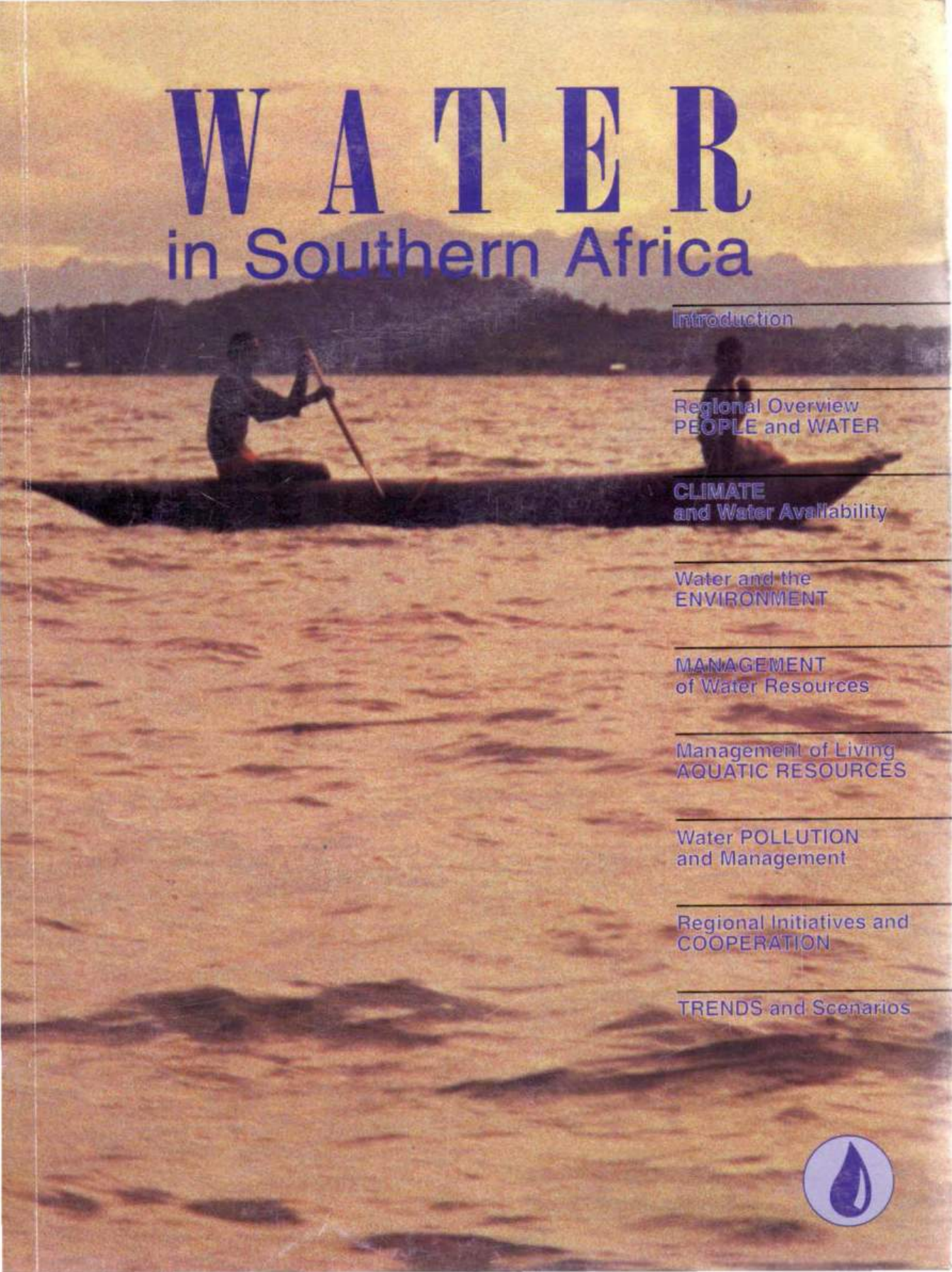
WATER
in Southern Africa



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PEOPLE and WATER

CLIMATE
and Water Availability

Water and the
ENVIRONMENT

MANAGEMENT
of Water Resources

Management of Living
AQUATIC RESOURCES

Water POLLUTION
and Management

Regional Initiatives and
COOPERATION

TRENDS and Scenarios

WATER
in Southern Africa

A Report by
SADC - Southern African Development Community
IUCN - The World Conservation Union
and
SARDC - Southern African Research & Documentation Centre

editors

Munyaradzi Chenje
Phyllis Johnson

writers

Munyaradzi Chenje
Maxwell Z. Chivasa
Alexandra Serra King
Elton Laisi

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IUCN
The World Conservation Union

SARDC
Southern African Research and Documentation Centre

SADC - Southern African Development Community
Environment and Land Management Sector Coordination Unit
Box 24, Maseru 100, Lesotho
Email: SADC@ELMS.RU.AC.ZA
Tel 266-312158 Fax 310190/310465

IUCN - The World Conservation Union
Regional Office for Southern Africa
Box 745, Harare, Zimbabwe
Tel 263-4-728266/7 Fax 720738

SARDC - Southern African Research & Documentation Centre
India Musokotwane Environment Resource Centre for Southern Africa (IMERCSA)
Box 5690, Harare, Zimbabwe
Email: IMERCSA@MANGO.ZW
Tel 263-4-720814/737301 Fax 738693

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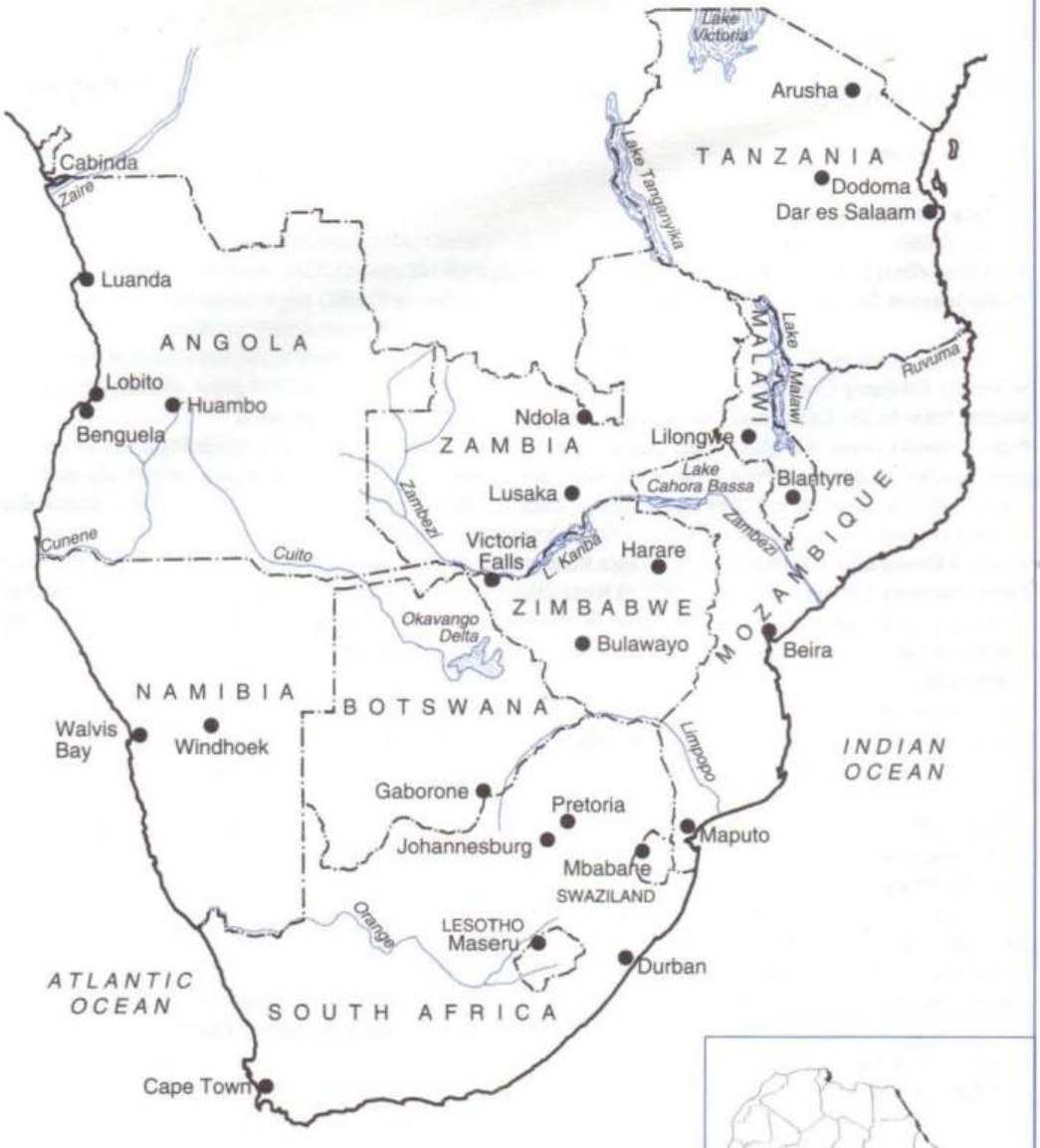

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COMMUNICATING THE ENVIRONMENT PROGRAMME (CEP)

Water in Southern Africa

SARDC-IMERCSA Staff

Munyaradzi Chenje, Director
Maxwell Chivasa, Projects Editor/Manager
Elton Laisi, Regional Consultant
Alexandra S. King, Researcher/Writer
Wilson Yule, Documentalist/Librarian
Rufaro Chigoma, Administrative Assistant

Production and Design

Paul Wade, Ink Spots Design Studio

Cover design by Paul Wade, photograph of Lake Malawi by Munyaradzi Chenje. The photograph of three traditional fishers, their dugout canoes, water and the land in the background, represent the living and non-living resources, emphasising the role water plays in influencing not only the shape of the land but also people's activities in different parts of the region.

CONTRIBUTORS and Writers by Chapter

1 Regional Overview PEOPLE AND WATER (by A. S. King and M. Chenje)
Munyaradzi Chenje, Director, IMERCSA, Zimbabwe

2 CLIMATE and Water Availability (by M. Chivasa and M. Chenje)
Bradwell Garanganga, Coordinator, SADC Drought Monitoring Centre, Zimbabwe
Maurice Muchinda, Chief Meteorologist, Climatology and Advisory Services, Zambia
Elton Laisi, Former Controller of Water Services, Water Department, Malawi
Moremi Sekwale, Coordinator, North-South Carrier Water Project, Ministry of Mineral Resources and Water Affairs, Botswana
Pelotshweu Phofuetsile, Acting Principal Hydrologist, Geological Survey Department, Botswana

3 Water and the ENVIRONMENT (by A. S. King and M. Chenje)
Harry Chabwela, Environmental Consultant, Ecosource Africa, Zambia
Tabeth Matiza, Wetlands Programme Coordinator, IUCN-ROSA, Zimbabwe

4 MANAGEMENT of Water Resources (by E. Z. Laisi and M. Chenje)
Elton Laisi, Former Controller of Water Services, Water Department, Malawi
Victor Kasimona, Chief Water Resources Engineer, Department of Water Affairs, Zambia
Piet Heyns, Director of Investigations, Department of Water Affairs, Namibia

5 Management of Living AQUATIC RESOURCES (by E. Z. Laisi and M. Chenje)
Moris Mutsambiwa, Senior Ecologist, Lake Kariba Fisheries Research Institute, Zimbabwe
Rudy van der Elst, Deputy Director for Research, Oceanographic Research Institute, South Africa

6 Water POLLUTION and Management (by A. S. King)
Mia Couto, Biologist, Mozambique
Solami Mavimbela, Chemist, Water Resources Department, Swaziland
Jennifer Mohamed-Katerere, Lecturer, Law Department, University of Zimbabwe, Zimbabwe

7 Regional Initiatives and COOPERATION (by E. Z. Laisi and M. Chenje)
Osborne Shela, Liaison Officer for Hydrology and Water Resources, SADC ELMS, Lesotho
Doctor Lukhele, Acting Project Coordinator, Water Resources Branch, Swaziland

8 TRENDS and Scenarios (by E. Z. Laisi and M. Chenje)
Trends and Scenarios workshop participants (Appendix 1)
Jennifer Mohamed-Katerere, Lecturer, Law Department, University of Zimbabwe, Zimbabwe

REVIEWERS by Chapter

1 Regional Overview PEOPLE AND WATER
Thomas Mpofu, Environmental Advisor, UNDP, Zimbabwe
Scientific Advisory Committee members

2 CLIMATE and Water Availability
Peter Tyson, Director, Climatology Research Group, University of Witwatersrand, South Africa
Alan Conley, Chief Engineer, Strategic Planning, Department of Water Affairs and Forestry, South Africa
Moremi Sekwale, Coordinator, North-South Carrier Water Project, Ministry of Mineral Resources and Water Affairs, Botswana
Victor Kasimona, Chief Water Resources Engineer, Department of Water Affairs, Zambia
Henry Sichingabula, Lecturer, Geography Department, University of Zambia, Zambia

3 Water and the ENVIRONMENT
Robert Crawford, Deputy Director, Sea Fisheries Research Institute, South Africa
Shirley Bethune, Chief Hydrologist, Department of Water Affairs, Namibia

4 MANAGEMENT of Water Resources
David Nkalai, Principal Environmental Officer, Lesotho Highlands Development Authority, Lesotho

5 Management of Living AQUATIC RESOURCES
D.D. Bandula, Principal Fisheries Officer and Head of the SADC-IFSTCU, Department of Fisheries, Malawi
Robert Crawford, Deputy Director, Sea Fisheries Research Institute, South Africa

6 Water POLLUTION and Management
George Mkudu, Chief Chemist, Municipality of Harare, Zimbabwe
James Kasonde, Deputy Director, National Council for Scientific Research, Zambia

7 Regional Initiatives and COOPERATION
Pedro Cambula, Chemical Engineer, Water Quality Department, National Directorate of Water, Mozambique
Henry Sichingabula, Lecturer, Geography Department, University of Zambia, Zambia
Thomas Mpofu, Environmental Advisor, UNDP, Zimbabwe

8 TRENDS and Scenarios
Scientific Advisory Committee participants
Henry Sichingabula, Lecturer, Geography Department, University of Zambia, Zambia
Thomas Mpofu, Environmental Advisor, UNDP, Zimbabwe
Paul Maro, Technical Advisor, SADC-ELMS, Lesotho

All CHAPTERS
Scientific Advisory Committee members **Tabeth Matiza-Chiuta**, Wetlands Programme Coordinator IUCN-ROSA, **Jacqueline V. Chenje**, Environmental Information and Communications Programme Coordinator IUCN-ROSA, **Pontso Mafethe**, Communications Programme Coordinator IUCN-ROSA, **Barbro Gretener**, Environmental Officer SADC ELMS

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This book underlines the importance of water not only as an environmental concern, but also as a political, social and economic issue. Over the past two years that this book has been under preparation, many thoughts and ideas flowed from so many different people — both water experts and water users — across the region. We would like to thank all the people who supported us during the preparation of this book.

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All contributors, reviewers and donors may not share all of the views expressed in this publication. While a process of wide consultation was undertaken, and every effort made to ensure a balanced presentation, we are entirely responsible for any errors of judgement, fact or balance, omission or commission.

Munyaradzi Chenje, Phyllis Johnson (Editors)

October 1996

FOREWORD

In Southern Africa, as elsewhere, sustainable development begins with water.

Rain can make the difference between good crops and food security, or drought and famine. Water shortage can cause conflict — between individuals, communities, countries and/or regions. The irony is that water is also nurturing, linking communities hundreds of kilometres apart, by lakes and rivers, and fostering kinship and trade relations.

The biodiversity of Southern Africa, for which the region is so famous, depends on water. The regional economy depends on it. Water flows through every economic sector in the Southern African Development Community (SADC): agriculture, energy, industry, mining, tourism, and fisheries.

In a region whose human population is projected to double in less than 25 years from 145 million in 1995, water resources are under siege. The demands being placed on these resources are growing daily, limiting the region's ability to provide its people with clean drinking water. With population growth, more crops have to be grown, more houses and infrastructure have to be provided, and industry has to produce more. All these activities need water. Population pressures, therefore, pose a major problem to sustainable socio-economic development in the region.

Coupled with population growth is poverty, a significant factor in environmental degradation. Poverty causes people to over-exploit their environment, including water resources, for survival. This can lead to depletion of resources and to pollution, exacerbating the status of the disadvantaged. More than half the population in Southern Africa has no access to clean water, health services and sanitation. Women and children are the most affected by poverty.

While some countries in Southern Africa are more blessed than others, rainfall in the region is generally low. Southern Africa suffers recurrent drought cycles which forces improved planning to reduce dependence on drought relief. The impact of drought extends beyond food shortages, and negatively affects national economies, reducing SADC countries' ability to export crops and generate foreign currency. Instead of earning the much-needed foreign currency, they are forced to spend their resources supplementing national food requirements.

Droughts also affect the availability of water, particularly in rural areas where the majority of the people live. It is not uncommon for rural women and children to walk as far as 20 kilometres in search of water. The hours which would otherwise be spent on productive activities are now spent fetching water. In some areas in the region, no sooner is a borehole sunk than it is dry. In some areas in the region, particularly rural ones, governments are being forced to drill deeper for short-term supply of water. The danger is that over-abstraction of aquifers may cause them to collapse, destroying that water source.

Pollution of both surface and groundwater is a major threat to the region's ability to provide its people with clean drinking water. Marine areas are also being threatened due to pollution caused by the discharge of raw sewage into bays, dumping at sea, oil spills and other human activities.

Pollution of the region's watercourse systems and the marine environment has a negative effect on freshwater as well as marine life. Both animal and plant life in these environments stand to be lost or degraded if pollution levels are not checked. The ability of our wetlands to act as sinks of waste generated by different human activities is threatened due to excessive pollution.

We cannot predict what the future holds for us, but we have been forewarned about climate change. While the jury is still out about its impact on Southern Africa, climate change and variability are becoming a major worry for the region insofar as it impacts on rainfall and water availability in the region is concerned. We in Southern Africa have to play our role in international efforts to reduce the emissions of gases which contribute to global warming and climate change.

Urgent measures need to be taken to better manage our water resources. There is need for a new water ethic in Southern Africa, one which takes into account the fact that we cannot continue to tap our freshwater assets, damming our rivers and channelling our water resources without due regard to the adverse impacts on communities downstream, ecosystems and biological diversity.

Due to the variability of water distribution across the region, we are certain to see an increase in water transfers between regions and between countries. South Africa and Lesotho, through the multi-million-dollar Highlands Water Project, are spearheading intercountry water transfer. There are also discussions of tapping Zambezi River waters to supply arid areas further south. While such ventures showcase humankind's technological ingenuity, they should not be implemented at the expense of water harvesting and conservation. It is essential to seek consensus among all stakeholder states in a basin.

The Protocol on Shared Watercourse Systems in the SADC region provides the foundation for closer cooperation in water management among countries in the region. The protocol, which was signed by the majority of member countries in August 1995, seeks to ensure that there is closer cooperation among SADC countries which share watercourse systems.

Management of water resources is often fragmented among different government departments, some of which have competing interests. SADC countries have to harmonise water management, first nationally and then regionally. There is a need to develop national water master plans, particularly by those countries yet to do so. These national master plans would then feed into the development of a regional water plan.

Agenda 21 states:

> "The multisectoral nature of water resources development in the context of socio-economic development must be recognised, as well as the multi-interest utilisation of water resources for water supply and sanitation, agriculture, industry, urban development, hydropower generation, inland fisheries, transportation, recreation, low and flat lands management and other activities."

To develop sustainable and integrated water management, SADC countries need to build a strong partnership involving different sectors of society. The strategy should be inclusive rather than exclusionary. It

should be participatory rather than restricted. People should be empowered not only to make decisions but also to own the problems. If they own the problems, they are better motivated to help solve them.

In our efforts to develop an effective water management strategy, it is important that we draw upon the many positive aspects of indigenous water uses. Indigenous knowledge systems tend to be neglected, to our own detriment, at the expense of science. Some of our people have contributed immensely to modern science's ability to locate groundwater supplies and to its knowledge of various species of fish. Such contribution should not be overlooked. Civil society should, therefore, be part of the decision-making process in any water management strategy. This is in line with Principle 10 of Agenda 21 which states:

> "Environmental issues are best handled with the participation of all concerned citizens, at the relevant level."

I note with satisfaction that SADC, through the Environment and Land Management Sector (ELMS) coordinated by the Kingdom of Lesotho, is an example of an inter-governmental institution which has taken positive steps to involve civil society in the area of water management. Through the Communicating the Environment Programme (CEP), SADC ELMS and its partners, the World Conservation Union (IUCN) and the Southern African Research and Documentation Centre (SARDC) have produced this book to draw attention to the need to develop an effective regional water-management strategy.

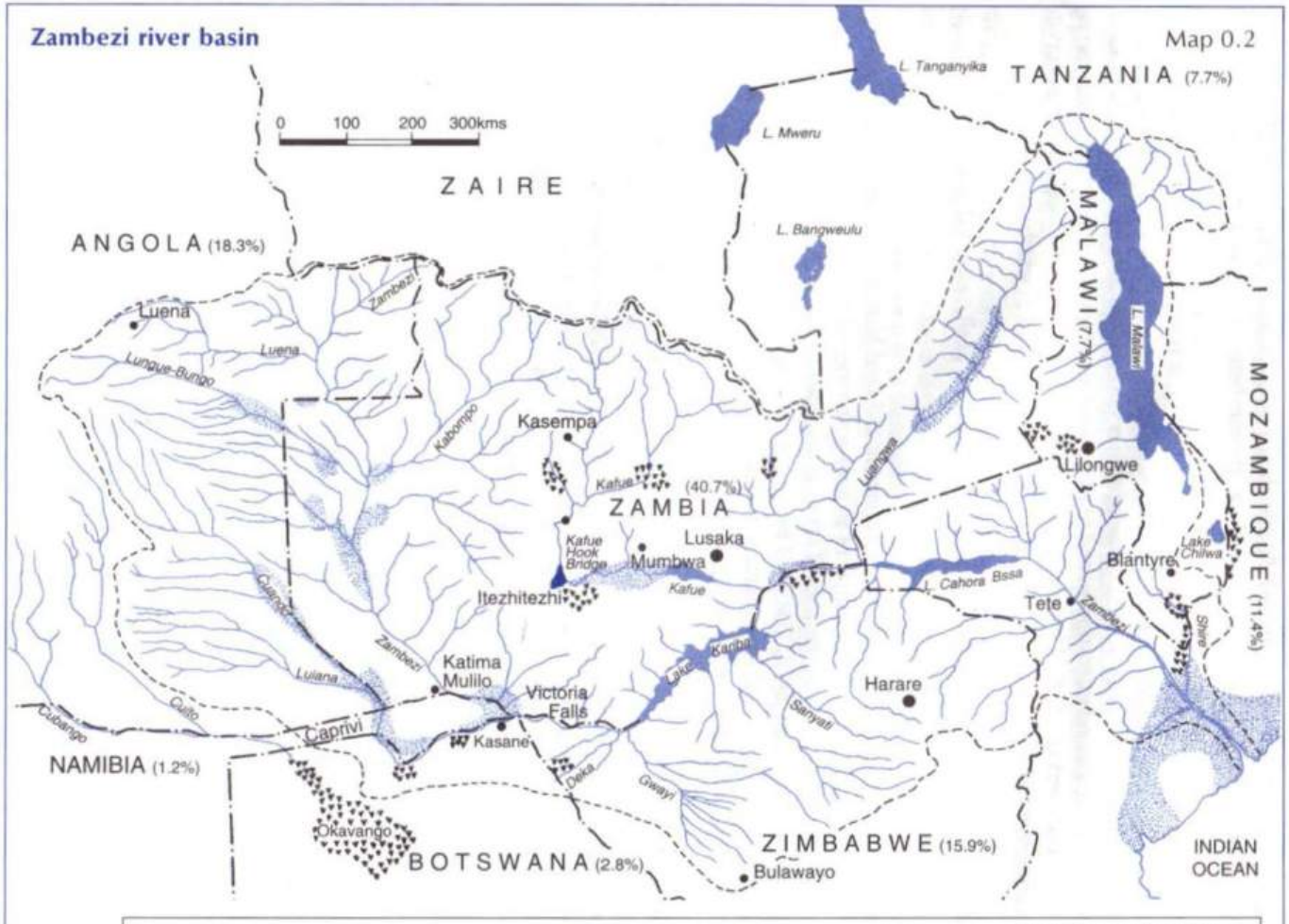
Water in Southern Africa comes at a critical stage in the development of the region. It highlights the issue of water and its central role in our own existence. The hope is that this book will be as much an empowerment tool in the policy-maker's office as in the home. The book is a reminder to all of us that proper water use doesn't start with drought-induced water rationing. It is an everyday existence. The people in Southern Africa need to have a grip on water harvesting, consumption and management for the present generation to give back what it has borrowed from future generations: clean water.

KAIRE M. MBUENDE (DR.)
SADC Executive Secretary

"You see, the sun sinks into the mud where the river begins, far over there. All night it is washed by the water as it is carried downstream. In the morning it rises bright and clean where the Zambezi meets the sea" — Tonga Folklore, Jan and Fiona Tredo, *The Zambezi, River of the Gods*, Andre Deutsch, 1990.

Zambezi river basin

Map 0.2



SOURCE: Matiza, T., Cragier, S. and Dale, P. *Water Resource Use in the Zambezi Basin*, IUCN, 1995.

INTRODUCTION

From the beginning, water has been central to life. Human cultures, nourished by water, flourished or decayed according to available water for drinking, cultivation and navigation. Great rivers such as the Nile, Niger, Limpopo and the Zambezi gave birth to African civilisations. Such rivers have sustained whole ecosystems, supporting biodiversity.

Today, water still dominates our life. Its presence continues to govern the locations of homes and cities; its availability or lack of it can cause deaths among people, animals and plants. Its intrinsic value may cause or exacerbate conflict, not only between states, but also between communities.

Everything in southern Africa starts with water. Because life is sustained by access to water, this book, *WATER in Southern Africa* is like a pebble thrown into a pool: it aims to have a ripple effect, enhancing the flow of information about water in the region.

Water issues in southern Africa are presented here as the resource occurs in nature — without national boundaries. This resource is shared by everyone in the region regardless of history, nationality, ethnic origin, gender, religion or class.

Eleven of the 12 member states of the Southern African Development Community (SADC), excluding Mauritius, not only share national boundaries but also share some of the major river basins in the region such as the Zaire, Zambezi, Limpopo, Okavango, Orange, Ruvuma and Cunene, whose total catchment area covers 6.76 million square kilometres.

This book, the first thematic update of the *State of the Environment in Southern Africa* published in 1994, looks at both freshwater and marine issues facing the SADC countries: Angola, Botswana, Lesotho, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

WATER in Southern Africa is a book for individuals concerned about inadequate water supplies, communities whose existence is threatened by shortage of water, institutions whose mandate is to ensure that people have access to safe drinking water and sanitation, governments which have to plan for the human population growing at an average rate of three percent a year, and the international community which is worried that, instead of dousing fires, severe water shortages may actually ignite wars in the 21st century.

The purpose of this book is to give an accessible overview of water issues in southern Africa. The contents are intended to inform, motivate and empower people in the region at different levels of decision-making to build upon the good, traditional, water-management activities passed down through generations, and to be aware of the need to conserve this finite resource. For without water, communities of southern Africa will not be sustainable.

THE FORMAT

Just as with the *State of the Environment in Southern Africa*, there has been a deliberate attempt to avoid technical language and explanations, and simplified definitions are provided when technical language is used. Maps, tables, photographs and other illustrations have been used to highlight the information contained in the text.

WATER in Southern Africa is in three parts. Part One sets out the background information on southern Africa, its people, and their traditional and current methods of managing water resources. The first chapter gives a regional overview in the context of related socio-economic issues, such as population growth, the role of women, and economic development. The second chapter deals with both climatic issues and water availability, discussing the region's geographical location and surface water distribution. The last chapter of this section looks at water use by the environment itself. The chapter on water and the environment looks at issues such as the effect of water and rainfall on the region's nine terrestrial and four marine ecological zones.

Part Two of the book looks at the utilisation and management of water resources in the region. The issues covered in the four chapters of this section are among the most serious concerning this region and were outlined following a meeting of regional water experts in Harare in February 1995. The fourth chapter deals with water management, covering domestic and industrial uses of both fresh and marine water. It also looks at management, technical, legal, environmental, socio-economic and institutional issues. Consumptive and non-consumptive uses of both water and its resources are discussed, looking at issues such as irrigation and hydro-electric power generation. The fifth chapter discusses the living aquatic resources, highlighting their socio-economic value to the people of the SADC region. Chapter 6 deals with water pollution and its management, outlining the sources of pollution and the impact on both water and its resources. Finally, regional initiatives and cooperation are examined, highlighting achievements, such as the Protocol on Shared Watercourse Systems.

Part Three is the shortest section, with only one chapter dealing with trends and scenarios. It looks at current trends, discussing the impact of population growth, climatic changes and economic development on water resources. The chapter also discusses desired changes needed to conserve water and to ensure that the resource is used sustainably. The future scenarios were developed at a workshop organised in Maseru, Lesotho, hosted by the SADC Environment and Land Management Sector (ELMS), in September 1995 to consider the region's strengths and weaknesses in water management, opportunities and problems.

WATER in Southern Africa also gives the environment a human face, highlighting people's opportunities and problems through well-researched articles written by journalists in the region. The articles cover a wide spectrum, documenting triumphs over natural phenomena such as drought (for which the occurrence, extent and duration cannot be controlled) to problems originating from human activities such as pollution (for which the occurrence, spread and impact on the environment can be controlled).

THE PROCESS

Work on this book started toward the end of 1994 following informal discussions involving environmental experts who were unanimous in their assessment that water and its availability were and still are the most crucial environmental issues in the region. This book is, therefore, as much a process as a product. As part of the ongoing Communicating the Environment Programme (CEP), the process involves the Southern

African Development Community's Environment and Land Management Sector (SADC ELMS), the World Conservation Union Regional Office for Southern Africa (IUCN-ROSA), and the Southern African Research and Documentation Centre's India Musokotwane Environment Resource Centre for Southern Africa (SARDC-IMERCSA). The latter is named after the late IUCN-ROSA regional director, a Zambian environmentalist, who initiated the process leading to the first book, *State of the Environment in Southern Africa*.

This is a unique partnership involving SADC, an inter-governmental organisation; IUCN, whose members include both governmental and non-governmental organisations; and SARDC-IMERCSA, a regional non-governmental organisation.

The overall objective of CEP is to:

> inform, motivate and empower people at all levels of environmental decision-making in southern Africa, from the individual and NGOs to the private sector and governments, to take positive actions to counter environmental degradation and move toward sustainable development paths by providing them with clear, objective and meaningful information on the environment.

The partnership is also to facilitate understanding and communication between environmental groups and decision-makers.

The CEP partners are also committed to identify, develop and implement various activities to enhance the exchange of environmental information in the SADC region. Each partner is responsible for various activities aimed at ensuring that people of the region are well-informed on issues relating to their environment. Activities include the gathering and storage of information on the environment in southern Africa, and researching and compiling information for thematic updates of the *State of the Environment in Southern Africa*.

For the purpose of this book, the information assembled by CEP over the past five years was distilled into a list of major points on each of the issues covered in the individual chapters. Water experts with different areas of specialisation and from different countries in the region were invited to be members of the Scientific Advisory Committee (SAC). The SAC members — from Botswana, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe — met in Harare early in 1995 to set the contents of this book. About 20 experts from the region were invited to contribute to various chapters. SARDC-IMERCSA staff carried out further research, and synthesised the various contributions into draft chapters, which the SAC members and other specialists reviewed for errors and omissions.

Following the review process, the first seven chapters were assembled into a draft manuscript for further evaluation by the SAC. Members of the SAC met to review the data and to forecast future scenarios for water issues and the environment in southern Africa. Immediately after the review of the draft manuscript in Maseru, the SAC members convened the scenario-building workshop to examine current trends in water resources availability and management, and to suggest ways to better manage the resources for present and future generations.

The result is this book — an accessible and well-illustrated document which has been rigorously examined for its scientific accuracy. It is not an academic or policy study, but is intended to give an overview of the current water and environmental issues in southern Africa. This should be a tool for decision-makers to use

in developing appropriate agendas for action, and a reference for the media and non-governmental organisations who communicate information to the public.

ENVIRONMENTAL INFORMATION

The overall intent of this publication is to challenge individuals, communities, organisations, the media and governments to strive for the sustainable utilisation of water in particular and natural resources in general.

The CEP partners believe southern Africa can use its water resources sustainably if there is a high level of environmental awareness. It is our view that southern Africa is still in a position to make choices about water policy and management, and that an informed population will not only widen and enhance the discussion, but also act to achieve sustainable development, "meeting the needs of present generations without compromising the ability of future generations to meet their own needs".

In the words of the President of Botswana and SADC Chairman, Q.K.J. Masire:

> "To all of us, a process of information sharing is of critical importance if we are to participate actively in shaping the path of sustainable development."

CEP partners believe that sustainable development is only possible if sources of essential information are sustained and sustainable. This book is the second publication to be prepared and published by CEP partners with the aim of empowering the people of southern Africa through environmental information. They are committed to sustain such an exercise with more publications over the years, making sustainable development a people's issue.

PULA Box 0.1

Water is so essential to life in southern Africa that the people of Botswana use the greeting *Pula*, meaning rain, a term also used for their currency. When a Head of State arrives, the Setswana greeting *A pula e ne*, translates as "Let it rain — may blessings come."

1 Regional Overview
PEOPLE AND WATER

From its source in northwestern Zambia, southern Africa's longest river, the Zambezi, flows (in some parts) and thunders (in others) for 3,000 kilometres[1] through gorges, rapids and cataracts, uniting eight southern African countries through the "veins" which flow into it along its way to the east coast, and giving the region the Victoria Falls, one of the majestic wonders of the world. Along its meandering journey to the Indian Ocean, nurturing life in its waters, along its banks and beyond, the mighty Zambezi is not only a source of water but also of food, electricity, transport, communication and recreation for millions of people in southern Africa.

The river drains its waters into the Indian Ocean, directly linking the southern African interior with the 9,870-kilometre coastal highway (excluding Mauritius' 177-km coastline), which stretches from Tanzania on the east coast round Cape Agulhas in South Africa to Angola on the west coast. The Zambezi, the Orange and other rivers; Lakes Tanganyika, Malawi and Kariba; and the Indian and Atlantic oceans, are all part of a network of water bodies on which the countries of the Southern African Development Community (SADC) depend.

Regional estimates put renewable freshwater resources at an annual average of 650 billion cubic metres (cu m), which is distributed in the rivers, lakes and groundwater bodies of these and other, smaller, river-basin systems.

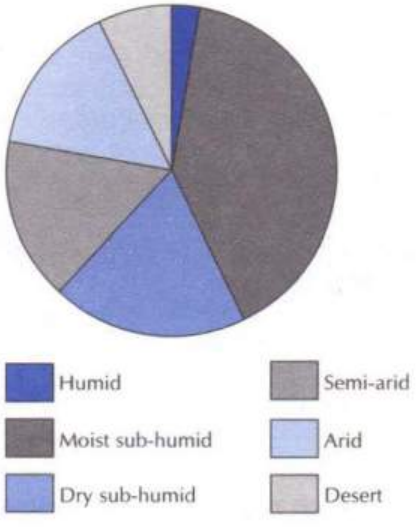
Mauritius, an island in the Indian Ocean, is the only SADC state that does not share a river or border with the other 11 members — Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

WATER AVAILABILITY AND DISTRIBUTION

The SADC region has a total land area of nearly 6.8 million square kilometres (sq km), at an average altitude of 1,000 metres above sea level, and has 16 main river basins. Of the region's total land area:

- three percent is humid, receiving more than 1,500 mm of rain per year;
- 40 percent is moist sub-humid, receiving between 1,200-1,500 mm/yr;
- 19 percent dry sub-humid, receiving 600-1,200 mm/yr;
- 16 percent semi-arid, 400-600 mm/yr;
- 15 percent arid, 100-400 mm/yr; and
- seven percent desert, receiving less than 100 mm/yr.[2]

Water distribution in SADC Figure 1.1



Water resources and use Table 1.1

Country	Land area (1,000 sq km) 1993	Irrigated land (as % of arable land area) 1993	Annual internal renewable water resources per capita (cu m) 1995*	Annual freshwater withdrawals	
				As % of water resources 1980-89	Per capita (cu m) 1980-89
Angola	1,247	2.5	16,618	0	52
Botswana	567	0.5	1,588	1	100
Lesotho	30	0.9	2,551	1	31
Malawi	94	1.7	1,678	2	20
Mauritius	2	17.0	1,979	16	410
Mozambique	784	4.0	12,997	1	53
Namibia	823	0.9	333	38	166
S. Africa	1,221	10.3	1,206	18	410
Swaziland	17	35.8	5,275	4	408
Tanzania	884	5.0	2,998	1	36
Zambia	743	0.9	12,267	1	86
Zimbabwe	387	7.0	1,776	5	138
AVERAGE		7.2	5,106	7.3	159

0 zero or less than half the unit of measure; — data unavailable

SOURCE: UNDP, *Human Development Report 1996*, Oxford University Press, New York, 1996.
*WRI, *World Resources 1996-97*, Oxford University Press, New York, 1996.

The distribution, occurrence and availability of water resources is uneven in the region as well as in individual countries; and availability depends on rainfall. Much of the region is arid or semi-arid and rainfall is variable, often unreliable. The SADC region is mainly wet in the north and east, and extremely dry in the southwest. The region is periodically affected by severe and prolonged droughts, which may be interrupted by equally devastating floods in some areas.

Droughts and floods may occur simultaneously in different parts of the region or a country, even in adjoining watersheds.[3] In December 1995, the floods which hit the KwaZulu-Natal Province were among the worst ever experienced in South Africa. Floodwaters left a trail of death and destruction, killing more than 130 people and causing millions of dollars worth of damage in urban and agricultural areas.[4]

The highest level of renewable water resources per capita in SADC is 29,545 cu m in Namibia, while the lowest is 1,206 cu m in South Africa. The water-use statistics, which also indicate availability of developed water-resources for human use, show that an average of 152 cu m of water are used per capita per year in SADC, with the highest of 410 cu m in both Mauritius and South Africa, and lowest per capita of 20 cu m in Malawi.

The high variability in the occurrence, distribution and availability of water resources for human and environmental use is a result of several factors.

Groundwater indicators Box 1.1

The presence of water at or near the surface is readily indicated by marsh plants such as the bulrush. Certain tree species are also indicators of groundwater, for example, the waterberry. This tree is commonly found along stream courses and fringing vleis. The "extensive lateral root system near the surface allows the tree to survive periods of water-logging during the rains and the tap root allows the tree to draw water from the receding water table during the dry season. It could, therefore, be an indicator of shallow but persistent groundwater. Our well-sinking experience tends to confirm that it is a useful indicator."

SOURCE: Hilditch, G.D. and Richardson, I., *"Well Siting Using Nature's Indicators"*, *The Zimbabwe Science News*, Vol.18, Nos.9/10, Sept/Oct., 1984, pp.113-115

These include population dynamics, economic development, water-related environmental issues, political and socio-cultural matters at regional, basin and national levels. The variation of physical characteristics and climate have also played a significant role in shaping the state of water resources, as well as development and management.

TRADITIONAL WATER USES AND MANAGEMENT

The people of southern Africa have a rich heritage of managing and living with their environment, including water. Traditional African societies have demonstrated themselves to be effective custodians of water. Rainfall and water were central to their lifestyle, influencing the activities in which they were involved. Such knowledge lives on, seasoned with thousands of years of communal practice. Some of the communities in the region have contributed immensely to modern science and to knowledge of the environment. Their knowledge of nature's indicators, for example, has been used for generations to locate groundwater supplies before digging shallow wells.

Communities in the region have been irrigating their lands for centuries. Valley-bottom soils in Angola have been exploited in an ecologically sound manner, using ditches and mounds to raise and lower the water-table. Another example is the irrigation and furrowing systems of the WaChagga people on the slopes of Tanzania's Mount Kilimanjaro. These systems are sophisticated and complex, and support high population densities.[5]

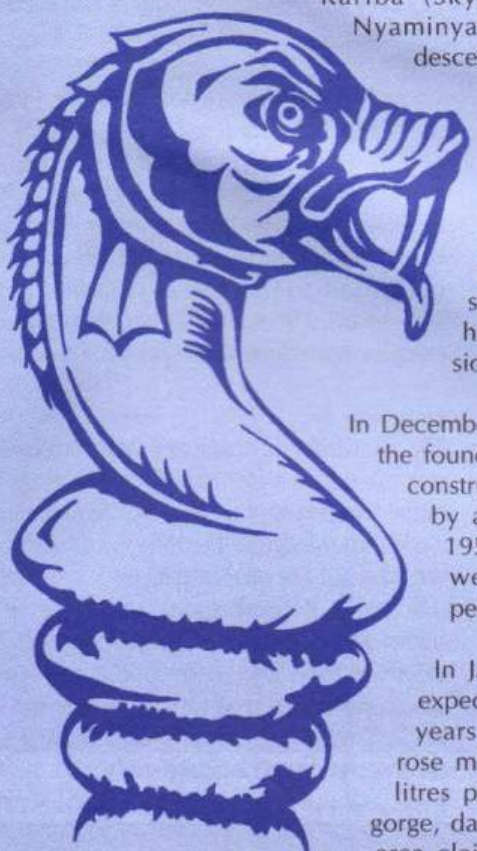
Fisheries

The knowledge of traditional African communities also extends to water resources. The Unga people of the Bangweulu swamps in northern Zambia have a wide knowledge of the different kinds of fish in the swamps. They are "acquainted with much lore, practical in its application, concerning breeding habits and fish ecology in general. Not all this extensive knowledge corresponds with European investigations on the same subjects, but on the whole Unga fish lore is sensible because it is based on observation and intimate study ...".[6]

Photo 1.1 SARDC-M Chenje

Women fish to supplement families' food needs.

Nyaminyami — Guardian of the river Box 1.2



Kariba (Skyhost) — According to local lore, Nyaminyami, guardian of the river, is a direct descendant of the Tonga soothsayers and *n'angas* who communicate with him telepathically perform many miraculous cures.

Angered by the removal of his people from the Gwembe Valley (now under the waters of Lake Kariba) during construction of the Kariba Dam, Nyaminyami has inflicted his revenge on many occasions.

In December, 1955 — in fact, on Christmas eve — the foundations of the coffer dam and a recently constructed pontoon bridge were washed away by a flood that swept down the gorge. In 1956, heavy rains fell a month before they were due and sudden flash floods hampered work on the dam.

In January 1958, a flood such as could be expected to occur only once in every 10,000 years, swept down the river bed. The river rose more than 30 metres and over 13 million litres per second came cascading through the gorge, damaging the coffer dam. The elders in the area claimed that it was Nyaminyami wreaking vengeance.

But the greatest disaster struck in February that year when the flood was at its height. Work came to a standstill when part of a platform collapsed in a shaft, killing 17 men.

The men had been working on a shaft which now carries water from Lake Kariba through the turbines of the underground power station to the southern bank of the Zambezi river.

Despite these tragedies, the completion of this awesome task in June 1959 was a moment of triumph. However, the Tonga are adamant that Nyaminyami is biding his time and one day he will exact a terrible revenge.

SOURCE: Adapted from *Skyhost*, Volume 3, Number 4, 1995.

Photo 1.2 SARDC-M Chenje

Fishing using dug-out canoes is a way of life for many people living near Lake Malawi.

The Unga have for generations depended on their environment for materials to make appropriate tools and equipment to catch fish. From reeds, they weave baskets which they use as traps in weirs to catch fish from the falling waters of floodplains, lagoons and backwaters. From trees, they make dugout canoes, some of which can last up to 30 years, eliminating the need to continue cutting down trees and contributing to deforestation. Fishing is also seasonal, depending on water levels. Strong beliefs in the edibility of certain species of fish or lack of it help to control overfishing. Other communities in southern Africa make reed fences for fishing. These long fences are stretched from shore to shore. Each fence is firmly held down by a group of about 30 fishers. Once they have gone a certain distance, they converge, until a circle is formed near the farther bank, and the catch is trapped in the fence.[7]

Agriculture

Rain-fed agriculture has played a major part in the lives of most people in southern Africa for thousands of years. The advent of the rainy season was a community event which was always met with excitement and anticipation. In Zambia, shortly before the first planting-rains of the year began in earnest, the Tonga people prepared beer for the *luinde*, as the ceremony is called. When the beer was ready, the villagers spent the evening of the ceremony dancing, singing rain-songs, and pleading to the *basangu* (rain spirit) to send them enough rain.[8] This went on until the rains came, after which the whole community, carrying axes, hoes, a chicken, and some meals, congregated at their rain-shrine. Such shrines were either large hollow fig-trees or small structures called *twaanda* (small huts) which were built by the community. During the ceremony the leader addressed the *basangu*: "Send us rain and good crops and health. We have done all the things you told us. We have not forgotten you. Send us rain. Help us."[9]

On the two or three days of the year when the rain-

rituals were enacted, a general district peace was imposed in the name of the shrine. The people believed that any disrespect toward the shrines, even on non-ritual occasions, brought disasters, such as droughts, upon the community, unless offenders were punished and a cleansing ritual performed. It was strictly forbidden for anyone to gather roots or wood around the shrines. Burning the grass in surrounding areas before the head of the rain-ritual in each district announced a communal hunt upon the slopes was also a taboo.[10] All these measures helped to protect the environment, upon which the people depended, from wanton exploitation and destruction. The rain-shrines were not only used to pray for rain but were also an integrating force in Tonga society at which communities appealed to the spirits on any occasion of general community disaster, such as epidemics or cattle plagues.

Rain-making ceremonies and rainmakers played major roles in the lives of many different communities throughout the southern African region. For example, in north-eastern Zimbabwe, near the Mavuradonha mountains (or *Mvuradonha*, meaning rainfall in the Shona language), a headman called Karuwa attracted under him many different communities because he was a famed rainmaker. When Karuwa died, such was his fame as a rainmaker, that his spirit became a *mbondoro* (spirit), controlling the rains and indirectly the crops. Sacrifices and supplications were, therefore, made to ensure good rains and consequently good crops.[11] The people in the area believed that if Karuwa's spirit was not appeased, he manifested his anger by upsetting the natural course of the rains, resulting in either drought or devastating floods.

POPULATION

In the case of modern southern African societies, population growth has added a new dimension to the demand and availability of water. The United Nations Environment Programme (UNEP) says even though progress has been made in key aspects of human development in the past three decades, population growth has outpaced the gains made in some sectors, such as the provision of drinking water and sanitation.[12]

Growth

The demands on water in southern Africa are constantly growing with the rapid increase in population. With an average three percent annual growth rate, the population of the SADC region is expected to double in less than 25 years, from about 145 million in 1995. The region, which contains just over two percent of the world's population, is expected to contribute about six percent of global population growth between now and the year 2050.[13]About four million babies are expected to be born in southern Africa in 1996.[14] These babies will need food and water, shelter and clothing. As they

Photo 1.3 NSSA
Water demands are constantly growing with the rapid increase in population.

grow older, they will need land for farming or jobs. They will want to have children of their own. Governments will have obligations to these babies throughout their lives, providing water and sanitation, health care, education, social services, roads and other infrastructure which citizens require.

To meet the food needs of an increasing population, forested or grazing land may be brought under cultivation, and irrigated production intensified. Yet research shows that the clearing of vegetation may modify rainfall, leading to a drier climate in certain ecological zones. Clearing for agriculture increases runoff and decreases infiltration rates, lowering the water table, particularly where dry weather conditions persist.

Demand for water resources

Increasing water demand is a crucial concern in southern Africa because of the increasing human population and associated demand for resources, especially food.

Population and densities in southern Africa Table 1.2

Country	Population (millions) 1995	Density per sq km (persons)
Angola	11.5	9.0
Botswana	1.9	2.6
Lesotho	2.1	67.5
Malawi	11.1	118.3
Mauritius	1.1	550.2
Mozambique	17.9	22.3
Namibia	2.5	2.4
South Africa	41.5	34.0
Swaziland	1.2	53.0
Tanzania	32.5	33.6
Zambia	10.0	13.0
Zimbabwe	11.3	29.1
TOTAL	144.6	
AVERAGE		77.9

SOURCE: WRI, *World Resources 1996-97*, Oxford University Press, New York, 1996.

In water-scarce Namibia, for example, demand for state-supplied water increased from 37 million cubic metres/year in 1970 to 95 million cubic metres/year in 1993. This is an average increase of 4.2 percent per year and well above the population growth rate of three percent,[15] although one variable is the number of exiles and refugees who returned in this period.

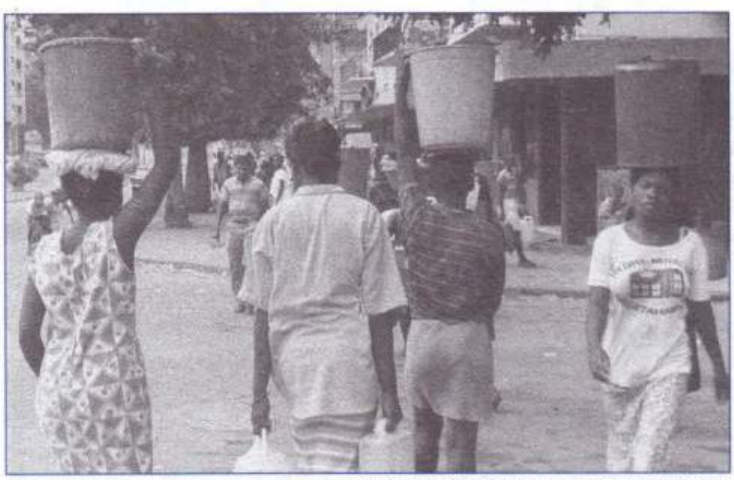


Photo 1.4 AGENCIA DE FOTOGRAFIA E AUDIO, LUANDA

People procuring water in Luanda, 1990. Infrastructural development lags behind population growth in many countries.

In Zambia, population growth has placed heavy demands on resources such as fish, resulting in overexploitation through the use of methods such as seine (a net which hangs straight down in the water), and drag nets with small mesh. This has enabled fishers to catch all sizes of fish, leading to the depletion of

Informal settlements thirsting for water Story 1.1

Johannesburg (SARDC) — For Johannesburg resident Beullah Tladi, 35, a bath means queuing at a communal tap, filling up her bucket, hiding in the bushes or behind a sagging shack she calls home and splashing the water all over her body.

"Living here is not pleasant, but there is nowhere else to go," explains Tladi who squeezes herself and four children into her two-roomed make-shift home. "We pay taxes, we voted the present government into power but this is the way we continue to survive."

Tladi lives in an informal settlement (shanty town) called the Steve Biko village in the former blacks-only township of Alexandra. She is one of millions of South Africans who do not have tapped water in their homes although she lives in one of Africa's most developed metropolis.

Steve Biko village is a sea of scrap-metal structures housing more than 2,000 families. Ironically, it faces Sandton, the former whites-only suburb which is one of the most affluent in sub-Saharan Africa, where an average family of four delight in massive houses, well-serviced by the same local government for this area.

But in the village, residents had to take it upon themselves to tap water from the formal part of Alexandra some two years ago using a disused pipe that siphons water for more than a kilometre to central points in the settlement. Tenants had to contribute $12 each into the effort. And since then have not paid a cent for the water.

The "village" has been in existence for more than a decade, gradually filling up with people over the years. Now, the water is failing to go round. Last year, efforts by the metropolitan council to remove the squatters failed, but it may only be a matter of time.

Alexandra is densely populated, with about 442,000 people squeezed into 450 hectares, with barely a metre separating the lines of shacks. It grew out of a formal settlement into a mixture of squalor and comfort as formal residents rented out their backyards and constructed make-shift tin houses. Today, about 94,000 squatters live here, many of them along the Jeskei river that is choking with pollutants.

"In some areas, we have provided tapped water at central locations for the squatters at a minimal charge of 10 rand per month (US$2.20)," notes Andronica Mathembani, a local authority official.

"We realised that if we didn't do that, the squatters would continue to help themselves to water belonging to our formal residents."

Informal settlements are not unique to this area. In the capital province of Gauteng, they are mushrooming everywhere, even on top of the high-rise city buildings. An estimated 9 million of the country's 41 million people live in squatter settlements across the country.

Between 13 - 16 million people do not have access to clean drinking water while 21 million do not have access to adequate sanitation (toilets and refuse removal).

South African Water Affairs Minister, Professor Kader Asmal, says such factors increase levels of disease, infant mortality, and the vulnerability of communities in such situations.

"The lack of potable water and sanitation contributes to the poverty trap into which these people have been pushed," he says, adding, "Investment in making water accessible is crucial to the battle against poverty."

Over the years, access to water was determined by *apartheid* policies that skewed basically every resource in the country towards the minority white population.

For the squatters in Alexandra, a lavatory comes in the form of a make-shift, mobile, chemical toilet located along the small paths that knit their way through the dense settlement.

"The communal toilets here are permanently padlocked and only official residents like me own keys to them," says another Alexandra dweller, Boykie Hlongwane. He works in a department store in the city, shares a shack with his wife and three children and owns a VW Beetle he proudly parks outside his house.

Short-term aims of the African National Congress (ANC)-led Government of National Unity are to provide every household in the country with at least 20-30 litres per capita per day within a 200-metre radius.

Government has also spelt out its commitment to deliver adequate sanitation facilities per site and a refuse removal system to all urban households. But the refuse in Alexandra lies unremoved for weeks and a strong pungent smell envelopes visitors and residents alike. Government departments claim they are under-funded and under-resourced to meet the challenges.

In its White Paper on water supply, the department of Water Affairs says its budget needs to be increased from about $400 million to 700 million a year if it is to provide most citizens with basic services in the next seven years.

The problem is further compounded by the fact that, "a number of communities have recently stopped paying for water services in the light of confusion surrounding government policy and with the expectation that it is government's responsibility to provide water without charge," notes the department.

— **Gumisai Mutume,** for SARDC, 1996

species such as the Luapula salmon and bream. "In a number of areas, fish poison and even dynamite have been used to make 'a quick kill'. Fishers have also frequented spawning grounds to catch spawning fish."[16]

Distribution

About 57 percent of the people in southern Africa live in rural areas. Only three countries in the region have at least half of their people living in urban areas — Namibia, 51.3 percent;[17] South Africa, 59 percent; and Zambia, 50 percent.[18] Southern Africa's average annual urban growth rate is 6.5 percent.[19] The rapidly growing urban population places heavy demands on water resources for consumption, power generation, mining, industry and agriculture. At current population growth rates, southern Africa will experience chronic water-shortage by 2030.[20] The relationship between population and the amount of water, measured in flow units, is a good indicator of water stress.

A flow unit equals one million cubic metres per year (mcm/yr). The overall ratio of population to flow units in southern Africa was estimated at about 360 in 1994, but with the population growing to more than 272 million people in just over two decades, the ratio will be 720 by 2016 and over 1,000 by 2030. A ratio above 1,000 indicates chronic water shortage.

The region faces the twin challenges of providing adequate, safe, water supplies and also increasing food production to keep pace with the fast-growing population — or reducing population growth. Today, more than half of the 145 million people in the region have no access to safe water and sanitation. In South Africa, for example, more than 12 million people have no access to adequate supplies of clean water, and about 21 million lack basic sanitation.[21] In Zambia, a survey conducted in 1980 showed that 40 percent of the rural population lacked access to safe water. Due to rapid popula-

Population with access to clean water and sanitation Table 1.3

Country	Population (millions) without access to		Population with access to (%)			
	Safe water 1990-95	Sanitation 1990-95	Safe water 1990-95 Rural	Safe water 1990-95 Urban	Sanitation 1990-95 Rural	Sanitation 1990-95 Urban
Angola	7.0	8.6	15	69	8	34
Botswana	0.1	0.6	91[a]	100[a]	41	91
Lesotho	0.9	1.4	49	70	36	53
Malawi	5.6[a]	4.9	42[a]	91[a]	51	71
Mauritius	—	—	100	95	99	99
Mozambique	10.1	12.1[a]	40	17	11[a]	61[a]
Namibia	0.6	1.0	42	87	12	77
S. Africa	11.9	—	—	—	—	—
Swaziland	—	—	—	—	—	—
Tanzania	14.0	10.1	46	67	62	74
Zambia	4.5	5.6	11	91	12	75
Zimbabwe	2.5	3.7	64	99	48	99

[a] Data refer to a year or period other than that specified in the column heading, differ from the standard definition or refer to only part of the country.
— Less than one-tenth the unit
SOURCE: UNDP, *Human Development Report 1996*, Oxford University Press, New York, 1996.

tion growth, it is feared that Zambia may experience a severe water shortage by the year 2000, if not matched with infrastructural development.[22]

Urbanisation

Within the trend to population growth is the strong trend toward urbanisation. The population growth rates of towns and cities are much higher than the national population growth rate — about double; so while more people are being born, many more are moving from the rural to urban areas. At present, it is estimated from urban population growth rates that over half of southern Africa's population will live in towns and cities by the year 2000, placing further demands on clean water supplies and sanitation. This means that population growth will put more direct pressure on urban areas and the associated services than on rural areas.

While population in rural areas is declining in percentage terms, absolute numbers of rural people are still increasing, such that urbanisation does not relieve the pressure on rural resources, but merely slows the increase.[23] While three-quarters of Africa's urban populations have water supply, rural populations are worse off: only 27 percent has access to safe water, and 16 percent to sanitation.[24]

Rural-urban and coastal migration

In Angola and Mozambique, the coastal areas provided refuge to millions of people displaced during the civil wars in both countries. In Mozambique, 3.5 million people, who abandoned their rural homes because of the war, resettled in coastal cities such as Maputo and Beira, and islands such as Inhaca, causing damage to sensitive ecosystems. At one stage, 75 percent of Mozambicans lived along the 50-km wide, fragile, coastal zone, which had an average density of 120 people per sq km.[25] This movement of people was not planned and often the settlers were not familiar with the environments in which they sought refuge.

Rural-urban migration in Angola saw people fleeing strife-torn inland rural areas to coastal and urban areas, increasing urban population by over 2 million displaced people. Less than six percent of Angolans lived in urban areas in 1950, yet today the majority of the 11.5 million people live in towns and cities. Luanda, Angola's capital city, was built for 500,000 people, but the population has increased to about 3 million over the years and has the highest population density in Angola — 500 people/sq km.

WOMEN AND WATER

In southern Africa, women are the main managers of environmental resources. As food producers, water collectors, and fuelwood gatherers, rural women are in frequent and direct contact with land, water and forest resources. Women fetch and supply drinking water for their families, and are heavily dependent on rain-fed agriculture and, in some areas of the region, fisheries. Rural women spend a lot of their time tending, gathering, conserving and using natural resources.

Photo 1.5 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO-Ussene Dauto

Displaced people often fled to fragile coastal areas, away from conflict, and adopted new strategies for survival.

Water supplies

With the scarcity of water in many southern African countries due to recurrent drought, women, particularly those in rural areas, are forced to walk long distances to fetch water. According to a World Bank estimate, some African women use 40 percent of their daily nutritional intake travelling to collect water.[26] Due to environmental degradation and deforestation, women in the region now spend more time looking for fuelwood, water and food, and have less time to cook, forcing them to cut back on the number of cooked meals and their nutritional value. In addition, as a result of their tasks as water suppliers, women are more subject to water-related diseases.[27]

Some of the activities undertaken by women, such as laundering in rivers, pollute the very resource on which they depend for their livelihood. This has serious health risks to women and their dependents.

Water resources

Women in some countries in the region are accom-

Women and water Box 1.3

In rural Botswana, when the groom's relatives arrive to seek the bride, they come to ask for a "calabash of water" — a poetic and symbolic expression of a cultural reality. This bride, like most women in rural Botswana and in villages all over southern Africa, will become the water-bearer for her family. But carrying water does not begin at marriage for such women — they are water-carriers from the time they are old enough to carry a bucket. So how involved are the women of Botswana in the planning, operating and maintenance of their village water-supplies since water is a sector so vital to their lives?

Improving the water-supply systems and keeping water clean are matters that rest largely in the domain of women, although obstacles to women's fuller participation are the result of traditional beliefs about the roles of men and women. In many southern African countries, women are not involved in initial planning, because at the community level, it is mainly the men who make decisions. Women working in the water sector are mostly water-supply operators who are paid less than men who hold professional and managerial posts; very few women go in for technical training, so they are confined to clerical jobs.

Difficulties in involving women in the water sector have been recognised for a long time. In 1983, the United Nations Development Programme (UNDP) launched a research and development project called PROWWESS (Promotion of Women in Water and Environmental Sanitation Services) to find solutions to this problem. The result is a set of training tools for community participation, with the particular goal of involving women in planning and decision-making. These methods have proved effective in achieving women's participation in a wide variety of cultural settings.

With the involvement of women, the main users of the water-supply systems, there is a better chance for these systems to be properly maintained and for the health benefits to be realised. Now, the challenge for southern African countries is to transform women from mere water-carriers into planners and managers of water-supply systems.

SOURCE: Simpson-Hebert, M., "Women and Water", *World Health*, July-August 1992, pp.20-21

plished fishers, providing an important source of income for their families. However, lack of alternative sources of income and increasing destruction of aquatic habitats for development often leads to overfishing to satisfy both subsistence needs and generate income.

POVERTY

Poverty in southern Africa has been described as "one of the root causes of environmental degradation" and poses a threat to human health. It is generally believed that poverty and environmental degradation are linked in a vicious circle in which people cannot afford to take proper care of the environment and lack clean water and sanitation. A degraded environment produces less, so people become more vulnerable,[28] especially to waterborne and other diseases. Poverty is one of the most urgent issues affecting women and children in the region, according to UNICEF. A National Nutrition Survey conducted in Lesotho in 1992 showed that, among children under five years of age, 40,000 were underweight, 80,000 were chronically malnourished and 6,000 were severely malnourished, mainly due to poverty in that country.

A driving force behind environmental pressures in southern Africa is poverty linked with population growth. When people lack adequate financial as well as other resources, they often have little choice but to take what they can from the natural environment to meet their needs, without consideration for the future.

Debt

Linked to poverty, and the resultant lack of access to clean water and sanitation, is the issue of debt servicing for many of the countries in southern Africa. Foreign debt continues to climb, at least doubling in most countries in SADC between 1980-1993, largely due to the cost of defence against South African destabilisation. In some cases, the debt burden increased by three or even six times during that period. For example, Zimbabwe's external debt increased by more than five times from US$786 million in 1980 to US$4,168 million in 1993. Tanzania's and Zambia's foreign debt almost trebled in the same period. Lesotho's foreign debt increased seven times to US$512 million.[29]

Some countries in southern Africa have "severe external indebtedness and extreme aid dependence. Poor external debt management and inadequate debt relief means that for some of the countries, indebtedness will continue to be a problem for macroeconomic stability."[30] Low global commodity prices have also cut export earnings in the region, requiring greater production of materials to earn sufficient foreign exchange to pay the interest on the debt.

Sir Shridath Ramphal, former IUCN president, described the flow of resources from Africa to the rich industrialised countries as "perverse". "Debt repayment," he said, "is very much at the heart of poverty alleviation"[31] in Africa.

Photo 1.6 IPS-G Mutume

Alexandra township in Johannesburg is home to almost half a million people, one quarter living in informal settlements.

ECONOMIC DEVELOPMENT

Water, be it fresh or marine, has always been central to human life — so central that civilisation began near rivers. In southern Africa, large cities such as Dar es Salaam, Beira, Maputo, Durban, Cape

Photo 1.7 APG-D Martin

Major seaports, such as Dar es Salaam, are commercial centres that support large cities.

Town, Walvis Bay and Luanda, grew as the major ports of the region. Fisheries, agriculture, transport and industry all depend on water for production, distribution and consumption. It is, therefore, not surprising that water has been described as the "single most important resource for our future" and "the pivot on which all future development depends".[32]

The unreliability and variability of rainfall in southern Africa has, therefore, a major bearing upon various economic sectors, particularly agriculture, which accounts for 90 percent of the water demand in the region.[33]

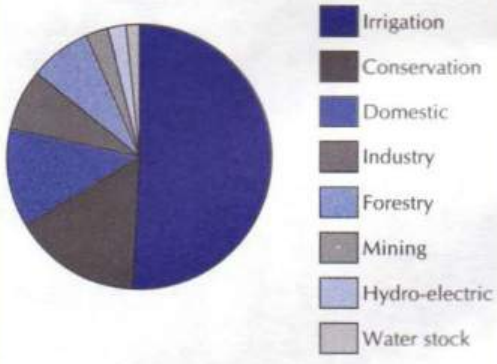
Agriculture

Irrigation

Seasonal variations and unreliability of precipitation make irrigation much more important in the region that might otherwise be the case. Irrigation is of particular concern when considering the region's future planning. With growing populations come growing demands for sustenance. Irrigation is often regarded as a way of increasing agricultural productivity without increasing the amount of land under production. In South Africa, the region's biggest irrigator, only one percent of the agricultural land is irrigated, but it produces 30 percent of the value of agricultural production.[34] Of the total amount of water available in South Africa in 1990:

- about 51 percent of it was used for irrigation;
- 15.5 percent for nature conservation and ecological concerns;
- 12 percent for municipal and domestic needs;
- 7.6 percent for industry;
- 7.5 percent for forestry
- 2.7 percent for mining;
- 2.3 for hydro-electric power generation; and
- 1.5 percent to water stock.[35]

Water usage in South Africa Figure 1.2



Irrigation accounts for more than half of all water used in the region. Of this, 40-60 percent of the water drawn from rivers and dams is lost before it reaches the land under irrigation, mainly through seepage and evaporation. This not only throws away a valuable resource, but causes serious environmental problems such as soil salinisation and waterlogging. Such conditions are often undesirable for crops and other plants, and ultimately remove land from production. Southern Africa has an estimated 9.1 million hectares of land where productivity could be improved through irrigation. About 1.8 million hectares are already under irrigation. While irrigation is desirable in some cases, it is often used to grow crops with low economic value. In South Africa, 80 percent of the irrigated crops, such as grain or pasture, are low value. This is an uneconomic use of water, normally requiring some form of agricultural subsidy.

Industry

Inland

The rivers, dams and lakes of southern Africa are a source of water, food, electricity and recreation, providing the engine of economic growth in various sectors. The region has a very large number of dams which generate hydro-electricity, including the Kariba, Cahora Bassa and Kafue Gorge. Only about one percent of the region's hydroelectric power potential, outside South Africa, has been developed.[40] Angola's sources contain the greatest potential; only about four percent of the existing capacity has been developed due to the 20-year civil war. The region is projected to record impressive growth, and availability of affordable power could be a strong impetus for that growth.

Despite the advantages brought about by hydroelectricity, conflict can occur with other uses of water. For example, in Tanzania, the national electricity authority, TANESCO, has accused upstream irrigation schemes of depriving its storage reservoirs of water and has demanded closure of the irrigation schemes.[41] The demand on electricity is certain to increase with population and economic growth, encouraging the development of more hydroelectric power projects which may have a negative impact on the environment if environmental impact assessments are not adequately undertaken.

The region's inland water bodies also support a thriving inland fisheries industry. Fish catches vary from place to place, with the largest yields associated with major lakes and dams. The large lakes, such as Victoria, Tanganyika and Malawi are quite productive in fish and provide almost all of the inland commercial and subsistence catches in the region, totalling about 500,000 tonnes per year (t/yr). According to SADC, about 200,000 people are directly employed in the SADC inland fisheries industry. Between 600,000-800,000[42] more are indirectly dependent on this industry, and fish are often a large part of the diet of people living in the region. Shallow lakes also make a substantial contribution to fisheries, but can dry up, as happened to lakes Xau, Liambezi and Ngami in Botswana, which have been dry since 1982.

Floodplains are also very productive aquatic environments. Several thousand tonnes of fish are harvested annually from these floodplains, including Barotse plains (part of the Zambezi) and Kafue plains in Zambia, which yield about 11,000 t/yr.

The United Nations Food and Agriculture Organisation (FAO) estimates that 50,000 people in Angola are seasonally employed in the floodplain fisheries, especially in the Zambezi headwaters of the central plateau. Significant fishing also takes place in the Shire river of Malawi. The Lower Shire produced 10,000 tonnes in 1986, and has a potential to produce more but is being severely threatened by water hyacinth.[43] Fish are caught throughout the Zambezi system -- on floodplains, in reservoirs, and on the river and its tributaries.

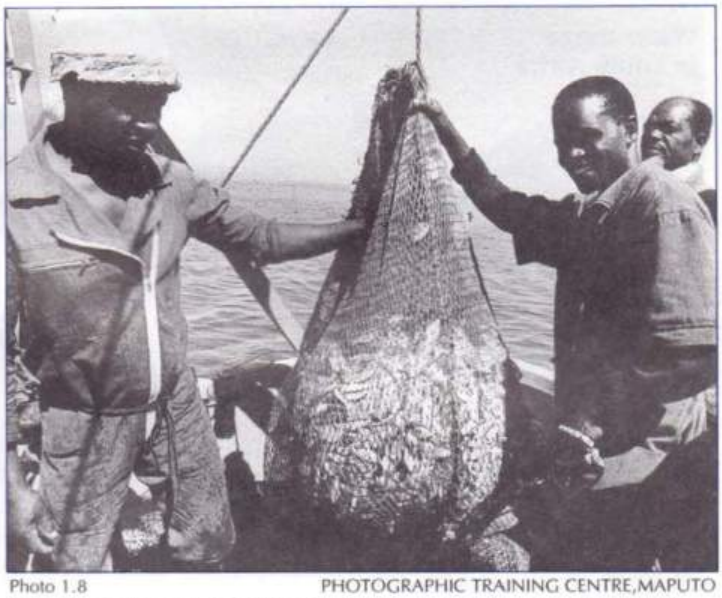


Photo 1.8 PHOTOGRAPHIC TRAINING CENTRE,MAPUTO
Fisheries in the region include commercial, traditional and artisanal.

