exterminated

finite - bounded, limited, restricted, the opposite of limitless or infinite

fissure - an extensive crack or break in the rocks

flood - a body of water which temporarily covers land that is usually dry throughout the year

flood discharge - the amount of water transported in a river channel

flood frequency - how often we can expect floods of a particular size

flood frequency curve - a plot used to graphically express information about flood frequency

flood velocity - how fast water moves past a fixed point, generally expressed in terms of metres/second

floodplain - the portion of a river valley, adjacent to the channel, which is covered by water when the river overflows it banks at high flood stages

fluvial - from a river, or in a river

forage - food for livestock or wildlife

fuel-efficient stove - stoves that reduce the loss of heat from fires, through more efficient burning of fuel, ensuring more productive use of the heat for cooking and heating. Such stoves require substantially less wood than does an open fire

geohydrology - branch of hydrological study that deals specifically with ground water

geology - study of the earth, including the composition, structure and origin of its rocks, and the processes of change which they have experienced or are currently experiencing

glacial erratic - a large boulder which is different from the bed-rock on which it lies and was transported there by a glacier

glaciation - alteration of the earth's surface through erosion and deposition of glacial ice

glacier - a mass of ice originating from compaction of snow under pressure, which moves very slowly in a definite direction

Gondwana - the ancient continent composed of Africa, South America, Antarctica, Australia and India which started drifting apart about 170-150 million years ago

gradient - change in a factor over distance, for example, rainfall, vegetation type, vegetation cover, temperature

gravel - loose, uncemented and waterworn rock fragments

groundwater - water found beneath the Earth's surface in the soil or in pores, crevices or caves within rock

gypsum - a hydrated form of calcium sulphate, a mineral

habitat - the natural home of an organism

halomorphic - a soil type which is mostly saline

hunter-gatherers - persons who obtain their food from wildlife and natural vegetation

hydrograph - a graph representing river discharge over time at a specific point along the river

hydrology - the study of ground and surface water, including its properties, distribution, movement and utilization

impermeable - cannot be penetrated by water

indigenous - originally or naturally from the area

infiltration rate - how rapidly water moves into a particular soil type; a property of soil which depends on compactness or friability of the surface, vegetation cover, and soil type

inflation - the situation where an increasing amount of money is needed to purchase a fixed amount of goods

infrastructure - the basic structural foundations of a society or business, for example, roads, bridges sewers; with respect to water supply, all man-made structures such as dams, pipes, water treatment plants

inhabitant - a person who lives in a specific area

inselberg - isolated hill or mountain (island mountain)

invasive - indigenous or alien plants that become established and proliferate, excluding other plants; commonly found in disturbed areas such as river beds, flood plains, overgrazed areas or road verges

investment - the application of money now to make a profit in the future

irrigation - the application of water to land for the purpose of growing plants

jurisdictional boundary - boundary of an area controlled by a particular authority (for example, regional boundaries)

land use planning - developing a plan for the sustainable use of an area and its resources

lava - molten rock which flows from a volcano or deep-seated fissure

legislation - all of the nation's laws

linear oasis - the narrow, vegetated strip associated with a river course crossing through an arid region

lithosol - a thin, weakly developed soil overlying a hard rock surface

littoral - of or on the sea or lake shore

loam - a soil type composed of a mixture of clay, silt and sand

loan - an amount of money obtained from someone or an institution (for example, a bank) that must be returned, usually with extra money for the length of time it was borrowed (interest)

management - the process of organising and regulating the use or production of something

mandate - an official command or instruction by an authority

meter - to measure using an instrument (meter) which determines the amount of something, for example, the amount of water being used in a town or home

millennium - one thousand years (plural: millennia - thousands of years)

natural resources - attributes of the natural environment such as water, minerals, soil, biodiversity and scenery, that can be used by people for various purposes

natural resource base - the core amount of a resource that must be maintained if use of that resource is to be sustainable

nomadism - the way of life which involves constant movement in search of water, food and livestock forage

non-consumptive wildlife use - the use of wildlife which does not involve its destruction, for example, viewing, photography and art (contrast with consumptive wildlife use)

non-governmental organisation (NGO) - organisations that do not belong to the government

operational cost - the amount of money needed (price) to run or operate something

opportunistic management - flexible management that allows one to use positive situations to their fullest advantage and to avoid the negative effects of bad situations

opportunity cost - the price to be paid for an opportunity lost, for example, building a dam may provide bulk water to a town but it will restrict water flow to the lower reaches of the river thus limiting the area's agricultural, environmental and tourism potential (the value of the best alternative use of a resource)

organic matter - the remains of living organisms in soil or water

orogen - a belt of deformed rocks

orogeny - the process of forming mountains, particularly by folding and thrusting

overgrazing - to use an area too much for the purposes of grazing, such that the area is degraded or damaged and will not return to its original state following adequate rains

palaeochannel - an ancient course of a river or stream, made obvious by the alluvial deposits associated with it

