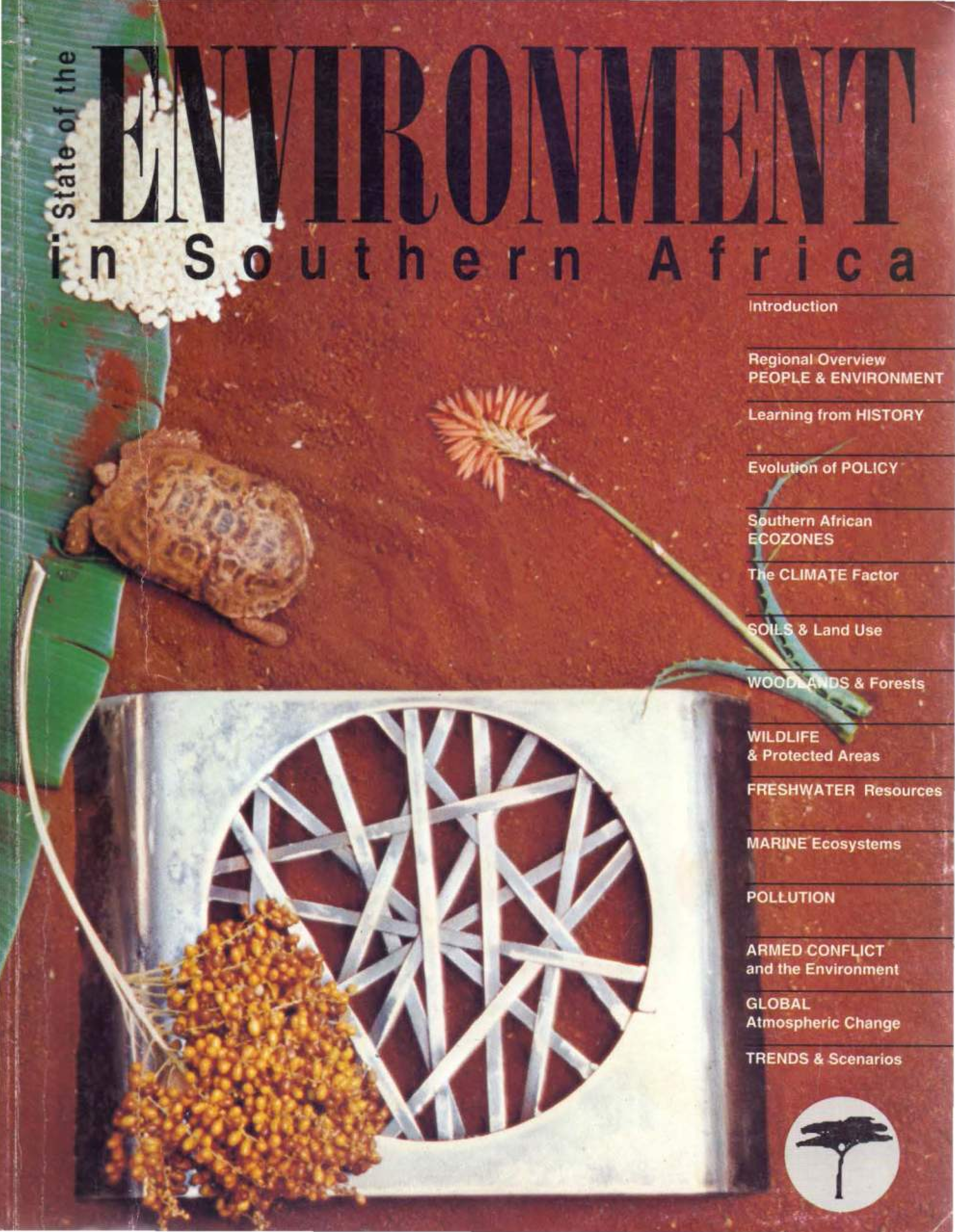

State of the ENVIRONMENT in Southern Africa

State of the ENVIRONMENT in Southern Africa

State of the Environment in Southern Africa, is "an important and timely state-of-the-art report in an area of crucial significance for the well-being of the continent. Easily readable and effectively illustrated, the book shows evidence of a huge amount of careful planning and synthesis of knowledge, presenting issues in a way that challenges decision makers to act."
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Special Commendation.