Marine

Half of the 12 SADC member-states have coastal areas: Tanzania, Mauritius and Mozambique on the east coast, South Africa on the southern tip of the continent, and Angola and Namibia on the west coast. Five of them, excluding Mauritius, not only provide access to the sea for the other landlocked countries, but also have thriving marine fisheries. For example, Namibia is poised to be a major world player in the marine fishing industry. The country expected total landings from its waters to be 850,000 metric tonnes in 1994; and government estimated that the fisheries industry would create 1,500 new jobs a year over the next five years.[44] The Namibian fisheries sector contributes more than 35 percent annually to the gross domestic product, and jobs have more than doubled to 12,000 since independence in 1990.[45]

Fisheries in the region include traditional and artisanal, as well as commercial. In Mozambique, for example, artisanal fishers — who own a total of 18,000 boats and canoes — use 13 different methods to harvest marine fish to optimise catches and meet market needs of the local community. On the Mozambican island of Inhaca, about 1,000 men use boats to fish and their annual catch is 400-500 tonnes.[46] Tanzania's artisanal fisheries employs about 2.5 million people.[47] These coastal areas have an enormous influence on trade, use of marine resources and recreation. The quality of marine waters also affects the health and development of coastal populations who depend on them for food and recreation.

Pollution

As demands for potable water have increased worldwide over the years so have human impacts on freshwater systems, according to the United Nations Environment Programme (UNEP).[48] Water used for domestic purposes, industry or agriculture is frequently returned to its original source polluted or contaminated with chemicals or other harmful substances, reducing the amount of good quality water available to people. For example, in Zimbabwe, the Mukuvisi river, which runs into Harare's drinking water supply, contains high amounts of nutrients, such as phosphorous and nitrogen, sulphate, calcium, magnesium and fluoride, aluminium and iron, largely from industrial dumps along the river banks.[49]

Terrestrial

Population growth, increasing urbanisation and industrialisation all contribute to the increase in waste and pollution in southern Africa. The main sources of pollution are found in urban areas and major developments such as mines, and irrigated and other rain-fed commercial agricultural estates. Water contaminated with poisons from agricultural estates, mines and industries runs through some areas where it may be used for drinking and washing or watering livestock and gardens. Cholera and other water-borne diseases are often found in water contaminated with untreated human waste and sewage.

Excessive use of nitrogen fertiliser pollutes the soil, resulting in acidification which releases toxic substances, impairing the growth of crops. About 5,000 sq km of land in South Africa are acidified – some 10 percent of the country's cultivated lands. A large proportion of fertilisers either washes off the soil into rivers or leaches through the soil into groundwater and then into rivers. These nutrients are as effective in increasing plant production in the water as they are on land. When in excess they can cause eutrophication (insidious form of pollution) which stimulates the development of blooms of algae, floating plants or expanding stands of rooted plants, any of which may reach pest proportions.

Manufacturing and service industries are the primary source of pollution in southern Africa, producing tonnes of effluents, solid waste and air pollutants. Major polluters include thermal-electric power stations which burn coal or petroleum products, fertiliser factories, textile mills, chemical manufacturing plants, pulp-and-paper plants, slaughterhouses and tanneries. Water is the usual recipient of industrial pollution because disposal of wastes into water bodies is cheap and convenient. Eventually these wastes can accumulate to a point where they become toxic and a health hazard.

Coastal areas

In coastal areas, most industries dispose of their untreated wastes directly into streams or rivers running into the ocean. Industrial wastes are found in ocean waters near major centres along the entire coastline — from Dar es Salaam and Maputo on the east coast, past Durban and Cape Town in South Africa, Walvis Bay in Namibia to Báia do Cacuaco, 15 km north of Luanda in Angola.

Photo 1.9 SARDC-M Chenje

Water tests are conducted along many rivers in the SADC region to monitor pollution levels.

Marine pollution due to human activities in and around major cities such as Beira, Maputo and Luanda has, in some cases, reached toxic levels. For example, Maputo had three times more people by 1992 than it could support, resulting in sewage and pollution problems. In Angola, untreated industrial wastes are being pumped into the Bay of Luanda, resulting in bacterial contamination.[50] Rapid and unplanned settlements have created a city with virtually no sanitation, sewage system and refuse collection facilities. Only 13 percent of Luanda's urban population is estimated to have sewage connections and 16 percent has septic tanks.[51]

Oil tankers can also be a major contributor to pollution in the marine environment. Some 650 large vessels transport more than 150 million tonnes of oil along the region's coast annually. There have been at least six major oil spills affecting South Africa since 1965.

ENVIRONMENTAL IMPACT ISSUES

Other major environmental impact issues in southern Africa — apart from population growth, poverty and economic development — include energy sources, soil erosion, river and dam siltation, sustainable use of wildlife resources, desertification and global warming.

Land-use practices

Tree logging to clear land for agriculture and for fuelwood, and intensive grazing, can increase surface runoff, while trampling and ground compaction can decrease baseflow as infiltration to groundwater aquifers is hampered. Some years after the prohibition of grazing in the central area of Tanzania, water supplies became more reliable, streams began to flow during the dry season. Wells which used to dry up began yielding water year-round.[52]

Conversion of indigenous forests to plantations of fast-growing pine and eucalyptus species has increased evapotranspiration rates and reduced the dry-season flow of rivers and streams. In the temperate-forest zone of South Africa, tree plantations have significantly reduced available groundwater and streamflow by an estimated 1.28 cubic kilometres per year (cu km/yr).[53]

Clearing land for agriculture increases runoff and decreases infiltration rates, lowering the water table. Vegetation reduces the impact of raindrops before hitting the ground, reducing the runoff and giving water a better chance to infiltrate into the soil. Compacted soil speeds up runoff by creating a hard, smooth surface — also creating ideal conditions for flooding. A study into the discharges of the upper Save river in Zimbabwe, found that mean annual stream-flow had increased by almost one-third between the mid-1950s and the late 1970s. The increase was attributed to more rapid runoff caused by a reduction in natural woodland and vegetation cover.[54]

Many of the rivers in southern Africa carry high loads of sediment, mainly due to poor land-management practices. About 120 million tonnes of silt go into South African rivers each year.[55] Siltation makes a river channel shallow, forcing water to overflow the channel barriers and increasing evaporation. In Malawi, increasing silt loads have caused rivers to meander more than usual and flood their banks more often, washing away riverbank crops.[56] Excess silt also clogs river bottoms, smothering insects and other small creatures, and ruining fish spawning areas.

Siltation of dams is a major concern in southern Africa and generally results from soil erosion, often caused by poor land-use practices. Siltation can cut the useful life of a dam by one quarter, with some major dams silting up in less than 20 years. A survey of 120 dams in Zimbabwe's Masvingo province showed almost two-thirds were over half full of silt and others completely silted.[57]

Mining

Mining contributes to over 50 percent of national economies of some member states in the southern African region, although it is a potential danger to the environment. Mining operations occur in a number of wetlands in the region, for example, the extraction of salt in Etosha (Namibia), gold panning along the Zambezi river, and iron mining in the Kafue Flats (Zambia). The copper mines of Zambia discharge waste in the Kafue river, polluting the Lusaka swamps.

Some of the environmental effects of mining are:

- excessive water extraction;
- water contamination by soluble substances and liquid effluents of toxic substances;
- dust and other mobilisable substances which

may settle on food plants and be ingested by animals or may be directly inhaled causing respiratory disorders; and
- vegetation destruction and erosion as a result of overburden removal.[58]

SUSTAINABLE DEVELOPMENT

Sustainable development has been described as the ability of the present generation to utilise its environment without putting at risk the ability of future generations to do likewise. In the case of southern Africa, the President of Botswana and Chairman of SADC, Ketumile Masire, has aptly stated: "Our ideals of sustainable development do not seek to curtail development. Experience elsewhere has demonstrated that the path to development may simply mean doing more with less. As our population grows, we will certainly have less and less of the resources we have today. To manage this situation, we will need a new ethic, one that emphasises the need to protect our natural resources in all we do."[59]

These resources include water. As it is, vast rural populations survive on a few litres of water per day, while industrialised regions consume 100 times that amount.[60] Meeting today's needs and those of the future will require a reorientation of social attitudes, particularly the belief that water is an abundant natural resource available at no or low cost, when in fact it is an essential commodity which is becoming scarcer and more valuable through increasing competition. The wise use, management and conservation of this finite resource, therefore, depends on the people of the region.

In light of increasing water demand due to population and economic growth, southern Africa needs a comprehensive annual water budget that not only takes into account all sources of "revenue" — surface, groundwater and marine — but also "expenditure", balancing the people's individual needs and those of other activities such as agriculture and industry.

This annual regional accounting of water resources should help reduce the ever-increasing water deficits and avoid disasters such as drought-induced famine and animal deaths. This should also help avert crises such as water rationing, industry closures, electricity load-shedding due to inadequate water to power hydro-electric turbines.

Competition over water can lead to conflicts among states and among communities in a particular country. For example, in Zimbabwe, the inequitable distribution of water resources between largescale commercial farmers on one hand and smallscale commercial, resettlement and communal farmers on the other have pitted one group against the other.

Photo 1.10 SKYHOST-S Nkhata

Royal paddlers participate in the annual Kuomboka ceremony during which the Lozi people evacuate their Zambezi plains homeland for higher ground.

Access to water generates heat in Zimbabwe Story 1.2

Harare (SARDC) — Access to water in Zimbabwe is arguably the next most controversial issue in the country after land distribution and indigenisation/affirmative action.

Dr Hugh Williams, an official with the government's Ministry of Lands and Water Resources, has described water as the "single most important resource for our future" and "the pivot on which all future development depends".

Recurrent drought severely impacts the availability of water throughout the country, increasing competition and tension among various users, particularly among commercial and small-scale commercial, resettlement and communal farmers.

While 70 percent of people in Zimbabwe depend on natural resources, including water, their access to those resources is constrained. For example, they are limited in their use of available water resources from major irrigation schemes. Small-scale, resettlement and communal farmers are also not adequately catered for under the present Water Act, hence the tension between commercial and small-scale commercial farmers. The Zimbabwe Farmers' Union, which represents the small-scale commercial farmers has even threatened to draw water from rivers in violation of the Water Act.

The impact of drought on communities throughout Zimbabwe has been severe, particularly during the 1991/92 and 1994/95 seasons. The government has already stated that the 1994/95 rainfall season was one of the worst on record. Authorities estimated that a total of 5.157 million Zimbabweans faced hunger due to the large-scale failure of crops during the 1994/95 agricultural season.

One of the rural people caught in the vicious circle of drought periods over the past five years is Maria Kudzingwa of Nhekairo village, in Wedza. She says in the 60 years since she was born, she has never experienced such severe drought periods. For Mudzingwa, the past holds the best of her life experiences. The present, with its droughts and failed crops, is a stark reminder of paradise lost: of abundant rain and many springs.

The majority of the rural people now depend on boreholes and wells rather than on natural water sources such as springs. Due to the unrelenting drought, more boreholes need to be drilled, and the Department of Water Resources estimates that it needs about US$8 million to sink an additional 600 boreholes in communal areas.

While the drilling of boreholes in communal areas is a matter of survival, in urban areas, they are mostly used to circumvent water rationing measures, and to water lawns and recreational facilities such as golf courses.

The use of water in urban areas is, therefore, seen as infinite and an issue of affordability. Little regard is paid to conserving this resource.

Effective water conservation measures are essential for Zimbabweans to cope with drought, and avoid the need for a water redistribution programme being planned by the government.

— **Munyaradzi Chenje**, SARDC, August 1995.

Population growth to outpace freshwater supply Story 1.3

Washington (Reuter) — Global population growth will outpace freshwater supplies in the next 30 years unless farming, industrial, and household consumption patterns change, wrote a team of American researchers in a recent edition of the Journal Science.

"You look at earth from outer space, you see this big blue sphere. You don't really think of it as a scarce resource, or think about how water — freshwater — can impose restrictions on human activity," Stanford University biologist, Gretchen Daily, said in an interview.

Only about 2.5 percent of the earth's water is fresh, and two-thirds of that is locked up in glaciers and ice caps.

So less than one percent of all the earth's water is freshwater in aquifers, rivers, soil, lakes, swamps, plant life and the atmosphere, said the team made up of Daily, Stanford colleague, scientist and author Paul Ehrlich, and Sandra Postel of the Global Water Policy Project in Cambridge, Massachusetts.

And not all water is easily accessible. Where there is lots of water, there are few people. And in the areas hospitable to human habitation, water is not necessarily abundant.

The possibilities of capturing more of the earth's available freshwater are limited. About 26 percent of the water available through rain is already captured, and there is not much more land available for rain-fed farming and grazing, they wrote.

Just over half the water from runoff, in lakes and streams, is already captured. Building dams could increase that by about 10 percent in 30 years, but the global population is forecast to grow by about 45 percent during that period.

Pressures on water supplies are already being seen in declining freshwater fish populations. But more problems can be expected in food supplies, which in turn can create more international conflicts, immigration pressures and public health problems, Daily said.

"We've got to bring human activity into balance with nature's bottom line," she said.

For instance, instead of using up water to clean up pollution, she advocated less pollution. Better irrigation and farming technology and ending subsidies that keep water artificially cheap were other remedies.

"Some regions are already facing constraints."

— Adapted from Zimbabwe Newspapers, "Population growth expected to outpace freshwater supply", 10 Feb 1996 p. 2.

Linkages to other chapters Box 1.4

2 CLIMATE

Climate is a major factor in the availability of water and southern Africa's ability to be self-sufficient in food production. Both climate and water availability have over generations affected people's lives, influencing the years of plenty with good rains and years of scarcity with droughts.

3 ENVIRONMENT

Water is the lifeblood of not only people but also other non-human species, supporting wildlife in different ecosystems such as mangroves and swamps. With increasing human pressure on this life-supporting resource, southern Africa's biological diversity may be at great risk.

4 MANAGEMENT

Proper management of water and aquatic resources is crucial to the survival of both people and non-human species of southern Africa. Overexploitation may lead to severe shortages, increasing conflicts among different users.

5 AQUATIC RESOURCES

Freshwater and marine living resources not only contribute immensely to the sustenance of many communities throughout the region, but also to the economies of SADC member-states through fisheries and tourism.

6 POLLUTION

Water pollution is now a major issue in some big cities of southern Africa, putting the health of some sections of the population at risk. Awareness campaigns must be intensified so that people become aware of the consequences of marine and freshwater pollution.

7 COOPERATION

Cooperation among southern African countries and peoples is the only way to achieve an optimal shared use of the water resources.

8 TRENDS

Population growth and consumption patterns are impacting on overuse and degradation of water resources in the region.

NOTES
CHAPTER 1

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2 CLIMATE and Water Availability

Southern Africa's environment is dynamic and rich. It is a shifting and complex landscape, shaped by ever-changing combinations of rainfall, temperature, fire, vegetation, people, animals and many other factors. Rainfall is its lifeblood. Much of the region is arid or semi-arid and rainfall is variable, often unreliable. Praying for rain is not uncommon in many parts of the region, and the onset of the rains is often viewed as the single most important event of the year.

Since colonial times, administrators and experts from elsewhere have looked at southern Africa and boldly made observations and drawn conclusions, based on models outside the region, without understanding the climatic conditions and ecological processes here. Despite decades of ecological research in the region, this work has started to influence policy-makers only recently.

CLIMATIC FACTORS

Water falls from the clouds in many forms. In its liquid or solid state, it may be rain, drizzle, sleet (freezing rain), hail or snow. In southern Africa, hail is not uncommon, but snow and sleet occur only in certain areas, such as Lesotho and the Drakensberg mountains in South Africa.

Weather systems

The Inter-Tropical Convergence Zone (ITCZ) brings most of the rain that falls in the southern African region. This zone occurs between a dry, warm air mass and a moist, cool air mass. The ITCZ is a zone of intense rain-cloud development created when the Southeast Trade Winds (from the southern part of the region) collide with the Northeast Monsoons (winds from the north). The movement of the ITCZ southward away from the equator marks the start of the main rainy season in the southern hemisphere.

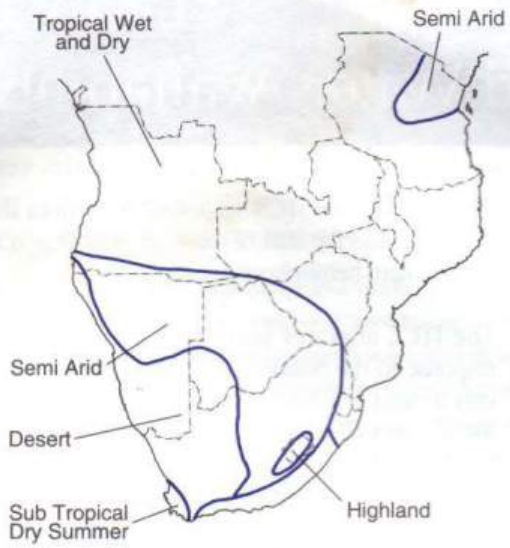
The ITCZ migrates seasonally over Africa, in response to the position of the sun, and its arrival over an area generates substantial rain. One indicator of how well a season is performing is to monitor the position of the ITCZ. In a normal year, it can fluctuate between mid-Tanzania and southern Zimbabwe, bringing good rains to most of southern Africa. The ITCZ dominates the weather north of the Limpopo river, and seldom penetrates south of this river. Over Angola, it also swings northwards, seldom reaching Namibia.[1]

An atmospheric condition known as the Botswana Upper High creates unfavourable conditions for heavy or widespread rainfall across southern Africa,[2] and its frequent occurrence almost always results in drought in some countries in the region. The Botswana Upper High is a high pressure cell centred over Botswana (hence the name) between three and six kilometres above sea level. In some instances, like an expanding balloon, it tends to push the rain-bearing ITCZ and active westerly cloud-bands out of the region and over the Indian Ocean. During winter and dry spells, the Botswana Upper High, along with the eastern mountain belt stretching from the Drakensberg in South Africa right up to Tanzania, blocks the moist air from entering the region.

Rainfall patterns

Rainfall in southern Africa comes almost entirely from evaporation over the Indian Ocean, although several weather systems combine to produce the

Climatic conditions Map 2.1



SOURCE: USAID, *SARP - Southern Africa Regional Water Sector Assessment*, USAID/Stanley Consultants, Gaborone, Vol. 1, July 1995.

characterised by tropical lowland with moderate high temperatures and high relative humidity, while further south near the Tropic of Capricorn, the temperature variation is greater and the air is dry. However, there are localised dry or wet areas within this overall pattern. The northwest of the region (northern Angola) tends to be very moist, for example, while some parts of the northeast (Tanzania) are quite dry.

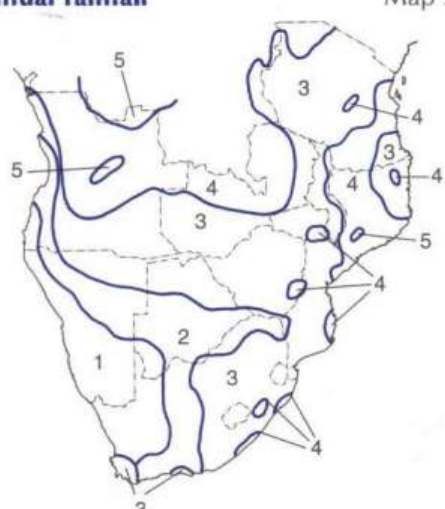
Rainfall is seasonal throughout most of the region. A five-to-seven month wet season occurs during the summer (roughly November to April) when virtually all annual rainfall occurs, followed by a virtually rainless dry season. Northern Tanzania experiences two rainy seasons. A small part of the southwestern tip, centred roughly on Cape Town, gets rain in winter. The northwest and some eastern coastal areas have rainfall year-round.

rainfall pattern. Evaporation is essentially the opposite of rainfall because the heat of the sun draws moisture from the earth, plants and water bodies back into the atmosphere. In many areas of the region the amount of rainfall over the year is less than the potential evaporation.

Moisture in the air is generally higher in the northeast of the region and lower in the southwest. Rainfall increases toward the equator, with the south and west of the region being arid or semi-arid.[3] The clouds gradually lose moisture as they move westward over the region, and less rain falls. This decrease in rainfall has an influence on rainfall variation, and areas with the least rainfall are most prone to high rainfall variability.[4]

Generally, there tends to be more rain in Tanzania and northern Mozambique, and less in Nambibia. Tanzania, toward the equator, is

Annual rainfall Map 2.2



Annual precipitation in millimetres

1	less than 250	4	1000 to 1500
2	250 to 500	5	1500 to 2000
3	500 to 1000	6	2000 to 2500

SOURCE: USAID, *SARP - Southern Africa Regional Water Sector Assessment*, USAID/Stanley Consultants, Gaborone, Vol. 1, July 1995.

The timing of rainfall is critical. Forests require regular rainfall throughout the year. In some cases, this can be partly substituted by conditions which give trees more access to water — high humidity areas (east coast) or low temperatures which decrease evaporation (high altitude or the southern part of the region). A long dry season during the cooler months leads to savanna mixtures of grasses and trees, but the unique *fynbos* vegetation (from the Afrikaans words for a fine-leaved bush) at the region's southwestern tip results from the reverse — with moisture in the cold season, and the dry season coinciding with the blistering heat of summer. When rainfall and moisture drop, the savanna gives way to a shrubby semi-desert, and eventually to full desert.

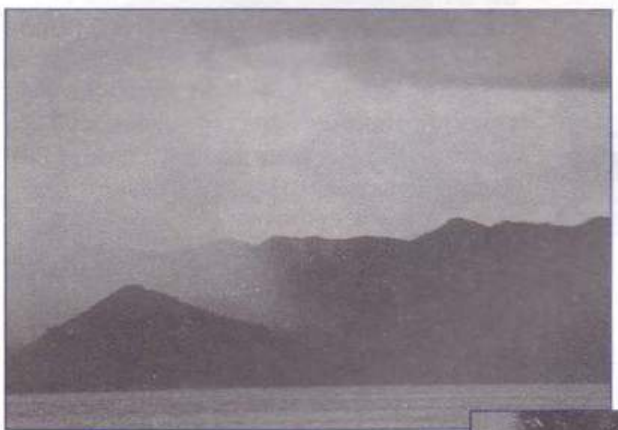


Photo 2.1 APG-D Martin

The dry savanna (which covers the southwestern part of the region and northeastern Tanzania) and *fynbos* (which covers the extreme southern tip of South Africa) have slightly more rain and less variability. The region's drier ecozones are particularly affected by rainfall patterns, and the frequency and intensity of drought cycles. Scientists studying these ecozones think that areas receiving less than 300-400 mm rainfall annually are controlled more by the short-term changes in rainfall than the long-term average. This is particularly so in areas where the amount of rainfall differs on a yearly basis from the average by more than a third.[5]

Areas receiving an average of 400-600 mm of rainfall per year can expect six droughts of two years or more in every 50 years.[6] Few areas in southern Africa receive rainfall in excess of 1,600 mm.[7]

Wet conditions in the far southern interior occurs sporadically in winter, due to cold fronts from the southern ocean moving east or northeast across the tip of the continent. The west coast is extremely arid.

Photo 2.2
Rainfall is seasonal throughout most of the region. There is generally more rain in northeast and less in southwest.

The Namib Desert, 80-160 km wide, occupies the coastal strip stretching some 1,700 km from Mocamedes in Angola to just beyond the mouth of the Orange river in South Africa. Prevailing southwesterly winds blow parallel to the coast, almost throughout the year, and are cool and very dry. Some areas may receive no rain and precipitation over most of the area seldom exceeds 50 mm in more than two months annually. Angola's tropical climate is characterised by hot and wet summers, and mild winters.

Temperature

Life on earth depends on the sun which changes temperatures, thus facilitating water transfers from the oceans to the land and back to the oceans. Atmospheric and surface temperatures set in motion the air vapour over land which precipitates as hail, snow, sleet, rain or drizzle.

When rain falls, it can sink into the ground, where it might be used by plants, or flow through the soil to a river or lake, or be stored as groundwater. If it does not sink into the ground it might run off over the surface to a river or lake. Most water evaporates. In southern Africa, an average of 85 percent of the rain will evaporate again under the heat of the sun in combination with dry winds. The water that remains amounts to about 600 cu km/yr[3] (roughly four times the total volume of Lake Kariba) of which 360 cu km/yr is feasible for use.

This process of rain evaporating from the ocean, falling on land and eventually returning to the oceans or the atmosphere is known as the water cycle.

Atmospheric temperatures are important for life forms on land just as water temperatures are for marine life. Seasonal and regional extremes of temperature occur throughout the interior plateau. Daytime temperatures exceed 40 °C in the low altitude areas in summer, while by contrast, frosts are common in the south in winter. Two lowest temperatures recorded in the region were -18 °C at the top of the Drakensberg Escarpment in Lesotho, and -19 °C on the Old Planalto in Angola. Below freezing temperatures are experienced in areas of over 1,600 m above sea level. Widespread frosts are common in the southern and central interior of southern Africa.

Seasonal variations of the mean monthly air temperatures in southern Africa are very small. Temperatures vary depending on altitude, latitude and proximity to large water bodies. The general pattern of daytime temperatures between 25-30 °C remains the norm in most countries of the region. The lowest temperatures of below 0 °C are observed in the highlands, mainly in Lesotho, South Africa, Angola and Zimbabwe. The coolest months are generally June and July. The warmest months are October and November when there is little predominant cloud cover as the sun moves southward and winds generally come from the tropical region.

Vapour in the atmosphere Box 2.1

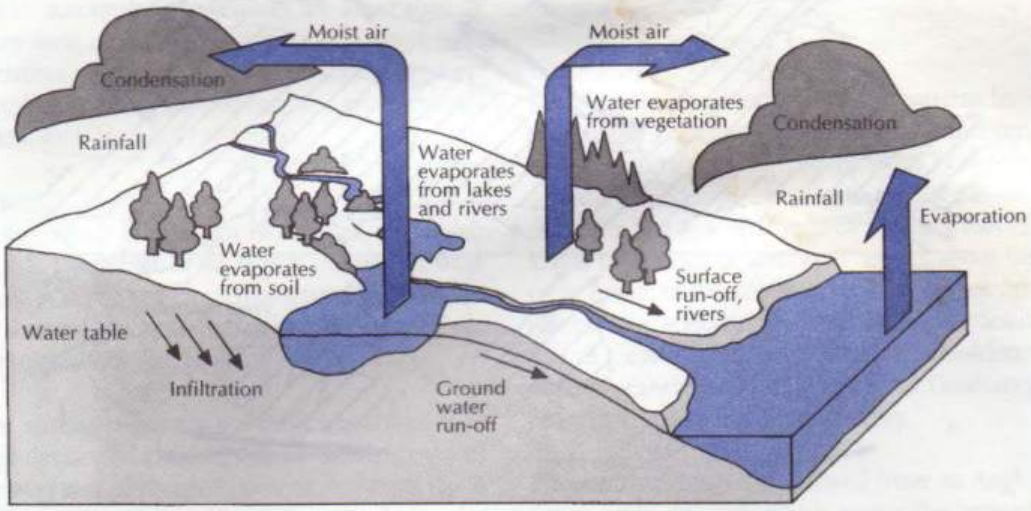
Nobody knows precisely how much water is contained in the different stages of the hydrological cycle at any one time. However, it has been estimated that the amount of moisture in the atmosphere at any one time is about 14 trillion tonnes (14 million million tonnes), which is the equivalent of 25.5 mm of rain over the entire earth.

It has also been estimated that if all water vapour in the atmosphere at any time were condensed, it would supply about 10 days average rainfall for the world as a whole. The water cycle may be completed and repeated every 10 days or more, and during the 10 days there may be several thousand kilometres separating the areas of evaporation, transpiration and precipitation.

Even in the absence of rain, the air contains large amounts of water in the form of water vapour. Since warm air can hold proportionately much more of this gas than colder air, some of the greatest amounts of moisture drift invisibly above deserts. The problem of aridity in deserts such as the Namib in this region, is, therefore, of condensation rather than any lack of water vapour.

SOURCE: Muchinda, M. "Climate and the Water Cycle", for SARDC, 1995.

The Water Cycle Figure 2.1



SOURCE: Supplement, "Conserving water", *The Star*, Johannesburg, March 1996.

Evaporation consumes more water Box 2.2

A major factor in water availability is evaporation. It makes rain possible and is instrumental in transferring water from the sea to the land in the form of rain. Evaporation from the ocean contributes about 84 percent of total precipitation while evaporation on the land contributes 16 percent. Of the 84 percent evaporated from the oceans, 77 percent is returned to the oceans in the form of precipitation.

In Namibia, the potential evaporation rate exceeds rainfall by far. In South Africa, where evaporation exceeds precipitation over most of the country, oil is poured on the surface to reduce the amount of water evaporating from dams. This includes the most extensively farmed area, in the 52,000-hectare Vaalartz irrigation scheme, where rainfall is about 150 mm a year while evaporation claims 3,000 mm.

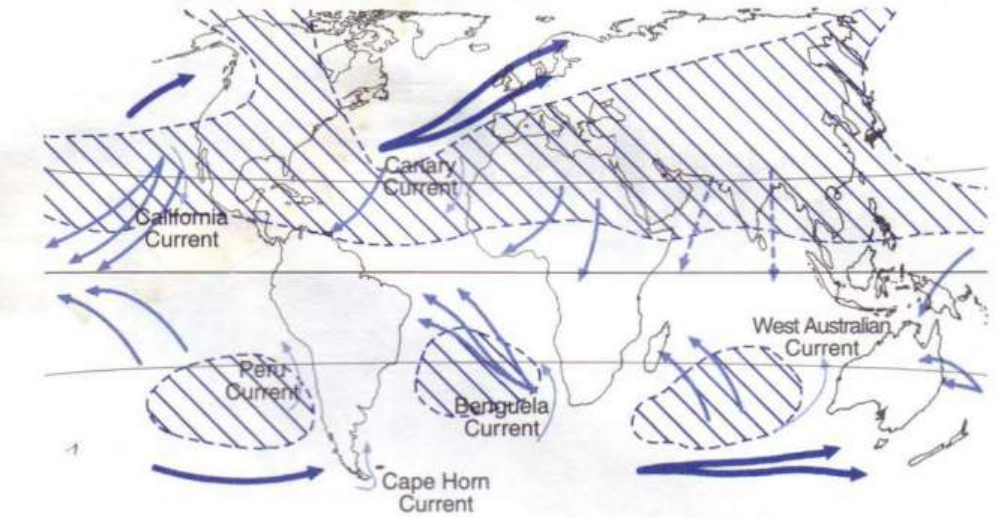
Where evaporation is high, dry conditions will prevail unless there is very high rainfall to offset it. The high temperatures in southern Africa mean high rates of evaporation, leaving only 3-15 percent of the rainfall to runoff. Conversion of indigenous forests to plantations of fast-growing pine and eucalyptus increases evapotranspiration rates (the rate at which trees transpire water which evaporates) and reduces the dry-season flow of streams because fast-growing trees also consume more water.

Evaporation from a free water surface is likely to differ from that which occurs from land surfaces, which again may have different covers of vegetation or may be under different land-use patterns.

SOURCES: Clarke, J., *Back to Earth: South Africa's Environmental Challenges*, Southern Book Publishers, Halfway House, 1991, p. 103
Sichingabula, H.M., "Water and its Availability", for SARDC, 1995.

General atmospheric circulation in January

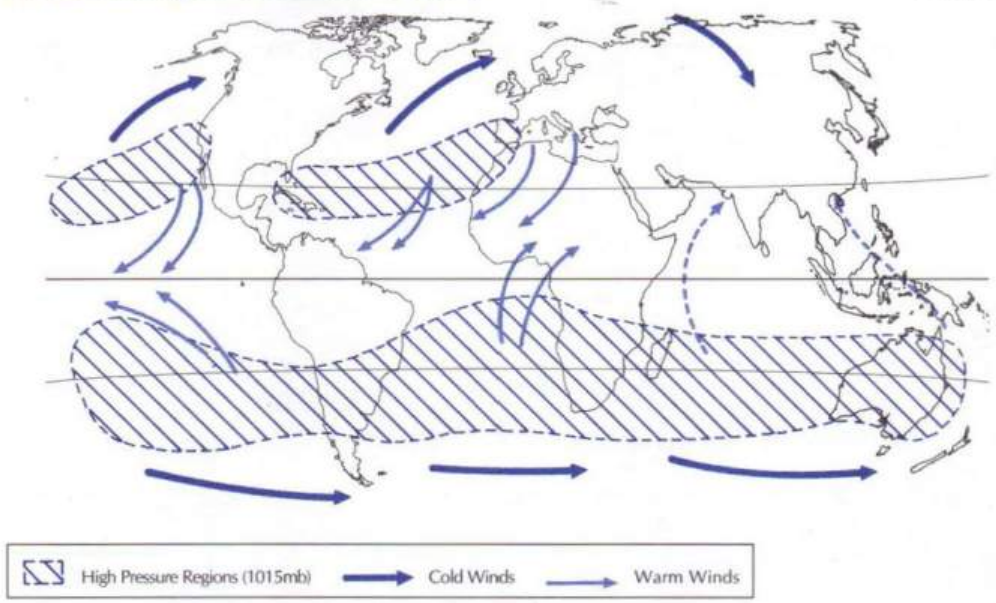
Map 2.3



SOURCE: Agnew, C. and Anderson, E., *Water Resources in the Arid Realm*, Routledge, London/New York, 1992.

General atmospheric circulation in July

Map 2.4



SOURCE: Agnew, C. and Anderson, E., *Water Resources in the Arid Realm*, Routledge, London/New York, 1992.

Although mean air temperatures in southern Africa may be higher than in most other areas of the world, maximum temperatures are lower than in many areas of Europe, America or Asia where temperatures near 40 °C are common during summer. Absolute maximum temperatures are generally below 40 °C in southern African.

Winds

Surface winds in southern Africa often reach high speeds. Over much of the region, the average wind speed is between 1 - 4 metres/second with very little seasonal variation. The winds are usually lighter in the afternoon and at night.

The strongest gusts are usually associated with well-developed thunderstorms or outbreaks of showery rain, although, in general, winds are much lighter and more variable in direction during the wet season. Winds tend to be strong during winter, blowing from the east-south-east over much of southern Africa.

Cyclones

Tropical cyclones are intense wind and thunderstorm systems rotating inwards to an area of low barometric pressure. They form at low latitudes, move from warm oceans to land, and finally "decay" due to friction and inadequate moisture, usually leaving a trail of destruction behind.

For a storm to be classified as a cyclone, the sustained wind speed must exceed 120 km/hr, increasing to more than 200 km/hr when fully developed. Tropical cyclones develop over water and lose their force over land.

In southern Africa, tropical cyclones are common, often sweeping across the Indian ocean islands of the Comoros, Madagascar, Mauritius and Reunion. They also affect some parts of the southeastern shores of the continent.

Cyclone Bonita, which formed over the Indian Ocean in late 1995, swept coastal areas in Mozambique before moving inland. Bonita was credited with bringing the rain to most of the region, causing a wet season after several years of drought.

DROUGHT

Southern Africa's climate and rainfall patterns have been highly variable for at least the last three centuries,[9] leading to recurrent droughts of varying severity. The region experiences regular wet and dry spells, that is, several years of abundant rain followed by periods of scarcity. Theories about the cyclic nature of the rainfall in the region were first recorded by scientists in 1888. By 1908, a South African scientist based in Natal had found evidence of an 18-year cycle of wet and dry years. Continuing research seems to support this theory.[10]

The word "drought" is derived from an Anglo-Saxon word *drugoth*, which means dry ground. However, meteorologists, hydrologists, agriculturalists and economists define drought differently.[11]

Meteorologists define drought solely on the basis of the degree of dryness and the duration of the dry period. Hydrologists link periods of shortfall to the effect on surface or sub-surface water supply (stream flow, reservoir and lake levels, and groundwater). Agriculturalists link drought to impacts on farming, focusing on shortages in rainfall, the differences between actual and potential evaporation, and factors such as the water deficit in soil. Economists associate the supply and demand of goods and services with meteorological, hydrological and agricultural elements.

Central to all definitions is the shortage of water.[12]

Drought is a condition of abnormal dry weather resulting in a serious hydrological imbalance, with consequences such as losses of standing crops and shortage of water needed by people, livestock and wildlife.

Changes in rainfall, whether in the total volume or in its frequency and reliability or changes in the evaporative demand of the atmosphere by which

Drought decimates status symbol Story 2.1

Mbabane (SARDC) — The status of the Swazi man, whose wealth for generations was measured in terms of his herd of cattle, is threatened by drought which is killing dozens of animals each month.

Many men have lost a lot of cattle: the safest form of investment in the rural areas. Water is the key to the large-scale livestock production. During the drought period that gripped the country up to 1995, about 55,000 cattle died in the lowveld mostly due to water shortage. Most of these animals belonged to Swazi men who held onto their wealth until drought decimated them. Commercial livestock farmers destocked heavily ahead of the drought.

Economic activity in Swaziland has also been affected by drought, placing the future of the sugar cane industry at risk as the major dams in the country dried up.

The affected lowveld areas included Lavumisa, Nhlane, Ka Langa, Siteki, Maphungwane and Big Bend. Major perennial rivers, such as the Great Usuthu, Ingwavuma, Black Mbuluzi, Phophonyane and many smaller ones, also dried up.

Large companies in the sugar-producing industry were forced to cut down due to lack of water. The water levels of the Mjoli, the Sand River dam and the Usuthu river, supplying three sugar companies, Ubombo Ranches, Mhlume Sugar Mill and Simunye Sugar dropped by at least 50 percent during the drought. In 1995, Swaziland expected to earn far less from sugar than the US$130 million it earned in 1994.

"And as conditions worsen, the companies would be forced to cut down raw sugar export, and quota allocations to blenders and manufacturers," according to a Swaziland Sugar Association official.

SSA also says it has been forced to abandon some of its sugarcane fields because of the low water levels. The country's only hydroelectric power station cannot produce enough electricity due to low levels of the Luphohlo dam. To avoid rationing electricity in three years time, the Swaziland Electricity Board is already planning to install a US$47 million fourth feeder line from South Africa.

Swaziland already relies on Eskom (South Africa) for electricity. Companies have also been forced to ration water, a move that has resulted in the imposition of restrictions on car washing and gardening.

Several communities have been forced to abandon vegetable production schemes due to lack of water. Boreholes cannot sustain such projects because the water tables are too low. The water crisis has rendered some communities that survived through self-help projects to look forward to government handouts.

— **Thulani Mthethwa** for SARDC, October 1995.

water is extracted from the land, have substantial impacts on a wide range of environmental and economic activities in southern Africa.

This has been witnessed dramatically in recent years in the region with the droughts of 1991-92 and 1994-95, both of which reduced economic production and impaired the quality of life for people and wildlife.[13]

In July 1995, the government of Zimbabwe appealed for aid to assist 5.157 million people whose lives were threatened by drought and needed food aid. In its appeal for donor support, the government stated, "In reality, the drought we confront in 1994-95 is worse (than the 1991-92 drought), particularly insofar as water is concerned."[14]

Droughts have occurred in the region throughout recorded history, but as yet it is not certain whether the increasing frequency and severity of these droughts are related to human activities or have some natural explanation or both. Extensive droughts have afflicted southern Africa in recent times, particularly during the following seasons: 1946-47, 1965-66, 1972-73, 1982-83, 1986-8, 1991-92 and 1994-95. The latter two periods have been described as the most severe ever in some areas of the region. These periods were also major *El Niño* years.

El Nino

El Niño is a weather condition which begins with the warming of waters in the western Pacific ocean, eventually affecting global climate.[15] *El Niño* means "the boy-child" in Spanish, because it occurs around late December, when Christians are celebrating the birth of Jesus Christ.[16]

This condition has an effect on weather over a quarter of the world's surface. *El Niño* develops as the warm waters of the tropical Pacific spread eastward in concert with shifting patterns of atmospheric pressure. These natural warming events alter weather patterns worldwide, probably causing droughts in southern Africa or contributing to their severity.

During the 1982-83 season, the severe drought in southern Africa and the Sahel, and the famine in Ethiopia, were linked to an *El Niño* occurrence.[17] During the devastating drought of 1991-92, *El Niño* lasted until the end of February 1992.[18]

About one third of the droughts in southern Africa may be attributed to *El Niño*,[19] a component of another global weather phenomenon, the Southern Oscillation. Together these are known as ENSO. During an ENSO phase, equatorial waters across the Pacific ocean get warmer. Normal airflow moves westward from the Pacific to the Indian Ocean, but during *El Niño* this movement is weakened or altered. This results in high rainfall in some parts of Latin America but low rainfall and even drought in southern Africa.

The opposite extreme of the ENSO cycle occurs when a cold phase known as *La Niña* (little girl) or anti-*El Niño* is experienced. The occurrence of *La Niña* results in unusually heavy rain in southern Africa. At this time the Pacific is cooler than the Indian ocean and wind systems move from the Pacific toward the latter.[20]

The region responds to *El Niño*-Southern Oscillation (ENSO) to an extent that during a warm ENSO phase there is general rainfall deficiency and during a cold phase there is above-normal rain. The wet seasons in 1984 and 1985 coincided with a cold ENSO, while 1987 was a transition from a warm ENSO to a cold one.[21]

Global climate change and drought

Scientists predict that global atmospheric changes could disrupt established weather patterns, so that existing weather conditions such as drought occur more frequently. It has been suggested that global warming may have caused or contributed to recent droughts, but there is no scientific evidence yet to support this. The fact that droughts have been an ongoing occurrence since prehistoric times makes

it difficult to assess the role of global atmospheric change.

Planning for drought

Climatic change and drought are recurring cycles in most parts of southern Africa. Drought has been studied here for over 100 years, and is recorded in text and oral history dating back many generations. It is reasonable, therefore, to expect and plan for droughts in this region — with or without global warming. Mismanagement of one drought leads to reduced productivity and greater susceptibility to the next drought.

Awareness, education and training can help to reduce drought susceptibility in the region. Today droughts are viewed as abnormal or unusual, particularly by urban populations, and not something for which people can plan or prepare. Droughts are also viewed entirely as environmental problems rather than problems exacerbated by people and their interaction with the environment. An improved knowledge base and increased understanding of all the factors surrounding drought is needed to improve awareness, education and training.

Early warning capabilities have been upgraded in the region, and information systems improved. Collection and dissemination of information can play an increasingly important role in drought anticipation and preparation. The challenge now is to encourage wider usage of this information for planning purposes.[22]

AVAILABILITY OF WATER

The socio-economic future of people in southern Africa depends on agriculture, fisheries, mining, industry, manufacturing, tourism, and industrial development to generate employment and economic growth. This can only be achieved if water of acceptable quality and quantity can be supplied in time at the right locations and at low cost to support the planned, expected socio-economic development in a country or region.[23]

Human activities and natural conditions which affect the environment also determine the availability of water in many ways, either by overuse or pollution of water resources or even the dry conditions.

Surface runoff and reservoir regimes

The flow of water on the surface of land, or runoff, responds to seasonal variations in rainfall. Distribution of runoff in a given year depends on the annual distribution of rainfall.

There is need to harvest as much water as possible during the rainy season for the dry times. When there is high precipitation and runoff during the wet season, most of the southern African rivers, streams and reservoirs fill up. The levels drop gradually as dry months set in.

In recent years, flash floods have occurred, largely due to poor land-management practices. Models for estimating flood magnitude become obsolete quickly due to changes in the natural environment. The recent droughts in southern Africa influenced the runoff regime tremendously on most rivers, lakes and reservoir levels in the region. Botswana, one of the driest countries in SADC, experienced the worst floods for many years in 1995, while Malawi suffered the same in the 1991-92 season.

Almost all of Mozambique (except areas to the immediate east of Lake Malawi and along the border with Zambia) as well as Lesotho, Swaziland, eastern South Africa, a greater part of Namibia and southwestern Angola, get up to 60 percent of their annual runoff during the three wettest months of the year. This figure increases to 80 percent in the central areas of South Africa, Botswana, Zambia, Zimbabwe and Malawi.

During dry months, less than 10 percent of total annual runoff is registered for the coastal areas of Mozambique, central Malawi, Lesotho, Zambia and Swaziland. Annual runoff drops to five percent in the dry season for a very large part of the region,

A historical overview of drought and rainfall patterns in southern Africa since 1800 Table 2.1

1800-30	Southern African rivers, swamps and other water sources dried up. Some well-watered plains turned to semi-arid karoo.
1820-30	This was a decade of severe drought throughout Africa.
1844-49	Southern Africa experienced five consecutive drought years.
1870-90	This period was humid in some areas and former Lake Ngami filled in the northwest of Botswana.
1875-1910	There was a marked decrease in rainfall in southern Africa, and 1910 experienced a severe drought.
1921-30	Severe droughts in the region.
1930-50	Southern Africa experienced dry periods alternating with wet ones, and in some years the rains were very good. The 1946-47 season experienced a severe drought.
1950s	There was abnormally high rainfall in some parts of the region. East Africa experienced flooding, and Lake Victoria rose by several metres. Elsewhere, the equatorial region experienced below normal rainfall.
1967-73	This six-year period was dry across the southern African region. The equatorial region experienced above average rainfall.
1974-80	This period of six years was relatively moist over much of southern Africa. In 1974, the average annual rainfall was 100 percent above normal throughout the region.
1981-82	Most of southern Africa experienced drought.
1982	Most of sub-tropical Africa experienced drought.
1983	This was a particularly bad drought year for the entire African continent.
1985	Conditions improved.
1986-87	Drought conditions returned.
1991-92	Southern Africa, excluding Namibia, experienced the worst drought in living memory.
1992-93	Conditions slightly improved, but previous year's drought effects continued.
1993-94	Conditions improved.
1994-95	Many SADC countries hit by worst drought in memory, surpassing the effects of the 1991-92 drought in some parts of the region.
1995-96	Widespread rains in most parts of the region, prompting forecasts of a bumper agricultural season.

SOURCE: SADC/IUCN/SARDC, *State of the Environment in Southern Africa*, SADC/IUCN/SARDC, Maseru/Harare, 1994; updated by IMERCSA 1992-1996.

including the Zambézia Province of Mozambique, a large part of Zimbabwe, central parts of Botswana and South Africa. Namibia's runoff is very minimal, due to the arid nature of the country.

Surface runoff factors

Several factors influence surface runoff. Initially the amount of precipitation and its intensity matters. With very light rains over a short period, surface runoff hardly occurs; the rain only raises moisture content of the soil. Depending on the nature of the soil and the intensity of the rain, adequate saturation of the soil facilitates surface runoff. Sometimes soil-moisture levels determine runoff. Heavy rains may cause rapid runoff when the soil is compacted, not necessarily saturated.

Topography is also important. The steeper the gradient, the faster the runoff through gravity.

The amount of water already stored in lakes, ponds, rivers and aquifers also influences the intensity of surface runoff. The influence of stored water on surface runoff has been noticed with the recent discharges of the Shire and the Zambezi rivers, which were heavily reduced due to a drought-induced decline in water levels in lakes Malawi, Kariba and Cahora Bassa.

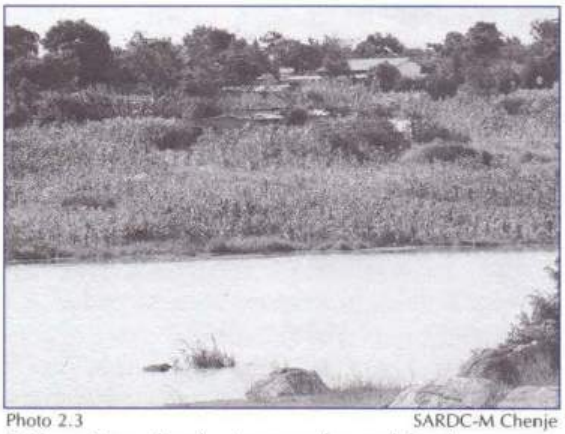


Photo 2.3 SARDC-M Chenje

Soil moisture levels, topography and land-use practices are among the factors that influence runoff.

Land-use practices have an influence on runoff regimes. In areas where deforestation is rampant or where poor land husbandry is practised, runoff tends to be exceptionally high.

In Malawi, for example, frequent flooding and abrupt cessation of flow or its general decrease, is largely due to bare lands extensively cultivated by the use of the hand hoe. Due to the degradation through erosion of the uplands, most river channels are filled with silt and sand deposited by the excessive runoff that occurs during the wet months.

Logging of forests, overgrazing and bush fires cause excessive surface runoff. Through the general increase in forest logging and extensive clearing for agriculture, much of the runoff occurs in a relatively short period during the year. More than 60 percent of the time the rivers' discharges are below their mean annual value. Land degradation causes sand and silt build-ups in river channels, completely changing the structure of the original channel bed. River discharge only occurs in the form of baseflow and access to water becomes very difficult. This may require heavy investment to abstract the water for any use. The Save (Zimbabwe, Mozambique) and the Limpopo (Zimbabwe, South Africa and Mozambique) are two major rivers that have virtually stopped flowing in dry seasons due to heavy siltation.

In highly urbanised areas, runoff tends to be correspondingly high due to the absence of an absorbing medium such as soil. Roads and concrete buildings both yield a great amount of water to the river channels.

Surface water distribution

Almost 13 percent of the Southern African Development Community (SADC), excluding South Africa and Mauritius, is made up of freshwater bodies known as wetlands, and much of the rural settlements, comprising about 60 percent of the population, is concentrated here.[24]

Freshwater wetlands can be divided into different types: rivers, including floodplains; lakes, deep or shallow; dams; and palustrine areas (swamps, marshes, fens, bogs and *dambos*).

Rivers

The principal rivers of the region have their sources in the mountains of the high rim of the central plateau. Africa's fourth largest and (southern Africa's largest) river, the Zambezi, is fed by tributaries in eight countries, draining about 40 percent of the region. Two of the other four major rivers in Africa have their headwaters in eastern and southern Africa, the Nile in Uganda and the Zaire, in Zaire. Only a few southern African rivers flow during winter as this season is very dry. During the most acute conditions of drought such as the 1991-92 season, only the Zambezi river retained a significant dry-weather flow.

A number of rivers have had changes to their flow as a result of damming either for hydropower schemes or for irrigation purposes. The flow of permanent rivers can vary dramatically between wet and dry seasons. Zambia's Kafue river, for example, at low flow can be just two percent of the amount at high flow. In the namakaroo, succulent karoo and desert ecozones, there are few permanent rivers. There are none between the Cunene and the Orange rivers, which mark the northern and southern borders of Namibia.

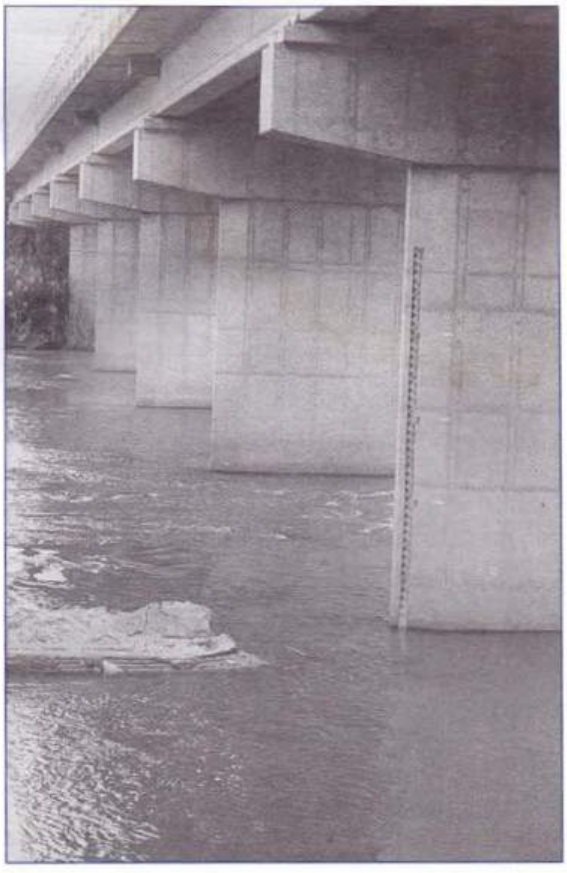


Photo 2.4 SARDC-M Chenje

The flow of permanent rivers can vary dramatically between wet and dry season, shown here in Swaziland.

The rainy season may bring river-flooding to some catchments in southern Africa, covering huge floodplains which may be associated with the transportation of silt and nutrients. This regular flooding gives rise to local areas of nutritious grassland for grazing of wildlife and livestock. This also provides the basis for floodplain agriculture, such as *molapo* in Botswana, which allows farmers to extend the growing season by clearing land in autumn and planting in spring, after the floods recede, but before the rains arrive.

Floodplains, including the Barotse (part of the Zambezi) and Kafue of Zambia, hold enough water during the rainy season to sustain economic activities such as inland fisheries. The Elephant marshes of Malawi are especially important for fish-spawning. The United Nations Food and Agriculture Organisation (FAO) estimates that 50,000 people in Angola are seasonally employed in the floodplain fisheries, especially in the Zambezi river headwaters of the central plateau. The Okavango river and floodplains are the only significant areas for freshwater fish in Botswana and Namibia.

In recent years, large dams such as Kariba and Cahora Bassa on the Zambezi, Kafue Gorge on the Kafue river, and a number of smaller dams have had a dramatic impact on floodplain ecology by controlling river flow and stopping flooding. Damming affects the intensity and duration of floods, reducing the area available for spawning in the plains below the dam. Low rainfall and increasing water demand are causing the shrinking of some floodplains once useful for fish production.

River basins

The management of river basins poses a serious challenge to the region. As demand for water and hydroelectric power increases, and exclusively national sources of water are fully developed, the only major new sources are likely to be international. Nearly 47 percent of the land area of the world (excluding Antarctica) falls within international river basins that are shared by two or more countries. Eight major river basins are shared by two or more countries in southern Africa — including the Congo, Zambezi, Limpopo, Okavango, Orange, Ruvuma and Cunene. Coordinated management of regional river basins is now being considered as a plan of action, although it has taken long to be prioritised due to the complex and intense processes involved.

The Zambezi river basin area covers 1.3 million sq km. The river carries more than 75 percent of the mean annual runoff of the region's interior, and drains more than 40 percent of the land mass.

Deep and shallow lakes

There are few large, deep natural lakes in southern Africa. The largest are the Rift-valley lakes — Victoria, Tanganyika and Malawi. The last two are the world's second and third deepest respectively. However, most lakes in the region are shallow due to the landscape.

Shallow lakes are quite different from deep lakes in that the water circulates most of the time, resulting in fairly uniform conditions such as temperature, nutrients and oxygen. Shallow lakes are generally no more than 10 m deep and often have large surface areas. They can lose a large proportion of their water due to evaporation; and the water-level rises quickly during heavy rains. These changes in water-levels also produce rapid changes in temperature, acidity and oxygen levels. Some shallow lakes in southern Africa can disappear seasonally or for longer periods, for example, lakes Liambezi and Ngami have disappeared.

"Soda lakes", such as Lake Manyara in Tanzania, have high salt levels (largely sodium bicarbonate, baking soda) and relatively alkaline water, with accompanying unique species which have adapted to such conditions. Most of soda lakes are found in the Rift Valley area in the northeast, in moist and dry savanna.

Pans, found in the dry zones such as the namakaroo and southern dry savanna, are usually salty. Soda lakes and pans provide a unique habitat, and their unusual collections of species, such as huge flocks of flamingos, are often conserved for tourism — Etosha Pan in Namibia, for example. They are sometimes mined for salt or soda such as the Sua Pan in Botswana.

Dams

The SADC region has many artificial dams, and Lake Kariba on the Zambezi is the most famous as Africa's largest artificial reservoir. The Kariba Dam and hundreds others found in the region are used for various activities ranging from hydroelectricity generation and/or irrigation to supplying both urban and rural communities with water for household use and/or improving inland fisheries. The major rivers as well as some of their tributaries have been dammed for such activities. For example, about 30 dams, of which Kariba is the largest at 160,000 million cubic metres (mcm), have been constructed for domestic, industrial and mining use, irrigation and power generation. More dams are planned along the river.

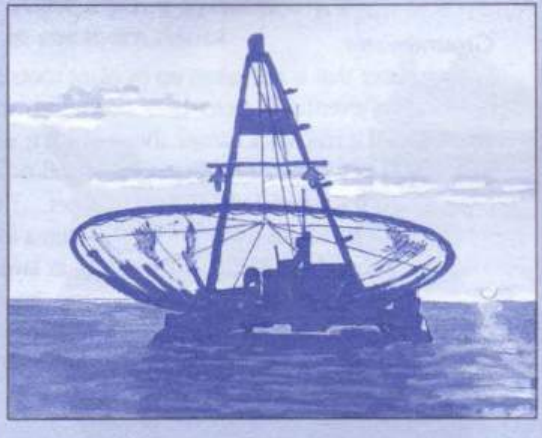
In the Incomati basin, a total of 10 dams with a total storage capacity of more than 12 mcm have

Water is a finite resource Box 2.3

Water is often confused as a renewable resource and an infinite resource. It isn't.

Of all the water on earth, 97 percent is saltwater — found in seas and oceans. Only three percent is fresh and most of it is locked away in the ice-caps and the world's glaciers. Very little of that three percent is readily available to people as freshwater.

Freshwater lakes and rivers, soil moisture and groundwater only take up 0.62 percent or less than 1.0 percent of the total volume of water resources on earth. It is this portion upon which more than 5 billion people, including southern Africa's 140 million, depend. More often, freshwater is located in areas where distribution to people presents engineering challenges.



At global scale, the proportion of freshwater stored other than in ice-caps and glaciers, and groundwater is insignificant and can be ignored. But at local scale, this is the water available to people for activities such as agriculture, mining and manufacturing.

The whole environment, including people, is heavily dependent on water. People gain direct and indirect benefits for their social as well as economic activities. A finite amount of freshwater satisfies the needs of the growing population, food production, industrial and energy production, urban and rural areas, and nature conservation.

An increased competition between different users of water, both within and between countries, can be a source of conflicts but also instrumental in creating opportunities for strengthening cooperation in the region.

SOURCE: Ohlsson, L., *Water and Security in Southern Africa: Publication on Water Resources, No 1*, Department of Natural Resources and the Environment, SIDA, 1955

Ill. 2.1; 2.2 & 2.3 INK SPOTS/IUCN-P Wade

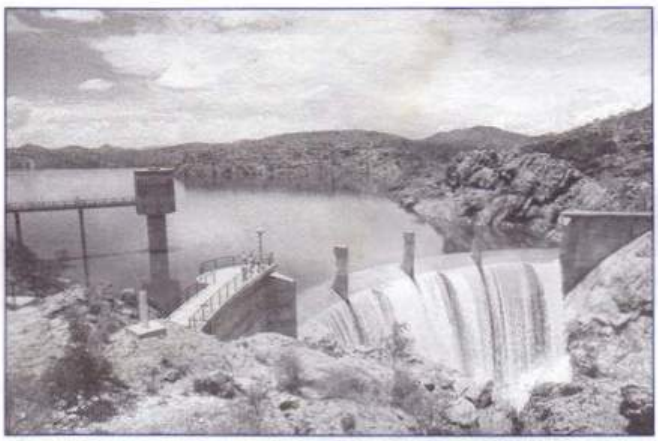


Photo 2.5 NAMIBIA REVIEW

Dams, such as the Oshivelo Dam in Namibia, can be used for many purposes, domestic and industrial.

been constructed along the Incomati.[25] In Swaziland, the water from the Incomati is diverted to irrigate about 12,000 ha of land.

In the Limpopo basin, more than 43 dams with a storage capacity of more than 12 mcm supply water for urban areas, as well as support industry and agriculture.[26] In Zimbabwe, the river has been developed almost to its full potential.

In the Save river basin, about 20 dams have been built to supply 2.6 million people with their water needs, and also for irrigation and mining. It is estimated that about 1.25 mcm of water is used in Zimbabwe alone annually.[27]

The Orange river is the most developed of all the SADC rivers with about 29 dams of which 24 are in South Africa. The storage capacity of the dams is more than 12 mcm. This is, however, to increase with the completion of the Lesotho Highlands Water project which will see a total of six dams built by the time the project is completed.

The filling period for a dam can cause major disruptions. Water flow can be cut off completely or nearly so, causing massive fishkills downstream. This happened when Cahora Bassa dam in Mozambique and Mtera reservoir in Tanzania were filled. In the dam itself there is usually a huge amount of trees, grass and other plants which drown, die and rot, using up large amounts of oxygen in the water. The lack of oxygen can kill fish. In some cases, floating plants take over, flourishing on the huge release of nutrients from the rotting vegetation.

A large amount of dam water evaporates. More than a quarter of the average inflow to Maputo's main reservoir, Pequenos Libombos, evaporates.[28] Annual evaporation from Lake Kariba is about 8 cu km/yr.[29]

Groundwater

Surface water that is not taken up by plant roots or evaporation eventually percolates down into the ground until it reaches a barrier above which it settles. It will get stored in the spaces in soil or in porous and fractured rock as groundwater. The water that occupies all voids or spaces within a formation is groundwater. It can also occur in layers of clay or other material that water usually cannot penetrate except in limited amounts. The top of the layer of water confined in the ground is known as the water-table.

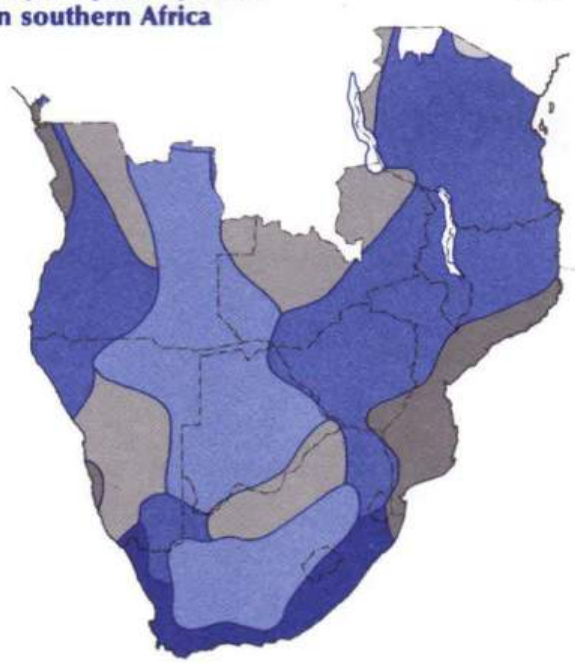
The medium of confinement, usually called an aquifer, may vary in nature. These may be in cracks of rocks or in huge caves or channels which form in some kinds of rocks. Groundwater flows from high to low areas, or from areas of high to low pressure, just as water does above ground, but over much longer periods of time — from a few years to thousands of years. Of the world's 0.62 percent volume contained as freshwater about half of this volume is below a depth of 800 m and practically not easily available for any use on the surface.[30] This proportion contains some of southern Africa's groundwater resources.

Groundwater is very important throughout southern Africa during the dry season and year-round in

the arid zones. The depth at which water is found increases from 30 m in the east to over 100 m toward the Kgalagadi. Boreholes in some dry areas of the region are as deep as 600 m. Groundwater is protected from evaporation, so much less water is lost than from dams, and it is more reliable.

Groundwater is drawn from hand-dug wells or springs, or pumped out from drilled wells and boreholes. It is the main source of water for many rural people throughout the region, catering for about 80 percent of the human and animal populations in Botswana and at least 40 percent in Namibia.

Major aquifer systems in southern Africa Map 2.5



SOURCE: Stanley Consultants from *Ground Water in Eastern, Central and Southern Africa*, United Nations, New York, 1989.

In Tanzania, in the Pangani Basin, there is a significant amount of groundwater abstracted for irrigation, with high yielding boreholes of more than 100 cu m per hour in the Kahe plains and 10-50 cu m per hour in the Sanya plains. In the Makutopora area, it has been established that the recharge areas are the major fault line which surround Makutopora. The established recharge is about 10-12 million cubic metres per year (mcm/yr).[31]

Natural recharge

Most aquifers are continuously recharged by rainfall, as long as the water is not used too quickly. Many seasonal rivers provide a good, reliable source of groundwater because they are replenished regularly. Dry river beds in Botswana often have aquifers under them which are recharged following heavy rains. These have limited amounts of water but recharge easily.

An interesting scheme to artificially recharge groundwater is being tried in Namibia. An important factor slowing down recharge is the amount of silt carried in the water following rains, which clogs the openings in the soil. By constructing a large dam to catch rainwater, allowing the silt to settle, and then releasing the water to huge infiltration areas, Namibia hopes to increase the natural-recharge rate of the huge Omdel aquifer.

Demand

Although parts of the SADC region are well-watered, the demand for both surface and groundwater is increasing rapidly and anxieties have begun to develop over access to water. Three of the region's 12 countries face inadequate freshwater supplies within 30 years — Botswana, Namibia and South Africa.[32] All have

Water: Lesotho's major export Story 2.2

Johannesburg/Maseru (SARDC) — Lesotho and South Africa's export-import business is set to become more fluid over the next few years when a huge water-project between the two countries is commissioned in 1998.

The Lesotho Highlands Development Authority (LHDA), which will boost water supplies to the rapidly developing industrial heartland of Gauteng province under which Johannesburg City falls, was reported to be a year behind schedule as at August 1995, due to an unforeseen requirement. It is now due for completion in March 1998.

The unforeseen requirement, to line the full 45-km length of the transfer tunnel, instead of only six provided for in the original contract, was due to unsteady rock conditions, which could not be established at contract tender stage.

A spokesman for the South African Department of Water Affairs and Forestry commented on the implications of the one-year delay: "Inevitably, this would impact on the availability of water drawn from the Vaal River Supply System, the main water supply source to the province of Gauteng.

"Potentially, this could affect the whole Gauteng population of 6.9 million people until the first water from Lesotho actually reaches the Vaal Dam."

However, the department noted that the supply from the Lesotho Highlands is intended to augment existing supplies to allow for a steady growth in demand.

"It does not mean that people will necessarily be without water since there is sufficient flexibility in the supply system," said the spokesman.

The water which should have been transferred to the Vaal river system from January 1997 would not be lost, but would be kept in storage in Lesotho for transfer to South Africa after completion of the transfer tunnel.

The 185-metre high Katse dam in Lesotho is the centre of the hydro-electric and water scheme which began in the mid-1980s. It is situated more than 3,000 m above sea level in remote mountain terrain. Tunnels with a diameter of five metres are being cut through solid mountain rock for 82 km to carry the water into South Africa's Gauteng province.

Tunnel-lining alone was expected to cost an additional R600 million (US$220 million), which includes financing cost up to the end of the construction period. This amount will be borne by the Vaal River System water consumer through water charges.

It had been planned that by 1997, some 18 cu m of water would be delivered to South Africa every second while another dam and a power station at Muela would generate 72 megawatts of electricity per hour. But this is now behind schedule.

— **Wilson Ncube** for SARDC, July 1995.

Photo 2.6 APG-D Martin
The water level of Lake Malawi has been dropping since 1990, causing water shortages for domestic use and power generation.

already experienced extreme water scarcity within the last decade.

Water demand is projected to rise at almost three percent annually, just about the region's average annual population growth rate, until at least the year 2020. Increasing water demand is a crucial concern in southern Africa because of the increasing human population and associated demand for resources, especially food. In water-scarce Namibia, for example, demand for state-supplied water increased from 37 million cubic metres/year in 1970 to 95 million cubic metres/year in 1993, an average of 4.2 percent/year and well above the population growth rate of three percent.

In most of southern Africa, inadequate water is the main limitation on living natural resources and development. Rising demand will exert pressure on available water for both human and non-human use.

In Malawi, experience during recent years has shown that the levels of Lake Malawi have gradually been lowering since the 1990-91 season and this phenomenon has caused great problems, particularly with water supply for the city of Blantyre and for power generation on the Shire River whose discharge is dependent on the levels of Lake Malawi.

Demand for groundwater in the region is increasing and will continue to do so in the years to come. Yet, despite the importance of groundwater for many people in the region, there is a general feeling among water managers in all countries that data on groundwater is insufficient and record-keeping is inadequate.

In areas such as Botswana and parts of Namibia where rainfall distribution is limited, the groundwater resources offer an alternative to water supply. Wherever groundwater is available in acceptable quality and quantity for domestic uses and agriculture, conserving such sources is important for posterity.

Ill 2.4

Linkages to other chapters Box 2.4

1 PEOPLE

The people of southern Africa have for centuries endured cyclic years of plenty of rain and periods of scarcity. They have adapted well to the vagaries of a harsh climate but increased population growth and economic activity are making the availability of water even more difficult.

3 ENVIRONMENT

The environment is a major player in influencing climate. Water used by the environment or its ecosystems, and that which evaporates, is not available for use by human beings. Therefore, human beings and the environment share the available water resources for their co-existence.

4 MANAGEMENT

Any water management plans have to consider climate. Effective water management is knowledge of water demand, which is essential for any short- or long-term planning. Little available water resources properly managed, can take people and the environment a long way.

5 AQUATIC RESOURCES

Water is the key element for commercialised use and management of aquatic resources, especially for inland water resources. The less water is available, the worse the balance in living aquatic resources.

6 POLLUTION

Water pollution reduces the amount of fresh water available for use by human beings. Industrial development and rapid urbanisation without proper planning have caused tremendous problems in managing pollution.

7 COOPERATION

Regional cooperation in development, management and use of available shared water resources between countries is essential to ensure that no other country is starved of a resource passing through its land.

8 TRENDS

Water availability in southern Africa could get critical, unless there are drastic changes to the environment and climate, and in management. The only option available to date is to use wisely and conserve the water resources.

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3 Water and the ENVIRONMENT

The environment uses water just as people do. It needs water for its natural systems, ecosystems, hydrological and biological systems. The water needs of the environment are not restricted to land only but extend to coastal and marine areas as well. Freshwater is necessary in marine deltas and estuaries to maintain the mangroves and other intertidal wetlands in which different forms of marine life breed.[1] River basin management should, therefore, consider the environment's water needs, among other things, to maintain the SADC region's biological diversity.