palaeohydrology - the study of ancient ground and surface water, including its properties and distribution

parastatal - a State activity managed by applying corporate values and financial motives (SWAWEK is a well known Namibian example)

perennial - a plant which grows for more than one season

perennial grass - a grass plant that grows from seed one year and continues to grow in following years (contrast with annual grass)

per capita - per person

planning - deciding how something will be organised or used

plant community - the group of plants growing in a particular area that generally require or can tolerate

similar physical conditions (for example, moisture, light, nutrients, disturbance)

poach - to catch or kill wildlife illegally

policy - a course of action or principle proposed and/or adopted by a government, business, organization or individual

population - the people that live in a specific area

population growth - the increase in numbers of people over time

post - a place with agricultural infrastructure, for example, water supply, kraals, holding pens

poverty - a state of scarcity or want; being unable to satisfy basic needs for food, shelter and peace of mind

precedent - an example or model that can be referred to in the future

predator - an animal which preys on other animals

prehistoric - relating to the period before written records

preservation - maintaining an area in its present state and allowing no use of the resources

primary production - the growth of plants

private-hold farms - farm land owned by individuals, and not by the State (contrast with communal land)

privatise - to assign a business to private ownership, being distinct from State control or ownership (contrast with commercialise)

proclamation - an official public statement or declaration

protectorate - an State that is controlled and protected by another

PTO - Permission To Occupy; permission acquired from the Ministry of Lands, Resettlement and Rehabilitation or the Ministry of Environment and Tourism by individuals who want to occupy a piece of property less than 2 hectares in size, on State lands, for the purpose of enterprise; no specific terms are negotiated with respect to duration or rental

radiocarbon dating - a method used to determine the age of water or an organism that died long ago (for example, wood, fossils, skeletons); the accuracy of which is limited to not more than 25 000 years before present

rain gauge - a container used to measure rainfall

rainfall isohyet - a line on a map connecting places that have the same amount of annual rainfall

rangeland - open country (usually grasslands) used by grazing livestock

ration - to share out in limited quantities

rationalise - to make more efficient by reorganising so as to reduce waste of labour, time or resources

recharge - the amount of water required to return an aquifer to its original level or to a sustainable level

recruitment - adding more individuals to a population of organisms (for example, more grass plants or trees to a savanna)

research - a well ordered and systematic search for the answers to specific questions in order to establish facts and reach a more thorough understanding of a subject

resilience - the ability of something to recover from disturbance to its original state

resin - a liquid secreted by some plants (gum)

resolution - settlement or solution to a problem

return interval - how often we can expect a particular event to happen again

riparian - of or on a river bank, or associated with a river

river bed - channel

riverine - of, or dwelling in or near a river

runoff - flow of rain water down a slope

rural - living in large open undeveloped land or agricultural land (contrast with urban)

safe yield (sustainable yield) - the rate at which a natural resource (for example water) can be used without exceeding the rate at which it is replaced by natural processes (for example, rainfall)

saline - containing salt

sand - a coarse grained inorganic soil type; particle size between 0.06 mm and 2.0 mm

saturate - to completely fill with moisture or soak thoroughly

savanna - grassland with few or no trees

seasonality - condition when processes occur only during certain parts of the year

sediment - matter that is carried by wind or water and deposited on the surface of the land, and may in time become consolidated into rock

seed bank - a store of seeds in the soil needed for subsequent recruitment

semi-arid - an area with mean annual rainfall between 250-600 mm; rainfall is seasonal, highly variable from year to year, and evaporation is high

silt - a fine grained inorganic soil type; particle size between 0.002-0.05 mm

social - relating to the organisation, functioning and behavior of humans as a group or society

social sustainability - the social framework which empowers self-control over resources, at the individual and national level; goals include population stability, poverty alleviation and empowerment of women

socio-economic - relating to the interaction of social and economic factors

soil - the upper layer of the earth in which plants grow; soil can consist of different types of disintegrated rock, organic material, moisture and air

spring - a site where groundwater flows to the surface

stabilise - to make something become stable or keep from changing further

State - an organised political community with a government recognised by the people

stock rotation - the continual process of moving stock between fenced-off camps, allowing them to graze and drink at artificial water points in each camp for a certain time period

stratification - arrangement or construction into layers or social grades

stratigraphy - the order and relative position of rock layers

subsidize - to pay a subsidy to someone

subsidy - any grant or contribution of money, often provided by national governments to reduce the price of commodities or services for people

succulent - a plant with thick and fleshy leaves adapted for arid conditions

sustain - to maintain for current and future generations

sustainable development - the process of improving or maintaining quality of life of the present population without limiting the social and economic development potential of future generations

sustainable resource use - use of natural resources in such a manner that the supply of that resource is never diminished or lost (for example, sustainable water use means that water will continue to be available at current levels for future generations)

tariff - a fixed amount to pay

tenure - the ownership of land or property

terrace deposit - the remains of a former floodplain of a river; in a coastal marine deposit indicating the position of a former shoreline