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1994

SARDC – Southern African Research & Documentation Centre
Box 5690, Harare, Zimbabwe
E Mail: SARDC@MANGO.APC.ORG
Fax (263-4) 738693   Tel 738694/5/6

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

SADC – Southern African Development Community
Environment and Land Management Sector Coordination Unit
Box 24, Maseru 100, Lesotho
Fax (266) 310190 Tel 312158

ISBN 0-7974-1374-X

First edition 1994, reprinted 1996
Reprinted twice 1997

Available in book form in English (1994) and Portuguese (1995)
and soon to be available on disc as a PC information product.

Cover and text design/DTP by Paul Wade of Ink Spots Design Studios, Box UA 547, Harare, Zimbabwe
Cover photograph by Trevor Davies of Southern Africa Media Services Organisation (SAMSO), Box UA 547, Harare, Zimbabwe
Cover sculpture, *Icon to the New Millenium*, by Stephen Williams, gallery delta, Box UA 373, Harare, Zimbabwe
Cover colour separation by Haylett Litho, Box 2725, Harare, Zimbabwe

Printed by CREDA GAUTENG

State of the ENVIRONMENT in Southern Africa

A Report by the
Southern African Research & Documentation Centre
in collaboration with
IUCN - The World Conservation Union
and the
Southern African Development Community

writers

Andrea Booth
John McCullum
James Mpinga
Mutizwa Mukute

editors

Munyaradzi Chenje
Phyllis Johnson

Communicating the Environment Programme (CEP) is a southern Africa partnership initiative of SARDC, IUCN and SADC ELMS. Panos Institute participated in the first phase of CEP. The programme is funded by the German Federal Ministry for Economic Cooperation (BMZ), with additional assistance from the John D. and Catherine T. MacArthur Foundation: Collaborative Studies programme, Oxfam UK, and the Canadian International Development Agency (CIDA).

COMMUNICATING THE ENVIRONMENT PROGRAMME (CEP)

State of the Environment in Southern Africa

Steering Commmittee
India Musokotwane, Regional Director for Southern Africa, IUCN
Phyllis Johnson, Director, SARDC
Tomas Hertzman, Environmental Advisor, SADC ELMS

Scientific Advisory Committee
Thomas Mpofu, Director, Department of Natural Resources, Zimbabwe
Elton Laisi, Controller of Water Services, Water Department, Malawi
Lota Melamari, Director-General, Tanzania National Parks, Tanzania
Anderson Lema, Senior Lecturer in Geography, University of Dar es Salaam, Tanzania
David Fig, Research Director, Group for Environmental Monitoring, South Africa
Carlos Figueiredo, Projects Staff Member, Action for Rural Development and the Environment, Angola
John Hatton, Lecturer in Ecology, Eduardo Mondlane University, Mozambique

SARDC Environment Programme Staff
Munyaradzi Chenje, Editor/Project Coordinator,
John McCullum, Environment Programme Advisor/Project Coordinator,
Andrea Booth, Environment Programme Advisor
James Mpinga, Guest Editor
Mutizwa Mukute, Researcher/Writer
Ida Sibaya, Documentalist/Librarian

Production and Design
Paul Wade, Ink Spots Design Studio

Cover design by Paul Wade, photographed by Trevor Davies, using materials from the southern African environment placed on a background of rich, red soil. The design is abstract and dynamic, and, like the environment, can be interpreted in many different ways. The effect is symbolic and holistic. The complete circle of the natural cycle is visible around the tree, in the globe, the pot of water and the sculpture. The impact of human activities on the natural environment and linkages between environmental components are symbolised by the metal sculpture *Icon to the New Millenium* chosen from the work of Stephen Williams.

CONTRIBUTORS and Writers by Chapter

1 Regional Overview PEOPLE AND ENVIRONMENT (by J McCullum)

2 Learning from HISTORY (by J Mpinga)
Francis Musonda, Project Director, National Museums Project, Zambia

3 Evolution of POLICY (by J Mpinga, A Booth, M Mukute)
SADC ELMS, IUCN-ROSA

4 Southern African ECOZONES (by J McCullum)
Peter Frost, Senior Lecturer, Department of Biological Sciences, University of Zimbabwe, Zimbabwe