The water needs of the natural environment have not been included in national and regional water-demand planning in southern Africa until recently. While it may seem strange to include environmental usage as a "demand", it could be necessary in future to determine minimum amounts of water needed for ecosystems to survive, especially during drought periods. In the SADC region, a big fraction of the potentially available water is needed for nature conservation and ecological purposes. This is the water used by wildlife and in lakes, swamps and estuaries that support the region's ecology. In South Africa, for example, the quantity of water required for environmental management is projected to reach 2,954 million cubic metres (mcm) by the year 2000. This would be about 13 percent of total water demand in that country.[2]

Water reserve Box 3.1

South African Water Affairs Minister, Prof Kader Asmal, has announced the concept of a water reserve — that available water will first be used to satisfy the needs of the environment and of basic human needs.

Only then will the water be available for other uses. The environment, he says, should be recognised as "humanity's life-support system" — we abuse it at our longer term peril.

With an increasing population, increasing consumerism and the need to conquer poverty, as well as the threatening consequences of global warming, there are inevitable trade-offs which are usually at the expense of the environment.

Although some degradation is inevitable, the announcement is an indication that short-term opportunism will be countered.

SOURCE: Supplement, "Conserving water", *The Star*, Johannesburg, March 1996.

ECOLOGICAL ZONES

Water not only affects the soils, vegetation and wildlife, determines the type of land-use possible in an area, but is also the most important factor influencing most of the SADC region's ecological zones or ecozones. These are the natural units which make up the environment. They are controlled by a set of common processes, mostly climatic, and are dominated by life forms with similar physical adaptations to those processes.

Apart from rainfall and water, other factors which influence ecozones include soils and soil nutrients, fire, animals and climate.[3] Human activities also affect ecozones.

Rainfall and water

Areas of low rainfall tend to have relatively little vegetation, limiting the number of animals which can live there. High rainfall areas are more productive, but vegetation is often less nutritious. Extreme variations in rainfall, including droughts, can devastate an ecozone, with normal production reduced by over 90 percent.[4]

The variation in rainfall from year to year makes a difference to ecozones, especially in drier areas. Where annual rainfall varies by more than 30 percent, and is less than 300-400 millimetres per year (mm/yr), the variations affect the ecosystem more than the total rainfall.[5] In dry areas, it is difficult to tell the difference between drought-induced fluctuations and permanent changes in vegetation, because as rainfall becomes erratic there are large rainfall-dependent changes in productivity. The vegetation is continuously disturbed and has a very high resilience, or capacity to recover.[6]

Plants adapt to heat and lack of water in a number of ways. Their leaves are cooled by a process known as evapotranspiration, where water vapour moves through the leaves to the air, similar to the effect of human perspiration. Generally, hotter temperatures mean more evapotranspiration. To save water in hot, dry periods, some plants go dormant, appearing to die, while others shed leaves. In the arid savanna, trees tend to lose their leaves early and stay bare until just before the rains.[7] Others have developed thick, fleshy leaves which hold a lot of water and lose water vapour at much lower rates, or leathery leaves to protect them from the hot sun and strong, drying winds. While water planners often regard evapotranspiration as a waste of water that could be available for human use, it is, however, crucial as it drives plant productivity in the region's wetlands, contributing essential moisture to the hydrological cycle.[8]

Photo 3.1 APG-D. Martin

Variation in rainfall affects an ecosystem more than total rainfall.

Animals adapt to dryness too. Wildebeest are migratory in the dry Serengeti plains of Tanzania or the Kgalagadi desert in Botswana and Namibia, but sedentary in Tanzania's moister Ngorongoro Crater.[9] Wherever there is vegetation there will be animals to eat it, from the minuscule termite to the elephant. Grazing (grass-eating), browsing (leaf-eating) and other forms of feeding can consume large amounts of vegetation. Areas of high rainfall and low soil nutrients tend to have less animals than those with high amounts of both. Wild animals also affect other ecological functions. Trampling by many animals kills plants, exposes and hardens the soil so that water runs off, causing erosion. However, livestock grazing can have far greater impacts than wildlife whose numbers are naturally controlled by available water and food.

Ecozones of southern Africa

Southern Africa is divided here into eight ecozones and a ninth transitional zone:

- Lowland Tropical Forest experiences high continuous rainfall, and two months of low rainfall. This zone is divided into rainforest and coastal forest. Rainforest covers northern Angola's Zaire-river basin and gets an average annual rainfall of between 1,200-2,000 mm. The coast forest originally covered a 50-200 km eastern and western coastal belt, but is now narrower. Its average annual rainfall is 800-1,250 mm;

- Afromontane or Temperate Forest is scattered throughout the region and its minimum rainfall is 700 mm/yr. Rainfall variation prevents growth of lowland forests. While the afromontane zone is tiny and fragmented, it is important because of the high levels of biodiversity and its use for agriculture.

- Grassland covers mostly east-central South Africa and parts of Lesotho and Swaziland. Average rainfall is 400 - 800 mm/yr.

- Savanna is the biggest ecozone in southern Africa and receives average rainfall of 400 - 1,400 mm/yr. African savannas have been divided into two types — dry and moist savanna. Dry savanna receives relatively low rainfall over less than six months but has higher levels of soil nutrients, while moist savanna is the reverse, though other combinations of nutrient levels and rainfall certainly occur.[10]

- Nama-Karoo covers west-central South Africa, the Namibian coast and southern Angola. The average rainfall is 100-400 mm/yr, increasing from west to east with 60 percent of the rain falling in summer. Water is the main constraint in this zone resulting in low vegetation production.

- Succulent Karoo covers the area south of Luderitz, Namibia. Average rainfall is 20-290 mm/yr. More than 60 percent of the rain falls in winter. The low, erratic rainfall puts this zone in the "event-driven" category. During high rainfall events, carpets of daisies flower, covering tens to hundreds of kilometres, and then disappear, leaving their seed until the next high rainfall. It is classified as succulent karoo because many of the plants have thick, fleshy, water-retaining leaves. The succulent karoo has the highest diversity of succulent plants in the world, with over 200 rare and endangered plant species. This is a unique ecozone of international importance.

- Desert runs from north of Lüderitz in Namibia into Angola. Average rainfall ranges from 10-85 mm/yr, though fog can sharply increase average annual rainfall. Daily temperature range is very high, and soils are poor.

- *Fynbos* is found on the southern tip of South Africa and has an average rainfall of between 250-2,500 mm/yr. In the western part, 60-80 percent of the rain falls in winter, while the eastern part is more evenly distributed. The *fynbos* has a huge number of plant species — over 7,300 — and 5,000 of them are found nowhere else on earth.[11] Sixty-five percent of southern Africa's threatened and rare plants are found in the *fynbos*. Almost 500 are rare, threatened or endangered, and 35 are already extinct.

- Transition between Forest and Savanna, with average rainfall of between 1,500-2,000 mm/yr. Rainfall is too seasonal to support forests but not seasonal enough for savanna. The main reason for the transition is rainfall, which begins to become too seasonal to support a real forest.

- Wetlands are considered to be the tenth ecological zone in the SADC region, although not a formal ecozone. Wetlands include rivers, lakes, dams and swamps, and change the immediate area due to the presence of abundant water.

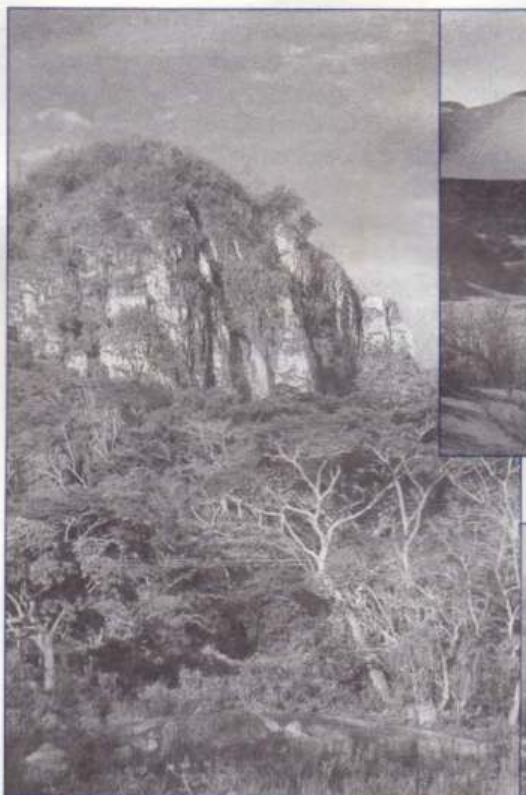


Photo 3.2 APG-D. Martin
The Afromontane/Temperate Forest ecozone is scattered through the region and has high levels of biodiversity.

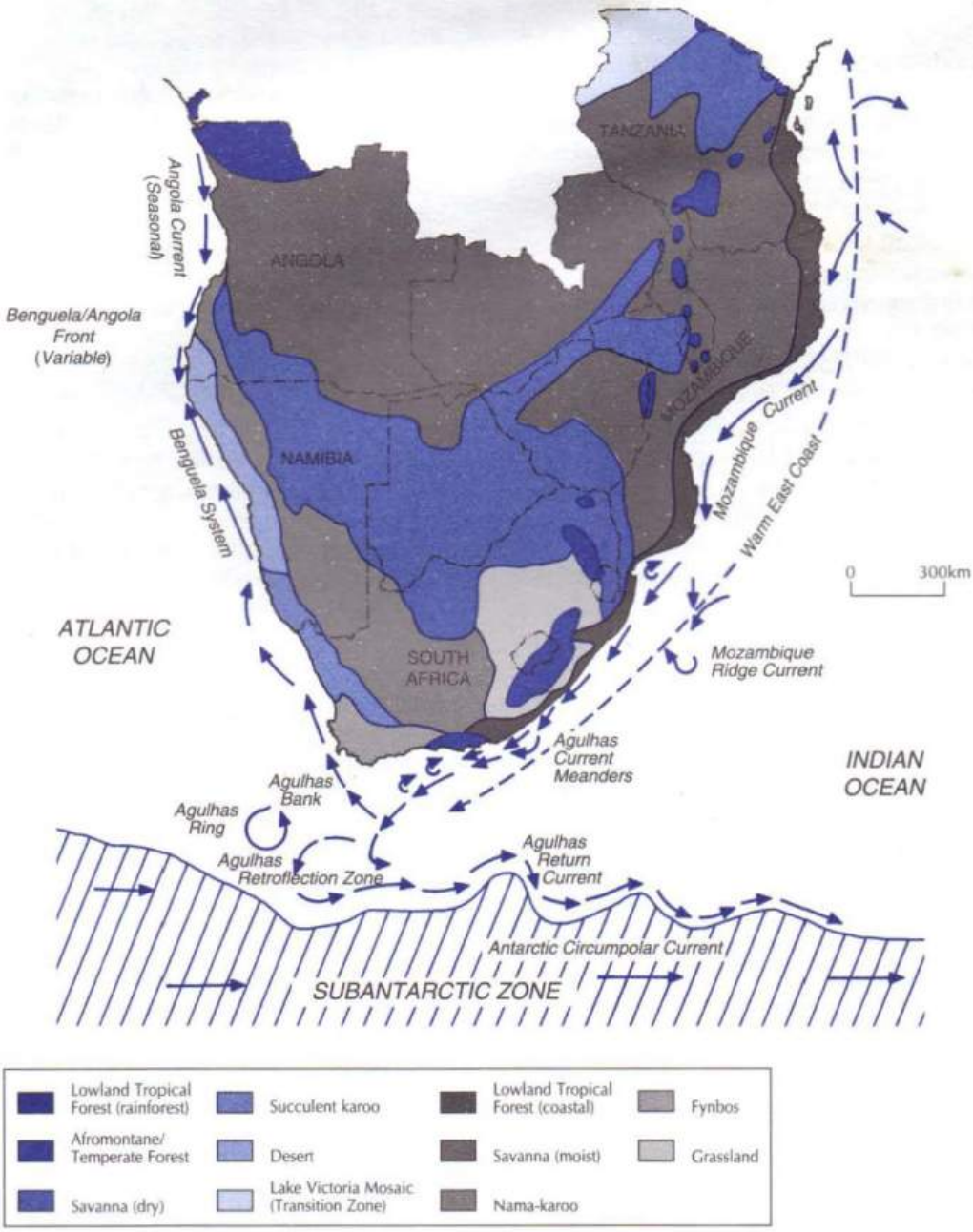
Photo 3.3 NAMIBIA REVIEW
Much of Namibia is desert, where rainfall averages 10-85 mm/year.

Photo 3.4 SARDC-M Chenje
Wetlands, such as the Okavango delta in Botswana, retain a large volume of water used for ecosystem maintenance.

Photo 3.5 APG-D. Martin
Oyster Bay, Dar es Salaam. Marine ecozones are divided into sub-tidal and inter-tidal.

Terrestrial and marines ecozones and ocean currents

Map 3.1



SOURCE: Frost, P.G.H., "Determinants of Structure and Function of southern Africa Biomes", for SARDC, 1993.
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WETLANDS

Wetlands retain a large volume of water which is used for ecosystem maintenance. They are important both as habitat for wild species and for agriculture during the dry season because of the water availability. Wetlands also provide a temporary habitat for migratory species, including birds which fly long distances between the southern and northern hemispheres, and are a refuge for some wildlife during droughts.[12] Wetlands and conservation areas have almost the same distribution patterns in the region; wetlands are widely distributed and cover about three percent of the land area.

There are five wetland systems in southern Africa: palustrine, riverine, lacustrine, estuarine and marine. These are grouped according to their common features, such as landscape, water chemistry, vegetation and formation.[13]

Palustrine

This system refers to vegetated wetlands, including marshes, swamps, ponds, pans, lagoons, *dambos* and springs. Palustrine wetlands may be situated along river channels, lake shores, and estuaries or in isolated catchments.[14]

Dambos

Dambos act like a sponge, storing large quantities of water during the wet season and gradually releasing it during the dry season.[15] There are four types of dambos in the region:

- the Kgalagadi *dambo* system, occurring on sand substrate (surface on which organisms live), in low rainfall areas, and largely seasonal. These are common in Namibia, Botswana, western Zambia and southern Angola;
- the highland *dambo* system, drainage and head water *dambos*. These are widely distributed in southern Africa's highlands and are dominant in Lesotho, Swaziland, South Africa, Angola, Zambia and Zimbabwe;
- the lowland or valley floor *dambos* are common in the lowland areas such as the mid and lower Zambezi valley, Luangwa valley and the Great Rift Valley. They are also referred to as pan *dambos*, and are seasonal; and
- the high rainfall *dambos* are mainly located in Zambia, Malawi and southern Tanzania. These are part of the drainage system and are perennial, but due to prolonged wetness, they have developed swamp features.[16] The system supports large numbers of terrestrial plants and animals, is a good source of grazing and allows the cultivation of maize, rice or vegetables.[17]

Temporary pans and vleis

In the more arid parts of the region, rain-filled depressions quickly dry out. These temporary or ephemeral wetlands are called pans or *vleis*. Pans usually have no established vegetation while *vleis* typically have some emergent plants. Although temporary, these wetlands support a wide variety of highly adapted organisms which can complete their life-cycles rapidly, can cope with large fluctuations in temperature and salinity, and can survive desiccation (drying out) or are mobile enough to move to another waterbody when theirs dries up. Ephemeral fauna typically include crustacea such as fairy shrimps, tadpole shrimps and clam shrimps, a variety of insect larvae, and tadpoles. Extensive pan fields occur in Namibia, Botswana and the north-western part of South Africa.

Marshes

Marshy areas are home to many kinds of plants and animals, including fish, which are often present in high numbers. The Elephant Marsh of Malawi are specially important for fish-spawning. Marshes also serve as stopping points for migratory species, especially birds.[18]

Springs

Springs form a major source of water supply for many rural communities in the southern Africa region. Their occurrence is to a large extent dependent upon climate.

Dambo-farming Box 3.2

From long experience, communities in southern Africa developed locally appropriate and sustainable systems for cultivation and grazing. Common throughout the region were strategies, including *dambo*-farming, to deal with environmental limitations such as unreliable rainfall. *Dambos*, meaning "valley meadowland", occupy about 10 percent of central southern Africa, including parts of Angola, Malawi, Mozambique, Tanzania, Zambia and Zimbabwe.

For example, in the Zvishavane district in southern Zimbabwe — a hilly region with limited resources, low productivity and only 450-650 mm of rainfall annually — *dambos* which dot the landscape are crucial to the survival of local people. The average household landholding is 5.8 hectares. The cultivation of drought-resistant crops — bulrush, millet, sorghum, cotton, sunflowers, maize — predominates. Most households have access to one or more *dambos* at the base of hills. About half of the households own draught cattle. Stocking rates are high — 4.6 ha/livestock stocking unit, compared to the ideal of 10. *Dambos* in the plains are reserved for grazing.

Dambos that hold water throughout the year are used mainly as a source of potable water. Crops, and in some cases, paddy production are often cultivated on the edges. The most common and preferred *dambo* type holds water for up to eight months a year. Such *dambos* are cultivated at least three times a year (August, December, May). The August/September planting is possible because a moisture flush enables the farmers to grow an early season crop, often maize and groundnuts — much of which is harvested and sold in late December. In *dambos*, with sandy loam or non-calcic soils, farmers grow such crops as bulrush millet, groundnuts, maize, and sunflower. On heavier clay and calcic soils, farmers grow rice and maize. Both soil types are well suited for vegetables. In many cases, rice, maize, groundnuts, sunflowers, and vegetables have been continuously cultivated in *dambos* for more than 100 years without any significant drop in productivity. Most of the produce from the *dambos* is sold locally, accounting in many cases for more than half of the family's income. *Dambo* yields fluctuate from season to season, depending principally on the amount of rainfall. More important, however, *dambos* almost always provide some produce. On balance, the average *dambo* farmer is better off than the non-*dambo* farmer.

Since they have high watertables, *dambos* are also the site of many hand-dug wells. Although most *dambo* grasses have low forage value at best, cattle are often grazed there during the dry season. *Dambo* grasses are an especially important source of forage during drought years. The grasses are also used for roof thatch and brooms, and trees on the edges of *dambos* provide fruit and fuelwood.

Most *dambos* are well managed to keep the resource base productive. To reduce soil erosion and improve water retention, most *dambos* are contoured and terraced. Land preparation involves ploughing between contours. Early planting helps ensure adequate crop cover before the main rains and guards against erosion. While most *dambos* are inherently fertile, many farmers apply cattle manure to further ensure fertility and maintain proper soil structure and texture. Some farmers also apply termitaria soils to sandy loam soils to increase their clay content. To protect soils and crops from cattle, most farmers have fenced their *dambos*.

SOURCE: Veit, P.G. (et al), *Lessons From the Ground Up: African Development That Works*, World Resources Institute, 1995, pp. 55-56.

There are many springs in the region, some producing hot water. The famous Ai-Ais (meaning "burning hole" or "steaming water") hot springs, where the water temperatures reach about 60°C, are one of the protected areas of Namibia.[19] Other examples are the Longola hot springs, situated outside the eastern border of the Kafue National Park in Zambia,[20] and the thermal springs of Nkhotakota, in Malawi.[21] The thermal springs in the region harbour a vast variety of algae species, which can exist at temperatures as high as 75°C.

Riverine

This is the largest wetland system among the inland waters in the region, and includes habitats dominated by rivers, floodplains and swamps, covering approximately 110,000 sq km. The Congo and Zambezi basins have the largest riverine wetlands.[22]

Rivers

Rivers are classified either as perennial (flowing throughout the year, such as the Congo, Cunene, Limpopo, Orange, Ruvuma and the Zambezi)[23] or ephemeral (flowing only after the rainfall).[24] Moist river-bank habitats are home to many wildlife species that would not otherwise be found, especially in arid areas. Rivers support a wide range of plant life adapted to a wide variety of conditions due to the variations in the river's flow levels.[25]

Rivers in southern Africa are habitats of many fish species and significant fishing takes place in rivers such as the Shire of Malawi and the Kafue of Zambia.[26]

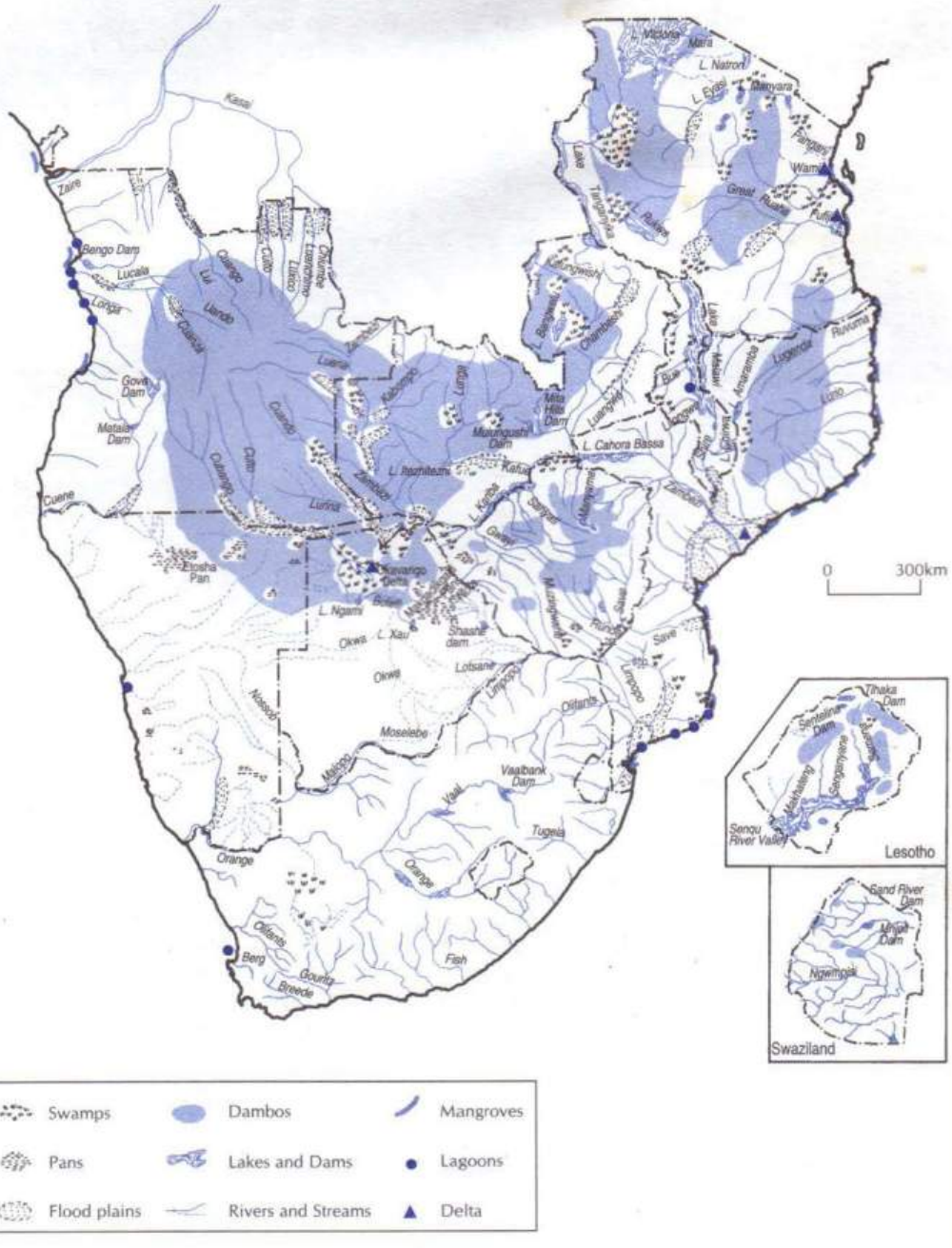
Characteristics of river ecological zones Table 3.1

Zone	Physical	Vegetation	Animal	Fishery potential
Upper	- steep slope - fast, cold, clear - high oxygen content - rocky bottom - low nutrients - little sunlight	- little - low nutrient and lack of sunlight which is blocked by dense trees on the banks of the river	- adapted to fast water - small fish - plenty of insect larvae - fish feed on insects and deadleaves	- low
Middle	- shallower slope - slower, wider - warmer - less oxygen - less rocky - more nutrients - more light	- much more vegetation - some reeds	- larger fish - molluscs - insects	- can be high
Lower	- low slope - slow, wide muddy bottom - high nutrients - low oxygen - lots of light (can be reduced by sediments)	- more vegetation - larger - more fish species - many bottom feeders	- large and small fish	- can be high

SOURCE: Day, J.A. and others, "Riverine Ecosystems", in O'keefe, J.H.O. (ed.), *The Conservation of South African Rivers*, FRD, Pretoria, 1986.

Wetlands of southern Africa

Map 3.2



Swamps	Dambos	Mangroves
Pans	Lakes and Dams	Lagoons
Flood plains	Rivers and Streams	Delta

SOURCE: SADC/IUCN/SARDC, *State of the Environment in Southern Africa*, Maseru/Harare, 1994.

The oshanas of Namibia Box 3.3

The *oshana* area of Owambo is located on the northern border of Namibia where it occupies a broad plain of low relief averaging 1,100 metres above sea level. The area is traversed by shallow, ephemeral water courses, called *oshanas*, that originate several hundred kilometres north of the border, in Angola, and flow southward through Owambo, to the Etosha Pan.

An *efundja* (a major flood) in the central *oshanas* occurs infrequently when good rains have fallen over the entire Angolan catchment area, and they are extremely important for the conservation of wild plants and animals in the area. Wild plant resources are well adapted to the semi-arid environment, irregular rain and water flow in the oshana area. Wild fruits (such as the ones from the *marula* tree) and spinach species grow well in the oshana area as do a variety of roots in the form of tubers, palms and flowers.

A wide range of medicinal plants also grow around the *oshanas*, and there is a long-distance commercial trade in aromatic plant parts for traditional perfumes. The major commercial trade in medicinal plants from Namibia is in *Harpagophytum* tubers, from which people make tea. Woody species traditionally used for dental care and other medicinal purposes, as well as other plant species, have been suffering over-harvesting for fuelwood, building or agricultural clearing, and this could mean the loss of many effective traditional remedies.

Photo 3.6 NAMIBIA REVIEW

The oshanas of northern Namibia are shallow, ephemeral watercourses which are important to the conservation of wild plants, birds and animals.

The *oshana* area was very rich in animal species, including the migratory wildebeest, zebra, elephant, oryx, springbok and other large mammals; but they disappeared over the past 50 years mainly due to the increase in human and domestic livestock populations, and agriculture. However, smaller mammals, such as the jackal and small antelope, still occur in some parts of Owambo. The entire *oshana* system is particularly important for birdlife, and 30 rare, threatened or vulnerable species of birds, such as the Wattled Crane, have been recorded there. Flamingos and White Pelicans also breed and live in the area.

The continued existence of the larger species in the Owambo depends on the continuing flow and protection of the *oshana* system.

SOURCE: Marsh, A. and Seely, M. (eds), *Oshanas - sustaining people, environment and development in central Owambo, Namibia*, Typoprint, Windhoek, July 1992, pp. 30-43.

Floodplains

Floodplains lie in areas surrounding lakes, such as Chilwa in Malawi, and in areas alongside rivers, such as Pongolo in South Africa and Rufiji in Tanzania. Although difficult to distinguish, two types of inland floodplains occur in the region:

- Fringing floodplains are the most common features alongside rivers, and follow the normal development of a river, occurring where the slope is favourable. The Barotse floodplain, Luangwa, lower Zambezi, Incomati and Kilombero are good examples;
- Internal delta floodplains include Kafue, Okavango Delta and Chambeshi-Luapula floodplains. These are characterised by the main river dividing into small branches, consisting of a series of lagoons.[27]

Photo 3.7 SARDC-M. Chenje

The regular flooding of floodplains give rise to local areas of nutritious grassland for grazing for wildlife and stock. This also provides the basis for floodplain agriculture, such as the *molapo* in Botswana. Fish follow the water and nutrients, breeding and feeding in the floodplain. Fish spawn and the fingerlings grow before they return to the rivers where some insects found in the floodplains provide food for the small fish.[28]

Floodplains also regulate water flow. For example, the Barotse floodplains which occupy much of western Zambia, "acts like gigantic sponge, absorbing the seasonal rains, holding them, and then slowly releasing them down the Zambezi river."[29] Without it, the Zambezi would in the rainy season be devastated by floods all the way to the Indian Ocean.

The Zambezi floodplains are rich in the diversity of flora and fauna, attracting more wild animals than just about anywhere else in Africa. "Its rich alluvial soils support a variety of habitats, from magnificent riverine forest to wide open grassland plains where birdlife is profilic, and its mighty waters provide a rich breeding ground for many species of freshwater fish, and for large populations of crocodile and hippo."[30]

Photo 3.8 APG-D. Martin

The Zambezi floodplains are a rich breeding ground for hippos and crocodiles as well as freshwater fish.

Riverine swamps

These are habitats developed in still water areas around lake margins. They may also occur in the estuarine and marine environments and in oxbow lakes, which are formed when part of a meandering river is cut off due to silt.

Swamps are generally dominated by vegetation either bottom-rooted or floating plants. Woody swamps also occur.[31] Swamps like those of the Incomati river in Mozambique, the Moyowosi swamp in Tanzania and the Malombe swamp in Malawi, support a variety of wildlife, and are a good source of grazing and fishing. Agriculture and harvesting of reeds are other special features of these wetlands.[32]

Photo 3.9 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO
Riverine swamps, such as those of the Incomati river, are good sources of grazing.

Lacustrine

These are wetlands situated in topographic depressions or dammed river channels. Changes in the water level follow the rainfall patterns. At least six types of lakes occur in the region,[33] mostly along the Great Rift Valley:

- Large freshwater lakes include Victoria (66,400 sq km) and Tanganyika (32,890 sq km). Lakes Mweru, Bangweulu, Mweru wa Ntipa, Chilwa, Chiuta and Rukwa are included in this category as well as the ephemeral lakes Liambezi and Ngami in Botswana.

- Alkaline or soda lakes and pans, such as Lake Manyara in Tanzania, Etosha pan in Namibia, and Makgadikgadi pan in Botswana occur in arid or semi-arid zones where evaporation is very high, and/or are shallow lakes with limited or no drainage.[34] Although these lakes do not have a high variety of species, they are very productive with a lot of algae. They furnish unique habitats for flocks of flamingos. Pans are particularly important as a habitat for migratory birds.[35]

- Oxbow lakes and lagoons occur along river channels, and in coastal areas.

- Volcanic (crater) lakes are represented by Ngorongoro and Ngurudoto in Tanzania.

- Seepage lakes are caused by underground water rising to ground level. Lake Bakabaka (Zambia) is a good example.

- Artificial lakes such as Kariba (4,300 sq km) in Zambia and Zimbabwe, Cahora Bassa (2,700 sq km) in Mozambique and Nyumba ya Mungu (180 sq km) in Tanzania represent a large group of such lakes in the region.[36]

The larger lakes are quite productive in fish which often form a large part of the diet of people living near the lakes, who depend on fishing for their livelihood.[37]

Lakes are special habitats as they are structured in three zones: shallow, open and deep water area. Primary production in these zones is limited by light penetration and largely supported by groups of emergent large plants.

Estuarine

An estuary is an area near a river mouth containing a volume of water of mixed origin: sea water is diluted with freshwater derived from land drainage. Estuaries can be distinguished by their physical features (such as drowned river valleys which are submerged at high tide or river delta estuaries) or by water circulation and stratification, mostly based on

levels of water salinity or water mixing. Sub-tidal (continuously submerged) and inter-tidal (exposed and flooded by tides) zones may be distinguished. Mud flats, marshes and mangrove swamp habitats are important in the inter-tidal zone, where life form is adapted to wide extremes of salinity, wave action, high turbidity and variable oxygen concentration.[38]

Common estuaries in southern Africa are delta formation. Estuaries are widely distributed along the entire coast of this region and the major estuaries are the mouths of Zambezi, Rufiji, Orange, Cuanza and Congo rivers.[39] In South Africa, there are more than 340 estuaries, covering about 600 sq km along that country's 2,881-km coastline.[40]

Estuaries are among the richest and most productive parts of the southern African marine environment. Storage in and abstraction from reservoirs change the waterflow, and may lead to adverse environmental effects on estuaries. Excessive abstraction of water in rivers may lead to salt water intrusion in estuaries, impacting the freshwater and seawater inflow and disturbing the ecological balance of an estuary.

The country most affected by saltwater intrusion in the SADC region is Mozambique, which has nine international river basins.[41] Between 40-60 percent of water is abstracted annually from international rivers such as the Zambezi, Limpopo and Incomati by Zimbabwe, South Africa and Swaziland respectively. This causes some perennial rivers in Mozambique to dry up for several months of the year.[42]

"Saline water intrusion occurs in a significant number of coastal rivers and aquifers, restricting the availability of freshwater for irrigation, industrial and public consumption," says a Mozambican government document on water issues.

Marine

The marine system consists of the open ocean overlying the continental shelf and the coastline. It covers the entire coastline of the region, from the northern coast of Tanzania, round the Cape, to the north coast of Angola. Marine habitat is exposed to the waves and currents of the open ocean. Average

Turtles in danger Box 3.4

Global populations of sea turtle are in danger and the eastern coast of southern Africa is not an exception. Here, five of the world's seven species occur — the green turtle, the leatherback, the hawksbill, the Pacific Ridley and the loggerhead.

Wild animals and dogs dig up and eat its eggs. Sea-birds and shore crabs catch and eat the hatchlings as they make their perilous journey from the nesting site to the edge of the sea, where many will be consumed by predatory fish, such as sharks.

Despite the large number of eggs laid (up to 1,000 per female, per season) very few survive to maturity.

Most adult turtles are killed on beaches, as females climb the shore to lay their eggs. This is doubly destructive; it prevents the female from laying her eggs and selectively destroys the biologically important female turtle.

The green turtle's critical habitats are seagrass meadows for feeding and sandy beaches for egg laying — both abundant on the eastern coast.

Turtle conservation must be a regional priority if these valuable reptiles and the resources they offer are not to be lost. Effective conservation should cover all critical habitats, including feeding and nesting grounds, and involve cooperation as these species migrate to different territories.

SOURCE: UNEP, *A Coast in Common - an introduction to the Eastern African Action Plan*, Nairobi, Kenya, 1989, pp. 18-19.

salinity of sea water is 35 parts per thousand with little or no dilution except outside the mouths of estuaries.[43]

The marine zone can be divided into sub-tidal and inter-tidal:

- The sub-tidal zone is that portion that is continuously submerged and often characterised by the coral reefs and seagrass beds. Seagrasses develop well in shallow waters where there is enough light for photosynthesis, the process by which green plants use solar energy to convert carbon dioxide and water into sugar and oxygen. Many species of algae grow on their stems and leaf surfaces. Seagrasses provide important habitat for fish to spawn and grow, and they also act as breeding grounds for dugong (a sea mammal now endangered) and as feeding grounds for turtles and some fish.[44]

Coral reefs are a unique sea environment that host about 3,000 species, including nearly a third of all marine fish. They are well developed in Mozambique, Tanzania and Mauritius. Inhaca Island, in the south of Mozambique, is the southern limit for coral reefs in the world (26°S), and these are the only protected coral reefs in Mozambique.[45]

The corals grow well in favourable temperatures (25-29°C), clear water and sufficient light. The fringing reefs, located adjacent to the shores of islands or continental coast are the most common in this region.[46] Coral reefs are complete ecosystems, and their communities have been described as the most diverse in the world. The reefs provide food and shelter for more plants and animals than the tropical rain forests. Large sedentary animals (giant clams, sponges, worms); commensals (coral gall crabs, shrimps); mobile crustaceans (crabs, lobsters); echinoderms (starfish, sea cucumber); and various types of fish are found in coral reefs.[47]

- The inter-tidal zone which forms the main shore, includes features such as mud flats and sand, rocky shore salt marshes and mangroves in sheltered coasts. In these wetlands, the water regime is determined by the ebb and flow of oceanic tides.[48]

Seagrasses Box 3.5

Marine plants, algae and seagrasses, which grow in profusion in many ecosystems, are among the most abundant renewable resources of the SADC region.

Seagrasses are flowering plants that grow rooted in the seabed, usually in lagoons behind coral reefs and generally in a shallow water zone, to a depth of 40 m where there is enough light for photosynthesis.

Lagoons and creeks are characterised by vast meadows of seagrasses, which are closely related to terrestrial flowering plants. The seagrass species are eaten by some herbivorous fishes, while important carnivores such as the emperor fish, feed on the molluscs, brittle stars and urchins which are part of the seagrass community. Surfaces of seagrass stems and leaves also serve as a base for the growth of many species of algae.

Turtle grass is consumed by the herbivorous green turtle, making it a plant of great importance. Several other species of seagrass are food for dugong, once abundant in many parts of the coast. Since the demise of the dugong, this enormous biomass of seagrass has been underutilised.

In addition to providing anchorage, food and shelter for various marine organisms, seagrass helps to stabilise the seabed by holding down sand at times of rough seas and ocean turbulence.

SOURCE: UNEP, *A Coast in Common — an introduction to the Eastern African Action Plan*, Nairobi, Kenya, 1989, p. 12.

Mangrove ecosystems constitute a valuable resource which, over the years, has contributed in several ways to the economy and fishery of many coastal peoples. Mangrove swamps occur at points such as the Rufiji delta region in Tanzania, the Zambezi river delta in Mozambique, St Lucia Bay in South Africa and Lucunga river mouth in Angola. They are dominated by terrestrial plants which tolerate sea water.[49]

Some of these tree species have unique features of adaptation such as aerial roots (to enable them to breathe since the soil where they grow has little oxygen) and to provide surfaces for attachment of marine organisms. They are extremely important as breeding grounds for many marine and freshwater species, including amphibious fish, crabs, shrimps and molluscs. The east coast of southern Africa relies on this wetland for shrimp production and export. Mangroves also support seabirds that feed on the fishes and crustacea. They also provide tannin, and are sources of medicines.[50]

WATER AND BIOLOGICAL DIVERSITY

The SADC region of eastern and southern Africa harbours a vast range of plant and animal species, and remains among the few regions in the world where abundant quantities and varieties of wild animals roam the wild. Tanzania's Serengeti National Park alone has over one million wildebeest, among other animals. Water is a major factor within its ecological zones: patches of different vegetation support different life forms in a uniquely rich terrain, such as wetlands and grasslands within the savanna. The variety of habitats, from the deep, species-rich Lake Tanganyika up to the nearly 6,000-metre high, snow-covered Kilimanjaro mountain — the highest in Africa — favours a diversity of plant and animal species.

The biological wealth is obvious when the plant and animal life in Lesotho, South Africa and Swaziland is compared with subcontinents of comparable size. The average number of plant species per unit area of land in these countries is almost double that of Brazil, almost four times that of the United States, and over six times that of Sudan.[51] While the world average for the number of plant species per 1,000 sq km is 1.69, these three southern African countries have 16 species per 1,000 sq km. In the case of mammals, the three countries average 0.18 species for every 1,000 sq km — six times the world average.[52] Some of the region's protected areas have been classified as world heritage sites in recognition of their international ecological significance.

Wetlands productivity

The productivity function of wetlands varies considerably within the wetland system, but chemical and physical factors are most important. The distribution and abundance of wetland organisms are also determined by such factors.[53]

The primary productivity of wetlands is considered at two levels:

- Phytoplankton productivity, which is usually dominant in stagnant water, particularly that which is rich in dissolved organic and mineral nutrients, is also the most important source of production in oceans, especially in systems such as the Benguela off the west coast of southern Africa. Species include groups of tiny algae, green algae and blue-green algae in the freshwater habitats. Productivity at this level varies with the season. In most of the region's rivers and lakes, phytoplankton production is highest in the dry season and diminishes during floods. In the Benguela system it is highest in summer.

- Emergent hydrophytes (plants which live in water) are dominant in the shallow water while floating hydrophytes can occupy the open water zone as well.[54] The productivity of some rooted swamps can be as high as 16-30 tonnes per hectare/year and of floating swamps can equal 48-143 tonnes per hectare/year.[55]

Primary productivity, the rate at which plants produce organic matter through photosynthesis, is even higher in mangrove swamps.[56] Secondary pro-

Nature people, leave us alone! Story 3.1

KwaZulu/Natal (Mail & Guardian) — Take one of the dirt roads that run off the main tar road to St Lucia into the dense undergrowth of the Dukuduku, and visit one of the settlements that has been carved into the forests. It will be a salutary lesson in how the poorest of the poor in this country experience nature conservation.

KwaZulu-Natal's northern region was richly endowed with coastal lowland forests — a mosaic of indigenous hardwoods, herbs, shrubs, ferns, vines and cycads — until sugarcane farmers and commercial foresters chopped them down in the early part of this century.

The 3,500-ha Dukuduku Forest is the last remaining ecosystem of this type in the province. Conservationists want to preserve it at all costs and have, according to the people who live there, sometimes sided with police and officials from the Natal Provincial Administration in taking harsh action against the "squatters".

The residents have a litany of allegations: their houses have been burnt down, fishers caught in the lake have been assaulted, fridges have been confiscated, crops have been destroyed and, in one case, a man was buried alive by these groups of outsiders.

The result is that white men driving around in government vehicles have sometimes been shot at and the community has earned a reputation for being a group of wild men who cannot be visited easily or consulted by representatives of officialdom.

We drove in and found, instead, a group of old men waiting next to a *spaza* shop made of cheap planks to hold a meeting with their councillor — and very keen to explain their point of view to outsiders.

"You ask how we feel about being told to leave the forest. We look around and see people over the river in St Lucia have cut down trees to build their big homes. Farmers up the road have cut the forest to grow eucalyptus," said one of the elders who did not want to be named.

"They have destroyed the forest. Now they say we are the ones who are destroying it. Yet we stay here because we like trees.

"We like to live among them because we can grow bananas here, we can grow two kinds of *madumbes* (sweet potatoes), paw-paws, cabbages and wild trees give us all kinds of fruits. So why should we destroy it?"

The official version is that the forest dwellers are "invaders" or "squatters" who came into the area from the outside. At least three of the old men in the gathering at the forest *spaza* shop said they had been forcibly moved from the eastern shores of St Lucia in the 1950s.

— **Eddie Koch,** "Nature people, leave us alone!", *Mail & Guardian*, Vol 12, No 12, 22-28 March, 1996, p. 9.

ductivity is also high in wetlands. Most wetlands support a high biological diversity. Some important species of fishes, reptiles, amphibians, birds and mammals have been recorded in major wetlands, such as Okavango Delta, Bangweulu swamps, Kafue flats, Lake Malawi and Zambezi floodplain.[57]

Lake Tanganyika is 20 million years old and has 1,300 species — of which more than 500 are found nowhere else. These include 230 species of fish, 150 endemic (existing only in a certain area) to the lake.[58]

With no less than 400 species of fish, Lake Malawi boasts a more diverse assemblage than any other lake in the world. Although more than 10 families of fish are found in the lake, more than 90 percent of its species belong to one family, the *Cichlidae*. Most of the *cichlid* species are endemic and only four are found in other lakes or rivers.[59]

These two lakes are very important for both maintenance of biodiversity, and as a resource for the people of the region.

Plants

In addition to ecosystem maintenance, a considerable amount of water is used by plants. They absorb water through their root systems and diffuse it back into the atmosphere through transpiration.[60] The amount of water lost through transpiration varies with climatic conditions, the type of plant and the amount of water available.[61] This process occurs primarily in daylight hours and can vary from as much as 180 litres/day for a large tree to about two litres/day for a small crop plant under the same environmental conditions.[62]

A large amount of water is lost through evapotranspiration. The Okavango Delta is a good example. About 10 cu km of water flows into the Delta annually, five times the amount consumed in the entire southern African region each year. Of this, 95 percent evaporates or evapotranspirates.[63] Since trees use a lot of moisture, cutting trees can increase the minimum flow of streams in the dry season (baseflow), leaving more groundwater available to feed the streams. One study concluded that removal of *miombo* woodlands in Zimbabwe's communal areas reduced water loss and may have contributed to reactivation of some *dambo* systems.[64]

Conversion of indigenous forests to plantations of fast-growing pine and eucalyptus increases evapotranspiration rates and reduces the dry-season flow of streams. In the temperate-forest zone of South Africa, tree plantations have significantly reduced available groundwater and streamflow by an estimated 1.28 cu km/yr. This has led to the introduction of a permit system for commercial afforestation based on runoff reduction. The maximum allowable reduction is 10 percent in some areas, down to zero in others. No more than three-quarters of a permitted area can be planted.

Water hyacinth

Large amounts of water can be used by plants such as the water hyacinth. The water hyacinth is an aquatic, free-floating noxious weed found in most of southern Africa. Ninety-five percent of the weight of the plant is water[65] and the plant can double its mass every four days or so, given warm eutrophic conditions. By this very growth, the plant actively pumps water through its tissues and releases it into the air in the process of evapotranspiration. Through this process, the water hyacinth

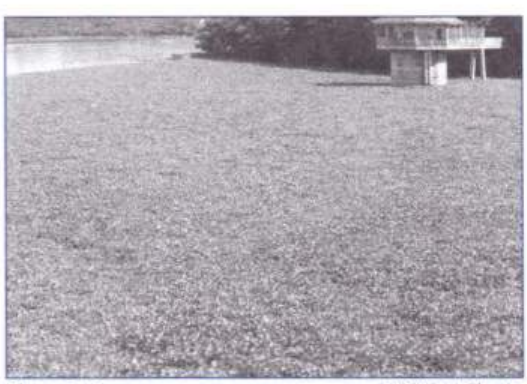


Photo 3.10 SARDC-M Chenje

Water hyacinth, shown here in Zimbabwe's Lake Chivero, increases the moisture loss from the surface of water bodies by pumping it into the air.

Reasons for loss of African wetlands Table 3.2

	Estuaries	Open coasts	Flood plains	Freshwater marshes	Lakes	Peatlands	Swamp forests
Direct human action							
Drainage	C	C	C	C	C	C	C
Filling	C	A	A	P	A	A	A
Conversion for aquaculture and mariculture	C	C	C	C	P	C	C
Construction of dykes, dams and levees	C	P	P	P	P	A	A
Discharges of pesticides and nutrients	C	C	C	C	P	A	A
Mining	C	C	C	C	C	A	A
Groundwater abstraction	P	P	P	A	C	C	C
Indirect results of human actions							
Sediment diversation	C	C	C	C	A	A	A
Hydrological alterations	C	C	C	C	C	A	A
Subsidence	C	P	C	C	A	A	A
Natural causes							
Subsidence	P	P	A	A	P	P	P
Sea level rise	C	C	A	A	A	A	C
Drought	C	C	C	C	P	P	P
Hurricanes and storms	C	C	A	A	A	P	P
Erosion	C	C	P	A	A	P	A
Biotic effects	A	A	C	C	C	A	A

C Common and important cause of wetland degradation and loss.
P Present but not a major cause of loss.
A Absent or exceptional.

SOURCE: IHE/UNDP, *Water and Environment: Key to Africa's Development*, Proceedings of the Delft Conference, Delft, 1993.

increases significantly the water loss from the surface of water bodies (such as dams and lakes), by as much as three-and-half times that of evaporation from the same water bodies. This represents an enormous economic loss in water-thirsty countries of southern Africa.[66]

Mammals

Ecological factors, such as availability of water, determine why elephants are found almost everywhere in the region while black lechwe are restricted to particular areas. Such factors determine where all wild animals are located.

Animals require food and water to survive and the availability of both determines their distribution.[67] They also have habitat preferences which vary from one species to another, depending on how they have adapted to a particular environment. Over 40 different large-mammal species inhabit the SADC region. Of these five species are carnivores (animals that feed on flesh) and the rest are herbivores (plant-eaters).

Mammals which inhabit dry savanna are white rhino, nyala, oryx, springbok, Thompson's gazelles and the lesser kudu. Mammals more restricted to the moist savanna are kob, waterbuck, sable, roan and bushbuck. The largest mammals — including elephant, buffalo and hippo — are found in both the dry and moist savannas. In contrast to savanna ecozones, the afromontane supports fewer large mammals per unit area because rainfall and, ultimately, leaching of nutrients is high. The same is true of the lowland forests where rainfall is abundant. But here the large mammals include primates such as chimpanzees and gorillas.

Animal migrations are also prompted by rainfall patterns. Thus the wildebeest, zebra and hartebeest of the Kgalagadi migrate seasonally to the wet north during the dry season and return to the dry south in the wet season.[68] In the dry savanna, frequent droughts force animals to migrate to wet areas such as pans and floodplains. Human settlement and cordon fences have, however, blocked some of the major migratory routes, causing massive deaths of migratory species.

Lack of water brings death from thirst and hunger as drought kills plants on which wild animals feed. Animals can put up with short periods of drought and have historically migrated to other areas to find water and food. Today they are confined to smaller areas and often are not able to cross to more favourable areas due to fences and settlements. Moreover, droughts are aggravated as people harness the little water there is for domestic use and sometimes to supply their livestock. Ultimately, there is little left over for wildlife.

Wildlife deaths in the Kgalagadi have been associated with drought and were exacerbated by cordon fences. In Gonarezhou National Park in southeastern Zimbabwe, wildlife has died due to drought. The 1962 drought in Botswana nearly wiped out zebra, and hundreds of thousands of wildebeest, some sable, tsessebe, roan and rhino died. Central Kgalagadi, Botswana, lost 99 percent of the wildebeest and 95 percent of the hartebeest in the 1980s due to droughts.[69]

Marine life

The SADC region has four main marine ecological zones. Definition of the zones is based on water temperatures and ocean currents which have a bearing on plant and animal life. The ecozones are:

- the warm East Coast covering Tanzania, Mozambique and Natal;
- the temperate Agulhas Bank off South Africa;
- the cooler Benguela System off western South Africa, Namibia and southern Angola; and
- the Angola System.

Ocean currents, especially the Agulhas, are important in the dispersal of marine plants and animals even between different ecological areas. The Agulhas current carries fry, juvenile turtles and other marine plankton from the Natal coast to the adjoining Agulhas system. But ocean currents are

not the only means by which marine organisms move. In winter, sardines from the Benguela system migrate eastward in what is known as the "Natal sardine run".[70] They are followed by fish, bird and mammal predators Humpback whales instinctively swim from the Southern Sea to the Indian Ocean off Mozambique in July to calve. There is, therefore, considerable interdependence between neighbouring marine systems.

Warm ocean currents meander through the Indian Ocean off the coast of Tanzania and Mozambique. The surface temperatures of the sea vary between 25-29 °C while further south, off Natal, the surface temperatures range between 22-27 °C. Many animal and plant species thrive in these warm waters.

The East Coast zone is rich in species diversity but is generally poor in nutrients and supports limited

Sanctuaries for birds Box 3.6

Aquatic environments often provide safe breeding places for birds. Such localities cannot be accessed by terrestrial predators, such as cats, and the birds often breed in large colonies. Benefits of colonial breeding include increased protection against aerial predation, for example, from gulls, and information sharing — birds may learn from neighbours of the whereabouts of food.

In southern Africa, both freshwater and marine environments support large breeding colonies of water birds. Islands off southwestern Africa are used for breeding by 13 species of seabird, of which six (African Penguin, Cape Gannet, Cape Cormorant, Bank Cormorant, Crowned Cormorant, Hartlaub's Gull) are endemic to South Africa and Namibia. Two more (Kelp Gull, Swift Tern) are recognised as endemic subspecies. This high degree of endemism results from the relative isolation of the breeding colonies, which are separated by long distances from seabird breeding localities farther north in Africa or at subantarctic islands.

One of the five non-endemic species, the Roseate Tern, breeds in the Indian Ocean and occurs at the extremity of its range in Algoa Bay, South Africa. The other species (White Pelican, Whitebreasted Cormorant, Greyheaded Gull, Caspian Tern) also breed in freshwater habitats, which have provided links with colonies to the north.

Guano produced by seabirds was a valuable commodity in the 19th and early 20th centuries, prior to the introduction of artificial fertilisers. Accumulated deposits of guano at islands off Namibia and South Africa were cleared in the 1840s. Thereafter, guano production has been harvested on an annual basis. This is possible because of the large number of sea-birds which produce it and the densely-packed colonies to concentrate it. In Namibia, platforms to attract seabirds were specially constructed in the vicinity of Walvis Bay and Swakopmund.

Southern Africa is one of only two regions in the world where guano is harvested annually, the other being Peru, in the Humboldt Current, where there is a similar assemblage of sea-birds and fish.

Inland water bodies, such as Lake St Lucia in South Africa, the Chobe river in Botswana and swampland in Zambia, provide important breeding/roosting sites for birds. Several of these sites have been developed for tourism.

SOURCE: Crawford, R.J.M., "Sanctuaries for birds", for SARDC, 1995.

plant and animal production. A general rule for marine biodiversity is that the higher the temperature the more infertile an areas is, but the higher the diversity. This happens because where plentiful food abounds, some species out compete others.

Some nutrients in the surface water come from inland rivers and are dispersed by waves and currents. Unlike on land, where plant leaves die and become nutrients, which other plants reuse, when marine plants and animals die, they drop down to the dark seabed. Upwelling is then required to return them to surface waters, where there is sufficient light for their use by plants in the production of new material. Sheltered sections of the coast such as estuaries, mangroves and coral reefs are often rich in nutrients, plants and animals.

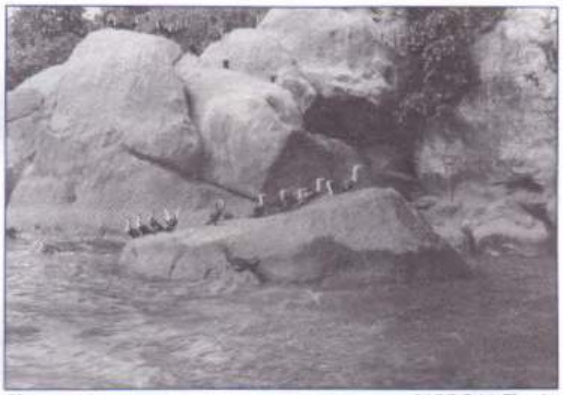


Photo 3.11 SARDC-M Chenje

Both inland and coastal habitats support teeming populations of waterbirds that feed on fish.

The main marine fish species of southern Africa are sardine, anchovy, horse mackerel, tuna, hakes and mesopelagic species such as latern fish. There are large commercial fisheries off Namibia and western South Africa, catching fish for human consumption and animal feed. Dominant seabirds that inhabit and breed in the East coast waters include the masked booby, sooty tern, swift tern and brown noddy.[71] Sea mammals such as whales and dugongs inhabit the coastal waters. The Benguela system supports large colonies of seals and seabirds, including penguins, gannets, cormorants, gulls and terns.

Coastal habitats

Coastal areas have many different habitats — estuaries, mangroves, coral reefs, islands, seagrass meadows, beaches and rocky shores. The coast is more accessible to all groups of fishers —subsistence, artisanal, sport and commercial. Estuary animals include burrowing worms, bivalves such as clams and sand prawns, crabs and fish such as mullets. The habitat also supports teeming populations of birds that eat the invertebrates and fish.

Biological diversity, mainly of fish species, in estuaries tends to fall upstream from the sea toward the river because very few freshwater species occur in estuaries. Estuaries are among the most productive habitats of the sea. Some turtles and birds depend on estuaries while fish use estuaries as nursery grounds.

Mangroves are ecosystems formed by flowering trees that can grow in estuaries. They are adapted to an environment which is flooded by seawater at high tide, freshwater during river floods and high salinity during low tides. Mangrove plants remove excess salt through openings on roots and leaves. Some of the mangrove species have aerial roots which enable them to breathe as the submerged saline environment in which they live is oxygen-deficient.

Mangrove plants also shed leaves which provide organic matter as well as nutrients which add to the fertility of the sea. Tidal currents carry this broth of debris from mangrove swamps to other marine habitats where they are eaten by some animals and used by plants for growth.[72] The roots of the trees protect coral reefs from river sediments by trapping silt.

A potential threat to marine resources is global warming, which may prompt a rise in sea level due to melting of glaciers and the expansion of water because of more heat from the sun. This may cause the submergence of low-lying areas, islands and

Alien plants threaten Cape Town water supplies Story 3.2

Johannesburg (SARDC) — Cape Town's water supplies are seriously threatened by alien plants which are invading catchments and using much more water than the indigenous *fynbos*.

Dr Brian van Wilgen, head of a project team sent by the World Wide Fund for Nature to assist key decision-makers to be aware of the enormous implications of the alien plants, described the problem as "very serious". The problem is worsened by a substantial decline in funding for the clearing of alien plants over the years. Left unchecked, the problem of invasive plants may result in Cape Town losing a significant portion of its water supply, according to *Africa Environment and Wildlife* magazine.

Fynbos mountain catchments yield about two-thirds of the Western Cape's water. Unfortunately, *fynbos* is remarkably prone to invasion by alien trees and shrubs such as pines and hakeas. These invasives increase the mass of plant material in a catchment between 50-1,000 percent.

"In some areas, these changes result in a significant decrease in the volume of water that reaches rivers and dams. In some areas, these changes have led to the deterioration of watersheds to the point that they become a financial burden rather than an asset," said Dr van Wilgen.

On the slopes of Table Mountain, invasion by alien plants increased fire intensities, causing severe soil erosion. As a result, enormous sums of money have to be spent after each fire to remove sediment from the city's stormwater drains, roads and houses.

Alien plants could increase from an initial cover of 5.4 to 80 percent within 100 years if they are not controlled. This invasion, if repeated over all *fynbos* catchment in the province, would result in an average loss of more than 30 percent of Cape Town's water supply. Losses could even be greater in drier years, particularly in large areas covered by mature trees.

With only about 160 workers involved in clearing the alien plants, the problem cannot be eradicated. It could, however, be controlled if staffing was increased to 1,000 workers. The annual cost could be about US$8 million. Besides the creation of over 800 jobs for 10 years, this investment would ensure that the Cape is better able to meet its water needs.

"Optimal catchment management will ensure that water is made available as cheaply as possible to as many people as possible," he said. Asked if it was simpler to build dams, Dr van Wilgen said that alone would not solve the problem. "In any case, the fact of the matter is that the Western Cape is running out of sites where major dams can be built."

About 2.2 million people live in greater Cape Town. By the year 2000 it will reach 3.5 million, and by 2020 6.2 million. The water demand will follow this trend, and it is due to outstrip supply.

— **Maxwell Chivasa**, SARDC, adapted from "Our Living World", supplement to *Africa Environment and Wildlife*, South Africa, October, 1995.

estuaries, negatively affecting the plant and animal species adapted to particular environments. Much of the coastal area of Mozambique, which is low-lying, could be submerged by a minor increase in sea level as might estuaries and beaches all along the coast.

Global climate change could result in changed wind pattern in a way that would decrease nutrient supply and, ultimately, fish production in the fertile fishing grounds off the Namibian coast.

Photo 3.12 PTC, MAPUTO-P Mondlane

Global warming could cause sea levels to rise, submerging low-lying coastal areas and altering fish production patterns.

CATCHMENT MANAGEMENT

With freshwater being such so crucial to ecosystems in the SADC region, there is a need to conserve it, protect the wetlands which store, purify and supply it, and manage its use. The term catchment management is being used more frequently, denoting the need to consider all activities in each river or stream basin, all water sources and wetlands, and the ways all these things interact. The lack of such management has, for example, led to dams being sited in areas of high erosion with no direct programme to promote or require proper upstream land husbandry, leading to high siltation rates.

Water engineers often consider all water as available for human use, although an environmental consciousness is beginning to develop in which natural resources and their water quantity/quality needs are taken into account. Namibia's Oanob Dam, for example, was specifically constructed to allow periodic release of water for ecological purposes in the ephemeral Oanob river to simulate flooding and maintain woodland growth.

Sudden changes in the temperature or other alterations in the habitat threaten the survival of marine organisms. Damming of rivers alters the estuaries upon which many fish depend, by changing the flow and sediment regimes of rivers. When too little freshwater reaches the river mouth, seawater advances further upriver, making the water too salty for some species. Also, silt coming from the land, where deforestation and poor farming practices lead to soil erosion, is a big threat to fish.

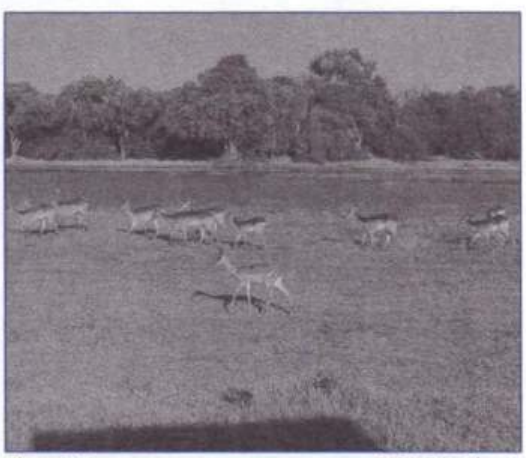


Photo 3.13 SARDC-M Chenje

Catchment management considers all activities in a river basin, all water sources and wetlands, and their interaction.

Linkages to other chapters Box 3.7

1 PEOPLE

The environment needs water as much as people do. Often people overlook the fact that the environment needs water to contribute to processes such as the hydrological cycle, which in turn contributes to rainfall in the region.

2 CLIMATE

Climate, including rainfall and its seasonality and temperatures have a major bearing on water available to meet the needs of the environment. Ecological zones with the least rainfall are most prone to high rainfall variability.

4 MANAGEMENT

In managing water resources in the SADC region, it is important that water planners take the environment's water needs into consideration.

5 AQUATIC RESOURCES

Water is crucial to the proper functioning of natural systems and ecosystems, and supporting habitats on which aquatic resources in the SADC region depend.

6 POLLUTION

Pollution negatively impacts the environment, reducing the ability of water to support various ecosystems and contributing to the destruction of the region's biodiversity.

7 COOPERATION

Regional cooperation is important to ensure equitable use of resources among not only upstream and downstream communities but also ecosystems, particularly in international river basins.

8 TRENDS

Global climate change is likely to negatively impact river flows and water resources, influencing the functioning of ecosystems and ultimately the distribution of wildlife.

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4 MANAGEMENT of Water Resources

The management of water resources involves different players at different levels. It is as much the responsibility of an individual as it is that of communities, civic society, the public and private sectors, and supra-national organisations such as the Southern African Development Community (SADC). The role of international organisations, both government and non-governmental, has also to be factored, particularly if water management issues assume international significance.

All of the region's 145 million people have a role to play, mostly as resource-use managers. Each one of us depends on water to drink and also to undertake disparate activities such as agriculture and fishing. In South Africa, for example, about a million people are added to the population annually, increasing the demands on water resources every year.[1]

The people in the SADC region also depend on water to flush away the waste left during production processes, which if left uncontrolled, could put both people and the living environment at risk. Left to each person to decide how, when, and where the resources should be used, it would be impossible to achieve optimum use of water resources, leading to severe scarcity in some areas. Resource-use conflicts would be unavoidable in such a situation.

CHECKS AND BALANCES

While competition within and between countries in the region over water exists, mechanisms are in place to better manage water resources and minimise conflicts.

Communities in the SADC region have a long history of managing water resources. Both traditional and modern societies value water and have for generations used various mechanisms and regulations to ensure that the resource is available in adequate quantities and good quality for their own use and for animals and plants.

Traditional society

The onset of rains was and still is a significant annual event among different communities, influencing human activities across the region. The Shona people in Zimbabwe, for example, could predict the onset of rains by observing, among other things, changes in leaf colour and wind direction. Such observations enabled them to make crucial decisions related to land preparation, planting and choice of crops to be grown.[2]

Indigenous farmers harvested rain for crop production by developing practical technologies applicable to their own environment. Some used tillage systems that harvested and conserved water while at the same time preventing soil erosion. In Angola, for example, valley-bottom soils have for generations been exploited in an ecologically sound manner, using ditches to raise and lower the water-table.

Water management in the region was in the past not restricted to use only but involved control measures to conserve resources. Traditional societies in the region have had in place various measures to regulate and manage resource-use, including water. These included rituals, ceremonies and festivals, myths and legends, and beliefs and customs. Penalties and sanctions were used to induce conformity. Traditional leaders such as chiefs and rain-

Traditional and modern management combine at Manjinji salt pan Story 4.1

Masvingo (SARDC) — A salt pan at Mabalauta, Mwenezi, about 90 km southeast of Masvingo is "an island of water" in dry southern Zimbabwe and an important protected area with deep traditional significance.

The Manjinji Sanctuary Salt Pan is an oxbow lake cut off from the Mwenezi river. This was the deepest bend of the river when it was flowing years ago, and is very rich in aquatic life.

The survival of the pan has been mainly due to the locals who respect the oxbow lake as a gift from the ancestors. Although this physical change of the river actually happened years ago, the local belief sidelines any geographical explanations, with people preferring respect for the ancestors who "give us dew". Such traditional beliefs have helped in the conservation of the pan.

"For us, this is a sacred place in honour of our traditional leader, Sibalaboyi Mazoche. That is why trees here have not been cut and the pan never dries, even in years of drought," said Albert Ndlovu, a local leader and secretary of the CAMPFIRE programme.

The Communal Area Management Programme For Indigenous Resources (CAMPFIRE) is a community-based wildlife management programme through which communities living adjacent to wildlife derive income from commercial activities, such as tourism and game-hunting.

People, their livestock, and wildlife drink at Manjinji pan. The "island of water" is also a bird's paradise for viewers. Dozens of different types of birds come and/or live here. Four huge crocodiles live in the pan, said Ndlovu, who keeps a record of all wild animals that drink here.

The community here only need a few commercial ideas and financial support to develop it and any benefits should accrue to them. The tourism potential of the pan is enormous.

Tourists elephant-watching in the nearby Gonarezhou national park would certainly not miss bird-viewing at Manjinji pan, contributing to the general facelift of the area. Roads and many other facilities would be developed, benefitting the local community who live in one of the remotest parts of Zimbabwe.

However, some members of the community are concerned about developing the area for tourism. They are worried that their livestock will lose access to the water at the oxbow lake once the area is fenced off and opened to tourism.

Plans to drill boreholes for water for both people and livestock could help to allay their fears.

— **Maxwell Chivasa,** SARDC, July 1995

makers had great influence on people's lives, determining when resources were to be used.

Modern society

Today, the situation is not that different. While the traditional system of managing water resources has given way to "development" with the advent of the nation state, the concepts are virtually the same. In most of the region, the role of chiefs and other traditional leaders has been taken over by various levels of government — central and local. Water management now consists of a whole set of technical, institutional, managerial, legal and operational activities used to plan, develop, operate and manage the region's water resources.

Management measures

Management of water is essential to produce optimum and efficient usage through the application of various technical, economic, and institutional measures:

- Technical measures include storage of surface or groundwater, aquifer recharge, water desalination, water re-use and recycling, reduction in water wastage, use of appropriate technologies and water pollution control;
- Economic measures refer to pricing policies or charges that control and limit wastage or control pollution or incentives such as tax exemptions to promote rational water use; and
- Institutional measures take into consideration existing administrative institutions and capacity, available water resources, existing service delivery programmes, and future systems needed to safeguard the quantities and quality of the water without jeopardising the environment.

The demand for water falls in two categories — consumptive and non-consumptive use. Consumptive use occurs when the water is removed from its source and supplied for a specific purpose such as domestic needs, stock watering, agriculture, mining, or commerce and industry.

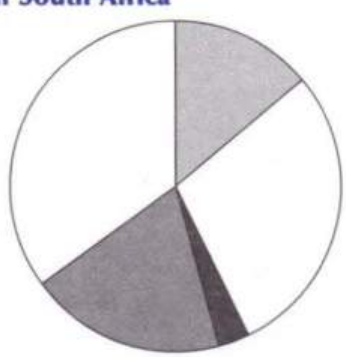
Irrigation is a consumptive use since the water is non-returnable — it is normally consumed by the crop or lost through evaporation. When water is used, a portion of it is usually returned as effluent which must be disposed of in an acceptable way. Water which is used by the environment is also consumptive, though productive.

Non-consumptive use is when the water is utilised without taking it out of the water body; it can be re-used and it is not lost, particularly in terms of its quantity.

CONSUMPTIVE USES

The relationship between the different consumptive uses of water varies from country to country in the region, but agriculture is the largest consumer of water in most SADC countries. For example, in 1996, irrigation accounted for more than 60 percent of the water consumed in South Africa. Municipal and domestic consumption accounted for about 18 percent; industry, 11.3 percent; and the remainder was for power generation, mining, nature conservation and stock watering.[3] In com-

Domestic water uses in South Africa Figure 4.1



SOURCE: Star Supplement, "Conserving Water", *The Star*, Johannesburg, March 1996.

parison, agriculture in Zambia accounted for only 26 percent, while domestic consumption was 63 percent, according to the World Resources Report 1994-95.[4]

People

Population growth has a major impact on demand and supply of water. With an average population growth rate of three percent annually, countries in the SADC region face great challenges in managing water resources to ensure that both urban and rural populations have access to clean water. Failure to take account of any growing consumptive use of water (such as for irrigation) may lead to a serious shortage of water for other uses, such as the environment.

The level of water stress grows with population increase in terms of people per flow unit of water, leading to water scarcity and negatively impacting on various activities dependent on water. A flow unit equals one million cubic metres per year (mcm/yr) and water stress starts where the ratio of population size to flow units exceeds 600 people per flow unit (p/flow). Chronic water scarcity is experienced once the ratio is more than 1,000 p/flow. Beyond 2,000 p/flow, there is extreme water scarcity.

At current population growth rates, the SADC region will experience chronic water-shortage by the year 2030. The challenge for the region is to ensure adequate water supply for all the people in the region. With knowledge of water demand, appropriate measures can be introduced to cater for the medium and long-term supply, even if this requires water transfers between river basins.