topography - the description of the surface features of an area, including land forms and all natural and man-made objects

tourism industry - the organisation and operation of holidays and holiday facilities as a commercial enterprise

transhumance - seasonal movement of livestock between specific areas (for example, high and low pastures on the Brandberg) driven by fodder and water needs

transpiration - evaporation from the leaves of plants; the flow of water through plants from soil to atmosphere

tributary - a stream or river that joins a larger one

trivialise - reduce the importance of something

ungulate - any hoofed grazing mammal

urban - living in, or situated in a town or city (contrast with rural)

urbanisation - the concentration of an area's population in towns or cities

variable - subject to change

vegetation - plants growing in a particular area

vertebrate - all animals with a backbone including fish, amphibians, reptiles, birds and mammals

volcano - a naturally occurring vent or fissure at the earth's surface through which molten, solid and gaseous materials flow

water efficiency - the non-wasteful use of water for appropriate reasons

water table - the upper surface of a zone of saturation in an aquifer

waterworks - any structure developed for the purpose of obtaining or accessing water

weir - any structure built across the width of a river bed to regulate its flow; in Namibia weirs are low concrete walls used to stabilize the channel bottom so that discharge can be accurately measured

wetland - an area where soil is continuously moist; associated with groundwater streams forced to the surface by shallow bedrock

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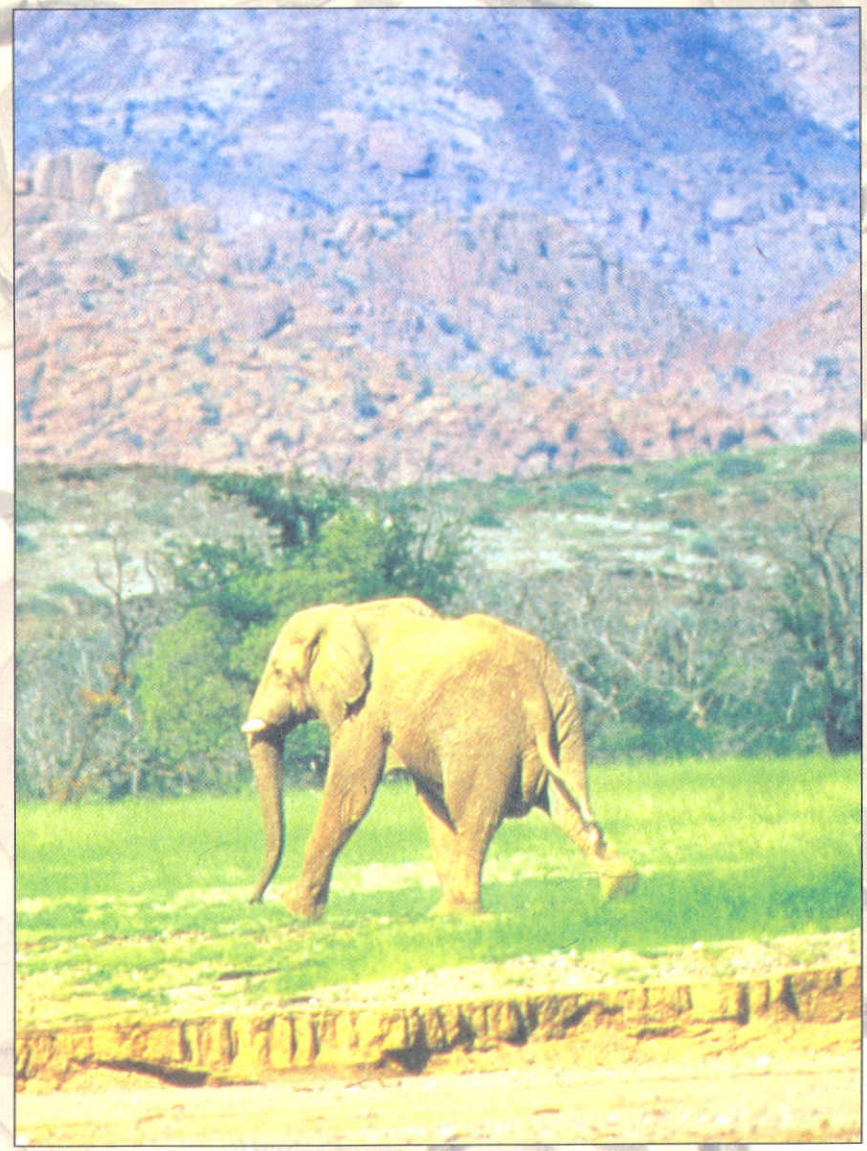

The fact to be remembered in regard to the westward-flowing ephemeral rivers is the importance of uninterrupted flooding. Any development within a catchment which alters runoff patterns can affect the environment and its users downstream. It is essential that all Namibians dependant upon the natural resources of the catchments are as aware of this fact as are these students, running from a flood in the Kuiseb River.