5 The CLIMATE Factor (by T Msengezi, M Chenje)
Bradwell Garanganga, Meteorologist, SADC Drought Monitoring Centre, Zimbabwe **Maurice Muchinda,** Chief Meteorologist, Meteorology and Advisory Services, Zambia **Jonathan Timberlake**, Plant Ecologist, Chesa Forestry Research Centre, Zimbabwe

6 SOILS and Land Use (by A Booth)
Jonathan Timberlake, Plant Ecologist, Chesa Forestry Research Centre, Zimbabwe

7 WOODLANDS and Forests (by A Booth)
Jeanette Clarke, Researcher, Forest Research Centre, Zimbabwe

8 WILDLIFE and Protected Areas (by M Mukute)
David Grossman, Ecologist, David Grossman and Associates Consulting Ecologists, South Africa **Francis Mkanda,** Chief Wildlife Officer, Department of National Parks, Malawi **Dorothy Mushayavanhu**, Senior Legal Officer, Department of National Parks, Zimbabwe **Raoul Du Toit**, Senior Lecturer, Department of Biological Sciences, University of Zimbabwe, Zimbabwe

9 FRESHWATER Resources (by J McCullum)
Piet Heyns, Director, Water Investigations Department, Namibia **Hilary Masundire,** Deputy Director, Kariba Research Station, Zimbabwe **Moremi Sekwale,** Deputy Permanent Secretary, Water Department, Botswana

10 MARINE Ecosystems (by M Mukute)
Robert Crawford, Deputy Director, Sea Fisheries Research Institute, South Africa

11 POLLUTION (by A Booth)
Victor Mtetwa, Dean, Faculty of Science, University of Swaziland, Swaziland

12 ARMED CONFLICT and the Environment (by M Chenje, M Mukute)
Simon Anstey, Ecologist, IUCN-ROSA **Jacklyn Cock,** Professor, University of Witwatersrand, South Africa **Werner Schellenberg,** Physical Planner, UNHCR, Malawi **Achim Steiner,** Programme Coordinator, IUCN-ROSA

13 GLOBAL Atmospheric Change (by J Mpinga)
Bradwell Garanganga, Meteorologist, SADC Drought Monitoring Centre, Zimbabwe

14 TRENDS and Scenarios (by J McCullum)
Southern African Environmental Scenarios workshop participants (Appendix 2)

REVIEWERS by Chapter

1 Regional Overview PEOPLE AND ENVIRONMENT
Scientific Advisory Committee members

2 Learning from HISTORY
Joe Matowanyika, Social Science Programme Coordinator, IUCN-ROSA,

3 Evolution of POLICY
Jens Fugl, Junior Programme Officer, IUCN-ROSA **Tomas Hertzman**, Environmental Advisor, SADC ELMS **Kagiso Keatimilwe**, Coordinator, National Conservation Strategy Coordinating Agency, Botswana

4 Southern African ECOZONES
John Hatton, Lecturer in Ecology, Eduardo Mondlane University, Mozambique

5 The CLIMATE Factor
Anderson Lema, Senior Lecturer in Geography, University of Dar es Salaam, Tanzania **Mary Seely**, Director, Desert Ecological Research Unit, Namibia

6 SOILS and Land Use
Henry Elwell, former Director, AGRITEX, Zimbabwe **Masego Mpotokwane,** Lecturer in Environmental Sciences, University of Botswana

7 WOODLANDS and Forests
Anderson Lema, Senior Lecturer in Geography, University of Dar es Salaam, Tanzania **Jonathan Timberlake,** Plant Ecologist, Chesa Forestry Research Centre, Zimbabwe **W. A. Rodgers,** UN Food and Agriculture Organisation, Dar es Salaam, Tanzania

8 WILDLIFE and Protected Areas
Herman Mwageni, Director, Wildlife and National Parks, Swaziland **Henry Mwima,** Chief Research Officer, Department of National Parks and Wildlife Services, Zambia **W. A. Rodgers,** UN Food and Agriculture Organisation, Dar es Salaam, Tanzania

9 FRESHWATER Resources
Harry Chabwela, Environmental Consultant, Ecosource Africa, Zambia **Elton Laisi**, Controller of Water Services, Water Department, Malawi **Paul Larkin,** Principal, Aqua Tech Groundwater Consultants, Botswana **Tabeth Chiuta,** Wetlands Programme Coordinator, IUCN-ROSA

10 MARINE Ecosystems
David Boyer, Marine Fisheries Officer, Ministry of Fisheries and Marine Resources, Namibia **Keto Mshigeni,** Professor, Department of Botany, University of Dar es Salaam, Tanzania