The amount of water consumed in the SADC region's urban and rural areas varies considerably from country to country and from city to city. The per capita water consumption may be as low as 25 litres/capita/day in the rural areas and up to 500 litres/capita/day in the cities. The per capita consumption also varies according to the accessibility of water, the standard of living of the consumer and efficiency of use. In Namibia, for example, affluent urban residents with swimming pools, well-watered lawns and washing machines use 24 times as much water per person as low-income rural people.[5]

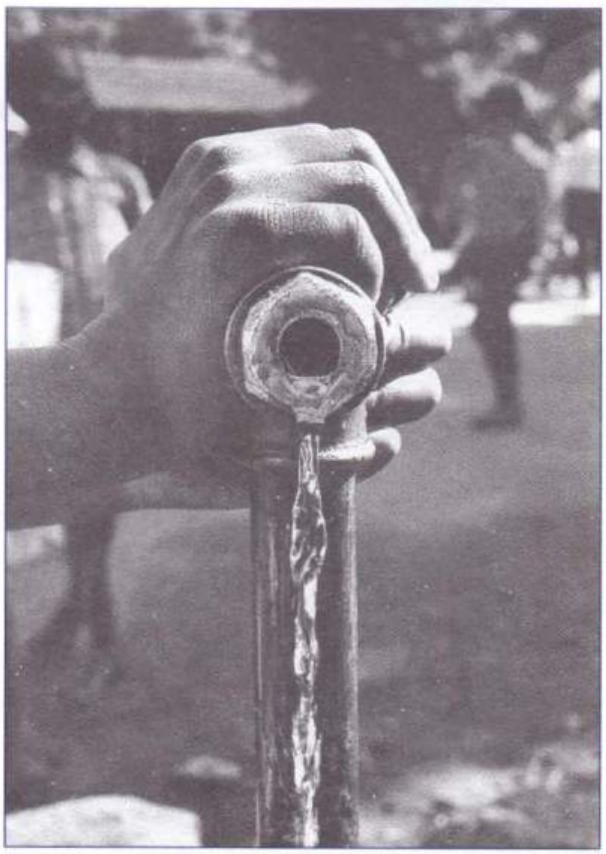


Photo 4.1 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO-J. Lopes
The per capita consumption of water varies from place to place, according to accessibility, standard of living and efficiency of use.

Urban areas

Demand for water is expected to increase in urban areas in southern Africa in direct proportion to the growth in the standard of living, industrialisation, and urbanisation due to population increase. In

An ideal urban water-supply system Box 4.1

An ideal urban water-supply system needs to satisfy the following conditions:

- The supply must be maintained 24 hours/day;
- All sources and service meters must register correctly;
- Routine inspection on the whole system must be maintained to check for wastage and leakages, and where necessary maintenance must be carried out;
- Plumbing to service lines must be adequate to avoid wastage;
- Record of all connections to the system must be of high quality and, as much as possible, no unauthorised connections should be permitted as these would distort the picture of demand;
- The price of water must not be so low since this would lower the apparent value of water and promote wastage by consumers;
- Communication between the service undertaker and consumers must be maintained, promoting education on reduced wastage and preventive maintenance of the system as well as hygiene.

SOURCE: Twort, A.C., et al, *Water Supply*, Edward Arnold Ltd, London, 1974.

Tanzania, for example, the demand for water supply in urban areas already outstrips supply mainly due to population growth and obsolete infrastructure.[6]

Traditionally, southern African rivers, streams and lakes have provided ready sources of water for its inhabitants. Water from springs and mountain streams have been used by people with minimum treatment, usually through boiling.

With the growth in population and industrial development, however, human and other wastes have impacted on the quality of water due to the increased number of pit latrines as well as industrial and agricultural activities. In such an environment, it is necessary to improve the water supply-systems to reduce the levels of health hazards that can cause water-borne diseases.

As domestic use increases, there is a corresponding increase in the volume of waste water and consequently the problems of polluted water begin to parallel that of water supply. In Mozambique, for example, some of the major urban environmental problems include insufficient clean drinking water and lack of sewage treatment. At a time when the

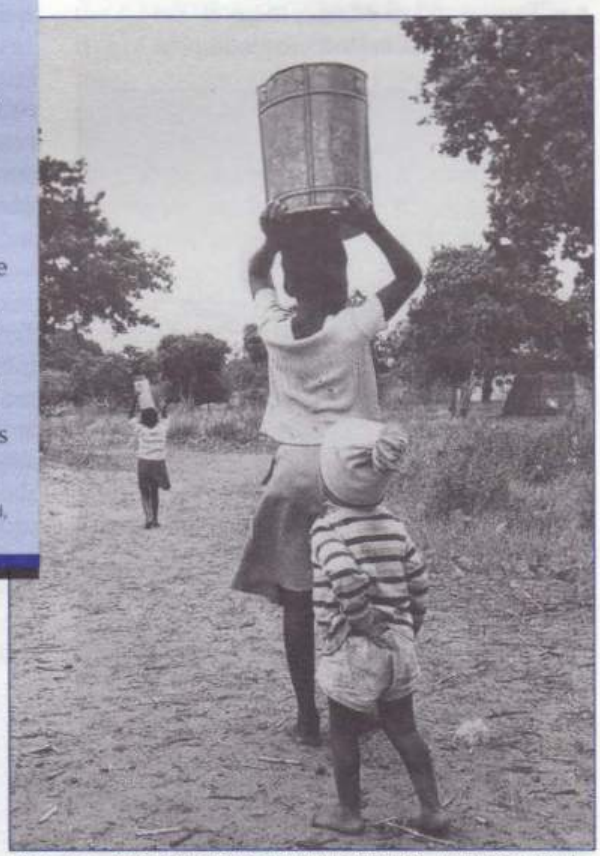


Photo 4.2 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO-J. Tembe
The level of water stress grows with population increase, and failure to take account of growing consumption can add to serious shortages.

country has an estimated seven-to-eight percent urban population annual growth rate, the situation can only get worse in the short-term.

Rural areas

The management of a reliable water supply in rural areas is dependent on several factors:

- the community's approach to and knowledge about water;
- willingness by the community to have a generally acceptable level of water-supply service and quality;
- willingness to participate in the design, implementation and maintenance of the infrastructure; and
- willingness and affordability to pay for the service in cash or in kind.

Photo 4.3 NAMIBIA REVIEW

Rural water-development projects have been most successful with communities involved in decision-making, and women trained in maintenance.

In Tanzania, as in most countries in the SADC region, the government has been responsible for supplying rural populations with water. It provides, operates, and maintains water supply systems. The government's water policy now requires rural communities to take over, manage, and maintain water schemes in their areas. "Most villages in Tanzania have established water committees and water funds and are contributing to the funds to help in the construction, operation, and maintenance of their water projects."[8] Sixteen of Tanzania's 20 administrative regions have developed water master plans which contain vital water resources-related data and information. The major weakness of the plans is that they vary in approach and methodology. They also lack consistent revision, updating, and implementation.[9]

Integrated water-development projects in some rural areas in the SADC region have been very successful where communities are involved in the decision-making process. Communities choose where to put a water facility, such as a borehole, and they form committees to oversee implementation and maintenance.

Technology choice is very important as an early failure of the project may demotivate other communities. During project implementation it is important to include training in the maintenance of water facilities, particularly by women. In Malawi, about 97 percent of boreholes in the northen district of Karonga are working at any one time in a month. This success story is due to the considerable involvement of women — the most frequent users of boreholes — who have received necessary training in the maintenance of hand pumps.[10]

Agriculture

Although rainfall may be adequate in some parts of the region, it is very scarce in others and this deficiency is worsened by consecutive droughts, particularly since the late 1980s and the early 1990s.

Irrigation

The aim of irrigation is to increase crop production

or grow crops in areas where normally such an activity would be impossible due to lack of water. This may appear to be a relatively new innovation in water-resources management, but it has played a significant role in intensifying agricultural production in different parts of the region.

In Tanzania the Wachagga in the Mount Kilimanjaro area, developed a network of furrows and channels to manage and distribute water for domestic use and irrigation, laying the foundation for intensifying agricultural land-use. "These furrows display ingenious engineering skill which involves leading water out of the deep river valleys and for long distances crossing other furrows and even other rivers using hollowed-out tree trunks."[11] Before the 1940s, land was managed by, among other things, terracing steep slopes and irrigation in the dry season, involving indigenous technology.

The general trend in the region shows that irrigation is mostly a preserve for high-value export crops that make significant contributions toward earning foreign exchange. Sugar cane is one of the most economically irrigated crops in the region with a total estimated land area of 292,000 hectares (ha). Other principal crops irrigated in the region include wheat, rice, cotton, maize, coffee, tea, tobacco, vegetables and fruit. In South Africa, the demand of water for irrigation was projected to increase from 8,504 mcm/yr in 1980 to 11,885 mcm/yr by the year 2010.[12]

There are many different types of irrigation systems, ranging from surface, conventional sprinkler, centre pivot to drip methods. In Botswana, for example, at least six different irrigation systems are used for surface and overhead irrigation. These include manual water, perforated pipe and sprinkler systems, and drip irrigation.[13]

Surface irrigation is used for rice-growing in river basins and may include traditional methods such as stream diversion, *dambo* or flood recession water. For most other crops, water is distributed gravitationally through lined or unlined furrows depending on the permeability of the soil. The *molapo* in Botswana and the *olonakas* in Angola are examples of traditional irrigation systems practised in the region. *Molapo*, a traditional flood-recession type of agriculture practised in the Okavango delta, mainly produces grain on a subsistence level in the delta area and on floodplains.[14]

Overhead irrigation involves spraying the water into the air over the land to be irrigated. There are various overhead irrigation methods, ranging from a simple watering-can to a sophisticated centre pivot sprinkler system.[15] Plants with restricted root systems, such as lettuce, onion and young plants can be watered using overhead systems. Overall efficiency ranges from 60-70 percent compared to drip irrigation whose water-use efficiency ranges from 85-95 percent. Overhead irrigation systems lose water through various ways, including evapo-

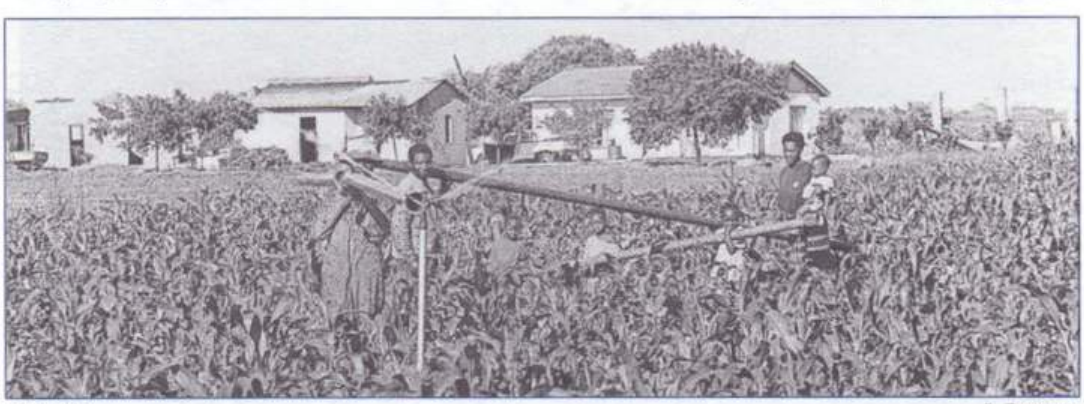


Photo 4.4 F. Zvomuya

Overhead irrigation involves spraying the water into the air over the land to be irrigated.

A drip for the water-wise Box 4.2

Water-wise gardening requires irrigating enough to satisfy different plants' needs. Gardens can be planned to contain plants which do not need a lot of water — numerous indigenous species are available and they are well-adapted to the drier African climate.

Water-wise gardening should become a way of life, not an emergency measure. By grouping plants with the same water requirements in the same bed, water is saved. One of the best irrigation methods is the drip system where the water is delivered directly to the plant's roots. Drip irrigation does not allow significant evaporation and modern systems can be designed to put very accurate amounts of water to the right place.

Irrigation must not take place too often. Thorough, less frequent watering not only saves water, but is healthier for plants.

SOURCE: Adapted from *The Star*, "Conserving Water" supplement, Johannesburg, March, 1996.

Photo 4.5 SARDC-M. Chenje

Porous clay pots,used to water plants/trees in different parts of the region, slowly release water over a period of two weeks and help to conserve water.

ration and seepage. Some of the water is blown away by wind, and this system covers a general surface while drip irrigation is more direct on the plant. Drip irrigation evaporation losses are very low because the soil surface is hardly wetted.[16]

Industry

Industrial growth, including mining, in the SADC region is certain to increase water consumption by industry. Water is crucial in industry since many production processes are water-based. Even though statistics show that industry presently consumes less water than agriculture in almost every SADC state, this is likely to change as industrialisation gains momentum. It is only in Zambia, where most of the water (63 percent) is for domestic consumption, that industry is a distant third, at 11 percent, despite that country's large mining base.[17]

In Namibia, people and livestock compete with mines, industry and irrigation for scarce water resources. Industrial and mining developments, together with new irrigation schemes, will combine to further increase Namibia's water demand in future.[18]

As the majority of industrial activities in the SADC region are located in urban centres, there is an additional demand for water over and above domestic requirements. With the growth of the industrial sector, it becomes imperative for the water planners to prepare for the development of water resources and related infrastructure to keep pace with demand.

To satisfy demand, the water supplier has to consider infrastructure and the available resource in relation to the present demand levels, and make

appropriate demand projections for the future. Should it become necessary, alternative sources need to be developed, even if these are far from the area of want.

In Namibia, for example, the Eastern National Water Carrier (ENWC) — an integrated long-distance water scheme — was designed to carry water from the wet north, via pipes and canals, to the drier areas of central Namibia. Four phases have been completed since 1970, and only the 250-km long Okavango-Grootfontein pumping station is yet to be completed. It will link the ENWC to the Okavango river.[19] Similar projects are either being implemented or are planned in Botswana (the North-South Carrier), South Africa (Lesotho Highlands Water Project) and Zimbabwe (the Zambezi Water Pipeline). The proposed Zambezi Water Pipeline would transfer water from the region's largest river to Zimbabwe's parched southern provinces.

NON-CONSUMPTIVE USES

Hydroelectric power

One of the cheapest sources of energy is hydroelectric power whose generation is dependent on water. Water is diverted to run through turbines, which by virtue of its pressure, rotate the turbines to generate the required electrical energy. The water is channelled back into the river where it runs its natural course. It can be used again for hydropower generation or other purposes such as irrigation or domestic and industrial requirements. The advantage of such non-consumptive use is that water is returned to the main stream with minimal change to its original quality or quantity.

The Cahora Bassa and the Kariba hydropower generation schemes, both on the Zambezi, are the largest in the region with a capacity of 1,266 megawatts (MW) and 2,075 MW respectively, and supplying electricity to Mozambique, South Africa, Zambia and Zimbabwe respectively. Kariba con-

Estimated water demand in southern Africa, 1995 Table 4.1

(million cubic metres/year)

Country	Domestic and Industry	Stock	Mining and Energy	Irrigation	Nature	TOTAL
Angola	1,720	272	15	750	—	2,757
Botswana	175	44	65	47	6	150
Lesotho	84	19	5	160	—	268
Malawi	730	23	5	1,820	—	2,578
Mauritius	—	—	—	—	—	—
Mozambique	135	65	10	3,000	—	3,210
Namibia	200	70	15	248	5	538
South Africa	10,397	368	1,937	12,764	4,702	30,168
Swaziland	25	13	2	331	140	511
Tanzania	1,690	70	10	10,450	—	12,220
Zambia	532	60	20	1,580	—	2,192
Zimbabwe	697	30	30	4,980	—	5,737
TOTAL	16,385	1,034	2,113	36,130	4,853	60,515

— means unavailable

SOURCE: P. Heyns, for SARDC, 1995.

Electric power generation and projects

Map 4.1

SOURCE: Southern Centre for Energy and Environment, Harare, 1996.

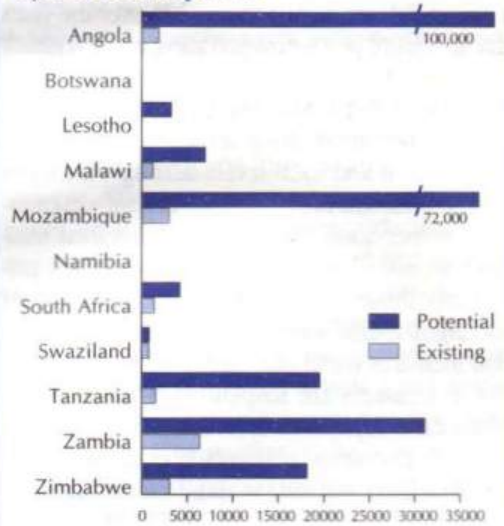
tributes 50 percent of Zimbabwe's electricity needs, but generation is vulnerable to drought. For example, a total of 1,578 MW were used in 1991 but the figure dropped to 1,458 MW one year later due to the 1991-92 drought.[20]

The impact of drought on the economies of southern African countries due to electricity loss can be severe. During the 1991-92 drought, the production of Zimbabwe's manufacturing sector declined by 9.3 percent. Drought caused a 25 percent reduction in volume of manufacturing output, and a six percent reduction in foreign currency receipts.[21] During that period, the Zimbabwe Stock Market was identified by the International Finance Corporation as the worst performer of 54 world stock markets, with a decline of 62 percent.

In Malawi, the Shire river has a hydroelectric-power-generation capacity of 600 MW. Of this potential, 214 MW has been developed and a further 128 MW will be completed by the year 2000. From the power generation station, water flows down the system and is used for the irrigation of sugar in the Lower Shire Valley and replenishes the Elephant Marsh, a haven of large quantities of fish and other fauna.

Hydroelectric generation accounts for 65 percent of the total commercial energy supply to SADC countries (hydro, coal, petroleum, natural gas) compared to thermal generation's 29 percent.[22] The SADC countries, excluding Mauritius and South Africa, have a hydroelectric capacity totalling 7,548 MW while South Africa generates 40,000 MW, most of it through thermal generation. In Zimbabwe, the total installed capacity is 1,961 MW shared between hydro and thermal generation. The use of electricity per capita in Zimbabwe is one of the highest in eastern and southern Africa.[23] The establishment of grid interconnections among SADC countries with hydroelectric capacity can facilitate the phasing out of South African thermal stations, according to SADC reports, alleviating the environmental impact of thermal or nuclear power generation.[24]

Installed and potential hydroelectric power Figure 4.2



SOURCE: Steer, A., "Water Resources Management in the SADC Region", *Conference on Water Resources Management in Southern Africa: A Vision for the Future*, Pretoria, 23 - 24 Nov, 1995.

Tourism

Tourism is another industry which relies on water resources. The coastal areas, the lakes and rivers, and national parks are the major tourism centres in the region. Three principal categories of tourist attraction are beaches, scenery and wildlife. All are based on natural resources. Wildlife is abundant in different areas across the region, including lakeshore and riverine zones; while beaches are found on the Indian Ocean islands such as Mauritius and Zanzibar, as well as on the mainland.

SADC countries such as Zambia and Zimbabwe host hundreds of thousands of tourists annually who visit the Victoria Falls (*Mosi-oa-Tunya*, "the smoke that thunders) and Lake Kariba, Africa's largest artificial lake. They also participate in white-water rafting down the rapids of the Zambezi river. Countries such as Namibia, South Africa and Tanzania draw millions of visitors a year to their beaches on both the Atlantic and Indian oceans. Angola and Mozambique have the potential to boost tourism arrivals with further investment in infrastructure in their coastal areas.

In the SADC region, tourism receipts which rose by 14.8 percent to US$1.8 billion in 1994 over the 1991 figures, are certain to increase over the years due to relative peace now prevailing in the region.[25]

WATER SUPPLY MANAGEMENT

While governments have several departments at both central and local levels dealing with water supply, recurrent droughts often expose weaknesses in conservation and supply. Conservation measures are often introduced when communities, particularly those in urban areas, are facing water shortages. Urban areas introduce water conservation measures (rationing) during drought periods. These measures are suspended as soon as adequate rains replenish reservoirs. Penalties introduced to discourage residents from abusing water are often lifted, resulting in abuse and wastage.

Groundwater resources are not protected in Zimbabwe and are often abused, particularly where drilling regulations are lax. Urban residents can drill for water to water their lawns even at a time when the majority of the people don't have enough water to drink. With a sign that says, "borehole water" on their gates, city residents can circumvent water rationing and conservation measures to water the gardens.

Efforts are being taken in some countries to ensure an integrated water-management ethic which would see the true value of water reflected in pricing structures, and involve communities in water conservation measures on an ongoing basis, not only when droughts occur. In South Africa, for example, the government has introduced the National Water Conservation Campaign to improve the efficiency with which water is used. The comprehensive campaign is also aimed at achieving equity in water allocation. A total of 48 projects have been developed as part of the campaign. "Water conservation is to become a way of life — a way of life that we need to embrace — and we need to do so quickly, through much of our subcontinent," says South African Water Affairs Minister, Prof. Kader Asmal.[26]

Policies and strategies

The integrated management of water resources takes into account appropriate management principles from the source of the water to the point of its disposal. Policies and strategies to guide the management of water are crucial to effective management of the resource. Such policies include the following:

- The provision of essential water supply and sanitation services to all citizens at a cost which is affordable for its varied uses;
- The equitable improvement of water supply services through the combined efforts of the government and the beneficiaries, based on

Ill 4.1, 4.2 SA Department of Water Affairs

Governments in the region often mount water conservation campaigns using various media, including stickers.

community involvement and community participation and the acceptance of mutual responsibility; and

- An environmentally sustainable development and utilisation of the water resources of the country must be pursued in addressing the various needs.[27]

Communities must have the right, with due regard for environmental needs and the resources available, to determine which solutions and service levels are acceptable to them. Beneficiaries must contribute toward the cost of the services at increasing rates for standards of living exceeding the levels required for providing basic needs.

Due to outdated water supply infrastructure in some parts of the region, the cost of maintenance increases expenditure. Adequate financial support for the maintenance and extension of the existing water supply infrastructure is essential. The provision of new water schemes rely on the funding of water-resource investigations to provide the necessary foundation on which to establish water schemes in the short, medium and long-term. The planning, programming and funding of the water-supply infrastructure required in future is a prerequisite for an improvement in the standard of living, socio-economic development and the improvement of health conditions through hygienic water-use practices.

Monitoring water supplies

The monitoring of water resources is essential as it provides a balance sheet for planning purposes. This includes the measurement, processing, analysis and storage of river, lake or reservoir levels, river flows, water quality, precipitation, evaporation rates and other variables associated with components of the hydrological cycle. A comprehensive outlay on monitoring water resources for Malawi, for example, considers all aspects, including institutional frameworks, data collection, processing and retrieval, availability of data on water projects, primary processing and publication, human resources, education and training, including research and development.[28]

Priorities for water allocation

In the past, there was little or no competition between different types of water users since each could be supplied from seemingly abundant sources of water, but it is envisaged that with the increasing demand for water as populations increase, and the standard of living improves with the growth of the economy, real competition will evolve, particularly between industrial and agricultural uses. Competition between domestic, stock and irrigation consumption in the rural areas will be just as important as domestic, industrial and mining consumption in urban areas.

The priorities for the allocation of water where resources are limited and the competition is great,

Ideal water allocation priorities Table 4.2

RANK	CONSUMER GROUP	PRIORITY
1	ENVIRONMENT People Animals Natural Vegetation Aquatic Systems	PRIMARY/ BASIC
2	INDUSTRY Mining Manufacturing Fishing Commerce Power Generation Tourism	SECONDARY/ PRODUCTION
3	IRRIGATION	TERTIARY
4 5 6	NAVIGATION RECREATION EXPORT	OTHER

SOURCE: P. Heyns, for SARDC, 1995.

differ from place to place. The allocation of water to each individual has to be evaluated in terms of feasibility and economics when certain consumers compete for the same quantity of water. Using water efficiently involves making choices aimed at ensuring that sectors are allocated water according to their contribution to the economy. In Namibia, for example, government policy relates to two basic priorities. The first priority is for domestic and stock drinking, and the second is for all other uses, depending on the economic viability, whether it is industry, mining or agriculture. In South Africa, the major priorities are agriculture, domestic use and industry.

A water allocation strategy is crucial since water is finite and demand is always increasing. In Malawi, spatial and seasonal variations in water availability and growing competition for use in a number of areas have led to full or over-commitment of water resources. Strategies for water allocation are important and implemented to avoid overallocation in areas where even little practical opportunity for reallocation may not be possible. These strategies are designed to:

- enable the requirements of the communities to be met at least for basic water services;
- provide infrastructure that underpins economic development effectively and efficiently; and
- protect the environment.

Water-supply infrastructure

The responsibility for supply of water depends normally on the state, municipalities or water companies which supply water to a large number of consumers. The state has a social responsibility toward the disadvantaged groups and may supply water to rural communities, especially in areas where the local people do not have the means to develop those sources.

In such cases, the state may require a contribution in kind from the beneficiaries. This is usually achieved when the people assist with the development of the water scheme. In many instances, the individual consumer is expected to provide his/her own water, for example, on commercial farms, where the development of dams and boreholes are the responsibility of the farmer.

The top-down approach in water-resources development has the obvious disadvantage that there is almost no choice given to beneficiaries or interested groups on the type of project they want. In this case, projects are regarded as having been imposed on communities. This situation leads to unwelcome developments where in a majority of cases the projects are regarded by the beneficiaries as belonging to the government. All maintenance programmes are, therefore, seen as the government's responsibility.

It is of great importance that all stakeholders be involved in the process of project identification, design, implementation and maintenance to instil in the community a sense of ownership for purposes of sustainability.

Sanitation

The provision of clean water to urban and rural communities is essential as it is intended to promote cleanliness of the habitat and inhabitants, and maintain certain standards of hygiene and health. However, every household or institution produces waste and it is indispensable that sanitation services be adequately provided to cope with the levels of waste produced.

In rural villages, pit latrines provide the most common type of human-waste disposal systems, but there is much room for improvement. In large villages, pit latrines, French drains and bucket systems are normally used while water-based sewage systems are more appropriate in the larger towns. For example, in the Tanzanian town of Mwanza in the Lake Victoria basin, where rudimentary pit latrines, septic tanks and soakaways cause groundwater and lake pollution, sewage ends up raw in the Mirongo river because pumps often break

down.[29] The pumps are supposed to lift the raw sewage to the Pasiansi oxidation ponds. In the urban areas, conventional sewage treatment facilities exist, but in areas where high evaporation rates and an abundance of sunlight exist, extensive use can be made of oxidation dams to dispose of sewage.

In many instances, sanitation services have lagged behind water development programmes. Emphasis is on providing more water for everyone, yet the levels of waste water and other wastes generated by development activities are often forgotten. For example, in Lesotho, in 1988, 59 percent of urban residents and 45 percent of rural people had access to safe drinking water, only 14 percent of the urban and 23 percent of rural residents had access to sanitation services.[30] Although the number of urban residents in sub-Saharan Africa provided with satisfactory sanitation is expected to double by 82 million people during the 1990s, "there will be more than twice as many urban residents without access to sanitation by the year 2000 as there are today".[31]

The two services often fall under separate institutions and liaison may be lacking. In the SADC region, sanitation services are mainly controlled by governments, with little or no private sector involvement. The levels of payment for sanitation services are relatively lower than the replacement value of the utilities, thus when the infrastructure breaks down, maintenance may take a long time.[32]

WATER DEMAND MANAGEMENT

Demand for water is not counted only by the volumes of water consumed. Wastage through faulty supply systems and leakages must also be quantified as this amount will still be lost over and above the actual demand. Wastage can originate from mains and service-pipe connections, under-registration of supply meters, from service reservoirs, by means of outflows or on consumers' premises.

Leakages in water reticulation systems at home, too much watering of gardens, evaporation from swimming pools, inefficient use of water in the domestic environment are all areas where water consumption can be reduced by an informed public.

An effective way to curtail water demand is, therefore, a sound water tariff policy. To this end, the major objective of a national water tariff policy should be to ensure that the water tariffs are directed at encouraging the consumer to appreciate the true value of water and participate fully in measures to conserve it.

To satisfy growing water demand, it is required that active engagement in the short-, medium- and long-term planning of water projects be undertaken. The prior establishment of major water-supply schemes for cities, towns, planned growth points and mines to cater for the reasonable domestic, industrial and agricultural water needs in a country should take place according to national water master-plans where they exist, and a regional one once it is developed. These must be reviewed from time to time to ensure that the plans remain in line with new or unforeseen development.

In the case of rural areas, the same principle holds. The population growth rates of specific areas should determine what facilities need to be put in place and how much water should be allowed for per person or household per day.

Management mechanisms

The limited availability of surface and groundwater resources in the southern African region is due to climatic conditions. However, control over the judicious management of the water resources is within the reach of society and this should allow for major capital expenditure to develop more water-supply infrastructure.

Infrastructure

The development of water and sanitation infrastructure is a function of demand for these services. However, infrastructure should ideally be developed ahead of projected demand levels. If infrastructure is old and was put in place many

decades before, it may not be possible to adequately provide the desired service.

For centralised, urban, water-supply services, the operation and maintenance of the infrastructure and the service will remain the principle task of the water utility. This requires a round-the-clock attention where consumers expect to have an efficient service and any faults and breakage in mains have to be maintained in the shortest span of time possible.

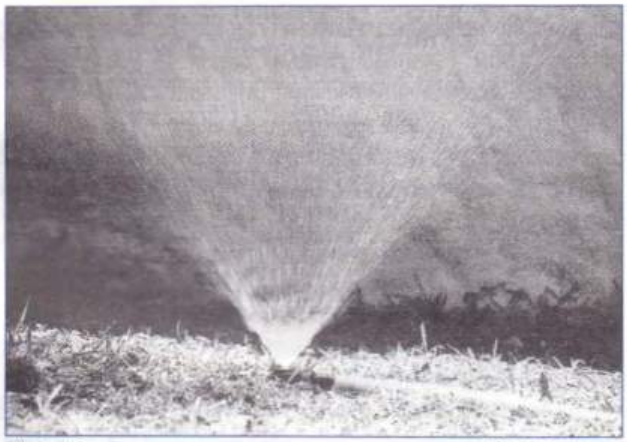


Photo 4.6 SARDC-M. Chenje

With a sign "borehole water" on the gate, some city residents can circumvent water restrictions, thus depleting groundwater resources.

For the rural sector, maintenance of water supplies has more often been centralised. The reason for this approach is historical. Governments have provided infrastructure to rural communities for decades and communities have regarded these facilities as belonging to the government. When water facilities have broken down, the government has been called upon to repair them. The sense of ownership and care has been absent. The new approach to the provision of water services to rural communities needs to include integration to beneficiaries in all aspects of development and project management.

Due to the relatively dry climate in the southern African region, groundwater sources are sensitive to exploitation and are exhaustible. Where they are replenished by natural recharge they can be utilised for almost unlimited periods, provided that abstraction does not exceed the long-term recharge potential. Efficient management and the protection of these renewable sources against overuse and pollution are of vital importance.

Some of the larger rural centres are already utilising their water resources to the maximum, while the improvement of the water supply infrastructure for isolated communities is difficult and expensive. Water conservation measures should, therefore, receive a high priority to reduce excessive demand.

Adequate financial support for the maintenance and extension of the existing water supply infrastructure is essential. The provision of new water-schemes rely on the funding of water-resource investigations to provide the necessary foundation on which to establish water schemes in the short, medium and long term. The planning, programming and funding of the water supply infrastructure required in the future is a prerequisite for an improvement of health conditions through hygienic water use practices.

Commercialisation of services

Since the provision of water is seen as a basic life-sustaining requirement, it is generally accepted that the government should supply water. However, in many cases government cannot operate commercially, ensuring cost recovery, which is often far below what is required to finance operation and maintenance.[33] This is often due to inefficient procedures and unauthorised connections.

Government often is reluctant to relinquish its water-supply responsibility by privatising it, but the state can maintain an interest by being a shareholder in a commercialised entity. The private sector can make a contribution to water supply by getting involved in cases where the water is required for specific industrial, mining or agricultural development.

Women trained to repair borehole pumps Story 4.2

Chivi (IPS) - A woman in rural Zimbabwe who repairs borehole pumps is an envy of many men, especially the white-collar workers in town.

Christina Dimaire, of Giri village, in Chivi district, 375 km south of the capital, Harare, is not a qualified artisan but she completely repairs boreholes in this area. The 30-year-old mother brags about her new-found career: "I am now able to repair boreholes, especially the B-type pump, at any time." Dimaire is one of about 150 women in this district who have been trained under a United Nations Children's Fund (UNICEF) water and sanitation programme to repair and maintain boreholes.

"I volunteered for training because I know if the borehole breaks down I am the one who suffers alone with the children," she said.

In a recent survey of water supplies in Zimbabwe, it was shown that only one-third of the population had permanent access to an improved water supply, 95 percent had no piped water. The lack of access to clean water makes life very difficult for women; most rural households use an average of 75 litres a day. This means between two and four journeys a day carrying about 20-30 litres per journey. Time spent fetching water varies according to distances from an hour to four hours.

"These days we do not need any professional pump minder to come and fix our borehole (pump) as we have been trained to do that."

Another village woman trained as a borehole pump-minder, Nyembesi Maribhangwatiwa, said: "This is our borehole and if we do not fix it ourselves nobody will and we will all die." She said before the project was launched in drought-prone Chivi district, boreholes would remain unrepaired for more than six months.

According to Wilbert Sadomba, the programme coordinator in UNICEF's water section, rural projects, especially those dealing with water, have often failed because they ignored women who constitute the majority.

"In any development aspect, women are the main beneficiaries and so by involving them you are assured that the projects are well taken care of," says Sadomba.

The role of women is very crucial because they understand the difficulties of fetching water more than men. Chivi district, with more than 158,000 people, has only 12 government pump-minders servicing more than 600 water points without adequate transport.

"In the past when the borehole broke down, we would have to walk for more that six kilometres to the nearest water point," recalls Agneta Zirima, a mother of five children. "This prevented us from doing other household chores as we would take half the day to fetch water only."

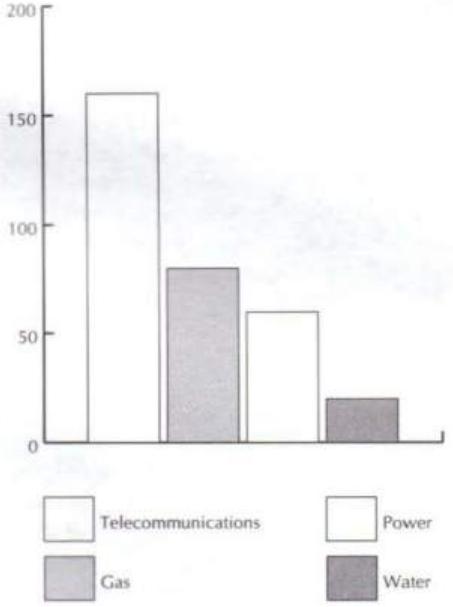
— **Lewis Machipisa,** Inter Press Service (IPS), 1994

Recycling and reclamation

The general rise in demand for water has been the result of the growth of cities and industry, resulting in the exploitation of almost all sources of water. While the demand of water for domestic and industrial use may depend on the same source, measures have been put in place to recycle water. Such an arrangement involves treating waste water and running it in the system so that it can be reused. However, it is generally accepted that water-quality standards for recycled water have to be developed, agreed upon, and maintained. In normal circumstances, recycled quantities of water would best suit the needs of the industrial and irrigation sector, while non-recycled water may be ideal for domestic use.

Windhoek, the capital of Namibia, already recycles 13 percent of its waste water for domestic consumption, while Harare in Zimbabwe recycles about 10 percent and may increase to 20 percent. In Botswana, Gaborone plans to recycle about 60 percent of its urban flow by the year 2020.[34]

Cost recovery Figure 4.3



SOURCE: Steer, A., "Water Resources Management in the SADC Region", *Conference on Water Resources Management in Southern Africa: A Vision for the Future*, Pretoria, 23 - 24 Nov, 1995.

Pricing and tariff structures

The cost of providing water has two major components: the capital cost to construct a water scheme and the cost to operate it. The operating cost of a water scheme is the cost of energy, of chemicals to disinfect or purify the water, and of labour. This cost is variable and is subject to inflation, meaning that the operating cost must be adjusted from time to time, usually on an annual basis. The operating cost is usually related to the volume of water supplied and, therefore, the consumer must pay a certain tariff per cubic metre of water supplied.

In cases where the full cost to supply water cannot be recovered from the consumer, at least the operating cost component should be recovered. Where possible, an attempt should be made to recover some of the capital cost. If the consumer cannot afford the water, then the consumer should be subsidised, not the supplier. Some economists say commercial undertakings such as mines or large industries should pay the full economic tariff because the water is a production input to generate profits. They argue that such enterprises are in a position to pay the economic tariff for water. The water tariffs should be subject to annual revision and periodic adjustment to keep up with inflation and costs.

To provide a satisfactory, reliable and sustainable water-supply service, it is important to consider among other factors, the price that the consumers pay for water. Water-supply development for rural areas needs to be addressed through an integrated approach involving communities in all stages of development, particularly in providing labour for implementation. The project is paid for in kind as the cost of labour can be reflected in monetary terms. Upon completion, the maintenance costs of the project can be reduced substantially if during the whole period of development, there is a component of training through the village level operation and maintenance (VLOM) approach.

Through this approach, communities form committees where they agree on levels of contribution per household of funds to their central account to buy fast-wearing spare parts which through a careful prearranged programme, can be purchased from a local shop. It thus only remains to the government to provide adequate stock of these essential parts at all times. The committees further have "mechanics", preferably women, who are able to maintain water facilities once they break down.[35] In Tanzania, for example, community participation has assisted in providing labour and cash contributions toward the construction, operation, maintenance and rehabilitation of water schemes in their areas.

In the case of urban areas, the situation is slightly different in that development and maintenance works are wholly the responsibility of the water and sanitation utility. The construction costs of water-supply and sanitation systems must be contracted and may be very high.

In a majority of cases, the average water tariff is less than the average cost of water. This means that revenues are meagre and water utilities in southern Africa can hardly afford to replace the infrastructure should rehabilitation be required. The obvious result of such inadequacies in revenues, is that private water vendors flourish to put up strong competition with the water utility. The vendors buy water from the utility, transport it and sell it at a profit. The disheartening fact of this situation is that many African city consumers who depend on water vendors pay 5-10 times the price of water paid by those who enjoy the luxury of private connection.

Institutional capacity-building

The need for a reliable and efficient water utility calls for adequate resource backup. In a situation where adequate infrastructure is available to supply water to consumers, an equally efficient labour force with relevant expertise and skills should also be developed. The labour force should keep pace with the growth of demand for the service for the urban as well as rural areas. Training should involve planning, decision-making and appropriate pricing levels to improve the performance of the water utility. Innovations, technology choice, research and development are all very important areas in which human resources need to be developed. Planning skills should include assessment of needs, problem definition, inputs and outputs, service sustainability, community management and the role of women, low-income groups and servicing, project development and funding, research, education and training.

WATERSHED MANAGEMENT

Water-resources management policies and strategies contain clear messages to promote environmental programmes on a sustainable basis. There should be a commitment from central government to ensure that environmental management is carefully considered in the planning, design and operation of water supply schemes so as to avoid unnecessary conflict between development and conservation objectives. This will ensure a well-balanced water infrastructure development.

Research and development

Applied research is essential and needs to be done within the available human and financial resources of a country, but where specialised expertise is required, the assistance of qualified and experienced consultants can be used.

Some of the major research activities often concern environmental management which should be done on site and cannot rely on basic research results from elsewhere. The following are some examples:

- the work by Botswana and Namibia on the aquatic weed infestation in Okavango Delta and the Eastern Caprivi rivers;
- the animal mortalities in the Grootfontein-Omatako canal component of the Eastern National Water Carrier in Namibia;
- the study on the floodplains of the Pongola river in South Africa; and

- ecological issues concerning the abstraction of groundwater, environmental issues concerning the construction of new dams and the possibilities to enhance the recharge of aquifers such as at the Omdel Dam on the Omaruru river in Namibia.

Development of appropriate technologies is necessary, especially for the rural sector, more so if research and development is to sustain the viability of programmes. The development of the shallow-well hand-pump for rural communities in Malawi is underway with a view of producing a model that will improve performance and withstand the levels of operation in the countryside where long queues of people work the pump for hours. It is also aimed at identifying mechanisms of manufacturing these locally, stocked in strategic locations at affordable prices.

Integrated development systems

The integrated, combined use of water resources in a systematic manner allows more efficient utilisation. This can be achieved by optimising the yield of water-storage facilities through the selection of sites where the least evaporation takes place. A way of improving the yield from dams is the conjunctive use of surface and groundwater sources. This is achieved by utilising dam water when it is available and conserving groundwater. When the dams are low, more groundwater can be used until the dams can again meet the demand. Although water conservation and other management mechanisms will reduce demand, the available resources are finite and will eventually have to be augmented when the demand exceeds supply. This can be achieved by utilising local non-conventional water sources or transporting water from a perennial river or dam located further away to augment water supplies.

In an environment of growing demand, it becomes necessary to transfer water from long distances or store water behind dams where the resource has been or can be used for agriculture, power generation, tourism, domestic and industrial uses, recreation and other purposes. The integration of the health education and sanitation programme in such ventures is of great value.

LEGAL ASPECTS

The major objective of water law is to establish a framework for the protection and control of water resources in a country. SADC countries such as Zambia and Zimbabwe, whose laws were influenced by the United Kingdom, follow the common law system which recognises no ownership of water and declares the resource common to all. The riparian owner, however, has a reasonable use of the water. Efforts are presently underway in a number of SADC countries to amend water legislation to achieve equitable distribution.

Environmental legislation under scrutiny Box 4.3

Law reform with regard to renewable resources should be premised on the resources being managed on a sustainable basis and cater for an optimum yield, while ensuring that the resources are not depleted.

In the area of water management, the Water Act, Act 54 of 1956, of which only certain sections have been made applicable to Namibia, makes provision for the protection of river catchments, controls effluent discharge into rivers, includes legislation covering water pollution, outlines regulations which govern the optimal use of water resources, and promotes a balanced development of people and their environment.

A new water act is presently being drafted, which builds on the existing provisions, to broaden the power of the Ministry of Lands and Water Development to ensure the effective protection and responsible use of surface and groundwater resources.

SOURCE: Corbett, Andrew, *Namibia Review*, Government of Namibia, December 1995.

Water legislation

The fundamental principle of water legislation is to safeguard water from wasteful and inappropriate use as it could be immensely degraded in quality, placing future generations at a disadvantage. In this case, water legislation tries as much as possible to harmonise with legal instruments relevant to the environment and any water-resources management policies that exist. The water law should define water rights and this may vary according to the traditional legal systems in each country. For example, in South Africa there is private water (belonging to a private individual) and public water (belonging to the state).

In some countries in the region, the water resources are public property and the land rights of a person do not confer upon the individual any right to water occurring on or under the land. In Namibia, the water resources belong to the state unless legally owned by any other person.

Another aspect covered in water legislation is the allocation of responsibilities for water-resource management and this may include ministries such as Water, Agriculture, Environment and Natural Resources, and regional and local authorities, water companies or private individuals. A water board may assist to protect water resources.

If water is perceived as a scarce and a critical commodity in a country, it is advisable to coordinate activities in the water sector to protect the resources and to establish mechanisms to allocate resources equitably. In the SADC region, governments do so under a national Water Act or equivalent. South Africa is currently reviewing its Water Act and has published a White Paper for public distribution and discussion. The fundamental issue the African National Congress-led Government of National Unity wants to address is that of equity. "The line which divides those with adequate access to water from those without is the same line dividing the rich from the poor, the hungry from the well fed, the line of race and privilege."[36] The new Department of Water Affairs and Forestry has committed itself to end the inequity in access to basic water supply and sanitation services.

Traditional use versus legislation Box 4.4

Most environmental legislation in the region has little regard for indigenous knowledge and management systems. The legislation pertaining to water use not only disregards customary management of water resources but effectively criminalises it.

In Zimbabwe, for example, one of the objectives of the Water Act is to protect river banks and water courses. It, therefore, criminalises any interference with banks, bed or course of a public stream or any marshes, springs, swamps, vleis, or farming the source of a public spring. The Streambank Protection Regulations, 1952, prohibit cultivation on wetlands and within 30 metres of a streambank.

These provisions essentially prohibit streambank and *dambo* cultivation, undermining a traditional agricultural practice.

Many communities have traditionally used public water for non-primary purposes. Of particular significance is the agricultural practice of farming communities in the Nyanga district in Zimbabwe which have traditionally practised gravitational irrigation.

SOURCE: Mohamed-Katerere, J., "Access to Water: Right or Privilege — Water Management in Zimbabwe", for SARDC, 1995.

Water apportionment

Water resources within a state belong to the population of that state. However, for river or other systems shared among states, riparian rights apply. To govern the use of intra-state water resources, the appropriate laws apply in that an application has to be submitted to the governing authority so that a right to use the water is offered. The basic idea of

granting a water right for abstraction from groundwater sources, river or lake is to assess the quantities of use against the purpose and allow for adequate reserves for other users.

Thus water will be apportioned in respect of the use and the governing authority maintains the right to grant the right for the whole or part of the quantities applied for. No legislation can be regarded as suitable if it provides that all the resources available can be apportioned for consumptive uses for there has to be adequate storage from the source to maintain the natural aesthetic value. Compensation flow has to be allowed for, to maintain the regime of the flows of river systems and sustain the ecological balance of the microsystems downstream. The legislation will normally prioritise uses, for instance during periods of drought, water supply for domestic use is considered a higher priority than for the irrigation of lawns.[57]

Access to water

In general, all water resources contained in rivers and lakes belong to the state. Every citizen of the country has an equal opportunity to access these waters only up to the limit that the use is not for any largescale consumption. For instance, access to public areas offering recreation cannot be restricted nor for minor irrigation of vegetables or nurseries.

In cases where an infrastructure is required, such as irrigation canals, or where an individual constructs a dam or drills a borehole, the law will normally require that a right for use of the water be granted. In this case, water contained on private land, for which a right is granted by the governing authority, can be regarded as being the property of the grantee.

Water boards

The governing authority over water resources, such as the Water Resources Board in Zimbabwe and Malawi or the Water Apportionment Board in Botswana, ensures that society abides by the provisions of existing laws governing water resources in a country. It is important that the composition of the board be diversified with members having different expertise and interests so that any decisions made take into account the varied interests of all members. For instance, an industrialist who defaults over any provision of the water law can quickly be penalised through the withdrawal of his licence. This is possible when a board member is also a member of the ministry responsible for industry.

The board needs to be an independent institution and should not be dictated by any interests other than those that are directly or indirectly called for by the relevant legislation. To be successful in water-resources administration, it is also important that adequate education be provided to citizens on issues that the law provides for water-resources use, and a strong inspectorate must be put in place.

Conflict may arise when a grantee for water use has contravened the provision of any part of the legislation or when there are conflicting interests over the same water resources by two parties. It is the responsibility of the board to intervene and resolve any dispute.

Enforcement

It is useful and important that the functions of the Water Resources Board be decentralised as much as possible to enable it to deal effectively with issues at different levels. Under this general arrangement, the board can have inspectors in all regions of a country to monitor how the public complies with the provisions of the law.

Although lack of legislative policy has generally been blamed for inefficient water use and management, the trend has gradually changed in that many countries in the region have formulated water management policies and strategies. However, some questions arise about their effectiveness and the capacity of the existing institutions to enforce them.

In some countries of the region, policies on water management do not address the issue from a holis-

tic and integrated viewpoint. For example, groundwater, which is more abundant and in some instances more reliable, could still not be under government control. As a result, its exploitation is not properly monitored or regulated. Furthermore, many Water Acts, particularly those inherited from an era when water demand was less, still distinguish between "public" and "private" water. Such type of classification imposes restrictions on the management authority.

Role of other stakeholders

Apart from communities, government and the private sector, other players in water-resources management in the SADC region include United Nations agencies, bilateral and multilateral donors, churches and non-governmental organisations.

UN agencies, such as the United Nations Development Programme (UNDP) play a crucial role in highlighting water-resources management issues in the SADC region.

In Zimbabwe, for example, the UNDP office has launched a "Give a Dam" campaign designed to help build dams in drought-prone areas of south-western Zimbabwe. Communities, district councils, government departments, NGOs and other stakeholders are involved in the campaign which has raised about US$380,000 to build dams for rural communities in Matabeleland South province. A total of seven small and medium-sized dams have already been completed and are 100 percent full.[58]Local communities not only provide labour during construction, but also choose the dam sites.

In Zambia, the United National Children's Fund (UNICEF) has been involved in programmes to drill and repair boreholes. The Norwegian Development Agency (NORAD), through UNICEF has funded courses in that country for trainers of village mechanics and water committees.

Non-governmental organisations continue to play a valuable role in supplementing efforts of government in water and sanitation services to society, such as provision of resources toward implementation of new water supply and sanitation services, or rehabilitation.

During the 1991-92 drought, the Lutheran World Federation (LWF) monitored 400 wells in Zambia's Eastern Province and found that 80 percent of handpumps were not working.[59]

"NGOs and local communities have been involved in the rehabilitation of water facilities, especially shallow wells and simpler types of borehole rehabilitation, sometimes with technical assistance from [Zambia's] Department of Water Affairs' staff, whose costs they have paid."[60]

In some cases, NGOs have also assisted in training local communities in the general maintenance of water facilities such as boreholes, standpipes at kiosks or even the provision of water-supply infrastructure in urban areas.

Of central concern though, if there is to be any improvement toward these complementary efforts, is the degree of collaboration between the NGOs and government. This is most important in that it offers the latter an opportunity of maintaining record of which areas have facilities, to facilitate planning for future projects. Adequate record of efforts by NGOs are important for water resources management, monitoring, research and development.

NGOs may want to provide water facilities to rural communities with a view to alleviating hardships. Yet adequate measures for the sustainability of these facilities must be put in place, including training of the beneficiaries in their maintenance at the local level. It is, therefore, important that adequate and exhaustive collaboration takes place involving the NGOs, government and the communities, to agree on a definite and acceptable approach toward any development projects.

Linkages to other chapters Box 4.5

1 PEOPLE

Better use of and improvement in the management of water resources, provides an opportunity to meet water demand in an environment where the population of the region is increasing.

2 CLIMATE

Climate change and variability have a significant impact on the availability of water in the region, and therefore, use and management of water resources must reflect the effects of climate.

3 ENVIRONMENT

Water supports the life of all living resources on land on which people also depend for their livelihood. Sustainable management of water, which takes the environment into consideration, will help in reversing the loss of biological diversity in the region.

5 AQUATIC RESOURCES

Considerable additional benefits can be realised from freshwater and marine resources of the region if countries adopt appropriate approaches in the use and management of water.

6 POLLUTION

Since pollution implies reducing the available amount of water that can be used by both humans and the general environment, it is extremely important that the use of water and its management take into account reducing and avoiding water pollution so as to maintain its quality.

7 COOPERATION

The distribution of water in the southern Africa region is uneven; water in one country is plentiful while in another it is scarce. As the prosperity of the people of southern Africa and the economic development of the region depends so much on water, realisation of prosperity and development will need environmentally sound management of the waters of the region through regional cooperation and development programmes.

8 TRENDS

Present water-use and management practices will determine future availability of the resource and assure its optimum supply in both quantity and quality in future; the present uses and management approaches must be environmentally sustainable.

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5 Management of Living AQUATIC RESOURCES

The Southern African Development Community (SADC) region is synonymous with national parks and wildlife, spawning a thriving tourism industry. Apart from hippos and crocodiles the region's other living aquatic resources — such as turtles, fish, shrimps, seabirds, mangroves, seagrasses and coral reefs — are often forgotten in glossy tourism promotional brochures.

These resources are found in different habitats ranging from floodplains, rivers, natural and artificial lakes and dams to coastal areas. Both the resources and their habitats form an important part of the environment in the SADC region, contributing to biological diversity and the livelihood of millions of people in different parts of the region.

FRESHWATER RESOURCES

Southern Africa's inland lakes (whether natural or artificial), rivers, streams, swamps, floodplains and pans are valuable social and economic assets, from which a lot of resources can be and are harvested or exploited. Some lakes in southern Africa contain fish that are endemic to them. The long-term survival of such endemic species, and any of the resources in such habitats, depends on policies that are put in place and their enforcement. Before the advent of commercial exploitation, most aquatic natural resources were exploited at the subsistence level, posing no real threat to sustainability.

Inland fisheries

The fisheries industry in the SADC region is centred on a variety of lakes, swamps, rivers, floodplains and other water bodies, both natural and artificial. Several of the region's fisheries are located on floodplains and, therefore, are sensitive to seasonal flooding and low water regimes. Due to the existence of vast inland aquatic systems in southern Africa, fisheries production has a high potential, depending on how individual countries conform to the management needs of the resource.

Floodplains

The SADC region has numerous floodplains which support a thriving inland fisheries industry. These vary in size and include Zambia's famous Barotse floodplains which regulate the flow of the Zambezi river waters.

The Rufiji basin contains three important floodplains: the Kilombero, Usanga and Rufiji. Freshwater fish in Tanzania account for 85 percent of the total landings in the country. The estimated potential yield ranges between 220,000-360,000 tonnes annually. This wide range of estimated potential indicates that actual knowledge of the resource is limited.[1] Further research is necessary. The total annual yield from the inland fisheries industry has reached 300,000 tonnes.

Zimbabwe's largest floodplains, Mana Pools, which is on the Zambezi between Kariba and Mpata gorges, are prone to periodic flooding and little is known of their characteristics or fisheries potential. The annual fish catch is about 22,000 tonnes.[2]

In Namibia, the Cuvelai river flows from Angola into a flat terrain and flooded soils to form *oshanas*. These are shallow channels with vegetation which fill with water and have small fish. The fish are caught as the *oshanas* dry out. Research shows that *oshanas* are productive. For example,

in 1991, seven *oshanas* yielded 250 t of fish in two months.[3]

Major floodplain/swamp systems in Zambia associated with rivers are:

- the Lukanga swamp on the Kafue river;
- the Kafue flats/gorge and reservoir on the Kafue; and
- the Luapula floodplain (Kifukula Depression) on the Luapula.

Other floodplains which contribute to fisheries in the SADC region include:

- the Ovambo floodplain on the Cunene river in Angola with a potential yield of 5,000 tonnes/year;
- the floodplains of Angolan coastal rivers, including the Dande, Bengo and Cuanga which together have a potential yield of between 5,000-10,000 tonnes/year; and
- the floodplains of the Okavango/Cubango river with a potential yield of 5,000 tonnes/year.

Ill. 5.1 FAO/ALCOM-J King
The SADC region has numerous floodplains which support a thriving inland fisheries industry.

Lakes

Malawi, Tanzania and Zambia are extremely well-endowed with natural lakes, and these contribute significantly to inland fisheries in all three countries. Natural lakes in the three countries cover a total surface area of more than 94,000 sq km,[4] about 1,000 sq km less than the total surface area of all natural lakes found in SADC countries. Countries such as Lesotho, Mauritius, Swaziland and Zimbabwe have no significant natural lakes while those in Tanzania alone cover a total of about 57,320 sq km.[5] The area covered by Tanzania's natural lakes is more than three times the size of Swaziland.

Tanzanian inland water systems cover 61,500 sq km, which is about 6.5 percent of the total land area. Of this, 88 percent is made up of lakes Tanganyika, Malawi and Victoria. Tanzania has about 50 lakes[6] including other large lakes such as Rukwa and Kitangiri, and a group of Rift Valley soda lakes such as Natron, Eyasi and Manyara.

In Malawi, which has some of southern Africa's largest inland water systems including lakes Malawi (which occupies 25.9 percent of the country), Malombe, Chilwa and Chiuta, the fisheries industry falls into three categories:

- ornamental, concerned with tropical aquarium fish for export;
- large- to medium-scale commercial operations; and
- commercially oriented artisanal or traditional fisheries, producing 85 percent of the total landings mainly using gillnets, long lines, seine nets and traps.

One of the most critical factors about Malawi's inland waters is the extent to which they fluctuate as a result of changes in climate and variations in lake levels. The estimated potential fish yield for Malawi ranges from 80,000-150,000 tonnes annually.[7] The total annual yield has reached 88,000 tonnes.

Southern African river basins Map 5.1

SOURCES: USAID, *SARP — Southern African Regional Water Sector Assessment Vol 1:Final Report*, Gaborone, July 1995.
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Zambia enjoys an abundance of freshwater resources which include significant portions of lakes Tanganyika, Mweru, Bangweulu and Mweru Wa Ntipa. Smaller lakes include Ishila Ngandu, Lusiwashi and Ben.

In addition to these natural water bodies, 45 percent of Lake Kariba on the Zambezi lies in Zambia.

South Africa has about 10 coastal lakes along the northeastern coast of which Lake St Lucia is the largest, covering 328 sq km[8], and six along the southern coast.

Dams

Dams play a significant role in the region's inland fisheries. SADC countries are involved in dam construction both at national and bilateral levels. South Africa alone built more than 410 large dams between 1880-1980.[9] However, most of its potential large dam sites have now been used. In Zimbabwe, there are about 10,750 small dams.

The largest dams in the region include Kariba, between Zambia and Zimbabwe, with a surface area

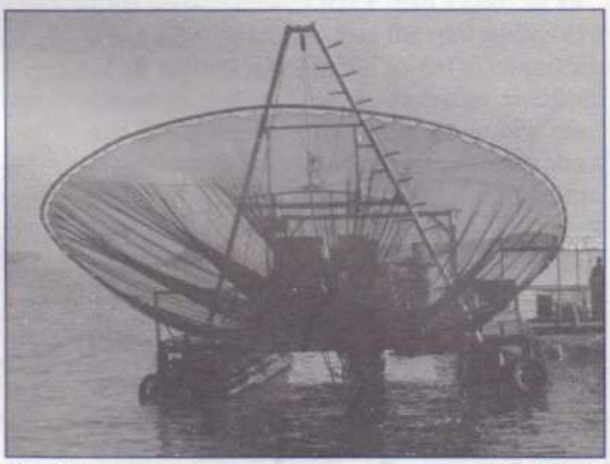


Photo 5.1 APG-D Martin

Zambia and Zimbabwe have different regulations although fishers from both countries fish in Lake Kariba.

Inland fish harvests in SADC countries (tonnes) Table 5.1

COUNTRY	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Angola	7,500	7,500	8,000	8,000	8,000	8,000	8,000	7,000	7,000	7,000
Botswana	1,500	1,500	1,700	1,900	1,900	1,900	1,900	1,900	1,900	2,000
Lesotho	13	23	25	26	30	30	30	25e	30e	35e
Malawi	65,064	62,067	72,852	88,588	78,811	70,765	74,094	63,726	64,000e	65,000e
Mozambique	4,000	3,000	3,767	3,267	3,248	3,500	3,500	3,800	3,800	4,689
Namibia	400	700	923	951	979	1,009	1,039	1,070	1,102	1,000
South Africa	1,150	1,200	1,360	1,410	1,577	1,674	2,673	3,270	2,375	2,375
Swaziland	90e	90e	100e	100e	110e	110e	110e	105e	100e	110e
Tanzania	237,318	257,904	265,770	303,433	343,759	327,532	357,331	272,370	275,500	300,000
Zambia	64,621	67,731	68,199	63,565	60,584	66,818	64,771	65,353	67,349	65,307
Zimbabwe	16,409	17,391	18,942	19,172	22,206	24,045	25,757	22,155	21,731	21,800

(Note: e stands for estimate)
SOURCE: FAO, Yearbook - *Fisheries Statistics, Catches and Landings, Vol. 76, 1993*, FAO, Rome, 1995.

Ill. 5.2 FAO/ALCOM-J King
Sun-dried bream and kapenta, Kamwala Market, Lusaka.

of 5,364 sq km[10], and Cahora Bassa in Mozambique, covering 2,000 sq km.[11]

Lake Kariba has a potential total yield of about 31,000 tonnes of fish per year. More than 2,740 fishers distributed into about 300 fishing villages in both Zambia and Zimbabwe are involved in fishing in Kariba.[12] Reports say that the annual yield for some kapenta (freshwater sardine) fishing cooperatives in Zimbabwe has declined from 20,000 t in 1980-81 to 15,000 t in 1996. The Kapenta Fishing Cooperative says since it started fishing in 1987, its monthly catch has been declining despite an increase in effort. Environmental causes and overfishing are suspected.

"When we started with only three rigs, we caught an average of 28 tonnes of kapenta a month, but nine years after, with five rigs, the best we can do in a month is 13 tonnes," says cooperative chairman Cephas Shonhiwa.[13]

Zambia and Zimbabwe have different fishing regulations. While entry into fishery in Zambia is free and fishers can fish anywhere in Lake Kariba, the government in Zimbabwe determines fishing regulations and policies. Zimbabwe controls entry into the fishery and also limits to five the number of fishing nets for each fisher.

The government of Zimbabwe, through the Ministry of Environment and Tourism, recently introduced a controversial sliding scale for fishing fees and also now require fishing permit holders to renew their permits annually. This enables the government to refuse renewal if there is evidence of overfishing in the lake.

The ministry has been embroiled in legal battles with a number of commercial fishing companies opposed to the new fee regulation, who have been challenging the ministry's decision in 1995 to cancel a total of 35 fishing permits for redistribution to disadvantaged groups.[14]

In Mozambique, a fisheries programme has commenced on Lake Cahora Bassa based on kapenta, which escaped through turbines from upstream Lake Kariba to colonise this lake. The fishery only became possible with the return of relative peace to Mozambique in the early 1990s. The country has a potential yield of over 55,000 tonnes annually[15] compared to only 5,000 tonnes harvested in 1993.

In Swaziland, some fisheries have developed around small artificial irrigation reservoirs. Estimates of the potential production are unavailable, but the total annual catch is about 100 t.

Rivers

The SADC region is endowed with many large and small rivers which contribute significantly to inland fisheries. The Zambezi and its tributaries are major sources of aquatic resources for many of the eight countries which lie within its basin. There are about 100 fish species in the upper and middle Zambezi alone. Annual potential yield in the Upper Zambezi, which part is of the Barotse Floodplain, is about 14,000 t. In the Middle Zambezi (between Kariba Dam and the Cahora Bassa Dam), the annual catch in Zambia alone is less than 1,000 t.[16]

Photo 5.2 APG-D Martin

Heron on a fishing expedition above Victoria Falls on the Zambezi river.

The SADC region's second largest river after the Zambezi, the Okavango (or Cubango as it is known in Angola), together with the Chobe river system, and their associated rivers and lakes constitute the main fishing grounds in Botswana. They have an estimated potential yield of 10,000-15,000 tonnes annually.[17]

The Orange, the third largest river flowing 2,160 km from Lesotho through South Africa to Namibia, has many tributaries which constitute the major fish sources for Lesotho. The Sengu, Makhaleng and Caledon are the largest of the rest. No significant fishery exists in Lesotho except for a sport fishery based on trout and yellowfish in the mountain streams and bass in the lowland reservoirs. The current estimated catch is 35 t annually, mainly of trout and yellowfish.

Freshwater fish production in South Africa rose steadily between 1983-1991. Inland fisheries are restricted mainly to perennial rivers and large dams. Introduced species in the rivers of Natal, have caused problems as they have fed on a rare species of *cyprinid* now found only in three small rivers of Lesotho.[18] Inland fisheries production, however, grew by almost 200 percent within the decade up to 1993, and the industry seems to be thriving.

Other rivers which contribute to inland fisheries in the region include Incomati, Limpopo, Pungwe, Rufiji, Pangani, Ruvuma, Malagarasi and Save. The Ruvuma, which forms a natural border between Mozambique and Tanzania, has a potential annual yield of about 2,000 t.[19]

Impacts on inland fisheries

Different factors hamper the full development of the SADC region's inland fisheries sector. In Angola, which has a potential of 50,000-55,000 tonnes/year but only records an annual yield of about 7,000 tonnes, civil war has prevented the exploitation of these resources at optimum levels. Lack of trained human resources, unavailability of fishing gear, and absence of adequate infrastructure for marketing, preservation and transport have also hindered the optimum development of Angola's inland fisheries.

Overfishing does not seem to be a major problem[20] in Angola, although the increasing use of smaller meshes and improper fishing techniques give cause for concern.

In Zambia, the major causes for the poor performance of the fishing industry include:

- inadequate knowledge of the sizes of fish resources in different water bodies, leading to overfishing in some places and underexploitation of some fish stocks;
- inappropriate fishing technology;
- inadequate fishery management services;
- critical shortage of trained human resources, particularly in assessing fish stock to devise appropriate fishery management strategies; and
- inadequate communications infrastructure resulting in limited access to fishery areas.[21]

The estimated potential yield for fisheries in Zambia of 116,000 tonnes annually is very conservative. All fisheries locations can support nearly double their present production levels through improved access and marketing. Total annual yield

is placed at 65,000 tonnes. Decline in the share of *clupeids* in catches of the industrial fleet of Lake Tanganyika is commonly attributed to the effects of beach seines that are landing too many juveniles and immature fish.

Fishing methods

Until recently, fishing in Botswana was mainly at the subsistence level by fishers scattered in remote communities, mainly in the Okavango delta and the Chobe districts, using rudimentary gear. The fisheries industry has developed in the last 20 years such that commercial fishing is now being pursued not only on the lakes, but also on the main rivers such as the Boteti and Boro, and even in the remote areas of the Okavango. The total annual yield is 2,000 tonnes.

Multifilament gillnets and handlines are the most common fishing gear used by Zambian fishers in Lake Kariba. Dugout canoes are commonly used for fishing, but the use of fibreglass boats has increased over the years. Before 1986 there were no restrictions for gillnets, but Zambia has set the minimum mesh size for gillnets at 76 millimetres.[22] Large net sizes allow young fish to escape and hence to grow.

Artisanal fishery

The artisanal fishery is a gillnet fishery based on species of riverine origin, which include bream, tiger fish, barbels, bottlenose, and cornish jack. Enforcement of regulations is an important prerequisite for successful fisheries management. It relies heavily on the capability of law enforcement agencies to patrol the fishing camps. However, it is impossible to effectively enforce these regulations without the participation of fishers.

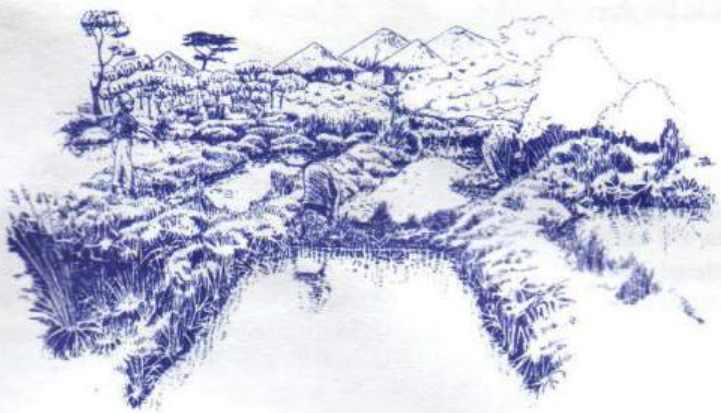
So far, control measures in the SADC region have generally been a prerogative of central authority and lack the participation of fishers. However, there is now a growing awareness that fisheries management should focus on people rather than solely on fish. Such a policy implies the involvement of fishers in the management of the resources they are exploiting. This is already being practised with wildlife resources on the Zimbabwean side of Lake Kariba under the Communal Areas Management Programme For Indigenous Resources (CAMPFIRE). Attempts are underway to introduce the same practice to the fishing community.

Zambia is moving toward a system where certain areas are closed to fishing for conservation purposes. Introduction of any new regulations in Zambia will rely heavily on the active participation and cooperation of traditional authorities such as chiefs and village headmen.

AQUACULTURE

Fish-farming is relatively new in the Southern African Development Community (SADC) region, contributing little to the total fish production. Accurate and reliable statistics for fish-farming are, however, difficult to get because fish-farming is rural and predominately production records are not kept.[23] In Africa, aquaculture production only contributes 0.5 percent of the world total. With a total production of 1,000 tonnes/year, Zambia is the only SADC country reported by FAO among the major freshwater fish producers in sub-Saharan Africa. The SADC region produces about 5,000 t/yr but has a potential of 250,000 t/yr.[24] More than 25,000 ponds are used for fish production in Malawi, Tanzania, Zambia and Zimbabwe. While fish-farming in other SADC countries is negligible at present, it is receiving more attention because of the increasing demand for fish and the overexploitation of many inland and marine resources.[25]

According to the Aquaculture for Local Community Development Programme (ALCOM), a SADC project managed through the United Nations Food and Agriculture Organisation, the best prospects for an increase in fish production lie with the more than 25,000 small water bodies, mainly multi-purpose dams. Research shows that annual fish yields in small water bodies in the SADC region are about



Ill. 5.3 FAO/ALCOM-J King
Woman harvesting a fish pond at Chibote, Zambia, one of the SADC countries which is a major aquaculture producer in freshwater bodies.

four times higher than the average of 17 intensively fished, large to very large African lakes and reservoirs.[26]

Species cultured in the SADC region include bream, catfish and trout, according to ALCOM.

Catfish culture is practised in Zambia, oyster-farming in Namibia and shrimp culture in Mozambique.

In Tanzania, women make coir rope from coconut husks for seaweed-farming.

ALCOM says fish-farming in the region ranges from extensive to semi-intensive and intensive. "Extensive practices, in which fish growth depends on natural food available in the pond, are the oldest and the most widespread."[27] Semi-intensive practices, which involve the use of organic fertilisers and cheap supplementary feeds, are used by small-scale commercial fishers in Malawi, Mozambique, Tanzania, Zambia and Zimbabwe.

Fish-farming is not restricted to rural areas only but has also been embraced by some urban residents. For example, in the peri-urban Kibahi district in Dar es Salaam, intensive backyard fish-farming is being practised. High fish prices have attracted small-scale farmers to integrate fish-farming with vegetable-growing.

While aquaculture is viewed as an alternative source of fish in the SADC region, constraints to its development include:

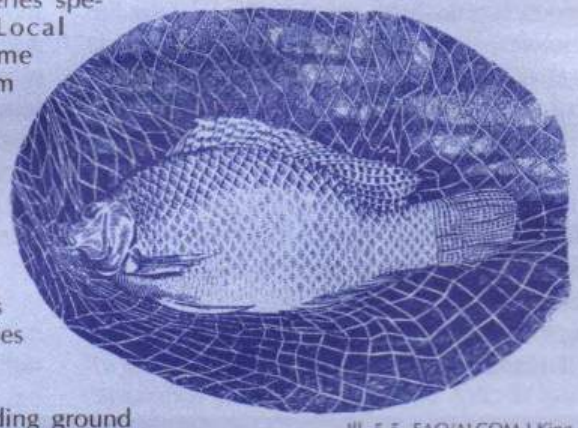
- limited water supplies and/or non-utilisation of small water bodies for fish production;
- restricted availability of soils suitable for the construction of fish ponds;
- lack of technical awareness and skilled human resources;
- poor transportation to and infrastructure at the markets;

Ill. 5.4 FAO/ALCOM-J King
Fish-cum-duck farm, Lusaka. More than 25,000 ponds are used for fish production in Malawi, Tanzania, Zambia and Zimbabwe.

Fish help to reduce diseases Box 5.1

Apart from providing much-needed protein to people in the SADC region, it is believed that fish can reduce the incidence of diseases such a malaria and bilharzia.

According to Lieven Verheust, a fisheries specialist with the Aquaculture Local Community Development Programme (ALCOM), samples of water taken from a dam before fish are introduced have more mosquito larvae than samples taken after the dam has been stocked with fish.



Ill. 5.5 FAO/ALCOM-J King
Bream

"Where there is no fish you will have more incidence of malaria," says Verheust whose organisation is involved in different small-scale fisheries projects in the SADC region.

Stagnant, shallow water is fertile breeding ground for carriers of tropical diseases such as malarial mosquitoes and bilharzia-carrying snails. Many fish species eat mosquito larvae, while some fish eat the snails which carry *Schistomiasis* (bilharzia-causing parasites).

Verheust says the two species of bream — *Tilapia rendalli* and *Oreochromis mossambicus* — that are mostly found in small dams in southern Zimbabwe, feed on mosquito larvae, reducing the incidence of malaria in the area.

SOURCES: Verheust, L., personal communication, 1996.
ALCOM, *Aquaculture in Southern Africa: A Sketchbook*, FAO, Harare, 1992.

- lack of operational funds; and
- insufficient seed supply and lack of good quality broodstock.

Several fish-culture stations exist in the highlands of Angola, but these have experienced a lot of difficulties in the past mainly from high cost of investment and inadequate training of personnel. There are no official statistics for aquaculture production in Angola. There are no records of aquaculture in Botswana. Aquaculture has been the main source of locally produced fish in Lesotho. However, setbacks in realising its full potential have included recurrent droughts. Aquaculture contributes about 0.1 percent of the total fish supply in Malawi. As the yield from fisheries is not expected to increase to any great extent, there is a major drive in this country to develop aquaculture. Responsibility has been given to the Department of Fisheries to promote small-scale fish-farming, which is undertaken in small earth ponds, and large-scale fish-farming in reservoirs, which belong to estate owners and community or public institutions, such as schools.

By 1987, production from freshwater aquaculture in Mozambique had reached 21 tonnes, but no further data are available on the number and area of ponds. Swaziland's climate is favourable for fish-farming, ranging from warm-water fish in the lowveld to cold-water fish in the upper reaches of the highveld. However, there are no statistics showing the national annual fish production from aquaculture.

While Swaziland has potential for aquaculture development, there are a few limiting factors which include lack of trained human resources, lack of aquaculture policy and development plan, and inadequate infrastructure.

A good potential also exists in Tanzania for the development of aquaculture. A number of ponds have already been constructed and several hundred water storage reservoirs are available. These could be supplemented by the development of the coastal belt through brackish water aquaculture.

Mariculture

There is great potential for mariculture, the production of fish in sea-water farms, in Angola, Namibia, Mozambique and Tanzania. For example, in Tanzania, seaweed farming has developed rapidly in Zanzibar over the past few years, with production rising to 5,000 tonnes/year in 1992.

In Mozambique, shrimp culture is still in its infancy but it is hoped that a pilot project will lead to commercial production. A government study has shown that about 18,000 hectares[28] close to the main coastal cities such as Maputo and Beira are suitable for shrimp culture. Potential also exists for seaweed and mussel culture but these are yet to be developed. Namibia is producing modest amounts of oysters, seaweed and mussels.[29] Four commercial oyster farmers are involved in mariculture in Namibia.

In South Africa, mariculture is a rapidly developing industry. Although the coastline is generally exposed to strong seas, there are some relatively

Seaweed Box 5.2

Ill. 5.7 FAO/ALCOM-J King
Harvest-time at a seaweed farm in Bwejuu, Zanzibar.

Seaweed is economically important in the SADC region where thousands of people depend on it for a living.

In Namibia, between 10,000-15,000 tonnes of seaweed are collected annually from stocks washed ashore. In Tanzania, the genus *eucheuma* is the most common, and the only one that is commercially exploited. Large populations of this genus are found around the islands of Zanzibar, Pemba and Mafia.

Seaweed — a general name for different species of large algae — picked from wild stocks washed ashore has been exported from Zanzibar since the 1940s. By 1951, Zanzibar was exporting about 390 tonnes of dried seaweed. During the late 1960s, annual export was between 500-800 tonnes, mainly for European markets.

Seaweed collection is mainly done by women and children. They usually collect during the northwest and southwest monsoons. Village communities in Paje, Jambiani and several other shoreline localities of Zanzibar now farm *eucheuma*. Between 10,000-15,000 villagers took part in seaweed farming in April 1991.

SOURCE: ALCOM, *Aquaculture in Southern Africa: A Sketchbook*, FAO, Harare, 1992.

sheltered localities, such as Saldanha Bay. The industry targets high-value products such as mussels and oysters. In 1993, about 2,300 tonnes of all products were produced by mariculture in South Africa, generating more than US$3 million.[30]

Crocodile farming and hunting

While the Nile crocodile is considered by many outsiders to be vulnerable or even endangered in Africa, there are large populations in different countries in the region, including Zambia and Zimbabwe.[31] Conservation and management of crocodiles are, therefore, usually low on the list of priorities in government wildlife departments. In crocodile management, conventional wisdom suggests that egg harvesting is more robust than cropping skins directly from the wild population. It also suggests that crocodile populations are least sensitive to the cropping of sub-adults, and that the monitoring of skin sizes can give information as to whether a harvest is sustainable or not.

The Okavango river system supports a crocodile population that has been variously exploited by hide hunters and crocodile farmers since 1957. Now it is considered that ranching based on wild egg collection is the most rational basis for exploitation of this crocodile population, with large scale wild harvesting of mature animals, either for hides or for stocking farms, having poor prospects. Botswana has registered two captive breeding operations, both being stocked with crocodiles from the wild. In addition, both operations have relied heavily on eggs collected from the wild. These two operations can take a harvest equivalent of up to 1,600 animals annually.

Malawi has a sound crocodile management system. It had a quota of 500 wild skins in 1985 and 1986, and 700 in 1987 and 1988. It also had provision for 200 ranch-produced skins for 1987, 300 for 1988, and 600 in 1989. Due to a greater than anticipated production success, the quota was increased by an additional 700 skins in 1988 and 1,000 in 1989. Thus, with good management there is potential for increased exploitation of crocodiles in Malawi.

By involving a private investor, Mozambique has promoted successful management, including the establishment of a crocodile ranch. Mozambique could harvest as many as 1,000 reptiles annually on a sustainable basis. However, logistical problems have resulted in undue animal cropping and egg collection from a section of the Cahora Bassa population only. It is unlikely that an annual offtake of 1,000 reptiles would be sustainable under these conditions. Ranching is, therefore, seen as the best option for Mozambique.

In South Africa, crocodiles are found in all of the perennial rivers in the Kruger National Park.[32] They also occur outside the park in rivers such as the Komati, Olifants, Blyde, Sabie, Letaba, Crocodile and Limpopo, and in rivers and lakes in KwaZulu/Natal. Management of commercial exploitation of crocodiles in South Africa is based on farming. A total of 28 crocodile farms existed in South Africa in 1990.[33] Breeding has been successful on 16 farms. The most productive stock has been imported mainly from Zimbabwe and Botswana.

There is no captive breeding of crocodiles in Tanzania. Licensed crocodile hunters are allowed to operate anywhere outside protected areas. There is considerable potential for the industry but success is unlikely without better planning. Tanzania could have doubled its earnings in the past on crocodile skins exported to international markets if the marketing of skins had been better controlled and organised.

Zambia has a well-developed crocodile ranching scheme, to which the government is strongly committed. Although the ranching industry has not been particularly successful in terms of production, with proper supervision and control, ranching is a strong force for crocodile conservation in Zambia .

Of the two crocodile species found in Zambia — the African slender-snouted crocodile and the Nile crocodile — the latter is more widely distributed, occurring in all the major rivers and lakes.

Crocodile farming under the spotlight Story 5.1

Lusaka (SARDC) - The recent deaths of about 50 young crocodiles at a farm on Lake Kariba in Zambia, have put the spotlight on crocodile farming, an innovative wildlife management programme that has brought back the reptile from the brink of extinction. The crocodiles died at a farm near Siavonga. The incident has triggered serious concern from environmentalists, some of whom are convinced that only nature is best suited to take care of its own.

A concerned environmentalist told journalists during a workshop at Lake Kariba that governments should introduce stringent measures to protect wildlife resources from poor or inexperienced wildlife management practices, or risk the extinction of some species.

As practised by most crocodile farmers, eggs are collected from the wild, from sands along the banks of lakes or rivers, and kept in hatcheries, thus taming the crocodile at an early stage. The fact that people have accepted or been attracted to farm the reptile means that the risk of extinction in some areas has diminished significantly.

Crocodile farming regulations stipulate that some young reptiles should be returned into the wild to allow for further natural breeding. But some farmers have been accused of overharvesting the crocodile eggs.

The Zambian farmer, who could not be reached for comment, is said to have closed down after experiencing financial problems, contributing to the lack of proper care for the reptiles. The workers also complained that they had not been paid for several months. Although the farmer was not charged for "gross negligence" some environmentalists feel that harvesting wildlife resources on a large-scale should be closely monitored to ensure that there is no overexploitation of the resource.

Crocodiles are an ancient group of reptiles and are one of the few surviving giant reptiles from the age of dinosaurs. Some *crocodilians* have changed little since the dinosaurs which ruled the earth 70 million years ago.

The Zambian National Parks and Wildlife Services has warned that the remaining reptiles are in danger of extinction due to indiscriminate killing for their valuable skin and through habitat destruction.

While the crocodile remains the key component in all major aquatic ecosystems, many communities fear the reptiles and kill them at first sight. In some cases, they are a threat to fishing nets and human life. Some communities, in many parts of the region, deliberately destroy the crocodile eggs and the young ones.

Crocodile skins produce a high quality leather. The reptile itself is a tourist attraction and is of immense scientific interest as the only surviving member of the long extinct *orchosaurian* group of reptiles.

The Department of National Parks and Wildlife Services also says: "In as much as the crocodile can be considered as a problem animal having conflicts with genuine human interests, its protection should be supported because continentally, its population has become vulnerable and quite scarce in some parts."

— **Katongo Chisupa,** Environmental Council of Zambia, for SARDC, 1995.

The African slender-snouted crocodile is not frequently seen and was last recorded only in the northern rivers and lakes such as Tanganyika, Mweru Wa Ntipa and Bangweulu. Even if the Nile crocodile is more abundant than the slender-snouted crocodile, however, both species are classified as threatened in some ranges.

The Nile crocodile population is estimated at 151,680 on the main natural range of about 12,640 km of shoreline running the length of Zambia's rivers and lakes. The major habitats of the Nile crocodile in Zambia are the Zambezi river on a shoreline length of about 1,400 km with a population of about 16,800, Kariba 18,000, Bangweulu 15,600, Mweru 8,880, Kafue 13,200, Luapula 12,480, and Luangwa 15,000, as at 1993 estimates.

There are about 45 crocodile farms in Zimbabwe. Broodstock and eggs are collected from the wild and five percent of the hatchlings are returned to the wild at some stage of their life cycle. This ensures that there is always a broodstock in the wild.

Photo 5.3 SARDC-M Chenje

Crocodile farms, such as this one in Kariba, are popular in Botswana, Malawi, Mozambique, South Africa, Zambia and Zimbabwe.

RESOURCE MANAGEMENT

The use and management of aquatic resources in the SADC region are guided by policies and strategies that control exploitation and manage the habitats in which the resources are found. A general objective of management is the attainment of the optimum rate of exploitation.[34] How this optimum is defined depends on the objectives of policymakers. In some cases, the objectives might have social considerations such as improvement of socio-economic conditions of small rural communities through the generation of jobs or improvement of income distribution. The design of any fishery management programme is aided by a clear understanding of the goals and targets for that programme.

Criteria for regulating fishing

Whether the objectives are explicitly or implicitly stated in policy discussions, they are often large in number, diverse, conflicting, and require consideration of trade-offs. The precise objectives for management vary from place to place and over time, and shift as external forces change. For example, the criteria used to regulate fishing falls into five broad categories:

- conservation;
- economic performance;
- social values;
- administrative feasibility; and
- political acceptability.[35]

Conservation

The most commonly recognised reason for regulating fishing is the need to conserve fish stocks and ensure that they provide a sustainable yield. Depleted stocks tend to retard growth, decreasing the chances of a sustainable yield.

Economic performance

To ensure the best economic value from harvested fish, emphasis is placed on the quality of fish as they are caught and they reach the consumer. Thus, regulations encourage fishing at certain times of year when quality is high, and processing and markets are conducive to maintaining the quality of the catch.

Social values

While equity is one of the most important social considerations used in assessing fishery regulations, it is not the only one. For instance, fishers often complain that their individual occupational objectives are inadequately considered when regulations are set. Many fishers choose their way of life because they wish to be independent while living an outdoor life full of challenge. They also want a great deal of flexibility in choosing target species, what gear to use, what time to fish and the area in which they fish. Some fishers prefer to fish throughout the year, while others temporarily desert fishing to farm.

This is quite common on Lake Kariba where the fishers are also peasant farmers in adjacent communal lands. Others move from one fishing camp to another, depending on how good the venture is. Such flexibility implies the ease of both entry to and exit from specific fishing grounds or even from the industry itself. These values might conflict with others, making it difficult to implement regulations that cater for all.

Administrative feasibility

Regulations need to be administratively feasible. The enforcement of regulations involves monitoring and control, and may be costly. There are two main areas of concern. The first, involves the extent to which it is considered necessary to monitor the activities of the fishing industry. Different regulations demand different types and levels of monitoring and data collection. The second concerns the fishers' understanding, of the regulations. If regulations are complex, difficult to understand and are perceived by the fishers to be against their interests, then their enforcement will be especially costly.

Political acceptability

Politics can influence the effectiveness of fishing regulations. Inundating the public with regulations may lead to resentment, criticism and finally lost political power. Recognition of political costs is one of several factors which make governments cautious, and therefore to adopt resource management measures which try to accommodate community expectations.

Management controls

Whatever the objective of fisheries management, it is likely to control fishing by, for example, designating fishing seasons or limiting some fishing methods deemed a threat to stock. The need to control fishing arises from what has become known as the "tragedy of the commons". In a situation where fishery practices are uncontrolled, high catch-rates and profits due to abundant resources can lead to overexploitation of resources, reducing fish stocks and ultimately forcing the industry to collapse. This scenario occurs wherever the "open access" situation is prevalent.

There are various ways of controlling fishing. Some of the most common methods are licensing, limiting fishing gear and catches, and enforcing seasonal or regional fishing. Licensing restricts access to, and hence harvesting of, a fish stock. To ensure success, licensing should be introduced early in the development of a fishery. Too often it has been introduced when exploitation capacity is already too high, so its conservation value is slight.

MARINE RESOURCES

In many regions of the world, the sea forms part of the fabric of life and the southern African region is no exception. The southern African region has an extensive coastline, bordering on two great oceans, the Indian and the Atlantic. The maritime influence on the socio-economic development of the region has been extensive, through trade, use of marine resources, recreation and cultural factors. The marine resources are often poorly managed, inadequately documented or studied, and plundered by opportunists — local and foreign. Yet, during times of natural disasters the marine resources become critically important for the sustenance of coastal communities. This was clearly demonstrated in Mozambique during the drought and war years, when securing food and products for trade from the sea often provided the only means of survival.

Main features of the marine environment Box 5.3

The western coastal shelf of the SADC region sustains a highly productive ecosystem known as the Benguela current — one of the world's major eastern boundary current systems.

The Benguela is an upwelling system, which brings nutrients on the seabed to the surface. The current is largely wind-driven, and in common with the other temperate systems, has relatively few marine species, but some occur in great abundance. Dominant species of value include the sardine or pilchard, anchovy, chub mackerel, horse mackerel and hake.

In contrast, the eastern seaboard is influenced by the Agulhas and Mozambique currents, both western boundary currents that induce a more tropical environment with lower productivity but much greater species diversity. Well over 2,000 species of fish have been recorded from this region and at least 250 species are harvested.

The continental shelf around southern Africa is mostly narrow, although wider shallow areas exist on the Agulhas Bank and opposite the main river mouths such as the Zambezi, Tugela and Orange. Although many rivers enter the sea, there are not many large estuarine systems, the largest one being the Greater St Lucia Wetland Park in South Africa. Despite this lack of rich coastal shallows, the coastal lagoons and bays that do exist are especially important.

Maputo and False bays are two examples of areas that represent rich nursery areas and sustain numerous small-scale fishing activities. Coral reefs also occur, especially in the Indian Ocean where corals extend south to KwaZulu/Natal.

SOURCE: Van der Elst, R., for SARDC, 1995.

There have been changes in the region which have given rise to new vision, aspirations and expectations that the marine resources will provide food and wealth. In effect, these are times of great opportunity for all coastal states in SADC because new structures and policies are being developed.

Main types of fisheries

Marine fisheries in the SADC region can be allocated to one of four broad categories:

- Industrial — large-scale, capital-intensive and conventional commercial fisheries;
- Semi-industrial — smaller-scale, commercial type fisheries with lower capital input, usually operating on vessels less than 20 m in length;
- Subsistence — fisheries that use less sophisticated gear, have very low input costs and are mostly not integrated formally into the national economies, such as traditional and artisanal fisheries;
- Recreational — consumptive and non-consumptive fisheries that are conducted for leisure, sporting or tourism purposes.

Each maritime region within SADC has a different mix of the above categories.

Industrial

The west coast is dominated by large-scale industrial fisheries, especially in Namibia and South Africa. These capital-intensive operations use large vessels and various gears to harvest species found at different depths of the ocean. Industrial fisheries also occur on the east coast, but on a more modest scale. In the east the Mozambican, Tanzanian and South African shallow and deep-water crustacean fisheries are important. They provide Mozambique with its biggest source of foreign exchange. Smaller industrial fisheries for sole, scad and other fish species occur in these countries.

Semi-industrial

Semi-industrial fisheries are more prevalent eastward. In South Africa, there are about 3,500 registered small commercial boats that harvest squid, linefish, tuna and snoek. In Mozambique, there are

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The Benguela is an upwelling system, which brings nutrients on the seabed to the surface. The current is largely wind-driven, and in common with the other temperate systems, has relatively few marine species, but some occur in great abundance. Dominant species of value include the sardine or pilchard, anchovy, chub mackerel, horse mackerel and hake.

In contrast, the eastern seaboard is influenced by the Agulhas and Mozambique currents, both western boundary currents that induce a more tropical environment with lower productivity but much greater species diversity. Well over 2,000 species of fish have been recorded from this region and at least 250 species are harvested.

The continental shelf around southern Africa is mostly narrow, although wider shallow areas exist on the Agulhas Bank and opposite the main river mouths such as the Zambezi, Tugela and Orange. Although many rivers enter the sea, there are not many large estuarine systems, the largest one being the Greater St Lucia Wetland Park in South Africa. Despite this lack of rich coastal shallows, the coastal lagoons and bays that do exist are especially important.

Maputo and False bays are two examples of areas that represent rich nursery areas and sustain numerous small-scale fishing activities. Coral reefs also occur, especially in the Indian Ocean where corals extend south to KwaZulu/Natal.

SOURCE: Van der Elst, R., for SARDC, 1995.

There have been changes in the region which have given rise to new vision, aspirations and expectations that the marine resources will provide food and wealth. In effect, these are times of great opportunity for all coastal states in SADC because new structures and policies are being developed.

Main types of fisheries

Marine fisheries in the SADC region can be allocated to one of four broad categories:

- Industrial — large-scale, capital-intensive and conventional commercial fisheries;
- Semi-industrial — smaller-scale, commercial type fisheries with lower capital input, usually operating on vessels less than 20 m in length;
- Subsistence — fisheries that use less sophisticated gear, have very low input costs and are mostly not integrated formally into the national economies, such as traditional and artisanal fisheries;
- Recreational — consumptive and non-consumptive fisheries that are conducted for leisure, sporting or tourism purposes.

Each maritime region within SADC has a different mix of the above categories.

Industrial

The west coast is dominated by large-scale industrial fisheries, especially in Namibia and South Africa. These capital-intensive operations use large vessels and various gears to harvest species found at different depths of the ocean. Industrial fisheries also occur on the east coast, but on a more modest scale. In the east the Mozambican, Tanzanian and South African shallow and deep-water crustacean fisheries are important. They provide Mozambique with its biggest source of foreign exchange. Smaller industrial fisheries for sole, scad and other fish species occur in these countries.

Semi-industrial

Semi-industrial fisheries are more prevalent eastward. In South Africa, there are about 3,500 registered small commercial boats that harvest squid, linefish, tuna and snoek. In Mozambique, there are

Photo 5.5 PTC MAPUTO-A Benzane

Photo 5.6 PTC MAPUTO-A Benzane

Photo 5.4 PTC MAPUTO-D Madeiro

Photo 5.7 PTC MAPUTO-I Ibrahim

From Ponto d'Ouro to Wimbe beach and beyond, the artisanal sector in Mozambique boasts more than 18,000 boats and canoes.

85 registered semi-industrial fishing craft that target mostly linefish.

Subsistence

Subsistence fishing, including traditional, artisanal and other forms of harvesting that do not depend on high-priced and sophisticated equipment, is the livelihood of millions of people in different parts of the region. A great variety of individual or community fisheries occur, from trapping fish in especially built intertidal pools known as *vyfers* around the Cape coast to stake nets erected in many east coast estuaries. In Mozambique, 13 different methods of harvesting marine fish are used by artisanal fishers, each designed to optimise catches and meet market needs of the local community. The artisanal sector in Mozambique boasts more than 18,000 boats and canoes, although accurate estimates of participation are difficult to determine.

Small-scale and informal fisheries occur throughout the region. In the past, their importance and consequent development was often overlooked, and generally their catches were not reflected in the total landing statistics of a country. Yet, they represent one of the most important aspects of marine resource harvesting worldwide, especially in an African context. Analysis of global fishing activities in 1990 demonstrated that in comparison to large-scale fisheries, small-scale fisheries employ many more people, have lower input costs, use less fuel, have a lower wasteful by-catch, and yet land almost the same tonnage of fish for human consumption.

Status of resources

About 70 percent of all the world's fisheries are considered fully exploited or overexploited, and increasingly the market is relying on low value species. Considering present levels of human population growth, the catch per capita is not being sustained both in the SADC region and other parts of the world. There have been massive changes in the composition and total landings of fish throughout the southern African region. The west coast of the region, regarded as one of the richer fishing grounds in the world, yielded three million tonnes annually during the 1950s and 1960s. However, this was short-lived and catches dwindled due to overexploitation. It was especially the landings of pilchards that caused alarm, dropping from 1.5 million tonnes in 1968 to near zero a few years later. Anchovies also underwent major fluctuations, partly offsetting the decline in pilchards. Catches of other species have dropped too: rock lobsters are down, and so are Cape hake, chub mackerel, Cape horse mackerel and kingklip. The African penguin population has more than halved, while the seal population has grown enormously. Numbers of Cape gannets have shown divergent trends in different parts of their range.

These trends highlight the importance of species interactions and, in part, reflect natural fluctuations in biomass. However, overexploitation of the resources by people has often been a major factor in their collapse. The Benguela system is currently yielding about 1.8 percent of the total world marine catch.

Along the east coast of the SADC region there have also been disturbing trends. In South Africa, the large linefish landings of endemic species in the 1920s have virtually disappeared. Line-fishing is used in areas where the seabed is too rough for trawling. Species such as the seventyfour, red steenbras and poenskop have been depleted by more than 90 percent. Their place in the linefishery has been taken by other, smaller and less valuable species. Not only has this resulted in human-induced changes in biodiversity, but also reduced potential profits for fishers. Further eastward, Indo-Pacific species dominate and generally have a wider distribution but a lower incidence of endemism.

Consequently, less dramatic changes in catch composition have been recorded. However, resident species and those most readily targeted on reefs have been depleted in several areas, including parts of Mozambique. In South Africa, the intense netting of large sharks to protect swimmers has resulted in removal of predators of smaller sharks that have in turn proliferated.

Namibia cracks down on illegal foreign trawlers Box 5.4

Shortly after independence, Namibia declared an Exclusive Economic Zone (EEZ), stretching 200 nautical miles from the coast. The aim of proclaiming an EEZ was to prevent further depletion of its potentially valuable fishing resource.

In February 1991, the Ministry of Fisheries and Marine Resources was established, leading to the setting up of a directorate of operations. The directorate was given the immediate responsibility of coordinating the surveillance and policing of the EEZ.

The ministry cracked down on trawlers fishing without permits in Namibia's EEZ, netting three on 21 March 1991 alone. These were in addition to others which had been apprehended four months before.

Fisheries and Marine Resources Minister Helmut Angula summed up the strategy of the ministry for the surveillance operation as follows: "The government had the will to end that illegal activity. It had the support of the locally based private industry which has interest in the long-term fishing rights and economic activity.

"Using the means at our disposal such as hiring private facilities, this combination helped a lot to put pressure on the illegal fishing."

By 1993, the situation had changed substantially as the surveillance function is now coordinated from a high-tech communications room in Swakopmund with an equipped surveillance team. Three vessels now police Namibian waters. The *Oryx* and *Tobias Hainyeko* set out to sea. One polices the northern waters and the other the southern waters. The faster *Cuito Cuanavale* is kept on standby to rush to the scene when an illegal vessel is sighted.

Besides the sea-going vessels, the directorate also has a fixed-wing aircraft and a helicopter; the former was donated by the French government.

The fixed-wing aircraft reconnoitres the entire EEZ. If irregular activities are sighted, a message is transmitted to the communication room. If the vessel is not within range of a patrol boat, the helicopter is dispatched to land inspectors and if necessary, defence troops aboard the offending vessel.

While the number of illegal foreign vessels has declined dramatically, operations director Axel Ishitile says the problem of illegal fishing still persists. Vessels licensed to fish in Angolan waters have been observed sneaking into the comparatively rich northern Namibian waters, fishing throughout the night and returning to Angolan waters shortly after dawn.

The proximity of illicit fishing operations to Angolan waters makes these vessels elusive targets. The ministry is discussing this issue and the possibility of hot-pursuit with its Angolan counterparts and an agreement could be concluded in the near future.

Such an agreement would allow Namibia to apprehend the foreign vessels in Angolan waters and vice versa.

— **Pierre Mare,** *Namibia Brief*, No. 18, June 1994, pp 50-51.

Photo 5.8 APG-D Martin
Marine fisheries along the lengthy SADC coastline, stretching from Zanzibar (shown here) to Cabinda, are threatened with overexploitation by foreign fishers, habitat damage and pollution.

Harvests along the east coast are generally much smaller than on the west coast. Total landings reported to FAO by maritime SADC countries in 1992 along the east coast was a mere 107,000 tonnes. With one or two exceptions, most marine fisheries in the region are fully subscribed. Many have already demonstrated significant changes in composition and yield. The moderate improvements in landings in recent years reflect an improvement in resource management and may largely be attributed to correct setting of quotas and sustainable harvesting techniques. However, many of the smaller-scale fisheries remain inadequately monitored or studied and hence their status cannot be assessed.

Threats to fisheries

Many activities threaten the SADC region's marine fisheries. These include overexploitation, habitat damage, fishing practices and pollution. Overexploitation, for example, is believed to have contributed to a noticeable decline of fish catches in Angola since the beginning of the 1990s. Angola's annual marine fish yield declined from a high of 103,302 t in 1989 to 67,518 t in 1992 and 73,723 t in 1993.[36] It is also believed that "large-scale illegal fishing in Angolan waters" has been taking place due to Angola's lack of capacity to patrol its territorial waters as a result of civil war.[37] The situation is certain to change as peace takes hold in Angola.

Dynamite-fishing is of concern on the east coast of southern Africa. In Tanzania, for example, dynamite-fishing kills "all fish including non-commercial species and immatures as well as other marine life".[38]

The blast kills fish within a 20-metre radius, leaving a crater on the reef surface and killing the coral. Damaged coral reefs support less fish and cause greater beach erosion by waves.

In Mozambique, there have been reports that prawn-fishing poses a serious risk to turtles. The United States government, which recently banned Mozambican prawns, alleges that the fishing gear used in the US$71.1-million prawn industry in Mozambique is a threat to the turtle.[39] Mozambican officials say they have laws protecting turtles; and special turtle protection areas, including the Bazaruto archipelago, have been decreed. Bazaruto, off the coast of Inhambane province, is now a national park.[40]

Other resources

While fish stand out as the main harvest from the oceans, other resources such as seaweeds, off-shore oil and gas, salt, and similar marine resources are also significant. In Tanzania, for example, from the island of Zanzibar, seaweed is a cash generator for women who have taken advantage of scientific studies for the culture and processing of this resource.

Recreational

Recreational fishing and the associated activities of marine-based ecotourism and non-consumptive use of resources, such as in scuba diving, form an increasingly important component of marine resource utilisation in the SADC region. In South Africa, an estimated 600,000 anglers fish in the sea annually. About 13,000 recreational ski boats are put to sea; and about 110,000 people have trained as scuba divers. On one small reef at Sodwana Bay, more than 100,000 dives were recorded in a single year. The coastal resorts of KwaZulu/Natal conservation authorities generate more revenue than do their inland game reserves that boast the big five mammals.

Coral reef threatened Box 5.5

Scuba divers on the Two-Mile Reef in the St Lucia Marine Reserve at Sodwana Bay in South Africa have, since 1994, reported increased sightings of the Crown of Thorns Starfish (COTS).

COTS is a reef-dwelling organism normally occurring at very low densities — less than one animal per hectare — and the fact that the current density of about 100 animals per hectare has raised concern.

The immature starfish feeds on marine algae while the adult animal feeds on hard corals and the Board and ORI are concerned that COTS have denuded several portions of the Two-Mile Reef through feeding activities in 20-27 metres of water.

The concern is heightened by the fact that the coral reefs of Maputaland are unique in that they are dominated by soft corals.

Research on COTS in other parts of the world has shown that the animal has increased dramatically in popular scuba diving points. The reason for this is not fully understood. Possible reasons are an increase in nutrients due to tourist accommodation facilities on land adjacent to reefs, or increases in pesticide levels in the sea which affect the survival of starfish predators.

A Natal Parks Board workshop in 1995 highlighted, among other issues, the urgent need to establish a code of conduct for scuba divers in relation to their use of coral reefs — especially as regards the practice of holding onto corals thereby damaging them.

SOURCE: Cameron Design, "You can look, but don't touch", *Earthyear*, Nov 1995, p. 7.

Marine landings in some SADC countries (tonnes) Table 5.2

COUNTRY	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Angola	64,700	66,497	49,436	74,936	93,783	103,302	99,035	68,201	67,518	73,723
Mozambique	31,847	33,306	38,671	36,321	32,185	27,560	32,919	25,536	27,808	25,506
Namibia	12,500f	13,000f	14,000f	31,486	32,416	20,216	261,393	205,100	293,381	328,790
South Africa	734,362	775,936	819,888	1425,798	1300,764	876,812	534,925	497,740	694,019	560,853
Tanzania	39,969	42,740	44,085	38,905	49,199	49,565	56,709	54,383	56,085	45,000

f represents FAO estimate from available sources of information or calculation based on specific assumptions.
SOURCE: FAO, *Yearbook - Fisheries Statistics, Catches and Landings, Vol. 76, 1993*, FAO, Rome, 1995.

The importance of such fisheries diversity to the SADC region is substantial. A study in KwaZulu/Natal identified 34 different types of marine harvesting along a mere 500 km of coastline. Whereas the total catch may have been a modest 4,500 tonnes, the overall socio-economic value was great, with a "free on board" value of US$18 million.

STRATEGIES FOR THE FUTURE

Maintaining existing fisheries

Sustaining the present fishing activities and landings must be regarded as a priority. Ideally, each fishery should operate in terms of a scientific management plan. Many do not and it will require a concerted effort to achieve this. The success achieved by better management of the larger industrial fisheries in recent years to stabilise landings should be extended to small-scale and subsistence fisheries. This will require a much greater level of management and fisher involvement than is presently the case. In particular, a number of specific tasks, such as monitoring, access and control, will have to be undertaken.

Monitoring

While data on the catch and effort of industrial fisheries are relatively easy to obtain, statistics from small-scale and subsistence fisheries are difficult to document. The informal nature and wide distribution of these fisheries present huge logistical problems. However, considering the importance and prominence of small-scale fisheries in the region, it is crucial to collect such data. In South Africa, extensive programmes have been underway for some time to obtain data from small-scale operators, while in Mozambique and other countries similar initiatives have also been initiated. The responsibility to provide data on a fishery should be given to the fishing community concerned. For example, in KwaZulu/Natal, a number of fishery monitors have been trained to record catches from fishing operations by their own community as a condition for access to the resource.

Access and control

Access should take into consideration the type of harvesting envisaged. It is also important that specific marine resources are harvested by the most appropriate techniques to ensure that they are realistically and profitably utilised. For example, hake stocks should be allocated to industrial operations and not to artisanal fishers because the latter cannot realistically harvest. Similarly, it may be socio-economically valuable to allocate some stocks to a large number of subsistence or recreational fishers than to a single industrial operator. Billfish landed at resorts throughout the region must surely provide greater commercial value as a recreational species than as a simple food resource.

Education and enforcement are crucial in controlling the exploitation of marine resources in the

Photo 5.9 PTC, MAPUTO-S Obisse
Excellent fishery schools exist in the region but fishery management and wise use of resources should be more prominent in curricula.

SADC region. Excellent fishery schools already exist in southern Africa but fishery management and wise use of resources should be more prominent in their curricula. Enforcement should be seen to benefit fishers, not work against them. For example, the levels of poaching lobsters in South Africa or the illegal dumping of fish that have exceeded the quota, impact adversely on bona fide fishers and negate any good advice or management that is already in place.

Marine reserves

There is good scientific evidence to suggest that marine reserves that are well designed, sited and managed play an important role in the maintenance of biodiversity and serve as viable tourist attractions. Although a number of marine protected areas exist, especially in South Africa, little effort has been made to identify critical habitats, representative ecological areas or the real need for marine reserves.

Improving existing fisheries

It may be possible and desirable to reconsider the way in which some fisheries are currently being exploited and used. Many stocks are not generating their potential socio-economic benefits. For example, the massive anchovy harvest is turned to meal, pet food and other products. The difference in value between an anchovy turned into pet food and one that is served to humans is enormous.

The quality of the landed catch is directly proportional to the profits made by the fisher. It has already been noted that fisheries today harvest less valuable species than those of yesteryear. Many fish are also caught in such great numbers that their quality deteriorates. For example, along the KwaZulu/Natal coast one tonne of prime quality sardines caught by beach-seine netting may yield the same financial return as five tonnes of poorly handled fish. Preservation technology needs to be extended to the more remote regions.

In a number of fisheries, the so-called "trash fish" is returned to sea since these fish are little sought after and storage capacity is limited. This is clearly a wasteful practice, which, if overcome, could lead to increased yields and revenues.

New fisheries

While the most accessible or valuable marine resources appear oversubscribed, some potential "new" resources do exist. In Namibia and South Africa, the capture of snoek by semi-industrial and subsistence fishers could be increased in years when this species moves abundantly inshore. In Tanzania, light-assisted seine netting of small pelagic species could add another 20,000 tonnes to the present catch. Based on survey results, it has been suggested that Mozambique could greatly increase its catches of small offshore pelagic fish, possibly by an additional 250,000 tonnes. Similarly, a potential harvest exists in trawling for small demersal species off the KwaZulu/Natal coast.

While these opportunities appear attractive, and will need investigating, they raise three problems.

First, the input cost for trawl and purse-seine operations is high, even at semi-industrial level. Second, most species involved are of low value, further aggravating the high input costs and reducing potential profits. Third, stock assessment and sustainable fishing levels have mostly not been determined. Careful planning is, therefore, required before funds are sought and fisheries developed.

Recreational and non-consumptive use of resources

There is a growing realisation that recreational fisheries can often generate greater wealth from a specific resource than direct commercial exploitation. The multiplier effect of costs associated with catching a fish through recreational fishing may increase the actual value of a fish sevenfold. Even better, and certainly more sustainable is the non-consumptive use of marine resources as practised by scuba and skin divers. The Aliwal Shoal reef along the KwaZulu/Natal coast attracts about 30,000 divers annually. These scuba enthusiasts contribute to the local economy for looking at and photographing fish — far more than the semi-industrial operators who once exploited the reef.

Tourism

The introduction of well-managed charter-boat fisheries can be beneficial. Besides creating additional employment in the fishery, charter-boats are popular with tourists. While developing recreational fisheries can be very productive and desirable, great care must be taken in their management to avoid potential negative implications. Tourist anglers may often plunder resources that are not their own. In some cases, the tourists even pay for their vacations by selling their catches in the host country, so that instead of contributing to the economy of that country they remove a valuable asset. This has been practised by South African anglers visiting Namibia and Mozambique.

If recreational anglers enter the economic side of fisheries then harm may be done, especially to vulnerable stocks. By entering a fishery with subsidised input costs, as is the case with recreational fishers, the bio-economic equilibrium will shift away from safe harvest levels, jeopardising sustainability.

For example, the setting of a high-prize award on a rare species as is the case in the Transkei region of the Eastern Cape Province where an annual angling tournament offers a four-wheel-drive vehicle to the angler who lands the largest red steenbras, exerts pressure on an already highly overexploited species. The competition targets a species that would otherwise not attract such attention.

In addition to recreational fisheries, there is a rapidly growing demand for non-consumptive recreational access to other marine resources, such as sharks, turtles, seabirds, seals and whales. For example, the number of visitors to a mainland penguin colony near Cape Town has grown exponentially in recent years. Because undue disturbance can adversely impact reproductive success of such species by causing birds to abandon nests, such ecotourism should be carefully managed.

Management and policy development

Management, and hence conservation, of all exploited freshwater and marine resources must take place if stocks are to be sustainably developed. Management can only occur within a framework of national policy objectives. These must be developed in conjunction with the communities.[41]

While Namibia has made good progress in developing national fisheries policies, South Africa and Mozambique still need to finalise their own policies. In South Africa a network of regional community forums, fishery interest groups and technical committees have been established to expedite this matter. An innovative national marine research programme has been launched to assist this process. Known as "The Sea and Coast," it aims to provide essential information on how best to use coastal resources for the benefit of local communities.

The freshwater and marine resources of the southern African region are in most cases fully harvested for consumptive uses and many are fully utilised for non-consumptive purposes. However, considerable additional benefits can be found through new approaches to existing fisheries and development of other resources for ecotourism.

Realistic management policies that take cognisance of the role of traditional authorities and people in general once they have been given responsibility are required.

Linkages to other chapters Box 5.6

1 PEOPLE

Freshwater and marine resources provide substantial protein and other requirements to the people of southern Africa. Management must aim to ensure sustainability for future generations.

2 CLIMATE

As freshwater and marine systems provide a natural environment for aquatic resources, any change resulting from climatic variability will have an impact on these resources. Water must be available in the right amounts and quality to maintain the natural condition of the ecosystems in which aquatic resources live.

3 ENVIRONMENT

Aquatic resources and ecosystems are part of the environment. The various species in these ecosystems depend on each other and on the state of their environment. Thus, their use has a direct effect on ecosystem functioning, and their populations are likely to be influenced by environmental change.

4 MANAGEMENT

As aquatic resources are dependent on the state of the water environment, the sustainable use and management of water will have a direct positive impact on aquatic resources.

6 POLLUTION

Pollution degrades the aquatic environment and adversely impacts aquatic living resources.

7 COOPERATION

Many of the river basins and marine ecosystems in which aquatic resources live are shared by SADC countries. What takes place in one country upstream, can have an effect on another downstream. Regional cooperation is necessary, especially in areas such as pollution control, management of shared living resources,research and legislation.

8 TRENDS

There is a need to review present approaches in the use and management of living aquatic resources to ensure holistic management measures. Such approaches should involve grassroots communities for without their input, success is likely to be limited.

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6 Water POLLUTION and Management

Pollution is the degradation of natural systems by the addition of detrimental substances such as sewage, heavy metals, pesticides and detergents. It is generally associated with industrial and agricultural development, and the rapid increase of human population densities. Economic growth leads to larger discharges of waste water and solid waste per capita. Given the high levels of pollutants from agriculture, industry and households in southern Africa, river systems are no longer able to effectively cleanse themselves. Contamination of groundwater is less evident but may be more serious as polluted aquifers may take decades to cleanse themselves.[1]

The increasingly intensive industrialisation and urban development of southern African countries has led to the emergence of several types of air and water pollution, which where unknown 30 years ago.[2]

Of the many sources of pollution, the following are considered to be serious:

- industrial and municipal waste, which can either be biodegradable or non-degradable, solid or liquid;
- agro-chemical pollution, which is a product of the application of pesticides, herbicides or fertilisers, all of which are widely used in southern Africa;
- pollution arising from health control, mostly for the control of mosquitoes, and other parasites such as spiders and mites;
- oil spills, arising from its transportation and use;
- industrial emissions (gaseous) and dustfall.[3]

Many of these pollutants are termed "ecological accumulators": they are not broken down in animal guts, or by plant or microbial enzymes. They, therefore, accumulate and are concentrated in the food chain, with disastrous toxic effects to humans and other animals.[4] Pollution also has a negative impact on the productive capacity of water. For example, the use of contaminated water in the production of fruits and vegetables may reduce the quality of the produce.

SOURCES AND EFFECTS OF WATER POLLUTION

Impact of air pollution on rain

The main sources of air pollution are found in urban areas and major developments such as mines and industries. Burning of fuelwood, fires, exhaust fumes from vehicles and the use of coal in factories cause air pollution.

Photo 6.1 SOUTHLIGHT-P Weinberg

The quality of rain reflects broadly the state of atmospheric pollution in the region. One of the more damaging products is acid rain.

The horseshoe area comprising the Zaire-Zambia copper-fields in the north, through the Great Dyke mines of Zimbabwe, further across eastern Botswana into South Africa's Transvaal, over the northern part of the Orange Free State and Cape Provinces turning north again into Namibia's northern mountains (at Tsumeb) and further into Angola, is where most of the large primary smelters (copper, lead, iron, nickel and many others) are located. These are also the largest emitters of air pollutants in southern Africa.[5]

The quality of rain reflects broadly the state of atmospheric pollution in the region. Acid rain is one of the more obvious and damaging products of atmospheric pollution. It is the result of sulphur dioxide which is set free in the atmosphere where it dissolves in the moisture to form sulphuric acid. Acid deposition then takes place both in the form of "wet" precipitation (as acid rain or acid mist) and "dry" deposition (where it is deposited on surfaces such as the soil, plant leaves and water), destroying forests, acidifying lakes and rivers, corroding materials and affecting human health.[6]

Examples of sources of sulphur emissions to the atmosphere are the copper/nickel smelters in Selebe Phikwe (Botswana) and in Tsumeb (Namibia); and coal-fired stations in the Eastern Transvaal Highveld (ETH) which generate 80 percent of South Africa's electrical power requirements.[7]

While the rainy season provides water to dilute pollutants, flooding from intense rains can make pollution worse. Storm waters dissolve pollutants on the ground and carry them into water supplies, making the water unsuitable for consumption, as in the case of Goreangab Dam in Windhoek, Namibia.[8]

Recorded wet sulphate depositions in the Vaal Dam catchment and the forestry plantations at Sable, South Africa, were found to be higher than the critical limits of 20 kg of sulphate/hectare/year, a wet deposition level suggested in Canada which was set to protect sensitive aquatic ecosystems. This critical limit was closely approached in some of the sites within the Eastern Transvaal Highveld.[9]

Industrial water pollution

Water is the usual recipient of industrial pollution because disposal of wastes into water bodies is cheap and convenient. The effects of pollution from toxic organic solvents, acids, heavy metal residues, pesticides and herbicides in the lakes are more serious than they are in rivers. This is because rivers comprise fast-moving water masses capable of flushing toxins, while the lakes are

Sulphur emissions by sector in some SADC countries (tonnes/year) Table 6.1

Country	Power*	Industry	Domestic	Traffic	TOTAL
Botswana	8,363	197,213**	240	457	206,273
Lesotho	-	75	845	71	991
Mozambique	1,400	758	2,012	1,277	5,447
Namibia	500	29,205	150	940	30,795
South Africa	599,207	99,220	12,300	29,305	740,032
Swaziland	-	3,400	161	260	3,821
Zimbabwe	60,090	52,330	1,523	2,361	116,304
TOTAL	669,560	382,201	17,231	34,671	1,103,663

* Power production
** Major sulphur emissions are from mining activities

SOURCE: Sivertsen, B., Matale, C. and Pereira, L., "Sulphur Emissions and Transfrontier Air Pollution in Southern Africa", *SADC ELMS Report No. 35*, Maseru, 1995, p. 30.

"standing" water bodies and accumulate rather than disperse materials in their catchments. In coastal areas, most industries dispose of untreated wastes directly into streams or rivers running into the sea. Industrial wastes are found in ocean waters near major centres along the entire southern African coastline, from Dar es Salaam and Maputo on the east coast, past Durban and Cape Town in South Africa, Walvis Bay in Namibia to Baia do Cacuaco, in Angola.[10]

Industrial pollution is varied, and it can be dangerous, depending upon the types and amounts of waste that reach the aquatic environment. The different types of industrial pollution existing, or capable of existing in southern Africa, are as follows:

- organic pollution due to the accumulation of various wastes that de-oxygenate the aquatic environment;
- bacterial pollution due to the presence of disease-causing organisms, resulting from the discharge of excrement into the aquatic environment;
- pollution due to the accumulation of nutritive salts, or certain ions (atoms with an electric charge), leading to the eutrophication of lakes, and encouraging the growth of algae;
- pollution due to toxic agents, detergents and tannins (acids) are among the most active of toxic agents;
- pollution due to heavy metal accumulation is directly dangerous for aquatic organisms because of the greater intrinsic toxicity of heavy metals;
- thermal pollution, although localised in the immediate region of factories transforming energy, can be serious in itself; and
- acid pollution can occur, which is directly linked to mining operations.[11]

Photo 6.2 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO
Water bodies are the usual recipient of industrial pollution because disposal is cheap and convenient.

Streams, rivers and lakes are linked tightly to their surroundings and serve in many cases to eliminate the metabolic products of terrestrial ecosystems. However, this natural process is often disturbed by the introduction of excessive amounts of waste matter, especially when a river system crosses a heavily industrialised or heavily populated zone.[12]

Mining

Most mining concerns use water as a medium for mineral extraction processes, often involving highly toxic chemical compounds. Seepage water from mines, particularly coal-mines, can have extremely detrimental effects if it enters river systems.

High levels of sulphuric and nitric acids, formed from oxides of sulphur and nitrogen in disused mines can drastically increase the acidity of such seepage water and of rivers in mining areas. The Olifants river in the Eastern Transvaal has stretches where the acidity is so high that no life is possible.[13] Polluted water with a low pH (measure of acidity or alkalinity of water) value is more acid and corrosive while a high pH value indicates increasing alkalinity.

The treatment of bentonite (highly absorbent clay used as a binding, filling or filtering agent) at Boane, Mozambique, generates waste which could contaminate the water of the Matola and Umbeluzi rivers, making it undrinkable. In the Alto Ligonha region (the Morrua and Muane mines), also in Mozambique, the surrounding rivers and other water sources are contaminated by waste products from the treatment of pegmatites.[14]

Siltation caused by small-scale, diamond-mining in Angola has destroyed fishing. Hippos are reported to be non-existent in affected areas. In Zimbabwe, gold-panning is causing major river-siltation problems in different parts of the country.[15]

River basins, lakes and coastal areas in southern Africa are subjected to various mining operations, because of the existence of products such as coal, iron, gypsum, salt, soda, coral sand and gravel. Examples are, the extraction of soda ash in Makgadikgadi (Botswana), gypsum and iron ore in Kafue Flats (Zambia), salt in Etosha (Namibia), coral sand along the coast of Tanzania, Mauritius and Mozambique, and coal along the Zambezi Valley. One of the main effects of mining is the contamination of water by soluble substances and liquid effluents of toxic substances.[16] Diamond production around Dundo, in the north-east of Angola, has caused a certain amount of pollution to the tributaries of the Kasai river flowing into Zaire. Diamonds are also extracted by opening up the river beds.[17] Mineral processing in the SADC region contributes more than one million tonnes of sulphates to the environment, annually.[18] In South Africa, for example, regular tests at more than 40

Trees and mine water pollution Box 6.1

Using trees to reduce the problem of acid mine drainage and groundwater pollution is the subject of a project run by the Land Use and Hydrology Programme at Jonkershoek, South Africa. The main objective of the project is to determine how effective trees and other types of vegetation can utilise unwanted water either before or after it drains through the disturbed area.

Acid or polluted water drains from gold-mine, sand-dumps and slime-dams, open-cast coal-mines and longwall mines, contaminating groundwater, streams and rivers.

"Trees are often criticised for high water consumption, but here we have one area where this characteristic can be used to good effect," says Dirk Versfeld, the project manager.

A forestry solution is seen as a logical way of reducing the water supply draining through disturbed sites, while giving the site time to recover. Trees planted in surface seeps can also be used to intercept acid and polluted water as it moves into streams.

Tree species considered for the study include eucalyptus. Indigenous species will also be considered for use on gold-mines in the Johannesburg area. The mining project has generated a great deal of interest. Clients want to prevent water draining through existing and old workings and are excited at the prospect of using trees to "recycle" polluted water, and factory and power-station effluent via irrigation.

Mine owners, already looking for the future demand trends for the region, are likely to find that benefits may be measured on both the economic and social scales.

SOURCE: FORESTEK, "Trees and mine water pollution", Division of Forest Science and Technology, Pretoria, Autumn, 1992.

sampling points in the Vaal catchment area show that mine dumps on the East Rand leach into the Rietspuit stream, among other toxic chemicals, "alarming levels of sulphates" that exceed European standards for surface water.[19]

Manufacturing

Manufacturing and service industries are primary sources of pollution in southern Africa, producing millions of tonnes of effluents, tens of millions of tonnes of solid waste, and hundreds of millions of tonnes of emissions.[20]

The spillage of toxic chemicals from the Usuthu Pulp Company into the Usuthu river in Swaziland, in August 1994, resulted in fish kills. Phenol was suspected to be responsible.[21]

The 126 factories in and around Maputo do not have waste-treatment systems and drain toxic products, poisons, non-biodegradable substances and organic matter into the environment. The main contaminants are: sulphuric and nitric acids, caustic soda, ammonium salts, phosphates and sulphates, organic substances and pathogenic organisms.[22]

Pulp-and-paper mills are among the worst industrial polluters, as are textile factories. Production of pulp-and-paper requires large quantities of water, so a large volume of liquid waste is produced. Pulp mills use strong chemicals, such as chlorine, to soften wood pulp and bleach it white. Dioxins and other organochlorines end up in rivers, where they impair the reproduction of fish, retard their growth or kill them.

In Swaziland, paper fibres are discharged into the Ushushwana river together with the effluent, and now carpet the bottom of the river where they will continue to rot and rob the water of oxygen, decreasing the survival of fish and fish eggs.

Wastes from fibre-processing mills can impose a heavy oxygen demand on receiving waters, while synthetic textile production can add organic solvents and metals, and alter the pH as well. Textile mills use caustic soda and other chemicals such as acids, dyes, detergents and starch. Treatment involves passing the effluent into sedimentation tanks from which sludge is removed and burnt.

Most of Tanzania's textile mills release dyes, bleaching agents, alkalis and starch directly into Msimbazi Creek in Dar es Salaam. Angola's largest textile factory at Lobito-Benguela discharges its effluent straight into the Cavaco river. The case of

Photo 6.3 & 6.4 SARDC-M Chenje

Manufacturing and service industries are primary sources of pollutants which can impair the reproduction of fish, retard their growth, or kill them.

TEXLOM, a Mozambican textile firm that also prints materials, showed a pH of the drained water equal to 11.6, polluted with caustic soda and dyes.[23]

Industries located away from the coast usually provide some kind of treatment for their liquid wastes before discharging them, though the process may be ineffective, and poisoning of fish is common in the region. The Peleng river Botswana, for example, has been polluted with liquid industrial waste to the point where fish and reeds disappeared and boreholes had to be closed.[24]

Heavy metals

Heavy metals are introduced into the aquatic environment by urban or industrial wastewaters, and also by the use of fungicides in agriculture (particularly copper and mercury). One real danger with heavy metals is that they can accumulate in the soil with apparently no effect until the pH of the soil drops under a certain level. Plants then start to take up the ions with effects still to be determined. In Lake Tanganyika in Tanzania, significant quantities of copper, iron, manganese and zinc were detected in flour made from oven-dried fish caught in the lake. The accumulation of copper in algae and macrophytes (large water plants) can inhibit the growth of fish that feed on them, and can even become lethal if the levels become too high.[25]

Cadmium, because of its high mobility is the element most likely to limit application of sludge on land, especially because of its toxicity to humans.[26] In South Africa, the highest proportion of sludge (over 46 percent) is being disposed of in landfills located near urban areas and centres of industrial activity.[27] Surface and groundwater sources are threatened with incoming runoff from these areas and percolation water of toxic heavy metals, such as lead, Molybdenum and nickel.

In Botswana, trace quantities of cadmium have been found in boreholes in the vicinity of the BCL copper/nickel mine of Selebi Phikwe.[28]

The central water laboratory in Windhoek recorded a content of one per cent arsenic, an extremely poisonous substance, in drinking water coming from a borehole next to a gold-mining area. This value is 200,000 times greater than the guideline upper limit of 0.05 milligrammes per litre (mg/L) in drinking water stipulated by the World Health Organisation.[29] Heavy metals can also suppress one or more links in the food chain, or even accumulate along that chain.

Marine pollution

Coastal cities and towns in southern Africa discharge more than 850 million litres of industrial and human wastes into the sea daily through more than 80 pipelines, largely without any treatment.[30] The sea water is beginning to show signs of pollution in the vicinity of major coastal towns.

By global standards, coastal pollution in Mozambique is still comparatively light, owing to the low level of industrial development. Nevertheless, in a few cases (Maputo being the outstanding one), untreated sewage combined with pollutants from industries are already having a local effect on the coastal environment.[31]

Recent studies of Maputo harbour indicate that the waters are not safe for swimming. Beaches of

Photo 6.5 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO
Untreated sewage combined with industrial wastes are polluting coastal waters near cities, such as Maputo, along the entire coast of eastern and southern Africa.

Maputo and Beira are now polluted from increased erosion, human-induced pollution (both garbage and faecal), and from ship traffic. Domestic and industrial residues are drained directly into Maputo Bay or through the five rivers that flow into the bay.[32]

Untreated industrial residues (from the cement and battery factories, an oil and soap factory, and a petroleum refinery) are drained directly into the Baía do Cacuaco, in Luanda. People living around the industrial park have no sewer pipes. As a result, the artisanal fishing is almost non-existent.

Oil leaks and spills

Oil threatens the marine environment in many ways: oil slicks can poison marine mammals, turtles, birds and fish, and smother bottom-living corals and other organisms. A coat of oil on mangrove pencil roots can prevent the trees from "breathing". Oil on birds damages the feather structure, breaking down their water-proofing capacity. Water then penetrates to the skin, and the birds become cold and no longer go to the sea to feed. As a result, they generally die of exposure and/or starvation. As oil breaks down, its chemical components, such as aromatic hydrocarbons, affect feeding and reproduction of many organisms, including crustaceans, molluscs and fish. Chemical dispersants, used to break down oil slicks, can create another form of pollution.

There are several major potential sources of oil contamination in the coastal areas of the region: from production and refining to shipping and destruction of pipelines (by corrosion) often used for direct transportation of oil. It has been calculated that, on one day, about 225 tankers move through the waters of the eastern coast of Africa, one of the busiest oil tanker routes in the world. The possibility of an oil spill from one of these huge tankers is the biggest single threat to the marine environment of the coastal southern African region. Spills also occur accidentally during loading or discharging operations in a port, as happened in Dar es Salaam in January 1981, when up to 100 tonnes of crude oil destroyed an area of mangrove forest.

Effects of oil pollution on the marine environment Box 6.2

Oil pollution, whether it is due to a spill or the discharge of crude oil or a refined product, may damage the marine environment in many different ways:

- destruction of organisms through coating and asphyxiation;
- poisoning of organisms;
- destruction through exposure to water-soluble toxic components of oil at some distance in space and time from the accident;
- destruction of the generally more sensitive juvenile forms of organisms;
- destruction of the food sources of higher species;
- incorporation of sub-lethal amounts of oil and oil products into organisms, resulting in reduced resistance to infection and other stresses;
- destruction of food values through the incorporation of oil and oil products into the marine environment;
- incorporation of carcinogens into the marine food chain and human food sources;
- low level effects that may interrupt any of the numerous events necessary for the propagation of marine species and for the survival of those species which stand higher in the marine food chain.

SOURCE: UNEP, "The status of oil pollution and oil pollution control in the West and Central African Region", *UNEP Regional Seas Reports and Studies No. 4*, 1982, pp. 67-68.

In 1992, a Greek oil tanker, *Katina P*, with 66,000 tonnes of fuel oil on board ran aground, spilling crude oil in the territorial waters of Mozambique. This was described as the most serious ecological disaster for Mozambique. The oil spill affected the mangroves in the surroundings of the delta of the

Photo 6.6 APG-D Martin
Bilge-pumping, oil refineries and shipping threaten the marine environment. The eastern coast of Africa is one of the busiest tanker routes in the world.

Incomati river, the beaches of Xefina Grande and Xefina Pequena and the beaches along the Maputo bay, in the form of scum and tar-balls. Dead fish from the bay and dead molluscs and crustaceans were found in the mangroves and on the beaches.[33]

In June 1994, an oil spill off Dassen Island near Cape Town affected an entire colony of 20,000 African penguins. The South Africa Foundation for the Conservation of Coastal Birds (SANCCOB), the Cape Nature Conservation (CNC) and the Department of Correctional Services worked together to save as many birds as possible from this accident described as a disaster affecting the whole marine ecological system.[34]

Luanda bay, in Angola, is polluted with oil discharges from bilge-pumping and other routine discharges.[35] Oil refineries also contribute to pollution. Dar es Salaam and Matola in Mozambique are two of the five biggest refineries in the region. The refineries discharge a considerable amount of oil into their respective harbours, since most of them lack control equipment to clean the waste water discharged into the sea.

WATER WEEDS

An aquatic weed is a plant growing in water where it is not wanted, thus interfering with intended uses of water, for example, human or livestock consumption, irrigation, and preservation of wildlife reserves.[36] Aquatic alien plants have caused problems in southern Africa since the 1950s. They include the Kariba weed, water hyacinth which has threatened to choke Zimbabwe's Lake Chivero since 1952, parrot's feather, water fern, and water lettuce.[37]

Aquatic weeds can be spread through natural means, for example, by elephants or hippos moving from one body of water to another, by birds which eat the seeds, or by the flow of rivers themselves. However, scientific research has shown that one of the major ways aquatic weeds are spread is through the transporting of boats from one area to another. People are, therefore, the main agents for dispersing aquatic weeds.[38]

These weeds can double their mass every four days or so in eutrophic water (water rich in dissolved organic and mineral nutrients). Growth can become so dense that the floating weed-beds become a layer for the establishment of a more terrestrial type of vegetation, eventually supporting grasses, shrubs and even small trees.[39]

By covering and choking vast water areas, the water weeds prevent boating, angling and skiing, disrupt water flow in irrigation channels, and block sluices. They also create ideal conditions for malarial mosquitoes and bilharzia snails to breed, since the vectors anchor onto the snails and they are protected from waves. In addition, the mats of weeds help disperse the snails as they can comfortably float on them.[40] The Kariba weed interferes with normal activities of many lakes, such as lakes Kariba and Chivero in Zimbabwe and Kafubu in Zambia, and in the Eastern Caprivi wetlands. At one stage it covered more than 2,000 sq km of the surface of Lake Kariba with mats more than half-a-metre thick.[41] In Malawi, it has inhibited the ferry-

ing on the Shire of people and goods between Malawi and Mozambique.

This weed exaggerates evaporation of the water, in some instances as high as 30 percent, creates undesirable sediment and debris along river beds, and eventually affects the quality and quantity of water available to the public.[42] The mats of these weeds prevent oxygen and light from penetrating the surface of the water and the decomposition of the weeds themselves together with that of the submerged vegetation, leaves much of the water body anaerobic (without oxygen) and toxic with hydrogen sulphide. In some lakes, many fish species die through the resulting anaerobic conditions, and affecting the fishing industry, a principle means of survival for rural residents.[43]

Countries in southern Africa sharing water bodies are jointly finding ways to control the spread of these weeds and, they can further strengthen this process by conducting regional training programmes, undertaking cross-border weed surveys, prohibiting transportation of plants across borders, harmonising biological control methods and establishing early warning systems on the occurrence of the weeds.[44]

Controlling water weeds Box 6.3

Basically there are two ways of controlling the Kariba weed — eradication or utilisation. Eradication can be done through:

- manual and mechanical means (most inefficient and rarely succeeds);
- chemical control (although cheap and efficient can also kill other non-target plants and animals, and pollutes the water); and
- biological control (reduces the quantity of the weed effectively).

The mechanical means to eradicate the weeds include blocking water in-flows, pumping water from infested lagoons, building fences to divert animal movement, rerouting tourist roads and manually removing weeds by raking and burning.

Since 1985, the Kariba weed is under biological control in Botswana due to the introduction of a weevil that only eats this weed and can only breed on it. It lays its eggs underneath the plant; the larvae then burrow into the plant's stem under the ground, causing the plant to collapse from within.

Other plants are not affected by the weevil, as it can only reproduce upon and gain nutrition from the Kariba weed. Insects are still being bred and released in Botswana and have been exported to South Africa and Namibia, to combat the weed problems there. No records of the Kariba weed are available for Lesotho, Angola, nor Swaziland, and it is not considered a problem in Tanzania.

A different weevil was introduced in Lake Chivero, Zimbabwe, in 1992 and has produced encouraging results in "killing" the water hyacinth (regarded as the world's worst water weed). The weevil control cannot eradicate the water weeds but can reduce their growth, facilitating effective control through mechanical means and/or herbicides.

Another way to control the growth of the weeds is by using them. For example, the water hyacinth can be used to purify water by removing certain effluents. This plant can absorb nutrients from sewage and heavy metals from industrial wastes. However, the practice may lead to its spread to areas where it is unwanted.

SOURCE: CEP Factsheet, "Water Hyacinth"; *Southern African Environmental Issues*, SADC/IUCN/SARDC, Maseru/ Harare, no 11, p. 3.

AGRO-CHEMICALS

In southern Africa, the potential of chemical pollution is high, as conventional agriculture relies heavily on herbicides and pesticides.

Pesticides

Most toxic pesticides are substances and include fungicides, insecticides and molluscicides. Pesticides are used extensively and sometimes indiscriminately in tropical rivers to control organisms such as snails, blackflies and mosquitoes.[45] When pesticides are used in agriculture or for public health, they enter aquatic environments in several ways. In some cases, there is a direct and/or voluntary introduction of substances that attack particular aquatic organisms. In other cases, there is a direct and/or voluntary large-scale aerial spraying. Lastly, pesticides or their degraded products are carried by rainwater and reach the aquatic environment by runoff.[46]

Pesticides such as dichloro-diphenyl-trichloroethane (DDT), endrin, aldrin and toxaphene used in Tanzania reach the Indian Ocean via rivers and from the major towns of Dar es Salaam, Tanga, Lindi and Zanzibar.[47] In Tanzania, pesticides are increasingly used on cotton fields. In 1986, in Zimbabwe close to 175 pesticides were officially registered for cotton alone.[48]

One problem encountered with pesticides is the development of resistant strains of organisms. Another problem is the harm they may cause to species that are beneficial to humanity.[49] Pesticides can cause great changes in the ecosystem: the destruction of one part of the food chain can alter the whole ecosystem. Pesticide contamination can also lead to behavioural changes or even death among fish.[50] The effects of pesticide pollution on aquatic life are now becoming apparent in Mozambique where fish have been found dead in the Limpopo river after aerial spraying with parathion, an organophosphorous insecticide.[51]

In general, pesticides are not biodegradable; they persist for a long time in the environment, are absorbed into living organisms and accumulate along food chains. One of the most dangerous insecticides is DDT due to its high toxicity. Although it has been banned worldwide, is still used legally in some countries, for example, in northern Namibia, for control of the tsetse fly.[52]

To control malaria, a scourge in the low-veld region, the benefits derived from the use of DDT more than outweigh its deleterious effects on human beings. Because of resistance shown by cotton pests to other locally available pesticides, farmers now use dieldrin, a persistent insecticide. Dieldrin is, however, deadly as it can kill fish, birds and small mammals.[53]

Dolphins offshore of KwaZulu/Natal's commercial farming areas are the most contaminated in the region, with such levels of the pesticide DDT that they have trouble producing offspring healthy enough to survive.[54] Contamination of surface waters of the Mlumati river, in Swaziland, is due to aerial spraying aimed at combating severe pesti-

Photo 6.7 & 6.8 SARDC-M Chenje

Pesticides can kill fish, birds and small mammals.

Biofertilisers Box 6.4

Many southern African countries have a growing need for fertilisers, partly due to the expansion of agriculture into some marginal areas. Moreover, the soils of some of the potential areas have lost their fertility over the years, due mainly to continuous cultivation, resulting in the need for more fertilisers to enhance crop-yields.

Soils of the marginal arid and semi-arid lands in southern Africa are generally deficient in nitrogen, and the most common way to raise crop production is through the application of chemical nitrogen fertilisers.

However, most of the small-scale farmers, about 60 per cent of Africa's population, cannot afford them. But biological nitrogen fixation (BNF) might help to solve the problem. *Rhizobium* is one of the most important bacteria that fix nitrogen from the atmosphere into ammonia, a form of nitrogen which can easily be assimilated by plants.

It is estimated that *rhizobium* alone could provide for more than 50 percent of the fertiliser required for crop production in most of the marginal areas of Tanzania and Zimbabwe. Both countries are currently engaged in research on nitrogen fixation, with the aim to enhance soil fertility and increase crop production; increase residual nitrogen for some non-leguminous crops; and reduce the pollution of fresh and groundwater resources caused by heavy application of fertilisers.

The potential of BNF to promote sustainable utilisation of marginal lands and increasing crop-yields for small-scale farmers has been recognised by some researchers in southern Africa. At the national level, however, policies on BNF research are generally lacking. The current research efforts on BNF have evolved as a result of individual efforts with limited government support.

SOURCE: "Research on biofertilisers: Kenya, Zimbabwe and Tanzania", *Biotechnology and Development Monitor No 18*, March 1994, pp. 9-10.

lence. Air drift will almost invariably assist in transporting these pesticides which in the case of the extremely toxic parathion can cause the death of many fish species, even if existent at very low concentrations.[55]

Herbicides

Herbicides, as the name suggests are killers of weeds and are therefore, less likely to be toxic to animal life. This is inherent in the mechanisms in which they interfere with the biochemical processes in plants.

Aerial spraying of herbicides to eradicate *cannabis sativa*, commonly known as dagga, is extensively carried out in Swaziland and in KwaZulu/Natal. Due to its non-toxic qualities, the herbicide glyphosate (roundup) is used in this process, without putting aquatic environments at risk.[56] According to the World Health Organisation (WHO) classification, glyphosate is placed in class O, a class exhibiting no acute hazardous effects. Other herbicides, such as 2,4D (dichlorophenoxy acetic acid) are in class II, a class with a tendency towards acute hazardous effects.

Fertilisers

Fertiliser runoff transported to the ocean by rivers increases the supply of nutrients in lagoons and estuaries, causing algae to bloom artificially, die off and decay, using up oxygen needed by fish and other organisms. Surviving species are restricted to the few that can tolerate nutrient-rich and oxygen-poor environments.

The major sources of phosphate pollution in rivers and streams are agricultural and municipal areas. The Mbuluzi river basin profile illustrates the dangerous use of these fertilisers in Swaziland, having taken into consideration the existence of a dam downstream in Mozambique which serves the drinking water needs of Maputo.[57]

About 5,000 sq km of land in South Africa are acidified (soils have more acid and may cause the destruction of some living organisms) as a result of nitrogen fertiliser. Excess nitrogen readily dissolves and moves down to the root zone into groundwater. High levels of nitrates in drinking water can cause miscarriages, and blood poisoning in young children.[58]

In southern Namibia, borehole water with a nitrate content in excess of 200 mg/l is not uncommon. Standards in Namibia stipulate a maximum allowable of 20 mg/l for human consumption and 110 mg/l for cattle. Drinking of water with excess of 200 mg/l has resulted in cattle deaths. There are known cases of *methaemoglobinaemia* (blue babies) recorded.

In South Africa, sewage sludge, a fertiliser which is a health hazard is used mainly by vegetable farmers in the Cape area and in the KwaZulu/Natal province for forage grass and sugar cane production.[59]

HOUSEHOLD POLLUTION SOURCES

Domestic liquid wastes are generally discharged directly into open drains, streams or lagoons. Domestic solid wastes are likewise often dumped in streams, although open incineration and dumping at landfill sites also commonly occur in southern Africa.