11 POLLUTION
Solami Mavimbela, Chemist, Water Resources Department, Swaziland **Alice Mhlanga,** Principal Research Officer, Chemistry and Soil Research Institute, Zimbabwe **Kim Olbrich**, Ecologist, Division of Forest and Science Technology, South Africa

12 ARMED CONFLICT and the Environment
Carlos Figueiredo, Projects Staff Member, Action for Rural Development and the Environment, Angola **Stan Sangweni**, Director, School of Rural Community Development, South Africa

13 GLOBAL Atmospheric Change
Maurice Muchinda, Chief Meteorologist, Climatology and Advisory Services, Zambia **Robert Scholes**, Ecologist, Forest Science and Technology, South Africa

14 TRENDS and Scenarios
Southern African Environmental Scenarios workshop delegates

ENERGY Issues
Anthony Williams, Researcher, Energy for Development Research Centre, South Africa

POPULATION Issues
Alfred Opubar, Information, Education and Communication Advisor for Southern Africa, UNFPA **Jacob Tayo**, Statistician for Southern Africa programme, UNFPA

All CHAPTERS
Scientific Advisory Committee members **Olivia Bennett**, Editorial Director, Panos Institute **Tomas Hertzman**, Environmental Advisor, SADC Environment and Land Management Sector **Pontso Mafethe**, Communications Programme Coordinator IUCN-ROSA

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FOREWORD

The development of a strong and prosperous community in our region, Southern Africa, is like making a basket, taking disparate strands and weaving them into a product of strength and durability. One of the many strands that we in the Southern African Development Community (SADC) have to weave as we work for economic development and independence is our environment. Ironically, our collective effort is exacting serious environmental degradation in our fields, our cities and our waters.

SADC heads of government recognise the importance of the environment to the well-being of our people, as clearly shown in the Treaty establishing the Community that commits SADC to:

"achieve sustainable utilisation of natural resources and effective protection of the environment…".

It has become abundantly clear that the state of the regional environment determines our level of prosperity, not only in the short-term but also for future generations. We have had to exploit our environment and natural resources to alleviate poverty and raise the standard of living of people. Such exploitation, however, is not without cost. Overexploitation and abuse of our natural resources will not only lead to environmental degradation, but will also exacerbate the very poverty we seek to alleviate.

We cannot afford to continue with the economic development practices of the past which emphasised profit over our environment. As we strive to address social equity and economic development, a common thread of sustainable development practices will shape our future. It is necessary for us to integrate the sustainability of the physical environment with social, cultural, economic and political stability.

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.

In this region, we have a long history of traditional conservation methods that allowed us to live in harmony with our natural environment. As the 21st century approaches, we, the people of southern Africa, have the future in our hands. We can use our resources and fulfil our potential for development, or we can abuse them and not only slow our own progress but jeopardise security for future generations. The natural world of conservation and management of natural resources is our world. This is the world of consultation and tolerance and of sharing in our future as well as our present in a development process that is sustainable. We share many prospects and possibilities and we must learn to share our resources.

This book comes at a critical stage in the history of southern Africa. Its publication coincides, first, with a growing trend towards environmental awareness among our people and, second, with a genuine search for solutions to the many environmental problems we all face in our struggle to earn a living. 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. This publication is dedicated to empowerment through information in the hope that it will be disseminated through the region's communication channels, and through schools to the decision makers of the future.

The hope is that the book will also provide new insights to those of us in leadership positions (government and non-governmental) who hold the key to meaningful policy change. Ultimately, it should lead to popular action involving all sectors of society. SADC has, is and always will make concerted efforts to improve relations between our inter-governmental community of nations and non-govermental organisations within and beyond the region.

The *State of the Environment in Southern Africa* is in itself one major example of newly formed partnerships between governments and NGOs. Through our Environment and Land Management Sector (SADC ELMS) secretariat in Maseru, Kingdom of Lesotho, we are all proud to have taken part in this worthy and important cause, along with the Communicating the Environment Programme (CEP) partners, the Southern African Research and Documentation Centre (SARDC) and the International Union for the Conservation of Nature and Natural Resources (IUCN). It is from this growing constituency of individuals and institutions that sustainable development will be recognised by all and find practical and popular expression.