Sewage

Sewage is rich in both organic matter and nutrients.[60] The municipal or domestic sewage input is the most common source of contaminants in the coastal zone of southern Africa. Municipal sewage contains domestic wastes: organic matter, nutri-

Mzuzu needs proper sanitation Story 6.1

Blantyre (SARDC) — Residents of Mzuzu in Malawi are concerned about the lack of proper sanitation management in the city. Rubbish and sewage disposal have become serious environmental and health problems.

"Unsanitary conditions in Mzuzu may put the health of its residents at risk," said Tom Chirwa, a city market vendor.

"The city has no sewerage system at all," laments city chief health and cleansing officer, Obed Ching'oma. "The city also has inadequate public toilet facilities, which makes matters worse." Ching'oma said with the growing population, there is need for a well-developed sewerage system since human waste and rubbish could cause acute environmental and health hazards.

"The wastes get exposed at the surface because the toilets can now no longer hold the city's growing population but we try our best to empty them, using our small vacuum tank," Ching'oma said. The city needs more public toilets and a well-planned sewerage system to dispose of human waste and rubbish to avert disaster. Unfortunately, there is no funding for such projects.

A health official at the regional health office in Mzuzu said they feared an outbreak of water-borne diseases such as cholera and dysentery because some human waste and sewage were flowing into rivers. Water is becoming unsafe for human use. Ching'oma said: "The major worry is that scavenging, groundwater and river pollution is becoming rampant, threatening human health."

There are plans to put up additional toilets at the bus terminus and city centre market to improve the drainage system.

— **Julius Kaliya** in Blantyre, for SARDC, May 1995

ents, micro-organisms (bacteria, viruses) and parasitic worms. Oil and metals may also be present. Groundwater pollution in Botswana is caused by sewage and bacteria, usually via leakage from pit-latrines and cattle concentrations near boreholes.[61]

Marine pollution caused by domestic sewage discharged directly into the ocean is a problem in coastal areas throughout the region. It is associated with all major cities within the coastal area. Untreated sewage is likely to have been the source of the eggs of the bilharzia-causing flatworm which were recovered from the droppings of seagulls, at the mouth of Mbokodweni river in Durban.[62] The eggs are passed out by infected people in stools or urine and return to water where they develop in the water snail. The absence of proper sewage systems and the lack of any other treatment facilities lead to acute health problems in a few countries in the region, such as the cholera epidemic in Mozambique in the mid-1980s.[63] In recent studies in Maputo Bay, six out of 13 sampling sites indicated strong contamination by excremental coliforms (bacteria). Some of these areas were prohibited to swimmers. Nevertheless, due to the absence of education and supervision, the area has still been visited by hundreds of women who collect mussels during low tide.[64]

Water reclamation: a renewable source Story 6.2

Windhoek (SARDC) — The Namibian capital is one of the southern African cities far advanced in recycling water to augment inadequate water supplies exacerbated by a rapid population growth in the city. Windhoek's population has been growing steadily since independence in 1990 and now stands at about 564,000 people, representing 12 percent of the Namibian population of 4.7 million people.

The growth in the city's population has increased water use by about seven percent annually. The pressure on the existing water resources is further worsened by periodic droughts, reducing surface water sources. It is estimated that if the current trend continues, the city will have a critical water shortage before the year 2000.

With most of its water sources fully developed and nearing the limit of potential yield, the Goreangab reclamation plant now contributes between 15-20 percent of Windhoek's total bulk water requirements. "In the foreseeable future, the only practical and economical option to augment the present water sources, lies in further direct or indirect reclamation of water," said a Windhoek municipality official.

Although this water is regarded by some communities as "water from the toilet", Windhoek has since 1969 been using an advanced full-scale, multiple-unit, processing system to recycle water. Similar water-recycling processes are running in Harare and Johannesburg. The direct reclamation of potable water from treated domestic sewerage effluent is internationally recognised as a milestone for technology and expertise in the water industry.

Presently, about 36 percent of the average water consumption of Windhoek reaches the waste-treatment plant, and this percentage could increase once differentiated tariffs and limited water restrictions are introduced. The reclamation of purified sewerage effluent remains an assured water source even under severe drought conditions.

"The addition of reclaimed water will delay water shortages until the year 1998, after which all present sources will be exploited," says the official.

— **Mocks Shivute** in Windhoek, for SARDC, May 1995

Recycling: A good way of waste disposal Box 6.5

Throughout the region, it has been reported that industries, seeking to keep their costs down, dump wastes in vacant lots and beside roadways. Local councils often lack transport and equipment to collect and treat abandoned waste.

Nature deals with a normal amount of waste, but the great increase in population, especially in the southern African cities has overtaken nature's capacity to neutralise waste.

In the era of recycle and re-use, knots (rejected digested chips) from Usuthu Pulp Company (UPCo) in Swaziland, for example, which were in the past dumped as rubbish next to a perennially flowing stream are now a valuable resource and are being exported for re-use in the Piet Retief Paper Mill in South Africa.

The dumped knots were a nightmare for both UPCo managers and the Water Pollution Control Unit in the Water Resources Branch. More than 10 years after dumping of the knots was abandoned, the dumps are still active, producing leachate that seeps into the nearby Lamyiseni stream, a tributary to the Usuthu river.

SOURCE: Mavimbela, S., "Pollution and its management", for SARDC, 1995, p. 8.

Major inland cities in the region do treat sewage before discharging it into the aquatic environment. The effluent water is then used to irrigate agricultural land, although it is still contaminated with nutrients and toxic substances.[65] Some southern African cities have already recognised the value of recycling waste. Namibia recycles about 15 percent of its waste water for domestic consumption.[66] Bacteria are added to eat up the nutrients, and algae, filtering and chlorine can improve the quality of the water even more.[67] Although an adequate process in theory, most of the region's sewage-treatment systems are overloaded. For example, the sewage treatment system of Chitungwiza, an urban area just outside Harare, is under strain, handling about four times more sewage than for which it was originally designed.[68]

Dumping

Dumping of untreated sewage and household refuse on beaches and in other water bodies is probably one of the most serious pollution problems in some parts of southern Africa. The standard of rubbish disposal throughout the region is poor, due to the high disposal costs.[69] Dump-sites are not usually chosen with a view to protecting water supplies. Typical dumps produce thousands of litres of leachate, a sort of poisonous "tea" brewed when rubbish sits in rainwater. Pollutants dissolve and run into underground and surface water supplies. Another problem is that dangerous wastes are not always dumped in the "official" waste dump.

In many southern African urban areas, especially in Angola and Mozambique, people usually dump their wastes anywhere (by the beach, in front of the houses, on vacant land, on the sides of the roads), and this is due not only to inadequate waste-disposal services but also to lack of civic education.

The waste rock and soil dug up during ore extraction, called overburden, is piled in dumps which take up good land and pollute soil and water. Surface waters draining the dumps of waste rock carry pollutants to agricultural land and drinking-water supplies.[70]

Dumping operations at sea off South Africa have been relatively limited since the country's accession to the "London Dumping Convention" in 1978. They are now confined largely to the disposal of dredge spoils from harbour maintenance, derelict ships and out-of-date ammunition. With the exception of dredge spoil, dumping is restrict-

ed to specific, deep-water sites a considerable distance offshore.

Plastics and nylon

Plastic packaging, ropes and nets cause entanglement and, generally, slow death of marine mammals, birds and turtles. Birds often use such material in nest construction, laying both themselves and their chicks open to strangulation. Smaller pieces of plastic, particularly the pellets used as the feed stock in the industry, are commonly ingested by these same species. A recent study of albatross chicks, for example, showed that 90 per cent of them had plastic in their gullets. Such ingestion affects the bird's appetite by filling the stomach; it can lead to intestinal blockage; and toxic components of the plastic can be absorbed. It is estimated that some 100,000 marine mammals die every year worldwide as a result of plastic pollution.

In southern Africa's estuaries, pollution has potentially serious ecological implications since estuaries are important as breeding and nursery grounds for a variety of marine species, as well as being important habitats for large numbers of both resident and migratory birds. According to a 1991 report to the South African President's Council, more than 3,000 pieces of plastic are found in every square kilometre of coastal water, most of it dropped from fishing and pleasure boats.[71]

Plastics, nylon and other discards of our modern society are deteriorating the condition of beaches, affecting the quality of seafood products and the tourism industry.

Photo 6.9 PTC, MAPUTO-B Mucliate

Discards of modern society, such as plastics and nylon, often dropped from fishing and pleasure boats, are fouling the beaches and threatening human health.

SEDIMENTATION

Sedimentation is the process of deposition of particles transported by flowing water. Some sediments originate from the topsoil lost through bad agricultural practices. These sediments may carry adsorbed pesticides, heavy metals, nutrients or other toxic organisms into the rivers or lakes. Many of the rivers in southern Africa carry high loads of sediment, due partly to poor land-management practices. About 120 million tonnes of silt go into South African rivers annually.

Lakes usually serve as sedimentation basins for the suspended sediments of the rivers. This can result in a gradual loss of the lake's storage capacity. An example is Lake Arthur in the Eastern Cape which had its storage capacity reduced to 20 percent by sedimentation. The Orange river, each year carries to the sea an enormous sediment load eroded from the mountains and foothills of Lesotho, the rich farmlands of the eastern Free State, the poorer country of the central and Northern Cape, and the Kgalagadi sand-dunes.[72]

In Malawi, increasing silt loads have caused rivers to meander more than usual and to flood their banks more often, washing away riverbank crops.

The impacts of sediment releases are varied and numerous:

- sediments in suspension affect primary producers in the plankton and, by reducing light penetration to the bottom, also cause alterations in seagrass beds, corals and other benthic communities (living at the bottom of the lake/sea) dependent on photosynthesis;
- high concentrations of suspended sediment in the water also clog the gills of organisms filter-feeding from the water;
- after settlement, there is direct physical damage by smothering, but longer term effects can follow from changes in the particle size of the substrate (surface on which an organism lives), with consequences for the structure of the benthic fauna;
- since many contaminants adhere to particles, increased sediment input can bring increased loads of toxic chemicals.

Sediments can be seen as pollutants and in some parts of the world they constitute a major threat to coastal organisms. Pollution by sediment, for instance, caused by dredging of harbours or from rivers is a threat to the quality of coral reefs on the Mozambican coast.[73] High rates of sedimentation were also found in Lake Tanganyika, due to the clearance of the nearby forest by massive, uncontrolled fires.[74] Sediment control function is an important element in southern Africa where removal of vegetation in the watershed area is becoming a serious problem.

SALINISATION

Salinisation is the process, usually exacerbated by human activity, whereby soils and water become saltier until eventually they cannot be used for agricultural purposes. Salinisation can be due to water evaporation, wind-born sea spray, "fossilised" seawater or seasalt within rocks, easily degraded rocks with naturally high mineral levels, mining activities and long-term irrigation, particularly in dry areas and/or in areas where rocks have high mineral levels.[75]

Salt accumulation can be worsened in specific locations when waters are added to the soil through agricultural practices or where natural vegetation is cleared. It appears to be a problem particularly found in conjunction with irrigated lands. There are four reasons why irrigation causes salinisation:

- water leakage from supply canals;
- over-application of water;
- poor drainage; and
- insufficient water application to leach salts away.[76]

Pollution and human health Box 6.6

Many atmospheric pollutants, notably the oxides of nitrogen and sulphur, carbon monoxide and the hydrocarbons, are a danger to people who suffer respiratory and cardio-vascular diseases.

Industrial workers and those in the mining industry are often exposed to noxious gases and poisonous chemicals. Coalmines producing cadmium and lead can cause mental defects in new-born babies. Cadmium, a heavy metal of concern, can also cause anaemia and a malfunctioning liver.

Wastes from food processing industry — meat, dairy products, sugar refineries — are troublesome because of their content of rotting substances, which can involve the danger of infectious diseases. This type of industrial pollution is well documented in Botswana, where the Botswana Meat Corporation located in Lobatse, was a source of groundwater pollution.

In agriculture, the spraying of 2,4D (herbicide) in Natal province, South Africa, caused asthma and chest ailments to people living downwind of sugar-cane estates. High levels of nitrates (fertilisers) in drinking water can cause miscarriages and blood poisoning in young children.

SOURCE: SADC/IUCN/SARDC, *State of the Environment in Southern Africa*, Harare/Maseru, 1994.

The problem is often viewed as most acute in, but not confined to, drylands. In such regions, there is a natural tendency for the at- or near-surface accumulation of soluble salts due to high evaporation rates. The increase in salt content of the water is associated with excessive irrigation under arid conditions. Even though irrigation water may contain only very small quantities of dissolved salts, evaporation occurs when this water is sprayed or flooded onto the land and returned via groundwater or surface flow to the river.[77]

The ecological effects are poorly understood, although severe salinisation will undoubtedly result in a loss of most of the species of plants and animals normally associated with a river and hence eventually reduce its self-cleaning abilities.

For example, the salt stream in the Namib Desert is fed by a fresh groundwater spring but the extremely high rate of evaporation (approaching four metres per year) sucks moisture from the stream, leaving ever-saltier water behind, with deposits of common salt and gypsum. Salinisation is also affecting some rivers in Mozambique, such as Matola, Incomati and Púngoe.[78]

EROSION AND SILTATION

Erosion is prevalent in some parts of southern Africa where rains and consequently rivers can be very violent. Non-existent or sparse vegetation and the desiccation of soils during the dry seasons can make the soils particularly vulnerable to the water action. Although the dominant factors influencing the severity of erosion are rainfall, topography and vegetation cover, soil properties are also important.

Siltation, the consequence of erosion caused by a number of factors, has been threatening many wetlands in southern Africa. It refers to the deposition of particles of the river load. It is a normal process along a river, but the rate of deposition of sediment varies with the size of sediments and speed of flow. Large sediments are deposited first, while smaller particles are suspended in water and deposited further downstream.[79]

However, siltation over a short time is a serious problem:

- it causes water pollution and reduces primary production as water becomes turbid;
- too much silt can bury the entire wetland system;
- water quality decreases, making it less suitable for consumption; and
- siltation is a major threat as it lessens the life span of dams and irrigation infrastructures. Siltation can cut the useful life of a dam by one quarter, with some major dams silting up in less than 20 years. Siltation often reduces the potential of dams to generate hydro-electric power.[80]

Siltation arguably affects most African rivers. Major rivers that are threatened with siltation include the Save in Zimbabwe and Luangwa in Zambia.[81] Siltation of estuaries on the east coast of South Africa has greatly reduced the estuarine environment. South African rivers have been estimated to yield 233 million tonnes of silt per year.[82]

MANAGEMENT, POLICIES AND STRATEGIES

The control of water pollution is a very important aspect of water management and has important implications for human health, economic activity and development in southern Africa. Pollution control is of specific significance as access to clean water is essential for human life and thus is central to rights of access to clean water.

Access to water is of little value unless it is access to clean water. Polluted water imposes high costs not only on society but also on the environment. Access to clean water is thus an essential aspect of a right of access.[85]

Pollution legislation

Regulations to control pollution include specifying standards and issuing permits and licences, and land-use control. Under the regulatory system, manufacturers and individuals who do not meet the regulations are fined or penalised. To achieve

Zambia gets tough with water polluters Story 6.3

Lusaka (SARDC) - The Environmental Council of Zambia (ECZ) has set regulations to help reduce water pollution in Zambia. The ECZ has set up regulations on drawing and discharging water and waste water into the natural environment. Although these regulations are already in place, enforcement in most cases still remains "a pipe dream".

Some of Zambia's rivers are already polluted. The Kafue, an extremely important river to the Zambian economy, has been a major victim of pollution from industrial operations. In the Copperbelt, where the Kafue has its source, about 26 million tonnes of ore are mined annually, producing about 500,000 tonnes of copper.

A water-quality study conducted by the National Council for Scientific Research (NCSR) between 1987-1990 revealed that the river received mine sewage and industrial effluents seriously affecting its water quality.

Israel Zandonda, an inspector with the ECZ's water pollution control unit, says, "Several studies have been conducted by scientific and technological experts in order to determine the nature, load, control and abatement of pollution on the river.

"Unfortunately, the lack of an established system in the enforcement of pollution control policies has contributed to perpetual negligence, and indiscriminate discharge of industrial effluents into the aquatic environment."

A water officer can call upon the polluter to take adequate measures to prevent the pollution or fouling within a specified period. On good cause being shown, the board may extend the time. Failing to take adequate steps within the specified period means additional penalty.

The water pollution control (effluent and waste water) regulations are a statutory instrument of the Environmental Pollution Control Act.

The regulations allow one to obtain a licence to discharge effluent, keep records and samples of effluent and analysis, and the registration of licence and enforcement notices. Licence to discharge effluent or to withdraw water for treatment of effluent costs about US$40.

Water quality standards set by the regulations lists 59 items, including limits to physical, bacteriological and chemical content and specify conditions for metal, organic and radioactive materials.

Studies conducted by Nick Money, former Director of the Geological Survey of Zambia, showed that groundwater in Lusaka is polluted.

About 40 percent of the water supply of Lusaka is from groundwater sources. About 900,000 of Lusaka's 1.2 million inhabitants live in areas with no sewer and are serviced either by septic tanks or pit latrines, with effluent finally percolating into water sources.

Other sources of pollution include toxic substances, dumpsites, herbicides, fungicides, insecticides and several industries that discharge effluent without following regulations.

— **Mildred Mpundu & Katongo Chisupa,** in Lusaka, for SARDC, July 1995

this, the southern African countries have developed pollution control legislation while others have amended theirs to cope with the current state of affairs.

Polluter Pays Principle (PPP)

The PPP is a commonly applied policy whereby a specific industry is responsible for treating its effluent. The cost of treating effluents to comply with effluent standards is, however, not the only cost implication to industry. As industry often requires water of adequate quality and quantity, the questions of availability and quality of source waters together with the volume and nature of effluents produced have considerable bearing on the siting of industries.

The PPP seeks to rectify this by making polluters "internalise" the costs of use or degradation of environmental resources. The aim is to integrate use of the environment (including its waste assimilation capacity) into the economic sphere through the use of price signals and use of economic instruments such as pollution charges and permits.[84]

In a broad sense, Swaziland does have a PPP, but this has never been practised. The Water Act of 1967 provides for the issuing of exemption licences for polluting companies to pay compensation and this can be viewed as a PPP. However, Usuthu Pulp Company, Swazi Paper Mills and National Textile Corporation have never been compelled to pay this compensation.[85] Lesotho applies the PPP but the amount paid as compensation is a pittance. The PPP will be included in a new proposed Code of Ethics in Mozambique. The code may be a statement of policy or may be introduced as a legislative plan.[86]

Despite many countries in southern Africa having pollution control legislation, many have not been successful at enforcing it. This is caused by low penalties, lack of technological capacity as well as the practical problems of administering environmental regulations. In Zimbabwe, for example, while quality standards provided for in the Water Act (Effluent and Waste Water Standards) Regulations deal with individual acts of pollution, they fail to take account of the cumulative impact of this pollution. For standards to be effective, they must be implemented and monitored, alternatively some mechanism must be created to ensure compliance. Given the lack of institutional capacity both in terms of appropriate skills levels and human resources, the standards are generally not adequately enforced.[87]

Swaziland, Botswana and South Africa have used their legislation — designating protection zones which

Water pollution legislation Table 6.2

Country	Water Legislation
Angola	?
Botswana	Water Act of 1968*
Lesotho	Water Resources Act No. 22 of 1978
Malawi	Water Resources Act of 1978
Mozambique	Water Law Act No. 16 of 1991**
Namibia	Water Act No. 54 of 1956
South Africa	Water Act of 1956
Swaziland	Water Act of 1967***
Tanzania	Water Utilisation Act of 1981
Zambia	Environmental Protection and Pollution Control Act of 1990
Zimbabwe	Water Act of 1977****

* To control water pollution, Botswana also has the Water Works Act, the Public Health Act and the Atmospheric Pollution (prevention) Act.

** Mozambique's Water Act does not include effective regulation of water and air pollution or the control of toxic substances and waste. The new environmental plan and the Water Act under review at the moment will consider some laws on water (fresh and marine) pollution.

*** The Public Health Act of 1964, currently undergoing revision in Swaziland, includes anti-dumping legislation.

**** In Zimbabwe, there is also the Hazardous Substances Act of 1972.

include watersheds, major aquifers and dams — with a good measure of success.[88] Economic instruments used in environment include user charges, emission or pollution charges, taxes, subsidies, tradable permits and incentives or pricing policies that will correct distortion. Charges are aimed at encouraging polluters to avoid pollution or encourage companies to develop pollution control equipment.[89]

Various acts make provision for issuing exemption licences. These licences authorise certain industries under certain conditions to discharge effluents not complying to national standards if it can be proved to be of benefit to society.[90] Provisions allowing water departments to issue exemptions are liberally used. These departments seem to encourage polluters to bring their activities in line with the law by applying for permits rather than prosecuting them. There are few prosecutions as the focus of the monitoring institution tends to be on persuasion. In Zimbabwe, for example, there is no report on the Ministry of Lands and Water Resources ever withdrawing an exemption permit, either on the grounds that given new technology the permit is no longer appropriate or because it has not been adequately complied with.[91]

Legislation in some countries fails to establish incentives for compliance with anti-pollution standards. There is also poor use of pre-emptive and remedial measures. Some Water Acts tend to focus primarily on punishment for wrongdoing.

In Namibia, the problems experienced with effective law enforcement, have been mainly due to insufficient penalties for the transgression of legislation, while legal procedures have also delayed effective action against the perpetrators.[92] Cooperation with potential polluters to combat pollution is viewed as a much better approach than enforcement and policing.[93]

Pollution prevention and control to be successful requires that people be involved through awareness-building exercises. In this regard, a number of countries have revised curricula in schools and conservation clubs have been formed at community level. One such club is the Chongololo Club of the Wildlife Conservation Society of Zambia.[94]

National strategies to combat pollution

A number of southern African countries have developed National Environmental Action Plans (NEAPS) aimed at improving environmental management, through regulatory and educational instruments. In Swaziland, some watersheds, especially the sensitive catchment areas, are protected from industrial invasion to maintain a sustainable use of water resources.

In Botswana, just as Swaziland, the Department of Water Affairs has designated "protection zones" which include major aquifers and dams, where development is discouraged.[95] Also in Botswana there is an ongoing study on "waste management/protection of water resources", which seeks to identify and plan for waste disposal sites.[96] The objective is to be achieved through a legal and institutional framework for waste disposal and waste management at national level. This study will also come up with vulnerability maps which will act as tools for prevention of groundwater pollution.

In Zambia, some of the strategies to combat pollution include: registration of dangerous substances, control of transportation and handling of hazardous materials, and adoption of the PPP by ensuring industry devotes a percentage of their revenue toward environmental protection.[97] In Mozambique, with the creation of the Ministry for Environmental Coordination, more studies will be carried out on pollution.[98]

Mechanisms to combat pollution

The first step that can help protect the people and environment of southern Africa against pollution is education. Managers, workers and the public need more information about the hazards they routinely face.

A second step involves more research into particular groups of people and particular environments more likely to be subject to pollution hazards, such as areas downstream and downwind from industries and mines.[99]

A project to develop a National Policy on IPC for South Africa was initiated in 1992 by the Department of Environmental Affairs and Tourism in collaboration with the Departments of Water Affairs and Forestry, of Health and of Agriculture. The project aims at developing an integrated and well-coordinated system of pollution-control in South Africa to achieve sustainable social and economic development while affording a necessary protection to air, water and land resources.[100]

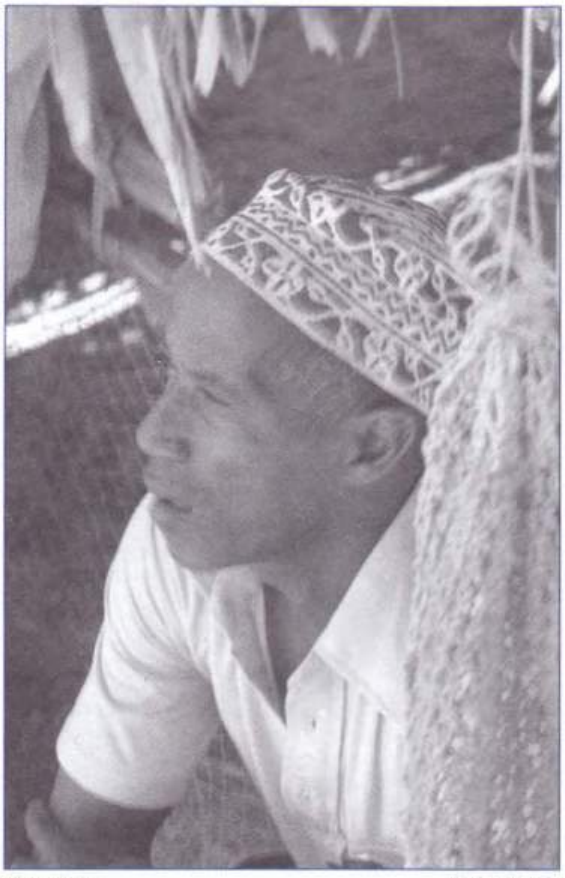

Photo 6.10 APG-D Martin
A first step is to provide information for education, and a second step is to identify vulnerable groups, such as this fisher/diver in Zanzibar.

Research and monitoring

In Swaziland, the Chemistry Department of the University of Swaziland has been involved in water-pollution research, collaboration with UPCo, for example, in researching into pollutants such as phenols (carbolic acids) in the effluent discharging into Usuthu river.[101]

In Zimbabwe, the government has not been able to carry out satisfactory monitoring due to human resources and technological constraints. Monitoring has depended on willing companies where the various control units only respond on demand or due to pressure from other resource users.[102] Research on water pollution has been done by the Chemistry Department of the University of Zimbabwe.[103]

The National Council for Scientific Research (NCSR) of Zambia is currently spearheading research into such fields as pollution monitoring and control methods, effects of pesticides and other agricultural chemicals on the environment.[104] In South Africa, the Department of Environment Affairs, the Department of Water Affairs, and the Institute of Waste Management are among several bodies involved in water pollution research and monitoring.[105] In Mozambique, the Ministry of Environmental Coordination, the Ministry of Health and the National Directorate of Water are working together to start a new era on pollution research and monitoring.[106]

Although there is a research division in the Namibian Department of Water Affairs, only applied water research is done in areas where there is a need for quick answers. The cost of basic research is prohibitively high, but effluent disposal and possible water pollution is well under control through the permit system, monitoring and innovative solutions in cases where special conditions exist.[107]

Coral sand exploitation threatens environment Box 6.7

The exploitation of coral sand to support Mauritius' construction industry is causing environmental problems in the Indian Ocean island. Accelerated economic growth in the 1980s, which was accompanied by a construction boom in offices, hotels and houses, has seen the extraction of coral sand rise from about 320,000 tonnes a year in the late 1980s to about 800,000 tonnes today.

More than 35 major tourist hotels now ring the island, together with multiple-storey office blocks in the capital, Port Louis. Such developments have put enormous pressure on the supply of construction aggregates, both crushed basalt and natural coral sand. Inland coral sand deposits are virtually exhausted, resulting in an increased amount of coral sand being extracted from the lagoons inside the reefs.

This has led to environmental problems such as beach erosion; increased seawater turbidity; disruption of the food chain in the lagoons; destruction of marine habitat, flora and fauna near dredging sites; loss in production of fish resources and damage to spawning grounds. Coral sand extraction is also killing coral populations due to clogging of pores and causing disposal problems of dredged sand. The coral sand resource cannot be managed in any sustainable way, as the replacement time for a few years' extraction must be measured in centuries.

Insofar as lagoonal mining causes beach erosion, continued extraction of coral sand will have a negative impact on the tourism industry. This, along with pollution of lagoons from hotel effluent, suggest the need to mediate conflicting uses within a systematic framework for management of the coastal zone. Innovations in Development for Environmental Action (IDEA), which is part of the Commonwealth Secretariat, set up a project to encourage the use of replacement materials for coral sand in construction, as a critical element in the sustainable management of coastal resources in Mauritius.

Although replacement construction materials are technically and economically feasible, there were no appropriate institutional arrangements in the country for mediating the need for replacement construction material with the need for economic growth and development.

The IDEA team has embarked on a public awareness programme and a systematic assessment of the organisational and economic constraints on outright banning of coral sand extraction. It has also embarked on a programme to encourage the construction and aggregate industries to make use of replacements on a voluntary basis, and is assisting in the re-training of builders to adjust to using the new materials. Some of the achievements of these programmes are, for example, the replacement of coral sand by rock sand in the preparation of pre-mixed concrete, by United Basalts, a stone-crushing company; and the use of rock dust instead of coral sand to fill trenches after underground operations, by Mauritius Telecom. Although the campaigns against exploitation of coral sand have been successful, there is still no legislation concerning coral sand exploitation. The committee on "Removal of coral sand from sea bed" will only submit its recommendations by October 1996.

It is hoped that the recommendations will be an important step to preserve the environment of SADC's 12th member state, which is rich in biodiversity and has a tremendous tourism potential.

SOURCES: Jhurry, S., personal communication, Ministry of the Environment and Quality of Life, Port Louis, July,1996.
Carley, M. and Christie, I., *Managing Sustainable Development*, Earthscan, London, 1992, pp. 229-230.

Linkages to other chapters Box 6.8

1 PEOPLE

Water pollution exacerbates the problems of access to clean potable water by millions of people in southern Africa, particularly those in rural areas.

2 CLIMATE

Floods can increase water pollution from overflowing waste disposal sites, affecting people's health in the region. The dumping of sewage and wastes from mines and other industries affects the amount of clean water available to the environment.

3 ENVIRONMENT

Water polluted by oil, sewage, chemicals and silt negatively impact habitats, posing a serious risk to the survival of various species. This can lead to a reduction of biodiversity in the region.

4 MANAGEMENT

Water pollution in southern African countries, although not a major concern at present, is largely due to poor management and enforcement of pollution legislation.

5 AQUATIC RESOURCES

Policies for the protection and management of living aquatic resources should be seen as a priority, since some areas of southern Africa suffer with pollutants discharged into the water bodies. This has an effect on the socio-economically important resources, putting at risk some of the region's export products.

7 COOPERATION

The southern African countries must put their efforts together to develop a comprehensive set of effective regional policies to discourage water pollution.

8 TRENDS

Research and awareness of water pollution is increasing in most parts of the region, among all sectors of society. This will help to improve the state of the environment, and combat pollution.

NOTES
CHAPTER 6

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7 Regional Initiatives and COOPERATION

About 70 percent of the land area of the Southern African Development Community (SADC) is occupied by watercourse systems that are shared by two or more member states. The waters of these systems, although renewable, are increasingly causing competition among the riparian countries through which the river(s) flow. Since these international watercourse systems are common resources that are shared by riparian countries, their development and utilisation should be governed by the principles of international law where each of these states has the right to an equitable and reasonable share in the conservation, protection, management, allocation and utilisation of these international water resources. This is in accordance with the Helsinki and other international conventions, and the Draft Articles on International Law of Non-Navigational Watercourses.

Such conventions promote the establishment of regional cooperation among the riparian countries to facilitate the applications and the implementation of the rules on shared watercourse systems. The protection and management of international systems in southern Africa require good coordination and cooperation among the riparian countries and their stakeholder communities.

Even though cooperation within the SADC region dates back to the colonial period with the establishment of organisations such as the Southern African Regional Commission for the Conservation and Utilisation of the Soil (SARCCUS) in 1948; and construction of large dams such as the Kariba between 1955-1959 and the Cahora Bassa between 1970-1974; countries are reinforcing such cooperation through various arrangements and projects. These include commissions, the Protocol on Shared Watercourse Systems and massive projects such as the Lesotho Highlands Water Project between Lesotho and South Africa.

Supplying Zambia and Zimbabwe with some of their electricity needs, spawning a massive inland kapenta fishing industry between the two countries, and generating an ever-growing tourism industry, Lake Kariba — which covers 5,000 square kilometres (sq km) of land and is 250 km long and 40 km at its widest point[1] — is arguably one of the greatest symbols of regional initiatives and cooperation in the region.

REGIONAL COOPERATION ACTIVITIES

In southern Africa, environmental awareness has been achieved at great cost. The socio-economic crises which ravaged the African continent from the early 1970s into the 1980s, particularly sharpened debate on environmental issues.

Over the years, most environmental initiatives were taken by individual countries or groups of countries affected by a common problem. This has since evolved, gaining regional perspective and attention with SADC countries strengthening cooperation in various areas in water management and resource utilisation.

Article 5 of the Treaty establishing SADC says one of the Community's major objectives is to "achieve sustainable utilisation of natural resources and effective protection of the environment".

Apart from the Treaty itself, SADC members have established a number of sectors involved in differ-

ent water management areas. Activities not only involve direct water management but also the management of aquatic resources, both terrestrial and marine.

The SADC sectors involved in water issues include:

- Environment and Land Management Sector (ELMS), which is based in Maseru, Lesotho;
- Drought Monitoring Centre in Harare, Zimbabwe;
- Food Security, in Harare;
- Energy, in Luanda, Angola;
- Inland Fisheries, Forestry and Wildlife, Lilongwe, Malawi;
- Marine Fisheries, Windhoek, Namibia; and
- Transport and Communications, Maputo, Mozambique.

Drought Monitoring Centre Box 7.1

Established in January 1991, the Drought Monitoring Centre seeks to contribute to the reduction of negative impacts of drought and other adverse weather conditions upon agricultural production in southern Africa. The centre also facilitates the rational use, conservation and protection of natural resources through improved application of meteorological and hydrometeorlogical data and products.

The DMC detects and monitors the intensity, geographical extent, duration and impact upon agricultural production of drought. It provides weather and climatic forecasts through 10-daily reports (Ten Day Drought Watch for Southern Africa) and monthly bulletins.

The centre contributes to the improvement of regional food security by reaching out to decision-makers, planners and research institutions with relevant climate and weather data from which to develop necessary strategies to combat adverse weather (drought, cyclones, floods) and its effects including reduced food production.

The DMC collaborates with both National and Regional Early Warning Systems, national meteorological services and other relevant institutions in the region, to reach out to the beneficiaries of their services, among them farmers, policy makers and research institutions.

The centre also evaluates and monitors climate change with a view to contributing toward the mitigation of environmental degradation by producing climate and agroclimatological atlases of the sub-region showing climate classification zones, drought characteristics, flood-prone areas, tropical cyclone activities, etc.

The regional DMC, based in Harare, has devised regional seasonal rainfall forecasting schemes that are largely driven by the *El Nino* Southern Oscillation (ENSO) phenomenon, the Indian and Atlantic SST, and regional pressure and wind anomaly fields. An operational regional ENSO signal interpretation scheme that has been successful in predicting the 1994-95 drought and the nature of the 1995-96 rainy season in southern Africa has been developed.

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ELMS was responsible for water management issues until August 1996 when SADC heads of state and government created a separate SADC Water sector at their summit in Maseru. In addition, they also signed three landmark protocols, all of which have a bearing on water management in the SADC region. These include the trade; energy; and transport, communications and meteorology.

Other regional activities being undertaken include collaboration in projects that repair and protect the land, catchment rehabilitation, water and biology of river basins. Examples include pollution and protection of biodiversity projects for Lakes Tanganyika and Malawi.

Lake Tanganyika

The biodiversity of Lake Tanganyika, Africa's largest water reservoir, is believed to be greater than in any other lake in the world. More than 1,300 species of fish, invertebrates and plants have been recorded. About 500 of them are endemic to the lake, 41 percent of which is in Tanzania and six percent in Zambia.[2] The rest is shared by Zaire, 45 percent, and Burundi, eight percent, both of which are not members of SADC. The biodiversity is threatened by pollution caused by sedimentation, from industrial and urban sources.

The Lake Tanganyika project, funded under the Global Environment Facility (GEF), seeks to address the lake's environmental problems, which have seen a decline in fish catches, by:

- developing a coordinated administrative mechanism for the environmental management of the lake and its basin;
- obtaining data on the lake and watershed by investigating biodiversity in the lake and introducing measures to conserve it; and
- strengthening national capacity in research, monitoring, and management of biodiversity and pollution control.

Progress in project implementation has, however, been hampered by civil unrest in Burundi.

Photo 7.1 APG-D Martin

Lake Kariba, between Zambia and Zimbabwe, remains a great symbol of regional cooperation.

Lake Malawi

The Lake Malawi project, being implemented by the SADC Inland Fisheries, Forestry, and Wildlife Sector (SADC-IFFW) and the Malawi Fisheries Department, is designed to catalogue the extent of biodiversity. It also seeks to address concerns over pollution caused by rapid human population growth along its banks. Activities under the project include:

- strengthening existing water quality monitoring efforts;
- surveying the fish species;
- preparing the lake's biodiversity map; and
- formulating a management plan.[3]

Catchment protection and rehabilitation

A number of SADC ELMS programmes — including erosion hazard-mapping of areas in Angola,

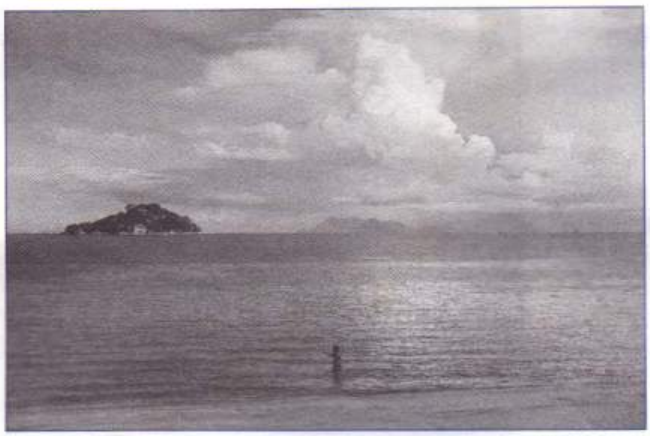

Photo 7.2 APG-D Martin
Regional activities include cataloguing the extent of biodiversity in Lakes Tanganyika and Malawi (above).

Botswana, Mozambique, Tanzania and Zambia — have already been undertaken. Similar projects are planned and include the Watershed Management Pilot Project in Lesotho, which will involve local people in conservation-based, land-use practices. The five-year, US$2.6 million project involves acquiring an accurate knowledge of the physical resource base, a thorough understanding of the people and their needs, farming systems, and problems if the people are to play a meaningful role in reversing environmental degradation.

The problems of sedimentation and its impact on water resources and river catchments have been highlighted in SADC countries such as Malawi, Tanzania and Zimbabwe. A recent water sector study[4] says that a pilot catchment rehabilitation and protection project could be implemented in one SADC country with a view of expanding it to other countries. For example, a project managed by the Association of Zimbabwe Traditional Environment Conservation Trust (AZTREC) in Zimbabwe could provide some useful lessons in such an exercise. AZTREC, a non-governmental organisation based in Masvingo, is working with communities in the southeastern parts of the country to rehabilitate river catchment area, springs, vleis as well as dams, deep wells and boreholes. With the guidance of chiefs and *svikiros* (spirit mediums), community groups plant water-conserving indigenous tree and grass species around water sources in the area. About 1,000 hectares are being rehabilitated.[5]

AZTREC is also involved in the Zimuto-Mushagashi-Save-river catchment pilot project whose objective is to serve as a model of how the entire Save river catchment, which has been heavily silted, could be rehabilitated. The project is coordinated by the World Conservation Union Regional Office for Southern Africa (IUCN-ROSA) and funded by the Netherlands government.[6]

The objectives of a region-wide catchment rehabilitation and protection project would be to:

- investigate root causes of catchment degradation;
- plan and implement rehabilitation projects;
- reduce erosion and sedimentation rates, and flood flows; and
- improve water quality.

Zambezi basin wetlands conservation project

While many of the regional projects are spearheaded by SADC sectors and other inter-governmental organisations, the Zambezi basin wetlands conservation and resource utilisation project is perhaps the best example of regional cooperation at another level. Coordinated by IUCN-ROSA, the goal of the project is to conserve the wetlands ecosystems of the Zambezi river basin while facilitating their sustainable use.

Its major objectives are to:

- articulate the true value and importance of the functions, products and attributes of wetland ecosystems at the local, national and regional levels;
- effectively communicate the true value of wetlands to the region's people, including key decision-makers;

- alleviate poverty in the local wetland communities and thereby assist these communities to participate fully in the conservation of the base of their own livelihoods; and
- address environmental health problems in wet lands management.[7]

Sub-projects are being undertaken in the Zambezi delta in Mozambique, the Lower Shire in Malawi, Barotse floodplain in Zambia and the Chobe-Caprivi area in Botswana and Namibia. The projects are expected to benefit communities in different SADC countries in which work is being undertaken.

INSTITUTIONAL ARRANGEMENTS

Watercourse systems and their resources in SADC, have a very significant role in the state of the environment and the regional integration process. Use of waters of an international basin or shared watercourse system is governed by treaties. Each basin state cannot act unilaterally without affecting the interests of other basin states. It is, therefore, obliged to cooperate by signing treaties and agreements with its riparian neighbours, recognising the principles of the Helsinki Rules.

There are predominantly two types of institutional arrangements under which southern African countries cooperate in the development and management of water resources of shared water courses. These are:

- A single coordinating institution where a body of technical experts is constituted and policy recommendations are left to ad hoc meetings of relevant ministers.
- A dual level coordination which consists of a policy formulating body, such as a joint commission or permanent technical committee, with monitoring, advisory and approval powers over critical issues relating to projects, and a body of technical experts, usually referred to as the implementing agency, to deal with the practical engineering and management aspects. The policy body oversees all the basins common to the party states while the implementing agency is constituted for particular projects usually by river basin.[8]

Dual level coordination is by far the most common in the region and is largely characterised by joint planning and management, providing optimum utilisation of water resources of a watercourse system and fostering a higher level of cooperation among the party states. Single coordination has been observed where each basin state undertakes its own national project under a general agreement between two states. Numerous cooperative ventures have been established in the region from the colonial times and new ones are still emerging.

River basin organisation in SADC

The existing political will and commitment to coordinate, cooperate and integrate the socio-economic development of SADC countries gives the region a great advantage to sustain regional cooperation in water resources and environmental management. Besides this, the international efforts to establish coordination and cooperation mechanisms for water resources and environmental management emerged outside or as an aftermath of the SADC cooperation.

SADC has, therefore, a role to play in establishing and promoting regional cooperation for water resources and related environmental management, particularly for those of shared watercourse systems. Various organisations and institutions have been set up to coordinate the formulation and implementation of policies, strategies, programmes and projects. The responsibilities of coordinating such activities lie with sector coordination units or commissions, and each member state plays host to at least one of such institutions.

One of the sectors is the Environment and Land Management Sector (ELMS), located in Maseru, Lesotho, which is responsible for the coordination of regional environment, and land management programmes. One of ELMS' major programmes on regional cooperation in water and environmental management is the Zambezi River Action Plan (ZACPLAN).

Water cooperation activities in SADC Table 7.1

Participating countries	Regional cooperation activities	Objectives
Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, Zimbabwe	Zambezi River Basin Integrated Water Resources Management Plan: ZACPRO 6, Phase I/II	To implement and update, at long-term, the integrated water resources management plan, using existing facilities to build mathematical models, and analyse various development alternatives
Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, Zimbabwe	Regional groundwater development studies	To carry out a regional groundwater resource assessment using remote sensing imagery, and maps indicating groundwater depths, potential yield and water quality
SADC countries	Basement groundwater study and pilot irrigation development	To review previous work on productivity of the solid aquifers, instigate pilot irrigation projects involving wells in basement strata, and monitor the wells and irrigation schemes to assess economic viability
SADC countries	Development of increased reuse of wastewater	To investigate the utilization of wastewater for irrigation; To develop a standard approach to wastewater reuse through the publication of a set of guidelines; and To train staff from interested countries on wastewater reuse techniques
SADC countries	Legal technical assistance for training lawyers in water law	To train lawyers in international water law so that they can participate in negotiations for basin agreements
SADC countries	Technical assistance to harmonise national water laws with basin agreements and the Protocol on Shared Watercourse Systems	To review legal provisions and water policies in each country, with assistance from national legal advisors in order to harmonize national legislations with regional agreements throughout the SADC region
SADC countries	Preparation of model river basin commission agreement with dispute resolution provisions	To produce a river basin commission agreement to assist countries in their negotiations. The agreement will include functions and powers; specific provisions on voting, elections, committees and meetings; powers to make binding decisions, and dispute-settlement resolutions
SADC countries	Capacity building/institutional support to International River Basin Commissions	To strengthen international aid on technical issues regarding the establishment of effective international river basin entities and training of local managers

Participating countries	Regional cooperation activities	Objectives
SADC countries	SADC hydrometric technicians training programme	To instil the capacity for teaching subjects such as meteorology, hydrometry, hydrogeology and data processing, at local educational institutions
SADC countries	Water resources planning study for SADC	To identify key issues to be addressed and actions to promote the development of regional environmentally sound strategies for managing the water resources in the future; To promote awareness of issues relating to water development and management among decision-makers; and To examine how practical and economical it would be to increase water supply in those water-scarce areas of southern Africa
SADC countries	SADC Water Resources Sector coordinating unit created in August 1996	To provide assistance to the coordinating unit in its duties and to member states in service training in the field of land management. This will be done through sharing of data, information, knowledge and know-how relating to the aims of the program, and assisting member states in preparing environmental impact assessments
SADC countries	Economic pricing of water	To develop appropriate pricing schemes for the different sectors of society in order to improve allocation efficiencies, save water and improve the environmental sustainability of water resources
SADC countries	Water quality standards and monitoring	To set water quality standards; train and equip regional and national staff; and monitor water quality; and To strengthen a number of previous regional projects on water quality standards and monitoring
Tanzania, Zambia (also non-SADC members, Zaire and Burundi)	Pollution control and other measures to protect biodiversity in Lake Tanganyika	To strengthen national capabilities and increase community participation in investigating the sources and effects of pollution and devising measures to control pollution and preserve the natural biodiversity of the lake
Malawi, Mozambique, Tanzania	Lake Malawi biodiversity conservation project	To make an inventory of the lake's biodiversity and address problems of pollution caused by rapid population growth along the banks; and

Participating countries	Regional cooperation activities	Objectives
		To formulate a management plan for the lake; recommend revisions to national environmental legislation and carry out environmental education activities
Malawi, Mozambique, Tanzania, Zimbabwe	Catchment protection/rehabilitation project	To involve local people in conservation-based land-use practices in view to reduce erosion and sedimentation rates, and flood flows; improve the quality of the water and potentially increase power and energy production from downstream hydropower plants
Angola, Botswana, Namibia	Okavango river basin environmental assessment and water resources management programme	To set up an Okavango Ecological Research Institute; To undertake assessment of the Okavango Basin, including hydrological, topographic and soil studies, and ecological observations; To prepare and implement an optimum resource management program which includes enabling legislation and international agreements
Botswana, Lesotho, Namibia, South Africa	Orange river project replanning study	To determine water losses, sources of pollution, methods for improving efficient use, effects of extra-basin transfers, and determination of better water allocation; To carry out environmental impact assessments of the area
Lesotho, Namibia, South Africa	Feasibility study of the Caledon Cascade scheme	To carry out a feasibility study to transfer water from the Orange river, to the Gauteng region of South Africa, through a series of 26 dams along the Caledon river
Lesotho, South Africa	Lesotho Highlands Water Project	To meet the growing water demands from the Vaal river system and to generate hydropower for Lesotho
Botswana, South Africa, Zimbabwe (Other Zambezi basin states)	Zambezi southern transfer reconnaissance study	To transfer water from the Zambezi river to the Gauteng region of South Africa
Mozambique, South Africa, Swaziland	Joint Incomati basin water resources investigation	To provide valuable information necessary to formulate a master plan for the basin

Participating countries	Regional cooperation activities	Objectives
Angola, Botswana, Namibia, Zambia, Zimbabwe	Chobe river - Caprivi Strip development planning	To produce an overall integrated development plan for the region in focus in order to ensure proper management for the sustainable development of its natural resources
Mozambique, South Africa, Swaziland	Pongola and Maputo rivers development planning	To study current conditions and future plans for the Pongola and Maputo river basin in order to ensure proper water flow quantities and water quality for the local population
Botswana, Mozambique, South Africa, Zimbabwe	Hydrologic model for Upper and Middle Limpopo river	To develop a model to meet future needs, including improvement of hydrological monitoring; improving understanding of the interaction of surface flows and groundwater in alluvial aquifers adjacent to the river; and determining the provisional historical firm yields for points of interest along the main channel of the Upper and Middle Limpopo river
Malawi, Mozambique, Tanzania	Regulation of Lake Malawi	To create a coordinated and agreed plan for the efficient regulation and management of Lake Malawi and Shire river, which balances regional and multi-sector interests
Malawi, Mozambique	Lower Shire river valley flood forecasting project, Phase 2	To carry out a study on a flood control dam on the Ruo river, mapping to delineate flood zones, develop a flood forecasting model, and implement an early warning system on floods
Malawi, Tanzania	Songwe river channel stabilisation and area development	To ensure a stable and definitive international boundary between Malawi and Tanzania by determining, both technically and economically, the best method for stabilizing the course of the Songwe river
Mozambique, Swaziland	Improved hydrological data collection	To update technology and equipment in hydrological data collection, through identification of national data collection needs, suitable equipment, staff training needs
Mozambique, Zimbabwe	Establishment of a river basin commission for the Pungwe and Save rivers	To produce a basin management plan to assess the sustainability of water transfer developments for the Pungwe and Save rivers, including environmental impact assessments

SOURCE: Stanley Consultants, *SARP — Southern Africa Regional Water Sector Assessment*, Vol 1, Final Report, USAID, Gaborone, July 1995, pp. 4/2-4/70.

A number of projects under this programme have been initiated and are in various stages of development. These include ZACPRO 2[9] — Development of Common Legislation for the Management of the Zambezi river; and ZACPRO 6[10] — Development of an Integrated Water Resources Management Plan for the Zambezi river basin.

Zambezi River Action Plan Box 7.2

In May 1987, an agreement was reached on an Action Plan for the environmentally sound management of the Zambezi river system — the Zambezi River Action Plan (ZACPLAN) — at a conference convened by the United Nations Environment Programme (UNEP).

ZACPLAN, which is the foundation on which the Protocol on Shared Watercourse Systems in the SADC region is built, was initiated in 1985 by UNEP, SADC and the seven Zambezi basin states, except Namibia, which was still under South African occupation.

The overall implementation of ZACPLAN was entrusted to the Environment and Land Management Sector (ELMS) in Maseru, Lesotho.

The main purpose of ZACPLAN is to develop regional cooperation on the environmentally sound management of water resources of the common Zambezi river system and to strengthen regional collaboration for sustainable development. ZACPLAN comprises 19 programme projects of which eight have a Category I priority for implementation and the remaining 11 a Category II priority.

ZACPRO 6, which deals with the development of an integrated water management plan for the Zambezi river, is presently a major ongoing activity.

Source: Adapted from Heyns, P., "Existing and Planned Development Projects on International Rivers Within the SADC Region", *A Vision for the Future: Conference of SADC Ministers Responsible for Water Resources Management*, Pretoria, Nov. 1995.

SADC regional cooperation under the 1992 Treaty has provided new impetus for the advancement of regional water resources and environmental management. New policies, programmes and projects are being formulated and implemented to promote the objectives of SADC and those of Agenda 21. These include the proposed SADC Policy and Strategies for Environment and Sustainable Development[11] which emphasises equity-led growth with environmental, economic and impact assessments forming an integral part of the development process.

The proposed policy and strategies have also reviewed the regional concerns and consolidated environmental policies for sustainable development and management of natural resources. The strategies and programmes which have been prepared, will facilitate the implementation of these policies in a coordinated manner. The key international environmental agreements were also reviewed, showing those supported by SADC countries. These international conventions have a significant role in improving water resources and environmental management. They are all, directly or indirectly, related to the protection of

Photo 7.3 APG-D Martin

Projects under the Zambezi River Action Plan (ZACPLAN) include management of the river and basin, shown here in western Zambia.

water resources. Adoption by member countries could promote protection of water resources from pollution or degradation, and unregulated activities.

SHARED WATERCOURSE ADMINISTRATION

The Protocol on Shared Watercourse Systems in the SADC region[12] was signed by most countries at the SADC summit of heads of state in August 1995,

Role of the United Nations Box 7.3

United Nations agencies have played various leading roles in promoting and establishing regional international cooperation in water resources management. The UN-sponsored Mar del Plata Plan of Action of 1977 was perhaps the first attempt to consolidate and further promote the international coordination and cooperation in water resources management.

The recent developments include those that took place in Dublin where the Dublin Declaration was adopted in 1992. It urged new approaches to the assessment, development and management of freshwater resources and the environment, through political commitment. The involvement and participation of the lowest to highest levels of communities and authorities in governments, public awareness, legislative and institutional support, were highlighted as the new approach in addressing water resources and environmental management issues. The declaration outlined four principles which define or declare that:

- the freshwater resources are essential to sustain life, development and environment;
- development and management be based on a participatory approach, involving users, planners and policy makers at all levels in the watercourse system;
- the involvement of women is central in the provision, management and protection of water resources;
- recognises water resources as an economic good in its allocation to all competing uses.

These principles were further elaborated and articulated to address the issues related to:

- water and alleviation of poverty and diseases;
- water resources, environment and human protection against natural processes and disasters; and
- water resources protection, conservation, utilisation and reuse.

The declaration was a major input to the formulation and negotiation of Agenda 21 adopted under the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro, Brazil, in 1992.

Agenda 21 consolidates the various concerns and opportunities in environment and sustainable development, and global policy and strategies that promote equitable development and utilisation of natural resources and environment, including those that deal with water resources development and management in a sustainable and equitable manner.

The UN agencies which are involved in water management initiatives include the UN Development Programme (UNDP), UN Environment Programme (UNEP), UN Economic Commissions, World Meteorological Organisation (WMO), and United Nations Educational, Scientific and Cultural Organisation (UNESCO).

SOURCE: Shela, O.N., "Regional Cooperation", for SARDC, Maseru, 1995.

as an agreement under the SADC Treaty. Its objectives are spelt out in the preamble, as to:

- develop close cooperation for judicious and coordinated utilisation of the resources of the shared watercourse systems in the SADC region;
- coordinate environmentally sound development of the shared watercourse systems in the SADC region in order to support sustainable socio-economic development;
- have regional conventions on equitable utilisation and management of the resources of shared watercourse systems in the SADC region;
- consolidate other agreements in the SADC region regarding the common utilisation of certain watercourses; and
- promote the SADC integration process in accordance with Article 22 of the Treaty establishing SADC.

The strategies for enforcing and implementing the Protocol on Shared Watercourse Systems are laid out in Article 3 of the Protocol which declares that member states shall undertake to establish appropriate institutions necessary for the effective implementation of the provisions of the protocol. The appropriate institutions are referred to as the SADC "monitoring unit, river basin commissions among basin states and in respect of each drainage basin, and river authorities or boards in respect of each drainage basin". The objectives and functions of these institutions are presented in Articles 4 and 5 as one set of objectives and functions but they are not linked to the implementation of the protocol and the fulfilment of the objectives and goals.

The Protocol is the main instrument of regional cooperation in water resources and environmental management of the shared watercourse systems of the SADC region.

The African Development Bank has recommended that SADC sets up a regional-water resources management centre as part of its integration process. The recommended centre has been proposed to cover broader issues of regional water-resources management and administration, particularly for the shared watercourses, than the objectives and function of river-basin institutions proposed by the Protocol. The proposed centre would deal with:

- water resources research and development, including water-resources data collection, processing and dissemination among member countries;
- integrated planning, development, management and equitable utilisation of water resources improvements in shared watercourse systems for the benefit of the region as a whole;
- liaison and implementation of measures for conservation, protection, administration and pollution control of water resources in shared watercourse systems;
- defining and guiding cost-sharing arrangements and fundraising for joint projects, especially in river basins that do not have river-basin organisations that can do so;
- implementation of regional projects and coordinating their operation and maintenance, especially for those projects in river basins which do not have river-basin organisations that can do so;
- defining and guiding equitable water-resources allocation among riparian countries and environmental use, to maximise regional benefits from water resources, mitigate environmental and user conflicts, and promote sustainable development; and
- promotion of joint and cross-border water-resources development investments and utilisation of schemes among the riparian countries or SADC member states.

The mandate of such a centre would cover regional issues on conservation and protection of water resources, water supply and sanitation, and irrigation. It would also carry out and disseminate river-flow forecasting and warnings. This information would be used by the centre itself or concerned regional and national agencies in flood and drought mitigation, reservoir operations,

SADC Protocol on Shared Watercourse Systems Box 7.4

The following are some of the major principles of the SADC Protocol on Shared Watercourse Systems signed by representatives of Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania and Zimbabwe — at the SADC heads of state summit in Johannesburg in August 1995:

- The utilisation of shared watercourse systems within the SADC region shall be open to each riparian or basin state, in respect of the watercourse systems within its territory and without prejudice to its sovereign rights, in accordance with the principles contained in this Protocol. The utilisation of the resources of the watercourse systems shall include agricultural, domestic, industrial, and navigational uses;
- Member states lying within the basin of a shared watercourse system shall maintain a proper balance between resource development for a higher standard of living for their peoples and conservation, and enhancement of the environment to promote sustainable development;
- Member states within a shared watercourse system undertake to pursue and establish close cooperation with regard to the study and execution of all projects likely to have an effect on the regime of the watercourse system;
- Member states within a shared watercourse system shall exchange available information and data regarding the hydrological, hydrogeological, water quality, meteorological and ecological condition of such watercourse system;
- Member states shall utilise a shared watercourse system in an equitable manner. In particular, a shared watercourse system shall be used and developed by member states with a view to attaining optimum utilisation thereof and obtaining benefits therefrom consistent with adequate protection of the watercourse system;
- Member states shall take all measures necessary to prevent the introduction of alien aquatic species into a shared watercourse system which may have detrimental effects on the ecosystem;
- Member states shall maintain and protect shared watercourse systems and related installations, facilities and other works in order to prevent pollution or environmental degradation;
- Shared watercourse systems and related installations, facilities and other works shall be used exclusively for peaceful purposes consonant with the principles enshrined in the SADC Treaty and in the Charter of the United Nations and shall be inviolable in time of international as well as internal conflicts.

SOURCE: SADC, *Protocol on Shared Watercourse Systems in the Southern African Development Community (SADC) Region*, SADC, Gaborone, August, 1995.

hydropower generation, and irrigation scheduling.

The incorporation of measures that sustain water-resources development and management, such as socio-economic and sustainable water-resources developments and services, would be part of the centre's responsibilities and would also guarantee continued financial support, from such investments, for its operations.

SADC water management agreements Table 7.2

Bilateral and/or multilateral agreements between/among SADC countries	Treaty between South Africa, Mozambique and Portugal on the Cahora Bassa hydroelectric power generation project. Agreement between Burundi, Rwanda, Uganda and Tanzania on the Kagera Basin Organisation (BKO), 1977. Uganda joined in 1981. Agreement between Malawi and Zambia on a Permanent Commission of Cooperation (PCC), 1 March 1982, Blantyre, Malawi. Agreement between Swaziland, Mozambique and South Africa on the establishment of a Tripartite Permanent Technical Committee (TPTC), 17 February 1983, Pretoria, South Africa. Agreement between Botswana and South Africa on the establishment of a Joint Permanent Technical Committee (JPTC), November 1983. In June 1989, the JPTC was replaced by a Joint Permanent Technical Commission on the Limpopo Basin as far as it constitutes the border between the parties. Agreement between Malawi and Mozambique on a Permanent Joint Commission of Cooperation (JPCC), 23 October 1984, Blantyre, Malawi. Agreement between Botswana, Mozambique, South Africa and Zimbabwe on the Limpopo Basin Permanent Technical Committee (LBPTC), 15 June 1986, Harare, Zimbabwe. Treaty on the Lesotho Highlands Water Project between Lesotho and South Africa. The Treaty established a Joint Permanent Technical Commission (JPTC) between the parties, 24 October 1986, Maseru, Lesotho. Agreement between the governments of Zambia and Zimbabwe on the Zambezi River Authority Act of 1987. Agreement between Angola and Namibia on the establishment of the Angolan-Namibian Joint Commission of Cooperation, 18 September 1990, Lubango, Angola. Agreement between Botswana and Namibia on the Establishment of a Joint Permanent Water Commission (JPWC), 13 November 1990, Windhoek, Namibia. Treaty between Swaziland and Mozambique on the establishment of a Joint Permanent Technical Water Commission (JPTWC), 6 March 1991, Maputo, Mozambique.

Bilateral and/or multilateral agreements between/among SADC countries	Protocol of Agreement between Angola and Namibia on the development of the Cunene river hydroelectric power generation scheme on 24 October, 1991, Lubango, Angola.
	Agreement between Malawi and Tanzania on a Joint Commission of Cooperation (JCC), 1992, Dar es Salaam, Tanzania.
	Treaty between South Africa and Swaziland on the Establishment and Functioning of a Joint Water Commission (JWC), 13 March 1992, Mbabane, Swaziland.
	Treaty between South Africa and Swaziland on the Development and Utilisation of the Water Resources of the Inkomati River Basin (KOBWA), 13 March 1992, Mbabane Swaziland.
	Agreement between Namibia and South Africa on the establishment of a Permanent Water Commission (PWC), 14 September 1992, Noordoewer, Namibia.
	Agreement between South Africa and Namibia on the Vioolsdrift and Noordoewer Joint Irrigation Scheme, 14 September 1992, Noordoewer, Namibia.
	Agreement between Angola, Botswana and Namibia on the establishment of the Permanent Okavango River Basin Commission (OKACOM), 15 September 1994, Windhoek, Namibia.
	Agreement between Angola and Namibia to endorse and affirm the old agreements between the colonial powers, Portugal and South Africa, to re-establish the Permanent Joint Technical Commission (PJTC) and the Joint Operating Authority on the Cunene river, 18 September 1994, Lubango, Angola.
	Agreement between Mozambique and Zimbabwe on the Pungwe River, 1996.
Proposed water management agreements in the SADC region	Proposed Agreement between Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe on the establishment of a Permanent Zambezi River Basin Water Commission (ZAMCOM).
	Proposed agreement between Lesotho, Namibia and South Africa on the establishment of a Permanent Orange River Basin Commission (ORACOM).

SOURCE: Adapted from Heyns, P., "Existing and Planned Development Projects on International Rivers Within the SADC Region", *A Vision for the Future: Conference of SADC Ministers Responsible for Water Resources Management*, Pretoria, November 1995.

River basin agreements in SADC

SADC countries are trying to create mechanisms for coordination and cooperation, going beyond the protection and management of water resources and the environment. The integration of water-related, socio-economic development and investments among member states are expected to be included. A number of agreements have been made to establish better mechanisms for planning, development and management of water resources in the region, particularly those of shared watercourse systems. These arrangements have resulted in forging regional agreements, negotiations or ratification. The agreements among riparian states on the management of shared watercourse systems have been developed outside the SADC framework of cooperation, but are essential ingredients in the advancement and promotion of the SADC objectives and goals.

There are 11 shared watercourse systems in the SADC region. The Zambezi river is the biggest and is shared by eight countries: Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe. The other sizable shared watercourse systems are:

- the Orange river, shared by Botswana, Lesotho, Namibia and South Africa;
- the Limpopo, shared by Botswana, Mozambique, South Africa and Zimbabwe;
- the Okavango inland drainage systems, shared by Angola, Botswana and Namibia;
- the Cunene, shared by Angola and Namibia;
- the Rovuma, shared by Mozambique and Tanzania;
- the Inkomati, shared by Mozambique, South Africa and Swaziland;
- the Songwe, shared by Malawi and Tanzania.

The relatively small shared watercourse systems are:

- the Save and Pungwe rivers, which are shared by Mozambique and Zimbabwe; and
- Lake Chilwa basin, which is shared by Malawi and Mozambique.

Angola, Tanzania and Zambia have other watercourse systems that they share with other countries which are not members of SADC. Seven of those shared watercourse systems in the SADC region have some form of agreements and institutional arrangements for cooperation, development and management of their water resources.

Zambezi river basin

Within the Zambezi river basin, there are the Zambezi River Authority (ZRA) and the Songwe River Boundary Stabilisation agreements. The ZRA was established under an agreement between Zambia and Zimbabwe for the joint development and management of water resources of the middle part of the Zambezi river course common to both countries. The agreement was ratified in 1987.

ZRA replaced and took over the properties of the old Central African Power Corporation which operated during the then Federation of Rhodesia and Nyasaland, and later in independent Zambia and Zimbabwe. Both countries set up a Council of Ministers and Board of Directors and ZRA itself, to implement the objectives and goals of the agreement. Under the Zambezi River Authority Act of both Zambia and Zimbabwe, ZRA serves as a secretariat and executing agency for the:

- operation, monitoring and maintenance of the Kariba Dam complex;
- investigations of new dam projects;
- collection and processing of hydrological and environmental data;
- liaison with utilities of the water and related resources of the Zambezi river common to both countries; and
- various administrative functions required for the implementation of the above activities.

However, ZRA has mainly devoted itself to the operation and maintenance of the Kariba Dam complex. In the late 1980s and early 1990s, it was also involved in investigating new dam projects, especially for the Batoka Gorge Hydropower Scheme, upstream of Kariba Dam. Extensive envi-

International watercourse systems agreements in SADC

Map 7.1

River	Name	Cooperating countries
1	Zambezi	SADC.
2	Songwe	Malawi, Tanzania.
3	Cunene	Angola, Namibia.
4	Okavango	Angola, Botswana, Namibia.
5	Orange	Lesotho, Namibia, S. Africa.
6	Limpopo	Botswana, Mozambique, S. Africa, Zimbabwe.
7	Incomati	S. Africa, Swaziland, Mozambique.

SOURCE: Adapted from Chabwela, H; *Wetlands: A Conservation Programme for Southern Africa*, IUCN and SADC, Harare, 1991.

ronmental impact assessments were carried out on the project. The implementation of the project, however, had not been started by early 1996.

ZRA had also intensified hydrological and environmental data collection and processing. The regulation and management of fisheries and other aquatic life in the Zambezi riverine ecosystem or agricultural and industrial activities in the catchment common to the two states, which influence quality of water resources in the Zambezi, are outside the mandate of ZRA.

Photo 7.4 APG-D Martin

The Zambezi River Authority covers management of the middle part of the river shared by Zambia and Zimbabwe.

In recent years, there has been growing concern of high levels of DDT and heavy metals found in Lake Kariba's waters, and of the interference with fish breeding, movement and management, due to the damming and regulation of the lake.

There is also an agreement between South Africa, Mozambique and Portugal related to the Cahora Bassa project. It includes the provision and sale of electricity to South Africa from the Cahora Bassa hydropower station on the Zambezi river in Mozambique. The agreement worked temporarily during the early days before the power line was sabotaged in the early 1980s during the war in Mozambique in

Photo 7.5 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO

The Cahora Bassa hydroelectric power station on the Zambezi river in Mozambique results from a pre-independence agreement with Portugal and South Africa.

which apartheid-era South Africa was heavily involved. The line was being repaired in the mid-1990s after peace returned to Mozambique.

A Zambezi basin cooperation agreement among all the riparian countries has been proposed but progress seems slow. The work on this started with ZACPRO 2, a ZACPLAN project, but was then revised to prepare the Protocol on Shared Watercourse Systems in SADC, instead. However, the Water Resources Subcommittee of SADC ELMS initiated the work again in 1994 to develop the agreement. This agreement is expected to consolidate all the existing agreements on the utilisation and management of water resources and related developments in the basin.

Songwe river basin

The Songwe river, which forms the international boundary between Malawi and Tanzania, is a tributary to Lake Malawi drained by the Shire river, one of the major tributaries of the Zambezi. The Songwe River Stabilisation agreement was signed in 1990 between Malawi and Tanzania and its objective is to stabilise and control flooding in the lower Songwe river, which changes course almost every year during the flood season, with an average of about 90 sq km of land inundated during this period. The agreement was negotiated under an existing Joint Permanent Commission, which is an intergovernmental/ministerial arrangement for promoting cooperation between the two countries.

The Songwe river agreement is headed by one co-chairperson from each country during ministerial and officials committee meetings which are held alternatively between Malawi and Tanzania. The agreement has already led to positive results. A project proposal was developed and its objectives include the development of flood-control mechanisms, stabilisation of the river channels, development of hydropower, irrigation, tourism and fisheries, as part of mitigating floods and flood damages thereby improving the environment and the lives of the people of the floodplain area.

Cunene river basin

The Cunene river basin management is based on a 1969 agreement between Angola and Namibia regarding the development and utilisation of the water resources potential of the river through the establishment of:

- a Joint Operating Authority to ensure the maximum beneficial regulation of the water flow at Gove required for power generation at Ruacana and to control the abstraction of water along the middle Cunene; and continuous operation and adequate maintenance of the water pumping works at Calueque and the diversion weir at Ruacana;
- a Permanent Joint Technical Commission to evaluate the development of further schemes on the Cunene river to accommodate the present and future needs for electricity in both countries.

The agreement of 1969 replaced the 1964 one for mutual interest and sharing of the resources of Cunene, and were both negotiated between and signed by Portugal and South Africa before Angola and Namibia became independent.

It is still honoured and has been supplemented by the agreement of Lubango in September 1990. It binds the two countries to adopt the best joint-utilisation schemes during planning, execution and operation of projects for water resources development in the basins of common rivers such as Cunene, Okavango, Cuando and Zambezi. This has led to further agreements, including that dealing with the development, cost-sharing, operation and maintenance of the Epupa Hydropower Scheme on the Cunene river. In 1995, the investigations for the development of this hydropower scheme were at an advanced stage.

Okavango basin

Angola, Botswana and Namibia established a Permanent River Basin Commission, called the Okavango Commission (OKACOM), which acts as a technical advisory body on matters relating to con-

servation, development and utilisation of water resources of the Okavango river basin, shared by the three countries. It is expected to perform functions pertaining to the development and utilisation of such resources as the contracting parties might, from time to time, identify and agree to assign to the Commission.

There are other agreements on the Okavango basin, including an understanding on the prevention and control of aquatic weeds. Weeds choke surface water bodies in the region, particularly in the Okavango basin, reservoirs in Zimbabwe and in the Shire river in Malawi. In Botswana and Namibia, the control of the spread of these weeds has been made possible through arrangements where both countries check and spray boats suspected of coming from areas where there are aquatic weeds.

Photo 7.6 APG-D Martin

Agreements for the Okavango river, shown near Papa Falls, enable Botswana and Namibia to conserve water resources and control the spread of aquatic weeds.

Orange river basin

South Africa has a number of agreements with its neighbours on the utilisation and management of common watercourse systems. The level of development and utilisation of water resources in those parts of the shared watercourse systems which are in South Africa, particularly on the Orange river, appear to explain the large number of agreements it has. South Africa has two agreements with Namibia on the Orange river. One is an agreement on the establishment of a Joint Permanent Water Committee. Botswana is also party to this. The committee's objective is to establish a Joint Permanent Commission which acts as the technical advisory body to the parties on matters relating to the development and utilisation of water resources of common interest.

The other agreement is on the establishment of a Permanent Water Commission that facilitates the founding of specific commissions such as the proposed Permanent Orange River Commission which is expected to include Botswana and Lesotho, for the development, management and allocation of water resources of the basin. It has also facilitated the establishment of the agreement relating to construction, operation and maintenance of the Marico Dam on Marico river, a tributary of the Orange river. This agreement includes the allocation and supply of water from the dam to both countries.

The agreement on the Lesotho Highlands Water Project is the most prominent basin agreement in the Orange (Senqu) river. It is an agreement between Lesotho and South Africa that would transfer water from the headwaters of the Senqu river in Lesotho to the industrial heartland of South Africa's Gauteng region. It was signed in 1986 and consequently established a Joint Permanent Technical Commission (JPTC) comprising an equal number of representatives from the two countries and charged with the responsibility of the project's implementation.

The executing agency for the implementation of the projects under the agreement was given to Lesotho Highlands Development Authority (LHDA) established by the Lesotho government. It implements project activities while the Trans-Caledon Tunnel Authority (TCTA) established by South Africa under the treaty and stationed in Gauteng,

was charged with the responsibility of executing works associated with the agreed joint projects in South Africa. The three organisations, JPTC, LHDA and TCTA, form a tripartite committee and resolve issues on all aspects of the project while allowing direct contact between the executing agencies with the JPTC whenever necessary.

Photo 7.7 SOUTHLIGHT-D Marie

The agreement on the Lesotho Highlands Water Project is the most prominent basin agreement on the Orange (Senqu) river, and covers transfer of water to South Africa's Gauteng industrial heartland.

Limpopo and other river basins

Mozambique, by virtue of being the downstream state of the eight of 11 shared watercourse systems in the region, is the most affected country regarding equitable utilisation of the water resources of those rivers. At the moment, Mozambique does not have agreements on geographically important watercourse systems such as the Zambezi river, although currently there is pressure to forge such agreements. This pressure emanates from the need for conservation, protection and equitable allocation of water resources in these basins so that Mozambique can continue enjoying their benefits. The water resources are under pressure due to competition for use in the upper riparian states and might also be subject to pollution. These observations are also true for the watercourse systems originating from Zimbabwe and flowing into and through Mozambique before terminating in the Indian Ocean.

Mozambique, however, has specific agreements for the development and utilisation of water resources south of the Limpopo river. Together with Botswana, South Africa and Zimbabwe, it is part to the agreement establishing the Limpopo Basin Permanent Technical Committee whose aim is to make recommendations concerning joint use of water and related resources effective.

Other agreements

There is also an agreement on the development and utilisation of the water resources of the Inkomati river basin with South Africa and Swaziland, which recognises the right of Mozambique as a riparian state to this river. The purpose of this treaty is to provide for the development and utilisation of the water resources, in particular, for the design, construction, operation and maintenance of the common water resources development projects.

Mozambique and Swaziland have also established the Joint Permanent Technical Water Commission to act as technical advisor to the parties on all matters relating to the development and utilisation of water resources of common interest to both countries and to implement measures pertaining to the development and utilisation of such resources. This covers the river basins of Inkomati and Maputo and their tributaries.

Another agreement is between Swaziland, Mozambique and South Africa, pertaining to the establishment of a tripartite Permanent Technical Committee. This agreement, signed in 1983, was initially between South Africa and Portugal, and Swaziland became a signatory in 1967. The committee's mission is to make recommendations relating to joint water-use of rivers and watersheds of common interest. An agreement has already been negotiated and signed regarding the utilisation of water of the Mbuluzi/Umbeluzi river shared by Mozambique and Swaziland. This agreement

entitles Mozambique to a specified percentage of the basin flow accruing within Swaziland as measured at two specific sites.

Based on the water allocation, each state has been able to construct storage dams to regulate its share of the waters. Mnjoli Dam in Swaziland and Pequenos Libombos Dam in Mozambique, were both planned, developed and are now managed independently by national institutions. No joint management board has been set up.

RESOURCE USE AND INSTITUTIONAL ARRANGEMENTS

The regional agreements on water resources in SADC are mainly single-purpose arrangements for particular exploitation of water resources. The recognition and existence of these agreements have acted as deterrent to activities that would have led to user as well as environmental conflicts. However, these agreements cannot satisfy the requirements of equitable and reasonable utilisation that takes into account all the relevant factors necessary to improve socio-economic welfare of the states without causing appreciable harm to other basin states. They do not take into account the requirements and need for the conservation, protection and equitable utilisation, and management of water resources. They do not even have the criteria to be followed in the equitable and reasonable utilisation of water resources in the shared watercourse systems. The appropriate institutional arrangements also appear not to be in place to effectively enhance the attainment of optimum utilisation of water resources and environment in the SADC.

Sectoral requirements

Integrated, equitable and reasonable utilisation takes care of all the sectors in the watercourse system as its basis for development and management of water resources. The calculated, balanced and negotiated allocation, through the assessment of the available water resources each year before distribution and apportionment to each state, should be administered by a commission or its equivalent established under an agreement among the riparian states. The approach minimises user conflicts among riparian countries and enhances environmental protection, as water requirements for servicing the ecosystem are equally considered and allocated for. This ensures that the use of water resources in one riparian state does not cause appreciable harm to another or the environment.

Intensive water-resources development and utilisation in the SADC region is localised mainly in South Africa and Zimbabwe, where generally, hydropower, municipal water supply and irrigation schemes are the dominating uses. The most regulated and used river is the Orange, particularly its Vaal river tributary. The Limpopo and Save rivers are also fairly overutilised. Water uses and environmental conflicts, however, are still considered low throughout the region, compared to other similar shared watercourse systems.

In economic terms, water resources are playing a significant role in the socio-economic development of the region. A major proportion of the region's

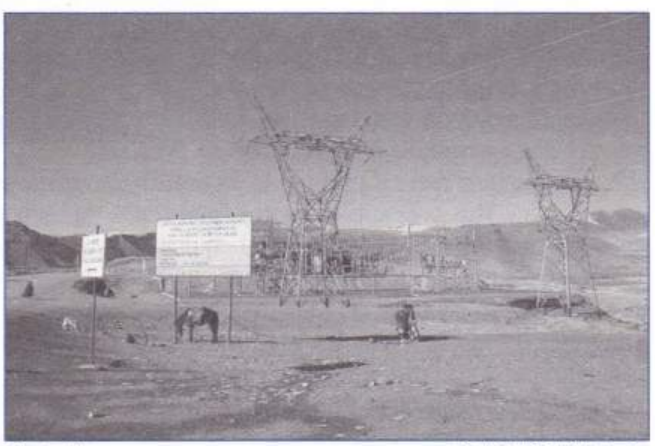

Photo 7.8 SOUTHLIGHT-D Marie

A major proportion of the region's electricity is generated from hydropower installations, which play a significant role in the socio-economic development of the region.

electricity is generated from hydropower installations, with a total capacity of more than 10,000 MW already developed. More than 4,500 MW of this is in the Zambezi river basin at Kariba, Cahora Bassa, Kafue Gorge and Nkula. There is a further development potential of 8,000 MW in the Zambezi river basin alone. Currently more than 280,000 hectares of land are irrigated, with the potential exceeding 8 million hectares.[13]

The lack of integrated plans has been recognised as one of the major constraints in promoting sustainable development and equitable sharing of water resources in shared watercourse systems in the SADC. This further limits socio-economic growth and environmentally sound management associated with water resources development in riparian countries. The efficient operation and management of water resources development and the equitable sharing and utilisation of their benefits are marginally realised due to lack of such a comprehensive integrated basin-wide approach in the development and management process. The conservation and protection of water resources are also marginalised or do not exist in the Zambezi river basin. Integrated planning will be among the issues to address in environmental management in the Zambezi river basin.

Conservation, protection, development and management responsibilities of water resources is distributed among various regional sectors and national institutions, usually for single purpose objectives. The main sectors and institutions forging this being the energy utility agencies. There are no single agencies or institutions that develop, allocate and manage water resources for multipurpose utilisation and effectively mitigate the environmental side-effects of such developments and management schemes.

However, almost everywhere, the use of water resources is being competed for by various sectors, such as food and agriculture, manufacturing, mining, energy, water supply and sanitation, tourism and recreation, transport and navigation. In most cases, technical, institutional, administrative and investment capacities are inadequate, particularly for multipurpose and environmentally sound water-resources development and management.

Photo 7.9 SARDC-M Chenje

Sanitation services compete for water resources with agriculture, mining, manufacturing, transport, tourism, recreation and domestic use.

Kariba and Cahora Bassa

The development and management of the Kariba and the Cahora Bassa reservoirs were for the purpose of hydropower generation and were developed by Zambia and Zimbabwe, and Mozambique, respectively. The economic value of these reservoirs and hydropower installations is, to a large

extent, dependent on inflows from countries, particularly Angola, with no interest, benefits or collateral arrangements to ensure sustained inflows from these countries. There are no agreements to control developments in these countries and ensure the availability of water resources flowing into these lakes. Besides, there are no joint operations between the two reservoirs to ensure the safety of the downstream areas and settlements against floods and droughts. Furthermore, these reservoirs are also being used for other purposes such as fisheries, tourism and recreation, navigation, whose requirements have not been adequately incorporated in the management activities of the water resources.

Water transfers

A number of national and regional water-resources plans exist in the basin, including those for inter-basin water transfers to the non-riparian member states of SADC. These plans or existing developments have not been harmonised and integrated into one basin-wide, water-resources management plan. Furthermore, the governments of Botswana and Zimbabwe have contemplated drawing water from the Zambezi for their drought-stricken towns and rural areas. There are even proposals to draw water from the Zambezi river to South Africa which is a non-riparian state. These proposals have not been examined for regional socio-economic merits and environmental consequences.

Lake Malawi and Shire river

The development of Lake Malawi and the Shire river is dominated by Malawi, despite the fact that Tanzania and Mozambique are also riparian countries. A barrage was built across the Shire river to regulate its flows and indirectly, the Lake Malawi levels, mainly for hydropower generation. It is inappropriate for regulating the floods which cause damage and loss of lives along the Shire river between Malawi and Mozambique. The conservation, regulation and protection of the water resources of Lake Malawi and the Shire river system, through to the Zambezi river and its artificial lakes, can guarantee a balanced ecosystem for the

Zambezi pipeline still a pipe dream Story 7.1

Jotsholo (The Herald) — Zimbabwe's President Robert Mugabe has said that although government is committed to providing permanent water sources in the drought-prone Matebeleland region, the implementation of the $6.5 billion (US$680 million) Matebeleland Zambezi Water Project will have to wait, as the government has to consult neighbouring countries.

Addressing an election campaign rally in Jotsholo, in Matabeleland North province, President Mugabe said the construction of the Gwayi/Shangani dam would instead take precedence.

Political and civic authorities, and other pressure groups have been pressing for the implementation of the Matabeleland Zambezi Water Project, which would tap water from the Zambezi river to the city of Bulawayo, a distance of about 470 km. Feasibility studies have been carried out and a fundraising campaign for the project has been launched.

There are eight southern African countries in the Zambezi river basin. South Africa, which is not within the basin but gets some of its electricity from the Cahora Bassa dam in Mozambique, has also laid some claim on the Zambezi river waters.

Mugabe said because water was a priority in the drought-prone province, more dams would be built to catch the water that went to waste in the Zambezi river while people and livestock suffered. He said dam construction would be complemented by acquisition of more land to resettle thousands of landless Zimbabweans scratching a living from barren lands, adding that these goals should be achieved by the year 2000.

SOURCE: Zimbabwe Newspapers, "Dam projects must come first, Zambezi water later", *The Herald*, 23 Feb, 1996.

survival and continued development of the fisheries, navigation, hydropower and other uses.

These benefits are severely threatened by the likelihood and possibility of returning to extremely low water levels and no flow conditions in the Shire river, as experienced between 1910 - 1935. The regulation of Lake Malawi water levels is essential for sustaining these socio-economic services while at the same time reducing the risk of lakeshore flooding or low lake levels.

Pollution

Although water resources pollution has not created regional conflicts, the potential of causing serious challenges in the future development and management of the water resources in the Zambezi river basin exists, unless coordinated efforts and plans are jointly instituted among the riparian countries. For example, mining and industrial activities are discharging effluent which pollutes the tributaries of the Zambezi river, such as the Kafue in Zambia and the Sanyati in Zimbabwe. These have the potential to become regional problems, particularly the pollution from heavy metals as evidenced by the existence of DDT and heavy metals in Lake Kariba. Planned or potential mining and industrial activities in the Lake Malawi catchment, particularly mining of oilfields in Mozambique, development of oilfields and pulp industries in Malawi and iron deposits in Tanzania, may pollute the lake, unless regional environmental considerations are employed during their planning and development.

Flooding

The Zambezi and the Shire river flow-regimes in their floodplains are complex and inter-related because of the Shire river's low gradient in the last 200 km (with only 10-15 m drop) before joining the Zambezi river. The floods are worst when both the Zambezi and the Shire are high and may last several weeks, with the Shire backing up 150-200 km, covering an area of about 1,000 sq km of total flooded area of extremely fertile land. The low flow characteristics of the lower Zambezi and the Shire create similar challenges. These sections were navigable since long before the days of Dr David Livingstone's explorations until the 1980s (except between 1915-1935). Droughts have obviously contributed to this, but it is not clear whether the recent water-resources developments in the Zambezi river basin have played a role. However, when the Cahora Bassa Dam closed for the first

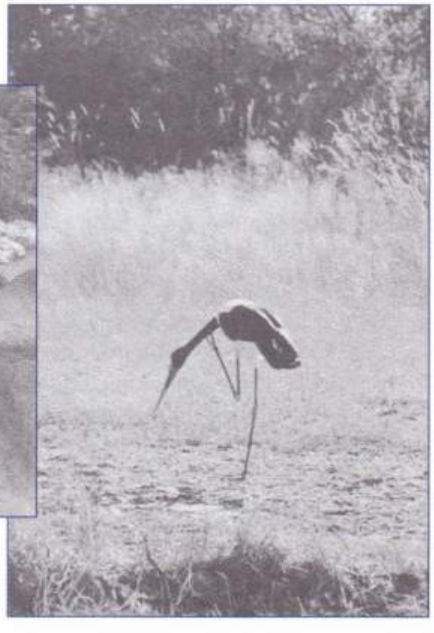

Photo 7.10 & 7.11 SARDC-M Chenje

Mining and industrial activities in a catchment area can pollute water resources, killing fish and threatening people, birds and animals.

time to allow it to fill in the late 1970s, the water levels in the lower sections of the Shire River suddenly dropped, prohibiting navigation ever since.

INTEGRATED WATER MANAGEMENT

The development and implementation of integrated water-resources management plans are designed to put in place mechanisms for equitable utilisation and reasonable allocation of water resources, the principles of which are enshrined in the SADC Treaty, the Helsinki rules and draft laws for the non-navigational use of international watercourses.

In the case of the Zambezi river basin, the development of the integrated plan was expected to be completed by 1988 and some preparation had already been made. A computerised water-resources information system exists, and contains historical data from 45 hydrometric stations, 60 meteorological stations, and about 30 water-quality sampling points, spread throughout the Zambezi river basin.

The database was expected to provide data to the sector studies which were to review, evaluate, and assess sectors that benefit from or affect water-resources management, and facilitate the identification of development scenarios in each sector. These development scenarios indicate water resources demands for various sectors, including the requirements for servicing the environment, from existing and planned programmes and projects in each sector. The sectors include water supply and sanitation, irrigation, hydropower, tourism and recreation, wildlife and navigation. The database could also provide information for the development, calibration, and testing of models and their use in environmental impact assessment and identification of the integrated water-resources management plan for the Zambezi river basin. In the long-term, it would also provide data relevant to the riparian countries and regional institutions for water resources planning and management, including data needed for flood and drought forecasting, warning and mitigation, and environmental management.

The observations are not limited to the Zambezi river basin but also apply to other shared and national watercourse systems in the SADC region. When these and other concerns are addressed by the integrated plan, the state of the environment and water resources in river basins in the SADC region will be greatly improved.

Lack of information on water and other aquatic resources in the SADC region has hindered the equitable and reasonable utilisation of the resources. The following are the major concerns in the region, which could be addressed by the integrated water-resources information system:

- inadequacies in the availability and dissemination of information on natural resources, particularly water, inhibiting investment opportunities, strategic planning and preparedness against environmental crises caused by recurrent droughts and floods, pollution, land degradation and knowledge of the state of water resources and the environment;
- lack of effective information exchange and consultation mechanisms among SADC countries, particularly among those sharing an international river basin which may or could create misunderstandings and lead to unnecessary conflicts among riparian countries; and
- limited coordination and cooperation in water resources development and management, especially with regard to multipurpose basin-wide approach inhibiting equitable utilisation and reasonable allocation of water resources for all the essential uses, including those servicing the environment and its ecosystems.

The concerns were also reflected in the World Bank and UNDP Sub-Saharan Africa Hydrological Assessment (SSAHA) report of 1990 which showed that the hydrological services were inadequately equipped[14] and offered inferior water-resources information. The report concluded that the hydrological and water-resources information services were unable to effectively and significantly contribute to conservation, protection, development and management.

A vision of cooperation Story 7.2

Pretoria (SARDC) - Southern African states have a vision of a future with adequate water supplies despite the region's recurrent droughts. The vision involves stronger regional cooperation and coordination in the management of water resources, placing water at the centre of human activity.

The Southern African Development Community (SADC) countries hope that such close cooperation will help to avoid possible conflict over water both at national and regional levels. SADC ministers responsible for water-resources management have held meetings to map out strategies aimed at better managing the scarce resource and ensuring that the region has enough water even in times of drought.

The cover of a SADC water conference file handed out to participants in Pretoria in November 1995 had a graphic of a suspended water drop and the words: "A vision for the future". However, the vision of water management in the region is more than just a drop of water suspended in time. It is about life itself, the environment, food production, hygiene, industry and power generation. It should not be a victim of crisis-management. It should be a well-coordinated and executed programme, involving all stakeholders at national and regional levels. It is about not giving war over water a chance.

South African Water Affairs and Forestry Minister Kader Asmal, said, "We have a potential long-term water crisis in the region which could cripple the sustainability of our development if not handled with great foresight. Conflict, both internally and between countries, could arise unless the challenge is dealt with in a progressive and transparent manner."

A World Bank official forecast that interstate and international conflict may in future increase as populations and demand for limited supplies of water increase worldwide. "Demand for water resources from competing uses will grow rapidly, placing increased stress on water resources (in southern Africa)," warned Andrew Steer, director of the World Bank's Environment Department.

But a water expert from one of the SADC countries dismissed the doomsday scenario of southern African communities and/or countries going to war with each other over water, saying that water management needs such huge financial investments that "we do not have the time and money to prepare for war."

Professor Malin Falkenmark, of the Swedish Natural Science Research Council, said the level of water stress grows (in terms of people per flow unit of water) as the population increases. A flow unit is equivalent to one million cubic metres of water per year. She says about 600 people/flow unit is the level of population pressure where water stress might be expected. Anything above 1,000 people/flow unit will cause chronic water scarcity.

In 1994, southern Africa had 360,000 flow units and the overall ratio of population to flow units was about 360, a situation not difficult to manage. But with the population projected to double in 24 years from 140 million people in 1995, the ratio will be 720 by 2016 and over 1,000 by 2030. However, Falkenmark believes that the region will experience chronic water scarcity even earlier.

— **Munyaradzi Chenje**, Southern African Research and Documentation Centre (SARDC), December 1995

The SADC region is expected to implement a number of regional and national projects to address these concerns. One project is the Hydrological Cycle Observation System for SADC (HYCOS-SADC) which goes beyond the concept of having a satellite-based telemetry system for observing water-cycle parameters for selected stations.

The strategy is to have a SADC water-resources information system that combines conventional hydrometry, telemetry technology and advanced information handling, exchange and networking. This would be used to monitor and disseminate water-resources data for forecasting and for issuing warnings of floods and droughts, for the planning and management of water-resources development (including strategic and contingency plans against water-related disasters), and environmental management.

The goal is to have a network of national hydrology and water-resources computerised databases linked in a network to a regional centre, where data gathered from selected water-resources monitoring stations and water-related sectoral information centres would be collected, processed, and stored. The data would be disseminated in a timely fashion to all member states through national hydrological services and other regional and global data-users, which would be ready for use for water-resources planning and management, and related environmental management.

The implementation strategy is to start with a basic network and facilities and build up the system to fulfil the vision, which includes the establishment of the SADC Regional Centre for Water Resources.

This, together with other arrangements, would facilitate the development and implementation of integrated water resources management plans, equitable utilisation and reasonable allocation of water resources and provision of information on the state of water resources and environment whenever needed, throughout SADC.

MARINE

The sheer size of the SADC coastline of over 9,870 km, and 200 nautical miles of exclusive economic zones (EEZs) covering more than three million sq km[15], renders protection by individual countries almost impossible. As a result, several regional networks are being developed to address marine conservation issues jointly.

Regional cooperation

Both individually and collectively, all SADC coastal states have policies establishing protected marine and coastal areas. To foster close cooperation and coordination in the SADC marine sector, member states in August 1994 approved a Marine Fisheries Policy and Strategy whose objectives include the following:

- raise production and improve processing methods, marketing and distribution of fish and fish products, and move toward greater utilisation for direct human consumption of species, bycatch and byproducts currently processed for animal feed;
- undertake marine research, stock assessment, management, monitoring, control and surveillance, and also socio-economic development of fishing communities;
- protect and enhance marine and coastal environments, control pollution and avoid harmful effects on other natural resources;
- provide training and assistance to promote profitable operations at all levels from artisanal to industrial;
- maximise the foreign exchange value of fish exports;
- strengthen and develop small-scale and artisanal fisheries and the economies of coastal fishing communities in integrated sustainable ways and by fully involving the people in development programmes and in the decision-making process; and
- base all development projects for the marine fisheries sector on sound, scientific analysis of resources and their sustainability, educate fishers and coastal people at all levels in environmental resource awareness and

involve them in management systems and decision-making.

Member states cooperate in the area of research. Namibia, which coordinates the marine fisheries sector, has made a vessel available for marine research and stock assessment in Tanzania and Mozambique. The member states are also trying to establish a fisheries research institution to formulate fisheries research programmes. It will also be responsible for a marine-fisheries resources evaluation programme. Its activities will include acquiring the necessary research vessels and equipment to effectively implement national and regional marine research programmes.

Bilateral agreements

In the area of cooperation among the SADC coastal states, bilateral agreements exist between member states, and some of these agreements may evolve into protocols in future. Angola and Namibia have signed a bilateral cooperation agreement on fisheries and so has Namibia and Mozambique. Angola and Namibia have developed air and sea patrols, and a fishery inspectorate to spearhead monitoring, control and surveillance. Both countries have surveillance fleets. These activities have been possible as a result of the March 1994 agreement between Angola and Namibia. The two SADC countries agreed to intensify cooperation in the following areas:

- research and assessment of the shared marine resources;
- joint surveillance of shared borders of the countries' EEZs;
- harmonisation of fishery legislation;
- training of personnel in research, surveillance and legislation; and
- the establishment of joint ventures.

On the east coast, Mozambique and Tanzania enforce regulations on foreign vessels through seagoing and land-based observers.[16] In addition, a Memorandum of Understanding (MOU) has been signed between Namibia and Mozambique. Bilateral fisheries agreements also exist between

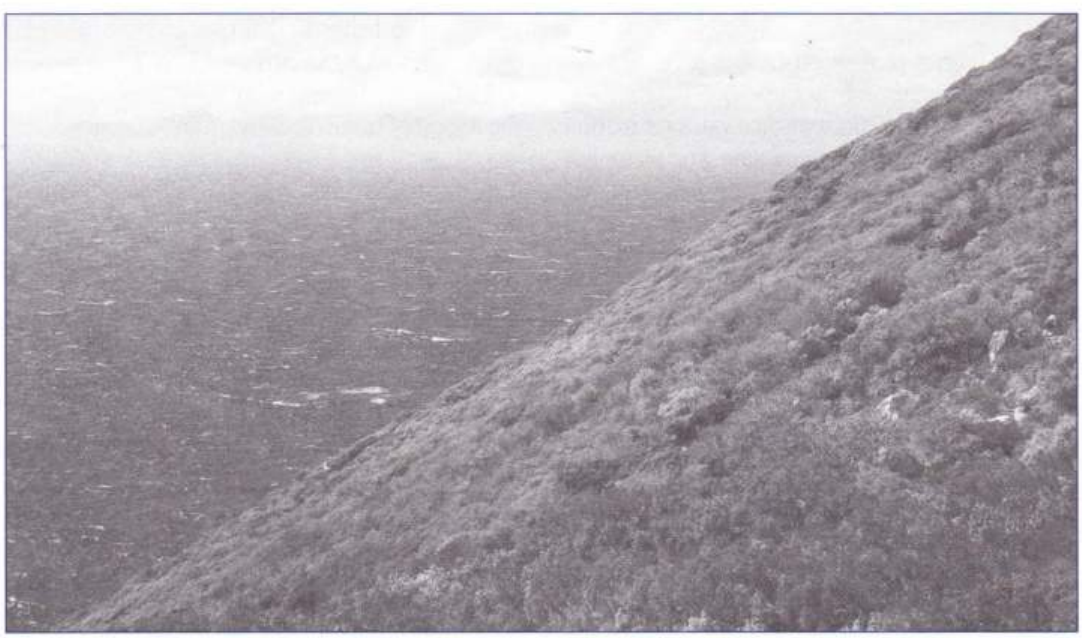

Photo 7.12 SARDC-M Chenje

Southern Africa's coastline, excluding 177 km of Mauritius is 9,870 km. Exclusive economic zones cover more than three million sq km, making protection by individuals or single countries impossible.

Mozambique and South Africa; and Namibia and South Africa. It is expected that with Mauritius becoming the 12th member of SADC in August 1995, the Indian Ocean island-state will forge closer ties and strengthen cooperation with the other coastal states, particularly its neighbours on the east coast.

Sustainable catch potential in southern Africa Table 7.3
(x 1,000 t per year)

Fish group	Ang	Moz	Nam	Tan	SA	TOTAL
Small Pelagic	440	350	900	20	480	2,190
Demersal	115	50	280	10	320	775
Large Pelagic	20	16	10	20	20	86
Shellfish	25	14	10	20	10	79
TOTAL	600	430	1,200	70	840	3,140

SOURCE: *Namibia Brief*, No. 18, June 1994.

Current regional efforts to improve the status of protected marine and coastal areas include training to develop necessary skills to manage designated protected areas and implement identified control measures. The University of Namibia now houses a regional training centre open to students from other countries in the region. A number of fisheries planning and management courses have also been organised since 1994.[17]

SADC countries plan to establish a regional computer-based, marine-fisheries-catch data system with capabilities to present data on total marine catch, species, area, vessel and time. The sector has also considered the possibility of establishing sea fisheries inspectorates in the SADC region, and a study will soon be launched to determine the viability of such institutions.[18]

Fisheries production

The SADC coastal states recognise the need to increase production and enhance sustainable utilisation of marine resources. The necessity to introduce technologies minimising harvesting and post-harvesting losses, regional resource assessment, management and surveillance systems has already been highlighted.

The annual catch of marine resources is about 1.9 million tonnes. The potential annual catch is estimated at between 2.7 million - 3.0 million tonnes[19] provided that there are good conservation and management policies. The importance of the SADC marine fisheries in terms of food to the whole region, not only the coastal states, can be illustrated by the success of an agreement between Namibia and Zimbabwe. The import of Namibian horse mackerel into Zimbabwe has greatly influenced eating habits in that country. For example, fish consumption has increased from 2.7 kg/person in 1992 to 6.4 kg/person in 1994,[20] mainly due to the import of horse mackerel from Namibia.

Threats to the SADC region's rich marine areas include mining and oil explorations. For example, diamond dredging off the south coast of Namibia may have adverse effects on the recruitment of juveniles to the economically important rock lobster stock. The SADC coastal states would like to see "strict environmental monitoring and control measures with regard to the utilisation of minerals and oil off the coasts of individual SADC coastal states."[21]

CONVENTIONS AND TREATIES

International Conventions

SADC countries are party to several international treaties and conventions. Whether regionally or individually as countries, some of these instruments influence regional initiatives and coopera-

SADC countries and international conventions Table 7.4

Convention/Treaty	Ang	Bot	Les	Mal	Mau	Moz	Nam	SA	Swaz	Tan	Zam	Zim
1963: Banning Nuclear Weapon Tests	–	R	–	R	R	–	–	R	R	R	R	–
1968: African Nature Conservation	–	–	–	R	–	–	R	–	R	R	R	–
1971: Wetlands of International Importance (RAMSAR)	–	–	–	–	–	–	R	R	–	–	R	–
1972: Bacteriological and Toxic Weapons	–	R	R	S	–	–	–	R	R	S	–	R
1972: World Cultural and Natural Heritage	R	–	–	R	–	R	–	–	–	R	R	R
1973: Trade in Endangered Species	R	R	R	R	R	R	R	R	R	R	R	R
1982: United Nations Convention on the Law of the Sea	R	R	S	R	R	S	R	S	R	R	R	S
1985: Protection of the Ozone Layer	–	R	–	R	R	R	R	R	R	R	R	R
1987: Montreal Protocol on Ozone Layer	–	R	R	R	R	R	R	R	R	R	R	R
1989: Transboundary Movements of Hazardous Wastes (BASEL)	S	–	S	R	R	S	R	R	R	R	R	S
1991: Ban on import of Hazardous Wastes into Africa and on Control of their Transboundary Movements (Bamako)	S	S	S	S	R	S	S	S	S	R	S	R
1992: Biological Diversity	S	R	R	R	R	R	S	R	S	R	R	R
1992: Climate Change	S	R	R	R	R	R	R	S	S	R	R	R
1994: Desertification	S	–	R	S	S	–	S	S	–	S	S	S
1995: Protocol on Shared Watercourse Systems in the SADC Region	C	R	R	S	R	S	S	R	S	S	C	S
1996: SADC Trade Protocol	C	S	S	S	S	S	S	S	S	S	S	S
1996: SADC Energy Protocol	S	S	S	S	S	S	S	S	S	S	S	S
1996: SADC Protocol on Transport, Communications and Meteorology	C	S	S	S	S	S	S	S	S	S	S	S

Key: R: Ratification S: Signature C: Considering

SOURCE: IUCN, *Status of Multilateral Treaties in the Field of Environment and Conservation; IUCN Environmental Policy and Law Occasional Paper* No.1, Third Edition, Bonn 1, 1993.
SADC-ELMS, *Proposed SADC Policy and Strategy for Environment and Sustainable Development*, SADC-ELMS, Maseru 1994.
Nagai, M, UNEP Environmental Law and Institutions Programme Activity Centre, Nairobi, personal communication, October 1995.

tion. There are also regional conventions which reflect collective efforts to set up institutional arrangements to solve common problems. These include the Protocols on trade; energy; and transport, communications and meteorology.

Most international conventions basically provide "frameworks" within which governments can work together in implementing new policies and programmes. The United Nations Convention on the Law of the Sea, ratified by eight of the 12 SADC countries, including four non-coastal states, is a case in point. Four of the six SADC coastal states have ratified and two are signatories to the convention which repeatedly stresses the obligation of states to cooperate on shared resources and such common problems as transboundary pollution. Mozambique and South Africa are the only SADC coastal states yet to sign the convention which came into force in November 1995. Four other SADC non-coastal states, Botswana, Malawi, Swaziland and Zambia, have also ratified the convention. The Law of the Sea convention has been described as historic in the "relationship between humanity and the oceans, and in the UN's efforts to set up a new world order based on respect for law".[22]

Regional conventions

The SADC Energy Protocol, signed by the leaders of all 12 member-states of SADC in Maseru in August 1996, provides for the harmonisation and integration of national and regional energy policies, strategies and programmes; cooperation in the development of energy pooling to ensure security and reliability of supply and reduction of costs. It also provides for cooperation in the development and use of energy in areas such as electricity, woodfuel, petroleum, new and renewable energy sources, and energy efficiency.[23]

The SADC Protocol on Transport, Communications and Meteorology provides for, among other things, the establishment and integration of transport, communications and meteorology systems to ensure an efficient, cost-effective and fully integrated infrastructure that promotes economic and social development in an environmentally sustainable manner.[24]

At different level, UNEP's regional seas programme divides the SADC region into two, hiving off Mozambique and Tanzania, and joining them with east African coastal states. Angola and Namibia are linked to the west African coastal states.

The West Coast is covered by two UNEP-brokered regional conventions:

- the Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment; and
- the Protocol Concerning Cooperation in Combating Pollution in Cases of Emergency.

There are two similar protocols for the East Coast. UNEP facilitates all these agreements. In the past, South Africa stood alone because of its long history of isolation from the region's mainstream political alliances.[25] South Africa is party to the London Dumping Convention which controls indiscriminate dumping of wastes at sea. It acceded to the LDC in 1978 and two years later incorporated the convention's principles into its local statutes under the 1980 Dumping at Sea Control Act.

In addition to regional seas conventions, there are several other joint projects including networks to combat fish poaching by foreign trawlers, staff training and environmental impact assessments of dynamite fishing on the marine habitats such as coral reefs. Both eastern and western coastal states now keep inventories of ecosystems and records of endangered species, and train staff on pollution monitoring.

There are also plans to strengthen measures to curb oil spills and contamination from heavy metals. South Africa is relatively advanced in marine research and has adequate facilities to handle oil spills. The rest of the region can draw on South Africa's experience and, already, neighbouring Mozambique has joint research programmes on shared fish resources off the east coast.[26]

Protocol on Transport, Communications and Meteorology Box 7.5

During the SADC Summit of heads of state or government held in the Lesotho capital, Maseru, in August 1996, all member countries of the Southern African Development Community except Angola signed, the SADC Protocol on Transport, Communications and Meteorology. Angola is still considering the Protocol which, among other things, commits SADC states to cooperate in protecting the marine environment.

Activities listed under the Protocol include:
- continuous creation of awareness in member states of marine environmental damage, cause and effect;
- preparation and implementation of oilspill contingency plans, including sharing resources;
- preventing and dealing with the dumping of toxic and nuclear wastes, sewage, dredger and land-based spoil, and other ordinary pollutants;
- combating erosion caused by depletion of coastal vegetation and fishing;
- upgrading facilities and developing capacity to prevent pollution and undertaking clean-up actions;
- monitoring the passage of vessels carrying hazardous wastes, including nuclear cargo around coastal states.

The Protocol also commits member states to develop a cooperation framework to:
- strengthen weather and climate monitoring systems;
- improve public and specialised weather services;
- promote sustainable development with the emphasis on climate change and protection of the environment; and
- strengthen meteorology research capacity in the region.

SADC member states are also expected to promote sustainable development, emphasising climate change and protection of the environment by:
- strengthening the capabilities of national meteorological centres in climate applications and advice;
- enhancing existing environmental monitoring activities;
- optimising the use of regional structures; and
- fostering an awareness of the contributions which can be made by national meteorological centres to planning sustainable development in agriculture, forestry and related areas.

SOURCE: SADC, *Final Draft: SADC Protocol on Transport, Communications and Meteorology*, SADC, Gaborone, July 1996.

Linkages to other chapters Box 7.6

PEOPLE

The success of the people of southern Africa depends on regional cooperation. Since water resources in each of the countries of the regionare unevenly distributed both at the national and regional levels, regional initiatives for the development and management of these resources are crucial.

CLIMATE

Climate has a significant effect on the water resources of the region. Therefore, cooperation in water-resources development programmes must be strengthened so that initiatives can benefit different communities of southern Africa.

ENVIRONMENT

Cooperation in regional programmes affecting environment, particularly insofar as water requirements by the environment are concerned, is of utmost importance. More and more the environment is being considered in water allocation among various sectors.

MANAGEMENT

The signing by most countries of the Protocol on Shared Watercourse Systems in the SADC region in August 1995 is an example of regional cooperation in the use and management of water-resources.

AQUATIC RESOURCES

The quality and quantity of aquatic resources depends on SADC countries cooperating in the use and management of those resources. Overfishing in one area has a ripple effect in other parts of the region, reducing their ability to utilise those resources.

POLLUTION

Cooperation in pollution-control programmes can only help improve the quality of life for people and sustain the environment's capacity to flush away toxic chemicals, polluting the SADC region's watercourse systems.

TRENDS

The environmental quality of the resources of the region in future depends on what is being done at present. As these resources are affected by human activities, the future state of the environment cannot be achieved through fragmented programmes. Regional approaches are required since water resources are either shared or could be shared.

NOTES
CHAPTER 7

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8 TRENDS and Scenarios

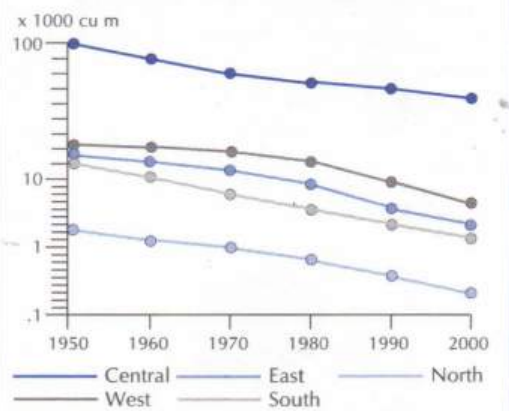
A common problem in southern Africa is one of a common resource: water. It is common knowledge that the region is drought-prone and suffers periodic water scarcity but it is not uncommon to see water wastage at every stage of its management. That is the root of the problem.

Water harvesting techniques are generally poor; the delivery system is wasteful; the pricing regimes are generally not cost-effective; consumption levels are high, particularly in urban areas; pollution control is generally ineffective; and actual management is fragmented, often among institutions with competing interests. The problem extends beyond water as a resource but to aquatic resources, both freshwater and marine. Southern African marine ecosystems are under seige due to overexploitation of fish stocks, localised uncontrolled discharge of sewage into rivers, lakes and oceans and dumping or accidental discharge of toxic or harmful materials both in rivers, reservoirs and at sea.

Despite the fact that water availability is variable both spatially and temporally, both in and outside national boundaries, there is a general perception, particularly in good rainfall areas, that southern Africa has abundant water resources. Studies show that the amount of water available annually to each person in southern Africa has been declining since 1950. The story is the same right across the African continent. However, water is more available in Central Africa and least available in the desert areas of the North. The amount of water available in east, and southern Africa is about the same. West Africa alone has about 10 percent more water than that available in southern Africa, "a rather gloomy picture for the region which calls for increased efforts to reverse this trend".[1]

The belief that good rains mean abundant resources has led to complacency in the management of the ever-dwindling resource in southern Africa, draining the capacity of communities to make full use of the little that is available.

Water availability in Africa per person per year Figure 8.1



SOURCE: Sichingabula, H., "Review Comments: Trends & Scenarios", for SARDC, 1996.

Perhaps Mutare, Zimbabwe's link to Beira on the Mozambican coast can best illustrate such illusions that more rainfall automatically translates into abundant water resources available for human use. The city suffers chronic water shortages despite its location in an area which receives more rain than Bulawayo in Matabeleland North province, one of the driest parts of Zimbabwe. Mutare, whose average annual rainfall is 791 millimetres (mm) compared to Bulawayo's 597 mm,[2] faces water shortages despite its smaller population estimated at 144,200 in 1995 than Bulawayo whose population was 682,200 in the same year.[3]

Today, both cities have one major issue in common — they are planning massive water-projects to augment dwindling supplies. Mutare has embarked on a US$60-million-project[4] to draw water from the Pungwe river while Bulawayo is interested in drawing water from the Zambezi river, about 470 kilometres away, under a project estimated to cost US$200 million.[5] The Pungwe project has received the green light from government but the Zambezi river project is still a proposal. Its future is still uncertain, yet the project was first proposed in 1912.

Written records dating back over a century show that droughts have regularly afflicted the region, while geological evidence shows recurring droughts dating back centuries. The scourge of drought in the region is no different today, although it is generally believed to be worsening. Data show that in southern Africa rainfall of the early 1990s was about 20 percent lower than that recorded in the 1970s. The 1991-92 season was the second driest year on record, after the 1921-22 season.[6]

This is evident in newspapers reports. Both small and large newspapers of the region devote many columns of print annually to water shortage and drought, and their attendant impact on people and wildlife. In the majority of cases, these articles are a montage of a region at the mercy of the vicissitudes of climate. While this may be true to some extent, it is within the power of countries in southern Africa to manage their water resources wisely, to plan better for the years of water scarcity, and to minimise the impact of drought on people, fauna and flora, economic activities, such as agriculture and industry, and the environment.

Planning for the future means looking back into the past and assessing the present to determine both the positive and the negative aspects of managing the region's water resources. It also means building upon the strengths of today and discarding those practices that waste resources. Factors which are crucial for the sustainable use of water and need consideration in developing future strategies include:

- growing demand due to population growth, improvement in the standard of living and economic development;
- establishment of water supply infrastructure which is influenced by the availability of water and demand; and
- legislation, policies, regulations, institutions and investment which support the effectiveness of water resources management.[7]

Photo 8.1 and 8.2 SARDC-M Chenje

In Botswana, where water has been a precious resource for thousands of years, villages often have their own water tanks and water-conscious rural schools place tanks to harvest rainwater from the gutters.

CURRENT TRENDS

Water availability and distribution

SADC's two major river basins are the Zambezi, which has been primarily harnessed for hydroelectric power generation, and the Orange, a major supplier of industrial, irrigation and potable water in South Africa.[8] Other important river basins include the Save, Limpopo, Okavango, Ruvuma and Cunene. The mean annual renewable water resources for southern Africa are about 1,870 cu km per year, of which more than 80 percent is available in the Congo basin, most of which is outside the SADC region.

In addition to these river basins, the region boasts a number of large lakes such as Victoria, Tanganyika and Malawi. The largest artificial lake is Kariba. There are also a number of wetlands which support various species of wildlife, some of them endemic to the region.

The region also commands a 9,870-kilometre coastline, stretching from Tanzania on the east coast, around the Cape in South Africa to Angola on the west coast. The region has four marine ecozones — the warm east coast, the temperate Agulhas Bank, the cooler Benguela current along the west coast and the warm Angola coast which are rich in marine living resources.

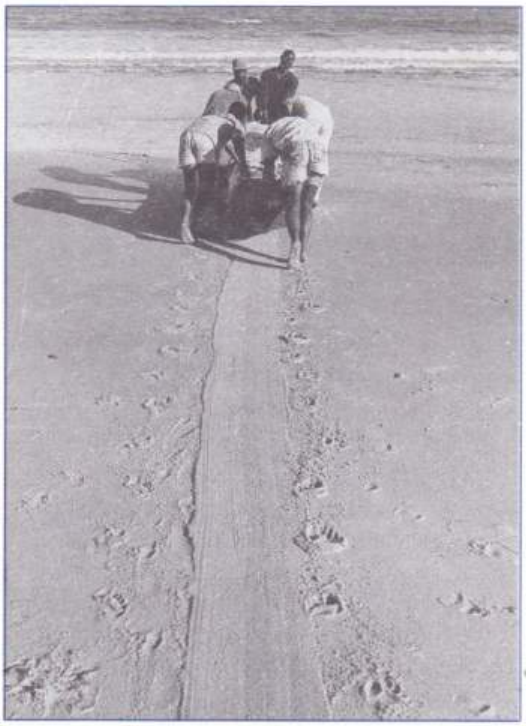


Photo 8.3 PTC, MAPUTO

The SADC region has four marine ecozones, rich in marine living resources.

Climate

Present experiences in the region have been dominated by erratic rainfall regimes, culminating in droughts that have drastically reduced agricultural production in many countries, forcing them to import food and other items. Cash crop production has also been poor during these times, necessitating excessive borrowing by SADC countries to make good for the shortfall.

Climate change

Climate change and variability will have a pronounced impact on the development of the region, particularly on those economies which depend almost entirely on agriculture. In the event of rising temperatures, consequences for regional water resources could be devastating. Under such circumstances, it is feared that systems such as the Zambezi basin would be severely affected because with only small increases in temperature, large additional amounts of water would be lost through evaporation.[9]

The water levels of large lakes such as Lake Malawi confirm this fear. The lake had no outflow between 1915-1935. If this phenomenon were to be repeated over a prolonged period, the consequences for hydropower generation, fisheries and water supply would be disastrous, and the general environment would be significantly affected.[10]

Global climatic changes may seriously affect the hydroclimate in the region, but the effects are difficult to estimate, particularly when national or regional water development projects are planned

for implementation. Even where rainfall and surface water have been used as traditional sources of water for agriculture, attempts to revert to groundwater would be a short-term solution because the availability of groundwater depends on rainfall and recharge. If this is reduced as a result of a change in climatic conditions, the water table will be further reduced due to increased demand.

Drought

Variability in climate has already had an impact on the region. The droughts of 1992, 1994 and 1995 caused severe constraints to water supply for agriculture, industry and for domestic consumption. Drought impacts on the economy, and while detailed and exhaustive studies need to be carried out in relation to global climatic conditions and trends, recent research using general circulation models seems to suggest a dominating influence of the greenhouse effect toward global warming. The warming of the globe is likely to have a large effect on the hydrological cycle, changing precipitation patterns and river runoff regimes, and causing excessive evaporation rates.[11]

In times of drought, severe water shortages occur. Domestic, industrial and other water demands may remain unsatisfied. Yet elsewhere, rivers continue to flow. Therefore, additional investment in water supply infrastructure may be required to transport water from areas of abundance to those of scarcity. During periods of heavy rainfall, most of the water is left to flow downstream and finally to the sea, unused. However, if impounded behind dams, these waters could be used during periods of water scarcity.

While the socio-economic development of the region is strongly tied to water availability, changes in precipitation and runoff would impact heavily on the region's water resources, influencing changes on existing systems such as reduction or greater variability in reservoir levels. In a region where water availability is anticipated to fall to 3,000 cubic metres per year, per capita, by the year 2000 and already well below the global average, relatively small climatic changes can cause large water-

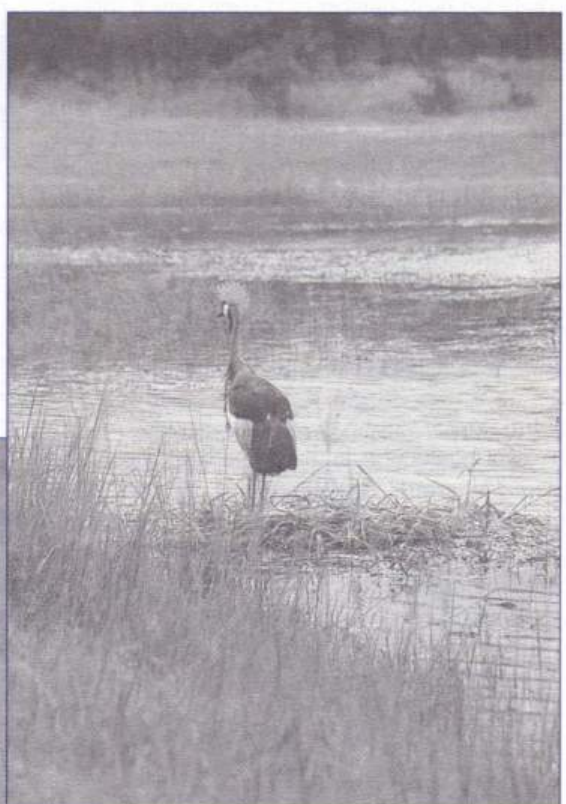


Photo 8.4 and 8.5 APG-D Martin

Ecosystems in the region support a variety of wildlife species, many of them endemic to this area.

SADC faces water woes Box 8.1

Severe water shortages are likely to afflict much of southern Africa by 2050, causing poverty and child malnutrition to mushroom, a US research group has said.

Ruth Meinzen-Dick, a researcher with the International Food Policy Research Institute (IFPRI), released a document at the world food seminar in Johannesburg predicting that South Africa and Lesotho will experience "severe" drought and water constraints by 2025, with Tanzania and Zimbabwe reaching a similar point by 2050.

"Action needs to be taken now if water resources are to facilitate, rather than constrain economic development and food security," says Meinzen-Dick.

A separate IFPRI report released at the conference predicts that the number of malnourished children in sub-Saharan Africa will increase by 50 percent to 43 million by 2020. Cereal imports are projected to increase by two-and-half times by 2020, according to Meinzen-Dick.

She paints a picture of southern African countries being forced to restrict and manage access to water-resources, either through government legislation, regional agreements or market restrictions. Increased irrigation could solve some of the region's food problems, she says, but will not transform its capacity to grow crops.

"Expansion of irrigation has slowed in southern Africa, while demand for food and water continues to grow rapidly," she says. Currently farmers irrigate less than 45 percent of the region's potential.

A relatively new demand being placed on water use is the environment, she says, with South Africa, Botswana and Zimbabwe increasingly using water sources to protect wilderness areas.

SOURCE: Ziana-AFP, "Region to face severe water woes, says report", *The Herald*, Harare, 25 June 1996.

resource deficiencies, especially where demand and pollution have led to scarcity of potable water.[12]

A rise in temperature would increase evaporation and, cause a reduction in the water levels in rivers, streams, lakes and dams. The moisture content of the soil would be reduced and would affect the agricultural industry, especially in dryland crop farming and irrigation.

Although fluctuations or a decrease in reservoir levels may become a real cause for concern in the medium- to long-term, it has already been observed that the water levels are slowly decreasing in the majority of rivers and lakes. Lowering of water levels and decline in runoff of streams and rivers in the region leaves little room in satisfying the ever-increasing water demand with a diminishing resource. Different ecosystems will be unable to support their diversity of species.

While studies show that climate change may have adverse impacts on countries in the SADC region, there are also indications that the region could derive some positive spinoffs from such change. It

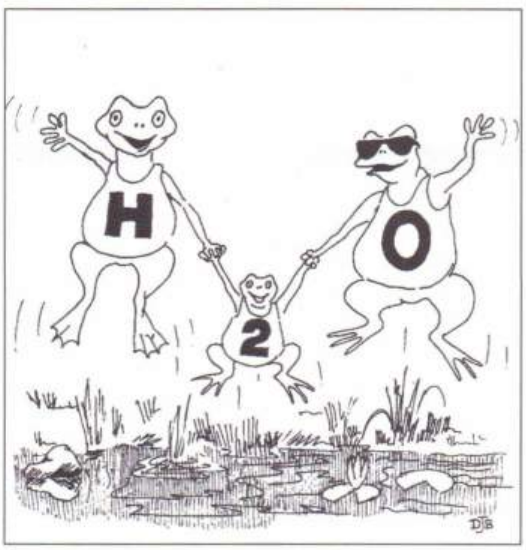
is assumed that climate change would promote an increase in sardine and anchovy distribution and quantities, particulary along the west coast off Namibia, guaranteeing large stocks of harvest from the sea.

It has also been deduced from recent research[13] that a 1.7 °C rise in global temperature would yield varying results for southern Africa as seen from different scenarios. Under the "wet" scenario, the SADC region would become wetter, eliminating the scourge of periodic drought periods. There would also be an increase of grassland and forest biomes under this scenario.

While a wet southern Africa with increased forest and grassland cover would be a welcome change to the region, the overall tilt of balance between the advantages and the disadvantages of climate change and global warming, is perhaps still an issue for further debate.

Floods

During years of good rainfall, precipitation in some of the countries of the region has been extreme, resulting in floods that have devastated the countryside, sometimes causing loss of life and property. In Mozambique's Nampula province, for example, floods caused by cyclone Nadia in March 1994, left 52 dead, 316 injured and 903,000 people lost their crops and their homes were destroyed. The floods also disrupted 95 percent of the province's energy supply, and water supplies were suspended for more than a week. The total damage was estimated at US$20 million.[14]



Ill. 8.1
Floods bring plenty of water but cause other environmental impacts.

The impact of these extremes, generated by the prevailing climatic conditions, has left behind a significant trail of other environmental effects that call for attention. Notwithstanding the bountiful supply of water during floods, severe erosion may occur with flooding. The degree of land degradation through erosion is associated with the level of vegetation cover which in turn is influenced by human activities. Huge floods sweep the land surface carrying with them large loads of sediments, which eventually end up and settle in dams, rivers and other wetlands. In Lesotho, for example, more than 220 of 590 dams were found to be silted up. A survey in 1994, showed that 16 of the 755 reservoirs recorded in Malawi were completely silted up.[15] Severe siltation reduces the space meant for water storage, shortening the economic life of the dam.

Population growth

The sustainable utilisation of both freshwater and marine resources is threatened, among other things, by the region's population growth; the average rate is about three percent annually. The SADC population is expected to grow from about 140 million in 1995 to about 292.6 million by the year 2025, contributing about 18.5 percent to Africa's population which is estimated to reach 1.58 billion people[16] by the same year.

By world standards, current water consumption per person in southern Africa is low. In many countries in the region, people get by on much less than the UN World Health Organisation (WHO) target of 50 litres per person per day. The increase in population means an increase in water use for domestic purposes, industry and agriculture.

Human activities

People are responsible for the struggle toward dominance over the natural environment that supports their needs.[17] This dominance gains more and more magnitude as human populations increase while seeking survival through finite resources. In the process, human activities have included the use of fire, cultivation, livestock husbandry and others which, through poor management, have led people to overexploit the very base of their existence.

The consequences of poor resource management are far-reaching, including global changes in climate, land degradation and water pollution. While the only available water resources require proper management, pollution reduces the available amount that can be put to use. Hence there is apparently an inverse relationship between demand requirements and water availability since population is increasing and water is constantly being mismanaged and its quality being reduced.

Some of the countries in the region have high population densities in areas where water resources are scarce and inadequate to satisfy the demand. This calls for the development of capital-intensive water-supply infrastructure to provide water for agricultural, domestic, industrial and mining purposes. Population growth is a major constraint to sustainable water supply. More people need more water while the resource base can only yield a finite quantity. Concentration of people causes land degradation, increases pollution and ultimately exposes a large number of people to diseases, especially when proper water and sanitation facilities are not available.

Domestic use

In some countries of the region, such as Angola, Mozambique, South Africa and Zambia, the rate of urbanisation is very high. Both South Africa and Zambia are endowed with significant mineral resources, which are being mined and entice rural migrants into urban areas to look for jobs. Migration to urban centres is a result of the inability of rural land and resources to support rural people who are forced to migrate to urban areas in search of new opportunities.

However, in the case of Angola and Mozambique, rural-to-urban migration has been the result of civil conflicts, and high concentrations of migrants occur in the majority of urban centres. In both cases, whether high urbanisation has occurred as a result of job-hunting or war, it has meant additional stress on water in the urban areas. The population would normally be highly concentrated in the peripheries of urban centres especially in the high-density housing areas, in mining areas, in coastal areas, and along watercourse systems for easy access to water.

Since urban areas generally provide higher living standards as opposed to rural areas, migrants to urban centres wish to achieve the same levels of living standards as their hosts and put an extra stress on demand for water. The demand for water in the urban areas, involves requirements for swimming pools, watering gardens and lawns, flush toilets and per capita requirements for washing and bathing among others. With continued development of the region, and without taking due regard of the factor of rural-to-urban migration, and particularly to the reasons which cause this translocation of people, demand for water is also certain to increase.

Agriculture

Irrigation

A large percentage of the available water in the region is used in agriculture, for irrigation. For example, South Africa, the region's largest irrigator, produces 30 percent of the value of its agricultural production through irrigation. About 60 percent of the total amount of water used in the region — almost 20 cu km of water in 1993 — is used for irrigation.[18] According to the World Resources Institute, between 1900-2000, agricultural water consumption will have grown sixfold to 3,250 cu km,[19] almost double southern Africa's mean annual renewable water resources, of about 1,870 cu km, annually. Irrigation in southern Africa is expected

Extrapolating the present trends into scenarios Box 8.2

The state of marine and freshwater resources in southern Africa is a subject of constant debate inasfar as their quality and quantity is concerned. In a situation where the region's population is increasing, there are definite areas of concern such as climatic variability, and poor land-use practices that indirectly affect the quality of water resources.

Pollution from agriculture, industry and poor sanitation facilities is a threat to the quality of the already scarce water resources and ultimately the quality of life. The general imbalance between demand and the need for expensive water-supply infrastructure, places a heavy burden on the economies of the region.

In dealing with a life-sustaining resource such as water, it is critical to extrapolate the present trends and come up with scenarios which show how a number of variables may affect the quantity and quality of future water resources in the region. It is also useful to consider how the people of southern Africa can be mobilised to meet the challenge of altering the course of the "boat" in which they are sailing together.

The scenarios set here were arrived at during a workshop of southern African experts whose aim was to categorise aspects that affect water resources in the region and provide non-prescriptive guidelines to try to address poor management practices. The workshop was attended by experts from eight of the 12 SADC member countries, with background and specialisation in communications, hydrology, hydrogeology, water quality, fisheries, ecology, climate, geography and economics.

The initial task of the experts was to identify and define those variables that affect water resources and, in each case, the positive and the negative impacts on water quality and quantity were discussed. In each case, this spectrum of scenarios was focused to the future, and the resultant effects on water resources predicted and analysed. Suggestions for possible courses of action were also outlined.

The workshop identified three major areas that require the attention of consumers and all involved in water management. These are:

Demand for water
Supply of water, and
Management of water and water-related resources.

In discussing demand for water, the following variables were identified as affecting water resources at the moment, and would in future:

- Population, with special reference to
  population growth
  population distribution and density
  living standards
  sanitation
  urbanisation.
- Industrial growth, with special reference to
  mining
  manufacturing
  tourism and recreation
  power generation
  navigation.

- Agriculture, which would be affected by
  resource unavailability for
  irrigation
  aquaculture
  livestock industry
- Ecological zones, particularly affecting
  wetlands
  forestry
  grasslands and rangelands
  wildlife and fisheries.

Under those aspects that affect water supply, the following were identified as being critical to the availability of water resources in the region today and in the future:

- Climate change and variability as it would affect
  lake and reservoir levels
  river discharges
  evaporation
  soil moisture content
  sea level
  groundwater
  flora and fauna, both terrestrial and marine.

It was, therefore, necessary that the twin aspects of demand and supply be weighed; and a third position was to consider management issues that would improve upon the availability of, and access to, water in the region.

- In dealing with management issues, the following were highlighted:
  family planning
  settlement patterns and urbanisation
  appropriate policies
  water-pricing structures and tariffs
  technology choice
  legislation
  participatory mechanisms
  regional cooperation.

These challenges require most immediate attention through better planning in areas that affect demand and supply as well as consolidating regional initiatives in water resources conservation and management.

SOURCE: Scientific Advisory Committee, Trends and Scenarios Workshop, Maseru, September 1995.

to expand as countries in the region try to grow more food to meet the needs of their increasing populations. At present, about 60 percent of the water used in irrigation is lost through evaporation and seepage, not only throwing away a valuable resource, but causing serious environmental problems. These include soil degradation through salinisation and waterlogging, which can harm or kill crops and other plants and ultimately take land out of production.[20]

Industry

Southern Africa has both large and small industries which contribute to the region's economic development. The region has different types of industries, ranging from those that produce fertiliser, textiles, chemicals and different manufactured goods to pulp-and-paper plants, slaughter houses and tanneries. Southern Africa has rich reserves of unexploited natural resources. The present level of industrial development in a majority of the countries of the region is still small compared to world standards. However, as economic development picks up in the region, it is expected that industrial growth will increase, including requirements for manufacturing. This growth in industrial activities

Photo 8.6 APG-D Martin
Large and small industries contribute to the region's development.

will exert added pressure on demand for water across the region. The general economic trend in the region is slow growth with population rising quickly, ahead of the growth in industrial development.

Manufacturing and service industries are the primary sources of pollution, producing millions of tonnes of effluents. Water is the usual recipient of industrial pollution because disposal of wastes into water bodies is wrongly considered as cheap and convenient by the polluter.

For mineral-rich southern Africa, mining is another source of water pollution. After the extraction of minerals, toxic substances remain in waste-rock powder which is deposited in the tailings at the mine-site. These toxic materials can contaminate rainwater or other sources of water if not managed properly. In South Africa, a mining company, Grootvlei Gold Mine near Springs on the East Rand, was banned in May 1996 by the Ministry of Water Affairs for pumping 100 million litres of contaminated underground water per day into a nearby wetland.[21] The decision has outraged organised labour as about 2,000 miners stand to lose their jobs. Such conflicts — the environment over economic growth — are becoming more common in the region.

Energy

Much of the high hydropower potential found in the major rivers in the region remains unexploited and if developed, could most probably satisfy all the energy needs of the SADC states. However, for hydropower generation, the limiting factor will be water availability.

In the event of diminishing water resources in the major drainage basins due to climatic conditions, or the increase in consumptive use, the production potential of existing or new hydropower schemes is likely to be affected. Since so many of the countries in the region depend so much on woodfuel for their energy needs, there is certain to be pressures to develop the potential sites for hydropower generation on the major rivers. Malawi, Mozambique, Tanzania and Zimbabwe rely on woodfuel for curing tobacco, one of the cash crops of these economies. In Malawi, tobacco estates consume a quarter of all fuelwood used,[22] while in Zimbabwe, an estimated 700 sq km of woodland are cleared each year to grow tobacco.[23] While this industry grows, alternative energy sources need to be made available to farmers, so as to stop deforestation and land degradation to protect the river basins which collect the waters needed for survival. The creation of the regional power pool linking countries with higher hydropower potential with those with limited or no potential, will cut down the use of fuelwood as a source of energy, reducing deforestation.

Ecosystems

Reduced water availability in the region is likely to have a marked impact on ecosystems. Flora and fauna often adapted to various levels of temperature, water, humidity and other characteristics. Changes in any one of these can produce unfavourable conditions for particular species. Organisms will migrate to new areas, leaving behind an environment that, perhaps, will be

colonised by new plants and animals. Terrestrial water may be influenced by:

- altered regional precipitation and evaporation patterns;
- shrinking freshwater storage reserves in areas of minimum precipitation, especially groundwater;

Overexploitation of freshwater and marine resources will reduce the available supply of harvestable resources such as fish, through lowering the reproductive potential of the resources. At the moment, many of the living marine resources are maximally exploited, leaving little potential for increased harvests except for some pelagic species off the south-east coast. There is, however, considerable scope for non-consumptive utilisation of some of the living marine resources such as whales, sea birds and seals for ecotourism.

Marine

A set of scenarios have been described for the southern African marine environment in the event of global warming.[24] A change in the temperature gradient between the equatorial and polar waters is projected. This may influence location and intensity of winds, of upwelling zones and the strengths of currents. It could result in increased frequency of Benguela *Nīnos,* which transfer warm water to the Namib coast, causing stratification of water, and reduced nutrients and productivity.

More frequent Benguela *Nīnos* may favour a sardine dominated pelagic system off Namibia, as occured in the 1960s.[25]

The "zero wind-stress curl" south of the continent may shift poleward, decreasing the volume of water transported by the Agulhas current and affecting the southern Benguela region. These may lead to coastal water becoming warmer, less turbulent and better stratified, off South Africa's west coast, with decreased offshore advection. As a consequence, the supply of nutrient-rich water may decrease, causing a drop in primary fish production. However, there may be better survival of fish eggs, for example.[26]

Scientists also think there may be a possibility of increased surface water temperatures which would expand or restrict the ranges of species, depending on their preferences.[27]

Water and resource management

In a situation where population and industry are certain to expand, a balance must be struck between the demand for water and its supply. Water scarcity in southern Africa may not be the problem, but rather what must be done with the available resources to make them accessible to those who do not have water in adequate quantities.

Governance

Social and political tranquillity in southern Africa has an important impact on the state of the resources in the region. Civil strife in Angola, South Africa and Mozambique, has seen the destruction of terrestrial and marine resources. This has also led to the neglect in managing these resources for the benefit of the economies of Angola and Mozambique, particularly through the total collapse of the structures that would otherwise have been responsible for this task.

Under a stable political environment, laws and regulations are more likely to be followed and adhered to. There is more chance for public participation in programmes that aim at conserving water and other resources. Institutional arrangements at the moment, at both national and regional levels, seem to call for improvements. At the national level, there is usually the need for sufficient allocation of resources, both financial and otherwise, including capacity to monitor resource availability and adherence to applicable laws. Similarly, there is also need for more examination of the quantities and quality of the region's water resources, and seeking means to satisfy demand at that level. The region's water laws need to be complemented by national water masterplans which give direction to the phased development of the resource. To meet water demand, laws need to provide for water pollution control, right and access to water, prioritisation on allocation, conflict resolution, monitoring and control.

The natural environment is the base for sustainability Box 8.3

Sustainable environmental management is intricately linked to the sustainability of the people. Water management strategies, therefore, need to address the issue of equity as a component of sustainability.

The natural environment should not be seen simply as a competitor on water resources. Instead, water management must recognise the principle of environmental integrity. It should also acknowledge the environment as the base from which the resource emanates and without which no use and development can be sustainable.

Presently, water management is not seen as part of the wider ecological process. Instead, it is seen simply in terms of direct human interest. While there is a duty to purify water, there is no obligation on industry in southern Africa to return the water to source.

Environmental factors are only a secondary consideration in legislation. The environment is portrayed more as a competitor for a vital resource than as an integral component of the resource's production, maintenance and reproductive capacity. Economic use is currently seen as the priority.

The legislation and the water courts adopt the attitude that every drop of water should be put to use in industry, agriculture, and cities. However, sound economic management is not achieved, as the resource is inadequately valued. The productive value of water is not established and water is essentially treated as a free commodity.

Given the cost to the environment and accumulated costs to future generations as a result of contemporary use patterns, it seems appropriate to consider the extension of rights to environmental resources to abate this trend.

This approach recognises the right of natural resources to survive independently of the human interests and moves away from the crudely anthropocentric view that has characterised natural resource exploitation. As a result of the overexploitation of water resources many once perennial rivers in southern Africa have become seasonal, placing massive strain on riverine biota and riparian vegetation and ecosystems.

The institutional framework is important for the effectiveness and appropriateness of environmental and natural resource management because it affects planning and the implementation of law and policy. Legal reform is, therefore, an aspect of institutional investment.

Where punitive measures are used to regulate use, they need to be designed in such a manner that they have the desired impact. Fines are meaningless where it is easier for the offender to pay the fine, than to change behaviour. A system of punitive measures can only be effective where there is the institutional capacity to monitor practice and enforce the regulations. Cumulative fines need to be considered as an option.

Further, the preventive or punitive measures should not only make an impact on the user

but also on the user community. Such an impact may be seen as a deterrent or disincentive. Increasingly, there is a recognition that environmental laws need to move away from criminal sanctions particularly where the country lacks the ability to effectively enforce them. Moving away from coercion and subjugation to ensure sound environmental practices involves using the law to create new incentives. At the crux of this is giving individuals and groups a direct and short-term stake in resource conservation.

Creating incentives for industrialists, to monitor and mitigate their impact on the environment, involves giving them an interest or benefit for doing so. Since industrialists' primary motivation is profit, the obvious starting point is fiscal incentives. This attempts to correct economic practices which not only pollute water but also damage the environment. Related to this, is creating effective and efficient production procedures to lower the cost of production and increase the profit margin in the long term.

Although subsidising abatement measures by the responsible public authority may have the same effect, it has more problems. The water polluter's only incentive is to reduce pollution to the value of the subsidy. When the cost of pollution reduction exceeds the subsidy the incentive is removed. A further problem is that the taxpayer pays for the subsidy. The subsidy may be misused unless there are appropriate mechanism to monitor its use.

SOURCE: Mohamed-Katerere, J., "Access to Water: Right or Privilege — Water Management in Zimbabwe, for SARDC, 1995.

Photo 8.7 APG-D Martin

A slackening in trade-wind intensities would influence the habitats of different species of marine life.

Regional Initiatives

The current strides by southern African countries to strengthen cooperation among themselves is a positive step that should see better resource use and management. Cooperation in the management of the region's biodiversity gives impetus to the preservation of the resources for the benefit of future generations and more so as a guarantee for secured supply that can satisfy the rising demand.

The recently signed Protocol on Shared Watercourse Systems in the SADC is a clear manifestation of greater cooperation in water programmes that are likely to benefit a majority of the inhabitants of the region. This is certain to be enhanced with the establishment in August 1996 of a SADC sector specifically dealing with water.

International initiatives

The countries of the region are signatories to a number of conventions and treaties which directly or indirectly address various water-related issues. By being signatory to these conventions and treaties, SADC countries stand to have a common voice on issues that concern them. It seems, therefore, that cooperation in the region is gaining strength and this needs to be encouraged.

A VISION FOR THE FUTURE

Water availability and distribution

The challenge for the future is to balance the demand for water with the available supply. As it is not possible to increase the amount of the region's water resources, alternatives exist to satisfy demand in both urban and rural areas with the available resources, so long as appropriate management mechanisms are adopted and implemented.

In soliciting these approaches, regional experts of southern Africa considered in September 1995 the present and future challenges that the SADC region faces with respect to availability of water resources. They then provided some directions that should be followed in the management of the region's water resources for the benefit of both present and future generations.[28]

Climate

Global climatic change is a world-wide concern and is likely to impact adversely over southern Africa. Climatic change would induce increased summer temperatures that could lead to the shortening of the growing season due to lengthened dry seasons. Studies done on climatic change in Zambia, further indicate that there would also be a north-bound shift of crop-growing zones leading to crop failures due to increased frequency of drought in the north.[29] These scenarios indicate that there would be increased adverse effects on water resources leading to increased frequency of droughts and possible onset and advance of desertification. Forest fires would be frequent.[30]

Since global warming is a universal problem, it calls for universal action by reducing the emissions of carbon dioxide into the atmosphere which, along with nitrous oxides, methane and ozone, contribute to the greenhouse effect. While studies done on long-term climate change indicate a rising trend of carbon dioxide in the atmosphere, this condition should indicate the need to take appropriate and urgent steps to reverse this trend. With increased droughts in southern Africa, water scarcity would be worse, particularly in those countries of the region which are semi-arid.

Human activities

Apart from the effects of climatic change and variability on water resources, consideration should be given to the impact that water scarcity would have on development. Almost all the countries in southern Africa rely heavily on groundwater although such dependence would be true for specific areas of each country.

In Botswana and Namibia, for instance, groundwater has been the main source of water supply with the exception of the urban centres. In Botswana, urban centres such as Gaborone, Lobatse, Francistown and Selibe-Phikwe get their water from surface sources[31] while the same applies to cities such as Windhoek, Rehoboth, Gobabis and Keetmanshoop in Namibia.

In other countries of the region, groundwater is the main source of water in rural areas and for irrigation and other uses. In Zimbabwe, poor rainfall years cause water-tables to fall, leaving many schools and clinics which depend on groundwater sources without water. In southern Zambia, poor rains have in the past led to the lowering of water-tables, drying up many small wells and reducing flows in permanent rivers.[32]

Excessive abstraction of groundwater resources can severely lower the water-table, causing salt-water intrusion and in extreme cases, destroying an aquifer. The general effect is that once there is salt-water intrusion, it is extremely difficult to remove the salt and, therefore, the aquifer is permanently damaged, polluted or contaminated. Similarly, overabstraction of groundwater may lead to the collapse of an aquifer also permanently destroying that water source.

Large development projects also influence changes in the microclimate, the climate of a very small area such as a field. The creation of large artificial lakes such as Kariba and Cahora Bassa, both on the Zambezi, has had an impact on the local climatic regimes of these areas.

To the present day, it is evident that water-related development projects have been initiated and implemented without due regard to the value and amount of the resource in the region. As part of future strategy for environmentally sustainable development of water resources, there is a need for:

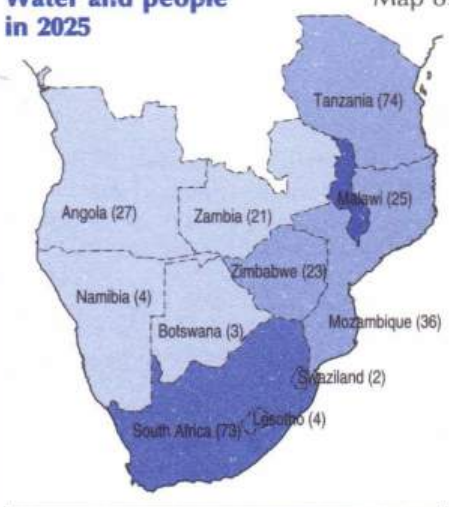
- water resources to be managed at the lowest appropriate level since centralised top-down management has often proved inadequate to address local water-management needs and fails to involve local communities; and
- water to be considered as an economic good where its value reflects its most valuable potential use.[33]

Population

Present population trends imply ever-increasing needs for land on which a large section of the region's population depends. With less land available, it is anticipated that people will start accessing or overutilising wetlands for water and agriculture. Until now, these wetlands have been left relatively undisturbed. Encroachment into them will significantly affect the natural conditions of these ecosystems, including their flora and fauna. As a consequence, it is expected that there would be further decline in water availability and other resources to the disadvantage of the region.

The above negative trends are a direct result of the ever-increasing demand to exploit the natural resources and the environment on which people rely. This need for resources, is justified in as much as humans are supposed to use the available resources in a sustainable way to maintain their existence. Yet, it is more sensible to make prudent decisions to prevent overexploitation and preserve the present resources which should also support future generations.

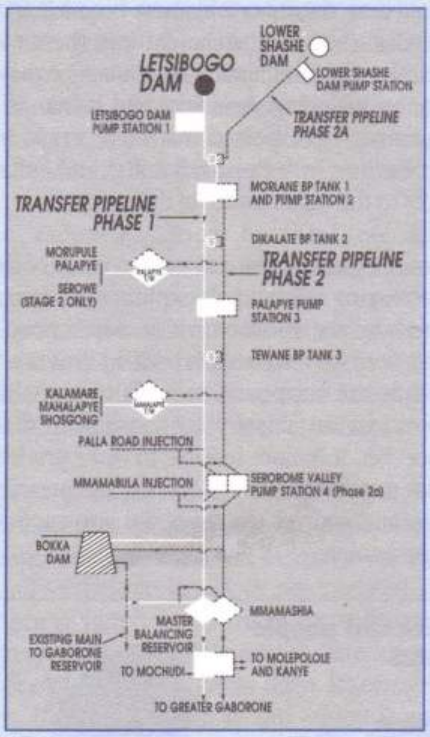
Water and people in 2025 Map 8.1



Figures in brackets refer to the estimated population (in millions) according to the UN medium projection.

SOURCE: Fruhling, P., *A Liquid More Valuable Than Gold*, Sida, Stockholm, 1996, p.33.

Water for Botswana Box 8.4



Ill. 8.2

Botswana's North-South Carrier Water Project, which is scheduled to start delivering water to the dry south by 1999, is already affecting water supply.

Already, because had the project not been under way we would probably have water restrictions in Botswana right now. And this in spite of the recent record rains. There will be no water rationing in 1996, and the position will be reviewed after the 1996 - 97 rainfall period, and again on a yearly basis.

In order to plan for any supply, you have to be able to forecast demand. Thus the growth in Botswana's water requirements has been forecast for a 20-year period, in the first instance. This forecast was arrived at by means of a computer model, or rather a series of models, which allows for economic factors, population growth, agricultural developments, construction and industrial requirements, and various other components. Planning was then based on the medium forecast. This forecast is, however, updated, monitored and modified on a continuous basis, and the reason for this simply is that if estimates are badly out and we experience another severe drought, its consequences could be too disastrous to contemplate. ...

Phase I of the project should cater for demand up until the year 2005. But obviously planning for catering for demand from 2005 onwards has to be completed long before that date, so that increased supply can be available when needed. So after Phase I will come Phase II, and Phase II is divided into IIA and IIB.

The planned Phase IIA is a dam on the lower Shashe river, at Polometsi. A new 100-km pipeline would carry the water to link up with the Phase I pipeline. An additional pumping station would be called for, or possibly two. The diameter of the first (Letsibogo to Gaborone) pipeline was originally sized so as to cope with the increased flow.

Phase IIB calls for a full second pipeline, a duplication of the first. This would double the volume of water supplied from the two dams, and this eventuality is seen as being needed between the year 2010 and 2013. The combined capacity of the two dams should meet the forecast demand until the year 2020.

Planning for Phase IIA would have to be completed some four years before delivery date. That is, our present schedule, planning will have to be completed by 2001 in order for the Polometsi Dam and the new 100 km pipeline to be delivering water by 2005. Now suppose planning is completed by 2001 but we then find that we don't have the necessary four years needed for implementation. Now what? There is a contingency plan.

Provision has been made for existing groundwater resources to feed the system at Pallo Road and Mmamabula. The aquifers at these locations could be tapped, quickly, but this is seen as last resource, and for as short a duration as possible. The reason for not utilising these resources is that they are generally regarded non-renewable, so if we do use them we have left ourselves with zero back-up.

Now another variable comes into the equation. Waste water. Recycled water. Two considerations arise in respect of recycling water. The first consideration is that of acceptability. It seems that there is a natural repugnance to the very idea of recycling water. The repugnance, however, is a luxury we may well have to discard. The second consideration with regard to the question of recycling, is its economic viability. At present this question remains unanswered. We do know that if we should recycle only one-quarter of our waste water, we could postpone the implementation of Phase II of the NSCW Project by between five and eight years.

Untreated effluent is not supposed to be discharged into natural drainage systems at the present time, but it very often is. Current legislation requires that effluent should be treated so that its quality level is equal to that of the river, seepage or dam into which it is discharged. So if we have to do some of the treatment anyhow, then perhaps it will be economically viable to go the whole way.

The year 2020 is critical, on the basis of current forecast, because that is the year that supply equals demand — remembering of course, that the waste-water recycling factor could significantly impact on this date. Without recycling and leaving aside the question of possible emergency recourse to groundwater, in that year, when supply and demand are equal, there will be no provision for increased demand. Unless there are more plans. ...

There is another major variable. Botswana isn't the only African country that must look to existing and future supplies of water. Zimbabwe has the same concern. So does South Africa. Zimbabwe will need to draw water from the mighty Zambezi river, probably by the year 2005. South Africa needs to search continuously for new supplies. The Zambezi basin offers the potential for the development of one of the world's great water-schemes. Zaire has immense reserves of surplus water. If Botswana should in the end find it impractical to participate in some such regional development, it would have to look to the Chobe river. But water supply is one area in which it is to everyone's benefit to participate in regional development.

As North-South Carrier Water Project Coordinator Moremi Sekwale points out, this kind of regional cooperation over development in areas of common interest would not be setting a precedent. Already there is cooperation and joint ventures in the field of telecommunications and electrical power supply.

The more stable political climate in recent years facilitates these moves toward interdependence and common interest. It is certainly not impossible that Botswana's longer term planning for water supply will become integrated with that of other countries in the region. If this materialises, then it might well be the scenario for Phase II of the North South Carrier Water Project would come up for reappraisal. Time will tell.

SOURCE: *Marung*, TA Publications, Gaborone, March/April 1996.

It is advisable that each of the countries of the region develops a comprehensive national water master plan (NWMP) which should account for all the water needs of all the sectors of society and the economy in general. It is also important to raise public awareness about the value of water, particularly as how it must be used in homes and industries. Countries such as Botswana and Malawi have already made great strides in developing their national water master plans.

Where opportunities exist, development of unexploited resources such as potential hydropower sites is necessary to reduce consumption of woodfuel for energy requirements in the region and help protect the river basins from further denudation.

Under normal climatic conditions, there is no regard for possible water scarcity which may affect water-intensive development projects. It is crucial that water projects consist of measures that re-use, reclaim and conserve water or reduce evaporation losses.[34]

Health

Further challenges for the future do not exclude decline in human health due to water scarcity. With the increase in the region's population, there will be a greater need for sanitation facilities, particularly in urban areas.

Water-borne sanitation will increase the demand for water, making it the more worthwhile to plan comprehensively for water projects to meet the present and future demand through appropriate policies and strategies for water resource development.

Reduction of water in the region's lakes and dams, is also likely to limit any opportunity to increase catches of freshwater fish in southern Africa. Since fish is one of the main sources of protein to a large group of the region's population, reduced fish catches would result in the overall shortage in protein intake, causing further deficiencies in health. This condition would occur not only due to reduced fish catches from the sea, lakes, rivers and streams, but also due to reduced harvests from aquaculture.

Agriculture

Current trends in water demand for agriculture, especially in irrigation, are certain to continue to rise. Irrigation, depending on what system and technology is employed, tends to use large amounts of water. It also tends to be highly favoured, particularly during droughts as there is no alternative to maintain food production. During droughts, evaporation rates are at their highest over and above the amount of water required by the crop.

To reduce water loss, irrigation projects should use appropriate systems and technologies that conserve water. Efficiency in water management under irrigation also applies to watering of lawns. In many urban areas, treated water is used for watering lawns. Where feasible, it would be most appropriate to use recycled water for this purpose.

Ill 8.3 FAO/ALCOM-J King

Reduction in water levels would reduce fish catches and therefore protein intake by people.

More water will be needed for livestock as well as for sustaining the grounds of pasture required to maintain large animal populations. The solutions for these added demands for water seem to heavily rely on management aspects. Agricultural requirements for water can be satisfied through water conservation schemes that can also include the requirements for domestic stock.

Industry

Water quality in the region is a major concern and a constraint in management. Industry and agriculture are some of the major polluters of water resources in the region. Industry is a point source of pollution and can be managed relatively easily, but agricultural pollution is very diffuse and difficult to control. Agro-chemicals, pesticides, insecticides and effluent from agriculture, such as from coffee pulperies, leave no room for environmentally sustainable management of water resources if there is no proper regulation and control over the use of chemicals.

Enabling environment

To satisfy water demands in the region, appropriate policies and strategies must be put in place. Environmentally sustainable development of water and resources in southern Africa depends on sound management principles. There is more reason at present for planned settlements of rural areas so that people do not live on arable and fragile lands. Such an arrangement would facilitate planning for water infrastructure and afford communities easy access to developed water-supply schemes.

While rural communities under subsistence farming are extensive farmers, education and suitable facilities required in intensive farming need to be provided to this sector. Depending on the carrying capacity of the land, intensive farming will increase output per unit area of land and compensate for the population increase.

Ecosystems

Ecosystem degradation can result through processes that are mainly induced by human activities, although climate is a major factor. It should, therefore, be possible to reduce ecosystem degradation through sound management. In its absence, terrestrial ecosystems can be destroyed, for example, through uncontrolled bush fires, soil erosion, chemical pollution, forest logging and many other activities.

Overexploitation of freshwater and marine resources and pollution of water bodies from the land are concerns that need to be addressed as these would reduce the availability of both water and living aquatic resources.

Photo 8.8 APG-D Martin

The solutions to increasing demand for water rely on management of resources.

Freshwater supply

While water is still regarded as a free commodity by many, it is crucial that both urban and rural communities are made aware of the fact that apart from water being a social good, it is also an economic good.

This message can be readily accepted only if there is full participation of all communities in the decision-making processes for implementation of water-development programmes. The top-down approach has failed, if the lessons learnt during the International Water Supply and Sanitation Decade of the 1980s are to be considered.

Ownership and the sharing of responsibilities gives communities the authority and pride to care for their own water facilities which, if otherwise considered government property, could be unattended while heavy water losses or leakages take place. Already a number of SADC countries such as Tanzania and Zimbabwe are involving communities in the planning, development and maintenance of water-supply systems.

Under an arrangement where the consumer and the water-supply undertaker or provider work together in decision-making, it becomes easier to implement policies and strategies that promote the conservation of water.

Water harvesting should be encouraged in SADC countries where this is feasible, as one way of conserving water which would not otherwise be used. Water harvesting can be one measure of increasing the availability of water supply for small urban communities as well as rural ones, leaving the conventional sources of water supply for future use. While water harvesting can be readily accepted, the major constraints are the inputs required for the infrastructure, such as roofing material, timber and tanks. However, in spite of this problem, roof and rock catchment water-harvesting methods are very popular in Zimbabwe,[35] and provide hope of success in other countries of the region.

Governance

With armed conflict virtually over in the region, particularly in South Africa, Mozambique and to some extent in Angola, possibilities exist for SADC countries to concentrate on their national and regional development programmes, including those that affect water resources. The state's role as guardian over these resources at the national level is critical. However, it is important to recognise that other interests exist locally.

Various stakeholders should be incorporated into decision-making. This may be achieved through a variety of mechanisms. New systems for public participation need to be created. Public participation may create more meaningful and sustainable management strategies. Southern African countries, along with the international community, have recognised the need for public participation in natural resource management.

Agenda 21 explicitly recognises the role of communities in the management of natural resources. Further, there is extensive international experience which suggests that if communities are not directly involved, development initiatives will fail. The involvement and empowerment of people is critical and this should be reflected in the democratisation of management institutions.

Individual or citizens' rights to action are important as they constitute an important check on how the state exercises its powers. Their organisations can play an important role in protecting the environment and in ensuring public compliance with designated environmental standards. They are well-placed to challenge actions or potential actions that impact negatively upon their right to use and enjoy their environment.

Citizens' opportunities for the enforcement or the safeguarding of rights are important means for ensuring sustainable water-management. The potential of constitutional and human rights, administrative and judicial actions in environmental management needs to be fully explored.

Incorporating public participation in decision-making may help to bring legislation in line with stated policy objectives. This necessitates a new focus on areas such as proprietorship, empowerment and cultural values. Communities should have a central role where their interests are at stake.

If it is accepted that a central aspect of policy is the recognition that "sustainability goes beyond the mere preservation of the environment and includes the sustainability of the human resource," then natural resources management, including water, is inextricably linked to human poverty. Therefore, a crucial objective of any strategy must

be the alleviation of such poverty. Traditionally, the law has not been concerned with the right to break out of this poverty cycle, instead it protects the "haves" and creates instruments to perpetuate the exclusion of the "have-nots".

Institutional framework

Institutions that deal with water resources management need to be strengthened. The obvious advantages would be that information on water availability would be easily accessed for management purposes. In this regard, financial and human resource, and other needs should be satisfied as required by the relevant institutions.

Enforcement

Legislation should be supported by those measures that ensure that the law, as applied to water, is adhered to. Such measures involve water resources inspectors to investigate pollution into state waters by farmers or industries, or abstraction infringements by water-right holders. Where a polluter is found guilty, penalties need to be imposed although light penalties can cause continued pollution since they are affordable.

Management must also include water-pricing. This can be done by allocating different tariffs for different economic groups of consumers or by volume of water consumed. Fee structures for the commercial use of water resources that adequately reflect its economic value need to be created to encourage applicants to only apply for that water which they are able to use. Where water is free, it tends to be excessively wasted.

A more problematic issue is the extent to which communities should pay for the use of water for domestic and primary purposes. A key hinderance to government efficiency is high subsidisation of essential services. In the long-term, this should be reversed. A study by the World Bank indicates the willingness of rural Zimbabweans to pay for the full cost of connections to public water points and improved services. However, there is some indication that in certain very poor areas, communities are unable to pay even very nominal sums for water.

Participatory measures

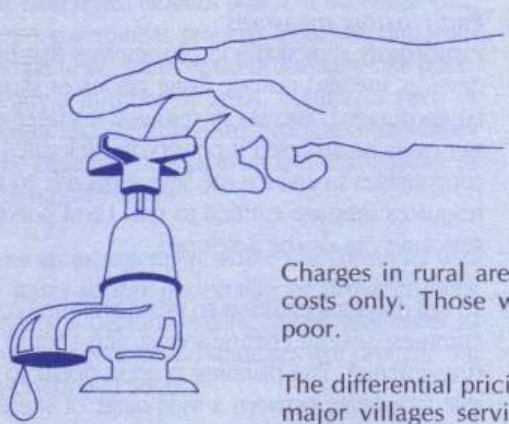
Participatory approaches in programmes that help develop, use and manage living resources should be encouraged. Success in resource management can easily be achieved if powers are delegated to communities to enforce the laws applicable to the resources they are entitled to use. Local policing structures can also be developed.

To sell development ideas to urban and rural communities, several channels exist and should be strengthened. The planning process needs to be able to mediate between a wide range of interests and to synchronise them with the objective of sustainable development, incorporating various levels of civil society. Simply incorporating community leadership groups does not adequately deal with the heterogeneous nature of, and the power relationships within, a society. Existing leadership structures in any society tend to reflect the dominant values of that society.

Women, poor farmers, the old, among others, need to be accorded a role. To make participation meaningful, these groups need to be included in training and information dissemination. The roles of non-governmental organisations (NGOs), as well as those of the community-based organisations (CBOs), are critical in information dissemination and programme implementation. A coordinating body responsible for all the NGOs and CBOs is necessary to allow for coordination between government plans and those of NGOs and CBOs. This can avoid duplication of scarce resources and effort.

Joint management and common-property resource management can be used to ensure public participation. Their creation involves giving communities some direct interest in resource management. An interest may be in multiple forms. It could be a financial benefit, joint ownership or some other real right in the property or simply a contractual right to utilise certain resources.

Paying through the tap Box 8.5



Pricing plays a crucial role in water conservation in countries in the Southern African Development Community (SADC) region.

Water is metered in urban centres of all SADC countries. In Botswana, the Water Utilities Corporation sells water to recover costs and where possible to make a profit. Charges in rural areas are lower and meant to recover recurrent costs only. Those who use more water end up subsidising the poor.

The differential pricing also discourages water wastage. In the 17 major villages serviced by the Department of Water, residents can either get water from communal taps 400 metres apart, in their yards or houses. Only residents with taps in their yards or home pay for water used.

Households pay US$1.60 per cubic metre (cu m) for anything above 40 cu m per month, nine times more than if they use five cu m or less. The break-even price is at about 10 cu m per household per month where villagers pay about US$0.58. Between 20-40 cu m, consumers pay US$0.72.

The poor, whose population is three times that of the rich, get water free but use only a quarter of the water supplied. Distance, not the price, determines this. The disadvantaged have to walk to the communal taps and to cut on labour, they use less water, while the affluent have taps in their houses and yards.

Currently, water consumption in small villages, which are serviced by local government, is 40 litres per person; in the 17 major villages, it is between 60-120 litres and in urban areas it is 170 litres.

About 60 percent of recurrent costs are being recouped but the government wants to recover annual recurrent expenditure in less than five years' time.

In the 400 small rural villages, there are fewer yard and house-connections compared to the 17 large villages. The average per capita consumption in 1990 was 34 litres in small rural villages. The district council subsidises water supply in the villages, recovering a small percentage of supply costs. The target is to recover 35 percent of the recurrent costs from the year 2000.

In urban centres, tariffs are determined by the cost of supply. Consumers in or near the wet northeast pay less per unit consumed than those in the dry south. On average, in urban centres, the first 10 cu m of water costs US$0.30. This meets a family's basic water needs. The charge per cubic metre rises to US$1.25 above 15 cu m and up to US$1.62 above 25 cu m.

In South Africa, the average price of water is US$1.00 per cu m. In more arid Namibia, consumers pay about US$0.28 per cu m but the actual cost is US$0.84. Government subsidises the rest.

The South African Department of Water Affairs says there are two reasons for managing water demand, "to limit demand by preventing wasteful use" and to make people value water as a scarce resource.

South Africa manages water demand in urban and industrial areas and on irrigated land by manipulating water prices. At the same time, it takes cognisance of the fact that water is both a social and economic good. The water pricing is sector-specific, with manufacturing industries paying more than agriculture (irrigation). Within urban and industrial areas, the sliding-scale system is used.

Water charges can be determined by the cost of supplying it and this is the approach being used in urban and industrial areas. In agriculture, the maximum price a farmer can pay without compromising the viability of his/her business is largely applied and farmers are often subsidised.

Arid Namibia used to aim at recovering operational costs only but this is ending.

"In Namibia, government policy is now to recover full cost and this has already begun in the mining industry," says Piet Heyns, the Director of Water Investigations Department in Namibia.

However, there is a "lifeline quantity" for which consumers do not pay. Above that, they are required to pay at rates that are above the operational costs so that they subsidise conservative water users.

Currently, the country recovers 26 cents out of the 28 cents per cu m spent on operational costs. Capital costs make up about two-thirds of the total costs. Namibia's new approach also requires the business sector to pay capital costs separately from operational costs.

In Zimbabwe, which receives an average of about 650 mm of rain annually, people in rural areas, except farmers who draw water from rivers for irrigation, do not pay for water. Potable water is paid for in all urban centres. Charges are made to recover capital and operational costs. In some cases, a small profit is made. In Harare, a household pays US$0.08 per cu m for the first 13 cu m, and US$0.16 per cu m for 14-39 cu m, US$0.31 for 40-69 cu m. Above 300 cu m, all pay US$0.38 per cu m. Industries pay US$0.31 per cu m for the first 300 cu m.

Consumers do not pay for water from boreholes. During droughts, urban dwellers who can afford to drill boreholes have unlimited access to groundwater.

In all countries, water prices do affect the way people use water. Some argue that the prices are still low in much of southern Africa compared to other parts of the world. But many consumers think otherwise.

— **Mutizwa Mukute**, SARDC, March 1995.

Such regimes have been attempted in Zambia with wildlife and woodland resources. Their success depends on the extent to which a user community feels a sense of ownership and hence responsibility for sustainable utilisation of the resource.

Private sector involvement has increasingly been recognised. In some countries, the water management system has been completely privatised. The private sector could potentially be an important partner of government in establishing sustainable water management. They have a direct interest in the sustainable use of water, as many production processes are dependent upon water resources. The private sector represents a vast resource base and could contribute to sustainable water management through capital investment, operations and maintenance, training and capacity building, and financing and commercial services.

The private sector may be directly involved in the management of water resources through the servicing of public utilities and the management of sewerage and waste management. The World Bank suggests that there is a need to separate provision and regulation, placing one of these functions in the private sector. The Bank argues that powerful incentives exist in the private sector for cost-effective management and the provision of high quality services.

This approach, however, ignores the fact that the market may serve to deepen existing inequalities. It is important to acknowledge the imperfections of the market. Given this, and the importance of water, it may be appropriate for the management function to stay with the state. The same result could possibly be achieved simply by separating the function within the public sector.

Alternatively new mechanisms need to be created through which the public is able to ensure that a good job is being done, including the adoption of appropriate policies and sound decision-making processes.

Regional initiatives

Water-related problems currently being experienced by southern African countries are not so much due to water shortages but rather because of a mismatch of availability and demand. The SADC, is moving in the right direction by promoting closer cooperation among member states. The critical role of water, and access to it, has been a subject of

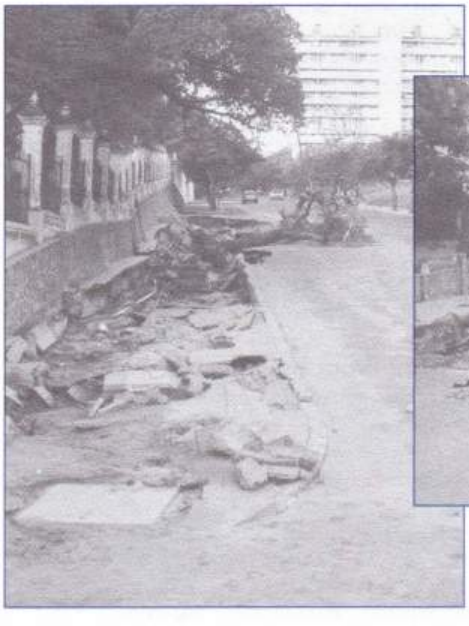


Photo 8.9 & 8.10 O Everett

The damage caused to Maputo streets during a thunderstorm in early 1996 illustrates the vulnerability of infrastructure to such events.

Water in Mozambique Box 8.6

The World Bank preappraisal mission for the Mozambique Water Resources Management and Development Project (MWRMDP) wrapped up in March 1996, just one week after the downpour which resulted in so much havoc in Maputo. Huge holes were eroded in streets in some of the more crowded neighbourhoods. The damage illustrated that a combination of various factors such as deficiencies in infrastructure and road maintenance services, dense informal settlements over natural drainage paths, pavement damage by frequently bursting water mains and flowing waste water, lack of local storm-water drains, and blockage of drains with solid waste all contributed.

Yet the rapid response of the authorities attested to some important recent progress. A feature of the World Bank mission was the emergence of a government-led strategic approach to dealing with aspects of this problem.

Through this project the government will prepare for the planned World Bank local government project (1988) which can be the vehicle to install sewerage and sanitation services to deal with the increased waste generated by the water services provided under NWRMDP.

The current project will include the following:

- private sector management of the water companies in Maputo, Beira, Nampula, Quelimane and Pemba, and reform of the tariff system;
- investment to bring the water systems to the point of adequate service and full cost recovery;
- assistance to improve management of water companies in smaller cities;
- a demonstration component to help generate community-led restoration and sustainable operation of small piped systems;
- a component to upgrade capacities to manage water resources and bulk water operations, including joint studies of critical international river basins; and
- upgrading the human resources skills of the sector.

The crucial water resources and rural water supply and sanitation components are underpinned by an evolving national strategic approach, just as the urban component. The government has taken some major decisions on these reforms, including the private management of the five water companies, the establishment of an interministerial commission to manage this process, the first step in tariff reform, and the establishment of an Office of International Rivers.

Work was also initiated on a proposed beneficiary assessment — a major effort to gain information from the communities that will benefit from the project. This should assist decision makers in setting the level and structure of tariffs, as well as help determine which communities are to be prioritised to receive formal water services.

Overall, this will keep the authorities better informed of the communities' values, needs and willingness and ability to pay.

SOURCE: World Bank in *Mozambique Market Watch*, The Africa Desk and Austral, Maputo/Johannesburg, Edition No. 14, May 1996.

Water supply to be privatised Story 8.1

Johannesburg (Business Report) - The distribution of South Africa's water could be managed by private companies before the end of 1996, the executive director of Lyonnaise Water Southern Africa, Jean Claude Ambert, has said.

"Before the end of the year, a few tenders for delegated water management could well come up in various parts of the country," he said.

Lyonnaise Water, in partnership with Group Five, has successfully operated the sanitation and water supply of Queenstown since 1992.

The project has become a model for the RDP with employees and consumers feeling the difference, Ambert said.

"In a township, a leak or block can be fixed in a matter of hours, where before it was insurmountable," he said.

The company, which has contracts in Morocco and Gabon, was confident that should it win water-supply tenders, it would raise the finance necessary for upgrading services and create an environment where people would pay for what came through the taps.

Ambert doubted whether local authorities could reform water provision "because of the complexity of the sanitation".

The pressure on local authorities to deliver should make them look for alternatives, he said.

He cautioned that though draft law allowed for private sector involvement, he did not wish to pre-empt "a political decision". Nor did he want management contracts confused with privatisation, he said.

A Ministry of Water Affairs and Forestry official, Themba Khumalo, said the ministry "was quite flexible on the issue" of private involvement in water supply, though "water as stated in the constitution remains a function of central government".

He said subject to negotiations with local authorities, the ministry had no objection to private sector participation "as long as they (private companies) don't make capital out of water, which is fast becoming a scarce resource".

Ambert said private participation in the supply of local water was gaining credibility as newly elected local authorities were faced with the task of supplying water and sanitation to poorly serviced townships.

About 80 percent of those people who receive water do not pay for it, while 12 million people in South Africa have no access to tap water.

— **James Lamont**, *Business Report*, 28 February 1996, Johannesburg, p. 1

discussion for a long period.[36] There has been growing realisation of the advantages of shared water projects and programmes in the region. These bring countries and their peoples closer together and promote development in other sectors of their economies.

This general agreement through the 1995 SADC Protocol, gives greater impetus to already existing plans to jointly use the waters of the region for the community's economic and social emancipation through resource management. The new SADC Water Sector and the new protocols on trade; energy; and transport, communications and meteorology should facilitate greater regional cooperation in water resources management.

The cooperation between Lesotho and South Africa in developing the waters of the Lesotho Highlands is another clear manifestation pointing to similar inter-basin water transfers in future.

For the purposes of sustainable development of water resources in the region, and considering that many of the countries of the southern African region are riparian to the major watercourses, cooperation among states should be the catalyst for conservation and management, particularly with regard to pollution control. Countries such as Mozambique and Namibia, who are at the receiving end in the case of the Zambezi river and the Orange river respectively, need not suffer pollution problems if greater cooperation is established in preventing pollution along these watercourses. However, each country must determine the relationship between growth and distribution of its population and resource base, and the level and quality of life its development policies and programmes are designed to produce for its people.[37]

As southern Africa moves into the 21st century, the peoples of the region will have to begin to appreciate that they belong to a region where the resource base is finite, but where they are able to sustain their livelihood into the following century and beyond, if the resources are carefully managed and conserved. If its resources are abused, the inhabitants of the region will suffer gloom and plight. The choice to conserve the natural resource base is left to the inhabitants of southern Africa and the time to take the correct and proper decisions is ripe.

Photo 8.11 SARDC-M Chenje

The time to take proper decisions to conserve the region's natural resource base is ripe.

Linkages to other chapters Box 8.7

PEOPLE

As the population of southern Africa grows and requirements for economic development increase, there will be added demand for water and sanitation requirements in the region and therefore advance planning and new initiatives in water-resources management need to be adopted.

2 CLIMATE

Since climate affects the amount of water that can be made available to the region, any change and variability is likely to have a significant impact on water availability in future, impacting on people and wildlife.

3 ENVIRONMENT

Adequate water resources are needed for use by the environment to sustain natural resources into the future. Therefore, appropriate management approaches and principles toward water and the environment must be adopted to achieve sustainability.

4 MANAGEMENT

The present use and management practices in water will determine the future supply. Poor water use and management would mean excessive and unsatisfied demand in future while sustainable use and management of the resources of the region provide hope for future generations.

5 AQUATIC RESOURCES

Environmentally sustainable use and management of aquatic resources gives assurance of their availability in future. Poor exploitation methods and management principles would result in reduced resources and quality.

6 POLLUTION

Increase in industrial development and poor management of pollutants would result in increased pollution that would have a significant impact on the state of water resources in the region.

7 COOPERATION

The Southern African Development Community (SADC), through its many regional initiatives, provides hope for a sustainable future guaranteed by intersectoral regional cooperation and affecting the resources and people of the region.

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A1 GLOSSARY

Aa

absolute humidity — maximum concentration (humidity - see humidity)

abstraction — tap or draw water from a source, for domestic or commercial use

acidification — the process of making or becoming acid

acid rain — rain (or snow) contaminated by acids formed when industrial pollutants undergo chemical changes in the atmosphere

acid drainage — water acidified after contact with mined rock, also containing dissolved toxic substances, and pumped into surface waters from mines or draining into surface waters from tailings

afforestation — planting trees in an area where there have not necessarily been trees before

Afromontane (and temperate) forests — distinguished from tropical forests by much cooler temperatures, greater temperature extremes and usually a longer dry season

agrochemicals — chemical fertilisers and pesticides used in agriculture

agroforestry — agriculture using trees, the trees serving multiple purposes including shelter from wind and sun, improving soil fertility, and providing fruit, fodder and fuelwood

albedo — reflective characteristics of water, dependent on solar sun angle, concept used in the identification of drought conditions

algae — plants which contain chlorophyll and have no stems, roots or leaves and live in water or in moist conditions

alien species — plants or animals introduced into an area, threatening the survival of naturally occurring habitats or species

allocation — distribution of water among the various sectors of society, according to their needs for consumption or economic activity

altitude — height of an object, especially above sea-level

amphibians — of a class of vertebrates with an aquatic larval stage followed by a terrestrial adult stage, e.g. frogs

anaerobic — non-oxygen-using organism

ancestor — person, animal or plant from which another has descended or evolved

angling — fishing by using a line and hook

anti-cyclone — a region of high pressure around which air flows anti-clockwise in the southern hemisphere, or clockwise in the northern hemisphere

aquaculture — the practice of raising aquatic life in created environments, such as ponds or dams

aquatic — of or living in water

aquatic weed — plant that survives by living entirely in water

aquatic weed control — mechanism or method of preventing the spread of aquatic weeds in a water body. Such mechanisms or methods can be biological, in which a particular weed-eating insect is introduced in the weed-infested water body to allow it to feed on the weed, or by mechanical removal or by use of chemicals - hence *biological, mechanical and chemical control*

aquifer — geological formation able to store groundwater

arachnid — animal with eight legs, such as spiders and scorpions

arid — area with less than about 250 mm rainfall every year

aridification — the opposite of waterlogging, comprises a drop in local groundwater level, resulting from crusting, compaction and/or overuse of water resources. Also results from the replacement of natural vegetation with a crop needing more moisture, such as the replacement of dryland grasses with wheat, reducing the ability of the soil to store water

artisan — a skilled manual worker or craftsman, hence artisanal

asbestos — fibrous mineral substance, used as a shield against fire and as an insulating material in many industrial and construction processes

Bb

basin (as in catchment basin) — area drained by a stream or river system

beach — the area along the shoreline of a lake, sea or ocean that is between the highest and the lowest water mark and usually covered by sand or pebbles

beneficiary — individual or institution or group thereof receiving benefit from a service provided by a benefactor

Benguela current — a cold ocean current of the Atlantic off the southern African west coast having dominant influence on climate and marine resources

Benguela Nino — incursions of warm surface water along the west coast of southern Africa into the Benguela system that results in unusually high rainfall in south-west Angola and north-west Namibia

benthic — pertaining to the bottom of a lake, river or sea
biodegradable — something that decays as a result of organisms such as bacteria or by the effect of sunlight, the sea, etc
biological diversity (biodiversity) — richness of the number of genes, species and ecosystems of an area
biomass — energy sources derived from plants and animals, including crop residues, wood
biosphere — where life exists on, in and around the earth
biotechnology — branch of technology which manipulates and combines different genetic materials to produce living organisms with particular characteristics
biotic — living thing
bloom — mass of algae which develops rapidly on the surface of standing water due to eutrophication
borehole — hole, drilled vertically or at an inclination into the ground and usually fitted with a mechanical or motorised pump to draw water from the ground
Botswana High — a high pressure area that builds up over Botswana, between three and six kilometres above sea level, and has marked influence over climatic conditions
brood stock — numbers of young ones already hatched and ready for raising

Cc

carbon "sinks" — bodies such as oceans and organisms such as plants which absorb carbon from the atmosphere as part of their biological processes
carbon sources — bodies and organisms which release carbon to the atmosphere as a product of biological or artificial processes, including death of plants and coal-burning industries
canal — artificial channel through which water flows, and mainly used in irrigation
carcinogen — substance which causes cancer
carnivores — organisms that feed on flesh
cataract — large waterfall or cascade
catch — amount of fish, prawns, crabs, etc. harvested from a water body, including dams and the sea
catchment area or basin — the entire area drained by a stream or river, equivalent to drainage basin
CFCs — chlorofluorocarbons, ozone-destroying chemicals released mainly by cooling systems such as refrigerators and air conditioners
chag nets — nets drawn through a river or across ground to trap fish
chichewa — language spoken by the Chewa of Malawi
clams — edible bivalve molluscs
climate — the type of weather that is particular to a region or area seen from a long-term perspective
climate change — any departure of weather conditions in a region or area from its normal climate
clupeids — microscopic aquatic animals that form part of zooplankton
coastline — shoreline
colony — group of animal or plants living close together
commensals — animals which develop a close relationship on tropical shores, by sharing food and shelter
commission — policy-making body with monitoring, advisory and approval powers over water management projects, usually made up of experts from two or more countries which share an international watercourse
community — people, plants or animals living together in a particular area
community participation — the process whereby a community or communities are encouraged to voluntarily take part in decision making and implementation of development programmes especially when the community is the beneficiary
conservation — wise use of nature's resources to prevent loss of ecosystem function and integrity
conventions — agreements made by nations over particular issues that are likely to benefit all
coral — hard, usually red, pink or white calcerous substance secreted by marine polyps for support and habitation
crab — ten-footed crustacean with the first pair of legs as pincers
crustacean — aquatic arthropod with a hard shell, e.g. crab, lobster and shrimp
cyclone — a region of low pressure around which air flows in a clockwise direction

Dd

dam — structure, usually of earth, concrete or both, constructed across a gorge, valley or river to hold water and create storage behind it for use in agriculture, hydropower generation, fisheries development, recreation or to supply water for industrial or domestic requirements
dambo — a shallow, seasonally or permanently waterlogged, grass-covered depression (Chichewa term, known in other southern African languages as mbuga, molapo, naka, bani or vlei)
DDT — dichloro-diphenyl-trichloroethane, a poisonous chemical pesticide that is also toxic to other living things, now not recommended for use due to its damaging effect to animal life
decade — period lasting 10 years
dead storage — water which fills a reservoir below and up to the level of the lower intake, and which cannot be abstracted for use
deforestation — logging, removal of trees from a landscape
density — number of objects per unit area, for example, people per square kilometre
desalination — process of removing salt from brine or sea water
desert — a region or area with little rainfall and little or no vegetation. For example, in the Namib desert, where rainfall ranges from 10-85 mm a year
desertification — land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities which make the land

assume the characteristics of a desert
detergent — synthetic cleansing agent used to remove grease and bacteria from the surface of some material
diatoms — unicellular algae containing a brown pigment and enclosed in a two-valved cell wall
ditches — long narrow excavated channels specifically for drainage
dolphin — large porpoise-like sea mammal with a slender pointed snout
downstream — the direction in which a stream or river flows
drought — continuous absence of precipitation during the period when it is normally expected to occur
drought relief — supplies of basic food donated to help people affected by drought
dry savanna — semi-arid area with widely-spaced trees, often *acacia* species, sometimes with touching crowns, but a light canopy that allows grass to grow beneath
dugong — endangered herbivorous sea mammal
dumping — throwing away waste. There is both legal dumping, on special sites, and illegal dumping and it is often difficult to monitor the waste until damage to the environment is already done

Ee

easement — legal agreement or arrangement providing for common access to a facility, commodity, resource or service that could be claimed to belong to more than one party
echinoderm — sea animal of the group including the starfish and sea urchin
ecology — the study of the relationships between all living organisms and their physical environment, including the ways in which human activities affect other wildlife populations
ecosystem — all living and non-living components of the environment that interact and influence one another
ecotourism — tourism which is sensitive to the environment and supposed to benefit local communities. It is being promoted as an alternative to mass, commercial tourism
ecozone — ecological zone, a large natural unit controlled by a set of common processes, mostly climatic, and dominated by life forms with similar physical adaptations to those processes
effluent — poisoned waste water discharged from industrial and mining processes, from agriculture and domestic use of water
El Nino — the warming of the Pacific Ocean waters, which influences world weather patterns by affecting air and ocean temperatures, and is thought to decrease southern African rainfall
endemic — plant or animal only found in a particular region
enforcement — follow up on the observance of legal requirements by ensuring that regulations are adhered to through penalties for non-observance of water restrictions, for example
environmental degradation — destruction of living and non-living things, reducing the productivity of an area
environmental impact assessment (EIA) — management tool to predict and mitigate negative environmental impacts of a certain project in a specific area
environmental institutions — organisations tasked with formulating, coordinating and implementing environmental law and programmes
ephemeral — lasting for a short period of the year
episodic — occasionally, usually memorable, such as a very large flood or severe drought
equitable utilisation of water — proportionate sharing of water among competing user interests nationally or across borders
estuarine — of estuary
estuary — part of the river where it meets the sea, with water of mixed origin: sea water and freshwater
eutrophic — (of water bodies), rich in dissolved organic and mineral nutrients
eutrophication — the excessive growth of organisms, usually plants, as a result of high levels of nutrients (inorganic ions such as nitrogen, phosphorous)
evaporation — the process by which a solid or a liquid turn into vapour; loss of moisture as vapour
evapotranspiration — the loss of water from an area as a result of a combination of evaporation from the soil and transpiration from plants lost to the atmosphere
event-driven — those ecozones where external events, usually climatic, have more influence over ecological functions than the interactions between species
exclusive economic zone (EEZ) — area, stretching 200 nautical miles off coast, of national jurisdiction of the sea under the United Nations Convention on the Law of the Sea
exotics — species not native to a particular area

Ff

fallow — allowing cultivated land to "rest" for a period to restore fertility, often with a cover crop
fauna — animal life
fertile — productive
fertiliser — chemical substance added to the soil to make it richer and stimulate plant growth
fisheries — the industry of harvesting fish and/or aquatic or marine resources
fish-farming — aquaculture, the breeding of fish in ponds under controlled conditions
flashfloods — large volumes of water overflowing a river channel, occurring in a relatively short period of time and usually likely to lead to loss of life and property
floodplain — area beside a river or lake which is seasonally flooded when water levels rise due to high rainfall
floods — an overflowing or influx of water beyond its normal confines
flora — plant life
flow unit — one million cubic metres of water per year
food-chain — series of organisms each dependent on the next for food and energy

food security — assurance that food will be available when needed, either by growing it, storing it or importing it into an area
forage — plants grown for consumption by livestock
forecasting — deduce a condition prior to its occurrence, especially of weather
fuelwood — wood used to produce energy for heating, cooking, particularly in the rural areas
fungicide — substance which kills fungi
fynbos — Afrikaans word for fine-leaved bush, an ecozone in South Africa's southern Cape area comprised of shrubs and shrubby woodland to three metres high, with patches of hardwood forest

Gg

geomorphology — land forms and their attributes such as rivers, mountains and valleys
global warming — the increase in temperature of earth's atmosphere caused by the greenhouse effect
grasslands — land covered by grass with some trees, but differing from savanna woodland by being generally cooler and drier
gravity — natural force that attracts objects to the centre of the earth (*of water pipes*, allowing water to flow to areas of lower altitude)
greenhouse effect — the warming effect resulting when greenhouse gases absorb ultraviolet light from the sun and prevent it from escaping back to space, in much the same way as horticultural greenhouse glass allows sunlight to penetrate and keep the heat in
greenhouse gases — gases causing the greenhouse effect, including carbon dioxide, nitrous oxides, methane and ozone
groundwater — water occurring naturally in an aquifer
groundwater recharge — replacement of water, usually through rainwater percolating into the ground, to replenish water lost from the groundwater through abstraction, evaporation or transpiration
gorge — narrow valley with steep sides
guano — excrement of seabirds, found in small islands in the sea, used as manure
gullies — ditches or drains caused by sheet erosion
guts — intestines

Hh

habitat — natural home of an animal or plant
hatchlings - young bird or fish emerging from the egg
heavy metal - metal such as lead, cadmium and zinc which stunts the growth of an organism if present in soil or water
hectare — a unit for measuring land, equal to 10,000 square metres
Helsinki Rules — a basis for international agreements related to water management, which state that each basin state has the right to a reasonable and equitable share of the water in the basin, and that maximum benefit should be achieved with minimum disadvantage to other states
herbicides — pesticides used to kill weeds
herbivores — animals that feed on plants
horse mackerel — an edible sea-fish which is part of the diet of many southern African people
humidity — water vapour content of the air measured using the wet and dry bulb thermometer
husbandry — practice, management of land, for example
hybrid — offspring of two plants or animals of different species or varieties
hydroelectric power — electrical energy generated by utilisation of water-power
hydrology — science dealing with the properties of water and its occurrence in space and time
hydrological cycle — see water cycle

Ii

impoundment — (of water), covered by or taken up with water
indigenous — people, plants or animals which originate naturally in a region; native
indigenous forests — assembly of plants (mostly trees) and animals which occur naturally in a certain place
indigenous knowledge — knowledge of the people native to a certain area
infrastructure — permanent installations, including water works, that form the basis for social or economic performance of a society
insecticides — pesticides used to kill insects
institutional arrangement — hierarchy of authority; (of water organisation involving various aspects of water management such as demand and supply)
integrated water management plans — laid down programmes of action which encompass sociological, economic, political and all such attributes of a society to achieve a desired and holistic development target
intensive agriculture — agricultural techniques which maximise agricultural production from a unit of land, as with irrigation and agroforestry
intercropping — several crops grown together in the same field to enhance soil fertility and/or pest control or as a drought-coping mechanism
international watercourse — a river, stream or canal traversing through or between countries
Intertropical Convergence Zone (ITCZ) — a zone of intense rain cloud development oscillating between the tropics created when the southeast trade winds meet with the northeast monsoon
invasive plant — plant which establishes itself in an area that is not its native place and can out-compete native species
invertebrates — organisms which do not have the bony framework in their bodies such as the small water beetles and shrimps on which fish feed
irrigation — watering land either by canals, sprinklers or

through drips for purposes of growing crops. Hence, sprinkler irrigation, drip irrigation

Kk

kapenta — origin of name unclear but it is Lake Tanganyika sardine introduced into Lake Kariba with the completion of the dam, has spawned a thriving inland fisheries for both Zambia and Zimbabwe
karoo — shrubby, semi-desert landscape
kiosk — booth for selling a commodity such as water
kuomboka — a traditional Lozi ceremony held annually in the Zambezi plains to mark the departure of people from impending floods to higher ground

Ll

lacustrine — of lake
lagoon — stretch of water separated from a lake or the sea by a sandbank, reef, etc
lake — large body of water surrounded by land
land allocation — distribution of land to people for various uses, defining people's access to resources and income opportunities, and is largely seen by governments as an equity issue though it has serious environmental dimensions as well
land tenure — system of land ownership
larvae — stage of an insect's development between egg and pupa
latitude — position on the earth's surface measured in degrees north or south of the equator
leaching — dissolving and carrying away of substances, usually referring to heavy rains removing soil nutrients
livestock — animals on a farm, kept for use or profit
logging — cutting down trees into logs

Mm

macrophytes — large plants
malaria — tropical disease caused by a parasite (*Plasmodium*) which enters the body following a bite from a female *Anopheles* mosquito
malnutrition — a dietary condition resulting from the absence of some foods or essential elements necessary for health
mangrove — ecosystem dominated by terrestrial plants which tolerate sea water
mariculture — the cultivation of seaweeds or algae in coastal areas, mainly for the production of nutritious human food, animal feed or for use in industry
marine — of the sea or ocean
marginal lands — lands with poor soils not suitable for cultivation
marsh — area of permanently wet land and the plants which grow on it
mesh — each of the open spaces in a net or sieve
meteorological station — a location or site where meteorological instruments are established for the measurement of weather conditions in an area of given geographic extent
microclimate — climate of small local areas, such as a field
migration — seasonal change of habitat
migratory routes — routes that animals follow on a regular basis between distant areas
miombo — a common type of moist savanna woodland
mitigation — reduction of impact or effect, for example, of natural disasters
moist savanna — a semi-arid area with a partly-closed canopy of trees five to 20 m high, often *miombo* species, a few shrubs beneath and an often sparse but continuous layer of grasses and other groundcover
molapo — type of agriculture practised in Botswana around floodplains
molluscs — invertebrates with a soft body and usually with a hard shell, for example, snails and oysters
molluscicides — substances that kill molluscs
monocropping — the planting of a single crop over an area, a system vulnerable to soil erosion because the soil is left bare and exposed after harvesting
monsoon — seasonal wind usually associated with rainfall

Nn

navigation — sail through a river, lake
nutrients — essential elements (carbon, nitrogen, calcium, phosphorus, etc) absorbed by plants and animals from food that enable growth and protection from diseases
nutrient depletion — process through which soil nutrients are lost through too-frequent fires, topsoil loss or loss of natural flooding regimes due to dam construction

Oo

oilspill — leakage or large dump of oil in the sea, ocean, or lake, especially by ships or from drilling platforms, usually accidental
omnivores — organisms that feed on both plants and animals
optimum use — use that is the most favourable and giving most benefits
oshanas — local name for the system of interconnected drainage channels that flow through central Owambo, Namibia
overturn — the mixing of layers of water in a lake, often due to cool air temperatures and strong winds
oxbow lake — a body of water that once formed part of a river but is separated from it due to change of course or extreme recession in the levels of the main channel
ozone — a naturally occurring form of oxygen which shields the earth from harmful ultra-violet rays from the sun
ozone depletion — loss of ozone from the ultraviolet light-blocking ozone layer in the upper atmosphere due to reaction with industrial chemicals, mainly CFCs
ozone layer — a layer of ozone in the stratosphere that absorbs most of the sun's ultraviolet radiation

Pp

palustrine — of marsh, swamp, pond, pan, lagoon, dambo, spring
pan — very shallow, often seasonal body of water, usually salty
parasite — organism living on or in another and feeding on it, hence harming it
pathogen — agent (germ, virus, etc) which causes a disease
perennial — lasting throughout the year
permaculture — permanent agriculture, a ecologically-designed sustainable agricultural system of annual and perennial plants which has the diversity, and resilience, of a natural ecosystem
persistent pesticides — those with a half life of greater than eight weeks in water
pest — destructive animals (generally insects) or plants, especially which attack food sources
pesticides — substances for destroying pests, especially insects
pH — a measure of how acidic or akaline a substance is on a scale of 1 to 14, with 7 being neutral
phenols — by-product of pulp production and other industrial process, poisonous to fish and other aquatic life and causing cancers in human beings
physical degradation — degradation characterised by physical changes in the soil structure and usually related to rainfall, including sealing and crusting of topsoil, loss of water holding capacity, compaction of topsoil, waterlogging and aridification
planktivores — organisms that feed on plankton
pneumatophores — aerial roots of a mangrove tree species, *Avicennia marina*
poison — substance that when introduced into or absorbed by a living organism causes injury or death
policy — a set of government or corporate objectives and guidelines deliberately chosen to influence future decisions
policy-maker — individual, corporate or government, making the policies
pollution — the poisoning of land, air or water with anything that reduces its ability to support life
population density — the total number of inhabitants per area
population growth rate — the annual growth rate of the population
polyps — sedentary aquatic organisms with a tube-shaped body
pond — small body of still water
potable — water safe for consumption
potential evaporation — the amount of evaporation that takes place from open water surface
poverty — state of being poor, lacking adequate money or means to live comfortably
precipitation — hail, snow, rain, sleet, fog, mist etc. falling to the ground
predator — animal which kills and eats other animals
pricing — setting a cost margin to a commodity such as water
private sector — independent individuals or institutions outside government playing a role in economic activity, including industry and commerce
protocol — original draft especially of the terms of a treaty between or among states on a specific issue

Rr

rapid — a steep descent in a river-bed, with a swift current
rainfall variability — the pattern of rainfall in arid environments where the amount of rain and where it falls differs widely from year to year
rain-fed agriculture — agriculture which depends on rain water for irrigation
rain-shrine — holy place where some communities meet to pray for rain
ranch — an area where animals are raised and have free range
reafforestation — planting trees in an area which previously had trees which were removed
recession — process of receding; falling or reducing
recharge — process of or amount, adding to the net volume of storage after experiencing outflow for a defined period
reclamation — recovering useful materials from waste
recycle — to process waste material so that it can be used again
reeds — any of various aquatic plants with a firm stem, growing by the shores of lakes and marshes
reef — ridge of rock or coral at or near the surface of the sea or ocean
refugee — person who moves to a safer place where his/her survival is not at risk
relative humidity — ratio of atmospheric vapour pressure to saturation vapour pressure expressed as a percentage
renewable resources — resources which renew themselves, such as trees and freshwater, and have the potential to be used on a sustainable basis without depletion
reptiles — cold-blooded animals which lay eggs and have scaly skin, such as crocodiles, snakes, tortoises and lizards
reservoir — a large collection of water forming a small lake especially used as a source of water supply
return flow — water from agriculture or hydroelectric power plant returned to source
rift valley — a deep valley created by geological faults such as along the western borders of Mozambique and Tanzania and extending generally toward the southern tip of the Red Sea
riparian — of or on a river bank; sharing basin
riverine — of river, floodplain or swamp
rough tilling — ploughing the soil in such a way that the surface is left rough, to reduce the likelihood of wind erosion and encourage puddling of rainwater on the surface and more water infiltration

runoff — storm water running off over the ground surface
rural community — group of people who live and work in a country area, as opposed to town
rural-urban migration — the movement of people from rural to urban areas

Ss

sacrifice zone — the 400 metre area surrounding boreholes and waterpoints in semi-arid and arid lands, where small-scale, sand-dunes (less than one metre) result mainly from trampling and local movement of soil
safe water — water which is suitable for consumption without putting public health at risk
saline — salty
salinisation — the surface or near-surface accumulation of salts, resulting in poor growth or death of crops, often the outcome of poorly-managed irrigation in dry areas
salt water intrusion — the process whereby salty water moves to take up space in freshwater aquifers especially as a result of overabstraction from the latter. Any such intrusion in a salt-free zone.
sanitation — the maintenance or improvement of sanitary conditions
savanna — arid to semi-arid area with a mix of grass, trees and shrubs, the proportions of each varying with rainfall, soil type and other physical factors
seagrass — grass-like plant which grows in the sea and floats due to the air channels between its tissues
sealing and crusting — the condition where, after heavy rains, the fine mud left on the soil surface dries, sealing the soil surface and making a water repellent crust which impairs oxygen and carbon dioxide exchange between the soil and the air, necessary for plant growth, and makes it difficult for seedlings to penetrate the surface and to establish roots
seaweed — general name for several species of large algae, growing in the sea and usually rooted to a surface
sedentary — almost still; with no movement
sediment — matter that is carried by water or wind and deposited on the surface of land or water
sedimentation — deposition of river-borne sediments in a lake, reservoir or pond
seine — fishing net for encircling fish, with floats at the top and weights at the bottom edge
semi-arid — areas where mean annual rainfall is between about 250-600 mm, rainfall is seasonal and variable, and potential evaporation is high
septic tank — tank in which sewage is disintegrated through bacterial activity
sewage — waste matter, especially excremental, carried away in sewers
sewerage — drainage system for carrying sewage
shareholder — individual or institution having economic rights to property
sheet erosion — the even removal of top soil usually by wind and rainfall washing evenly over the land and removing the most productive top layer, the most common and widespread type of erosion
Shona — language spoken by the people of Mashonaland area in Zimbabwe
shrimp — small edible crustacean; small prawn
siltation — deposition of silt by water in a channel or river
silt-hungry — water which is carrying a low amount of silt and has sufficient force to be erosive
slash-and-burn agriculture — (also called *chitemene* in Zambia) form of subsistence agriculture in which a piece of land is cleared and the slash is burnt to allow for enriching the soil with nutrients required by the crops; the land is then abandoned to regenerate and a new location sought, a practice that is basically nomadic
smelter — place where metal is extracted from ore by melting
smother — to suffocate, to stifle
soda lake — lakes with high levels of salt, usually sodium bicarbonate also known as baking soda
soil — a mixture of living and non-living substances with its main structural properties depending on the parent rock material
soil conservation — an intervention to stop soil degradation and even reverse it, through physical structures such as contours and terraces, or biological means such as intercropping and grass strips
soil degradation — declining productivity of soils resulting from a combination of physical factors such as drought, management factors such as cultivation of marginal land, and historical and socio-economic factors, for example, inequitable distribution of land
soil erosion — the process by which soil is removed from one place to another through natural mechanisms, such as by water or wind; hence wind erosion
southern Africa — the region encompassing Angola, Botswana, Lesotho, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe
southern oscillation — a change in global air circulation patterns associated with *El Nino*
spawn — be produced as eggs or young
species — classification of plants and animals into specific groups according to shared or common characteristics such as body structure
sponge — sea animal with a porous body wall and a rigid internal skeleton
spring — place where water wells up naturally from the earth
stagnant water - motionless water
stakeholder — party that is directly involved or affected
Sub-Saharan Africa — comprises all countries south of the Sahara desert, including Madagascar but excluding Mauritius, Reunion and Seychelles which are included with other Asian and Pacific islands
subsistence — a situation in which people provide for all their own needs from their immediate environment, rather than earning wages to pay for goods and services

succulents — plants with thick, fleshy leaves which retain water and have a low evapotranspiration rate
surface water — water found on the surface of the land, for example, rivers and dams
sustainable development — term coined by the World Commission on Environment and Development to denote development which meets the needs of the present without compromising the ability of future generations to meet their own needs, development that does not require a continuous input from outside to sustain itself
sustainable resource use — to use something in such a way that the supply is not diminished
swamp — area of waterlogged ground

Tt

tannery — place where hides are tanned
tannins — any of various organic compounds found in tree-barks and oak-galls, used in leather production
tariff — level or category of payment for a service
terrestrial — of or living on land
thalway — the longitudinal half of a river
thermal power stations — coal-powered plants which generate electricity, augmenting hydro-electricity
topography — natural features on the surface of the earth
tourism — industry which provides services for site-seeing visitors (both local and foreign), includes whitewater rafting, game viewing, birding, art
toxic — poisonous or harmful
toxin — poison produced by a living organism
trace metals — metals present in very small quantities in water or air which can, nevertheless, be hazardous
trampling — by cattle compacts the soil, with similar effects to sealing and crusting
transhumance — seasonal movements of cattle and human beings over great distances in response to the availability of water and grazing
tributary — a river or stream which feeds into a larger river
tropical forest — type of vegetation found in areas with high regular rainfall and no more than two months of low rain, having a completely closed canopy of trees which prevents sunlight penetration to the ground and discourages ground-cover growth
turbidity — the murky appearance of water due to the presence of finely-divided organic and inorganic particles in suspension
turbines — rotary motor driven by a flow of water, (steam or gas) usually to generate electricity

Uu

undertaker — one entrusted to operate or manage a system
upstream — the direction which is opposite to the flow of a river; the upper part of a catchment basin
urbanisation — expansion of urban areas (cities or towns)
utilities — essential public services, such as infrastructure, water, gas, public transport, which are or should be available to all people in general

Vv

vendor — informal supplier of commodity or service
vessel — carrier, especially of the sea, ocean or lake. A boat used for ferrying people and goods from one place to another
viviparous — organisms that bring forth young life
vulnerable — exposed to danger, damage or destruction

Ww

waste — by-products of industry or of organisms
waste treatment — industrial or municipal processes which use chemicals or natural organisms to reduce the amount of nutrients and other contaminants in them before being released to the environment
Water Act — law establishing the use and management of water resources in a country
water balance — the balance between incoming water and the loss or use of water in a given area for a defined period
water board — a group of persons or body set up to implement the provisions of a Water Act. Institution responsible for providing water to a community
water-borne — caused or carried by water
water-borne diseases — diseases that are caused by parasites carried by or living in water or through other carriers that habitate in water, for example, cholera, dysentery, typhoid, blood diarrhoea or *schistosomiasis*
watercourse — river, stream
Water Court — institution empowered and entrusted to deal with disputes affecting water and water resources
water cycle — a natural and continuous process in which water changes from one state of matter to another and redistributes itself to places replenishing and purifying itself in the process. Such changes include evaporation to clouds, rain, stream or river flow
water demand — total requirement for water by a community at a particular time
water demand management — mechanisms by which total community demand for water is accomplished to meet community satisfaction
water erosion — process of soil erosion beginning when raindrops bombard bare soil, loosening and washing away soil particles and culminating eventually in gully formation, most severe in areas with long dry seasons and agricultural practices that leave little vegetative cover on the soil
water harvesting — any system to collect and store rainwater or other precipitation for immediate or future use
water holding capacity — a measure of how much water a unit of soil can absorb and retain
water hyacinth — an aquatic, noxious bulbous plant, native to Latin America and exotic to southern Africa, notorious as a pollutant in many water bodies throughout southern Africa
water infiltration — water moving down into the pore

spaces in the soil

waterlogging — natural flooding and overirrigation which brings groundwater levels to the surface, displacing the air in the soil, with corresponding changes in soil properties and an accumulation of toxic substances which impede plant growth

water master plan — programme of action for improving management and use of water resources

water right — legal authority granted to an individual or institution to have access to water either from a stream, river or lake at a specified volume and for a defined period

water schemes — water projects

watershed — part of land separating two or more water basins, such as a ridge

water table — a level in the soil below which all spaces between soil particles are saturated with water

weevil — destructive beetle feeding usually on plants

weir — a small dam across a river or canal to raise the level of water upstream or regulate its flow

wetlands — areas of marsh, fern, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salty, including areas of marine water, the depth of which at low tide does not exceed six metres

wildlife — animals and plants not domesticated

worms — invertebrates living in large numbers in the soil, some of which are intestinal parasites

Zz

zone — an area of land or sea or of the atmosphere

zoogeographic — areas with a distinct distribution of specific animals and plants

zooplankton — microscopic aquatic animals which live and drift in water and are the basis of the food chain

TRENDS AND SCENARIOS WORKSHOP A2

Trends and Scenarios Workshop
Maseru, Lesotho, 12 September 1995

Facilitators

Paul Maro, Technical Advisor, SADC ELMS, Lesotho
Moremi Sekwale, SAC Chairperson, Coordinator of North-South Carrier Water Project, Botswana

Scientific Advisory Committee Members and other participants

Pedro Cambula, Chemical Engineer, Water Quality Department, National Directorate of Water, Mozambique
Jacinta Carlos, Infoterra Focal Point, Ministry for Coordination of Environmental Affairs, Mozambique
Harry Chabwela, Environmental Consultant, Ecosource Africa, Zambia
Robert Crawford, Deputy Director, Sea Fisheries Research Institute, South Africa
Bradwell Garanganga, Coordinator, SADC Drought Monitoring Centre, Zimbabwe
Barbro Gretener, Environmental Officer, SADC ELMS, Lesotho
Victor Kasimona, Chief Water Resources Engineer, Department of Water Affairs, Zambia
Pontso Mafethe, Communications Programme Coordinator IUCN-ROSA, Zimbabwe
Tabeth Matiza, Wetlands Programme Coordinator, IUCN-ROSA, Zimbabwe
Solami Mavimbela, Chemist, Water Resources Department, Swaziland
Osborne Shela, Liaison Officer for Hydrology and Water Resources, SADC ELMS, Lesotho
Ninima Motibe, Economist, Lesotho
Munyaradzi Chenje, Director, IMERCSA
Elton Laisi, Regional Consultant, IMERCSA
Alexandra S. King, Researcher/Writer, IMERCSA

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SADC
Southern African Development Community

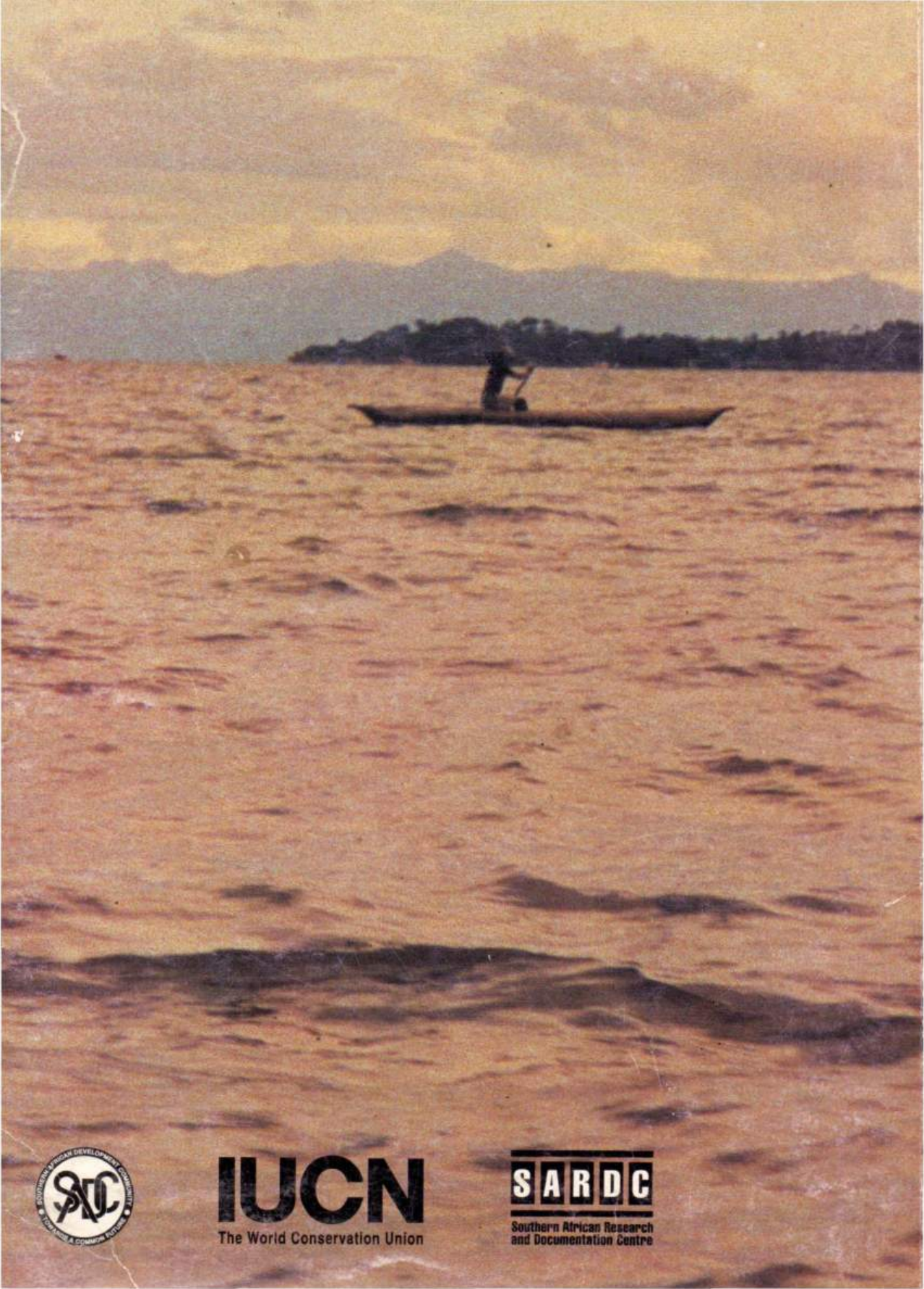
SADC is made up of 12-member states — Angola, Botswana, Lesotho, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. As intergovernmental organisation, SADC is structurally organised into several development sectors, whose respective coordination is entrusted to the government of a specific member State. Until August 1996, water resources issues were coordinated by the Lesotho-hosted SADC Environment and Land Management Sector (SADC ELMS), responsible for overall coordination of environmental issues within the Community and placed under Lesotho's Ministry of Agriculture. During the 1996 SADC Summit, a SADC Water Resources Sector was created, and its coordination was entrusted to the Government of Lesotho. As this book goes to print, a SADC Water Resources Sector Coordinating Unit is being established within Lesotho's Ministry of Natural Resources. Environmental information and reporting activities are key components in the SADC ELMS programme of work, and, for a number of years, SADC ELMS has been collaborating with IUCN-ROSA and SARDC in this area.

IUCN
The World Conservation Union

IUCN is an international membership organisation which brings together governments and a diverse range of non-governmental organisations in an international partnership concerned with environmental issues. The IUCN Regional Office for Southern Africa (ROSA) based in Zimbabwe and country offices based in Botswana, Mozambique, Zambia and in 1997, South Africa, develop the regional programme which is primarily implemented through partnerships with members and other key organisations. The IUCN-ROSA mission is to facilitate and strengthen an integrated approach for the sustainable and equitable use of natural resources and the conservation of biological diversity in southern Africa.

SARDC
Southern African Research and Documentation Centre

SARDC is an independent institution involved in the collection, analysis and dissemination of information about the southern African region, with offices in Harare, Maputo and Dar es Salaam. SARDC's objective is to improve the base of knowledge about regional economic, political, cultural and social developments, and their implications, by making information accessible to a wide regional and international audience. Under CEP, SARDC established the India Musokotwane Environment Resource Centre for Southern Africa (IMERCSA) which has more than 6,000 subject files on the environment and disaster management issues. IMERCSA's overall objective is to bridge the environmental information gap in the region by among other activities, producing state-of-the-environment reports and providing researchers with up-to-date information on the environment in southern Africa.



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