Q.K.J. Masire
President of the Republic of Botswana and Chairman of SADC

September, 1994

ACKNOWLEDGEMENTS

This book is a fruit of the southern African environment grown out of a need to make environmental information more accessible, and watered by the region's own fountain of knowledge: environmental professionals, organisations and institutions. It is also the fruit of a unique partnership involving SARDC, IUCN-ROSA and SADC ELMS.

The partner organisations would like to thank all of the people who participated in the preparation of this book — conference and workshop participants, contributors, reviewers, researchers, writers and editors.

The seven-member Scientific Advisory Committee (listed on a previous page), born from the June 1993 Mazvikadeyi conference, read through various manuscript drafts to check for omissions and errors of fact or presentation. Their expertise guided the process as we tried to meet our objective of making technical, scientific information accessible to a wider audience.

The delegates who met to discuss pre-chapter modules at the Mazvikadeyi conference — five from each of the 11 southern African countries — shared their environmental knowledge and some reviewed the final draft. We must thank also the chapter contributors, for their scientific input; chapter reviewers for their constructive comments; and journalists who wrote stories "humanising" the issues, as well as photographers, illustrators and cartographers.

We wish to express appreciation to the Government of Zimbabwe for hosting the conference and, in particular, to the Honourable Minister of Environment and Tourism, Dr Herbert Murerwa. He delivered an inspiring opening address, and has continued to give encouragement and support to this project.

India Musokotwane, the IUCN Regional Director for Southern Africa, who chaired the steering committee, and Achim Steiner, Programme Coordinator at IUCN-ROSA, were dynamic forces in developing the concept of **Communicating the Environment Programme (CEP)** and monitoring progress of the project. Tomas Hertzman, the Environmental Advisor at SADC ELMS, was a constant source of ideas, encouragement and support throughout the process.

The writers and editors worked exceptionally hard for almost three years, and we wish to acknowledge particularly the work of our environment programme advisors from Canada, John McCullum and Andrea Booth. Their environmental knowledge, research and organisational skills enabled us to identify and synthesise the wealth of knowledge available in this region into a computerised data base, and to establish the basis for a sustainable programme on **Communicating the Environment.**

Among the other SARDC staff who drafted and redrafted chapters, we wish to thank Munyaradzi Chenje for bringing to this project his many years of writing and editorial skills; Mutizwa Mukute, for his range of environmental knowledge, patient redrafting and lively discussion; and Ida Sibaya for sustaining and expanding the SARDC CEP library of environmental information. We also wish to thank the Environment Press Foundation (Tanzania) for seconding their director, James Mpinga, to SARDC as Guest Editor during this period. Acknowledgement is also due to Costa Chisvo and the late Tendai Msengezi for their initial input during the process of information collection and drafting.

SARDC Director Phyllis Johnson monitored implementation of the project, and worked on the final phases of editing and book production. Thanks also to SARDC Director David Martin who initially encouraged the organisation to get involved in environmental issues through monitoring the impact of *apartheid* on the region's environment.

Thanks to Paul Wade of Ink Spots Design Studio for designing the text and the cover of this book. Robert Maruziva of the University of Zimbabwe Department of Geography drew all the maps, and Debbie Rider prepared a comprehensive index. At Panos London, we want to thank the Director of Panos Books, Liz Carlile, and the Managing Editor, Olivia Bennett, for their ideas and sound advice, when beginning and ending the editorial process.

The publishers want to acknowledge all sources of information reproduced in this book. Every effort has been made to trace copyright holders, but if any have been overlooked, the necessary arrangements will be made at the first opportunity. We drew particular inspiration on presentation of contents from the World Resources Institute reports, and we wish to acknowledge their model and encourage them in the continued production of a valuable information resource.

We must also thank all environmental organisations, universities, governments, libraries and individuals who supplied us with documentation, references and information, now lodged in our data base, which we drew upon to write this book. Some not only opened their doors wide to receive us when we went around the region collecting environmental data, but also their drawers and filing cabinets to give us copies of their published or unpublished materials. Their insight also provided initial direction for the chapter modules, which were later reviewed and refined at the Mazvikadeyi conference.

There are literally hundreds of people who have had a hand in providing direction, sharing knowledge and experience, providing information or lending support in some way to the production of this book. While we cannot name them all, we would like to recognise them and their vision of the need for better access to environmental information in southern Africa.

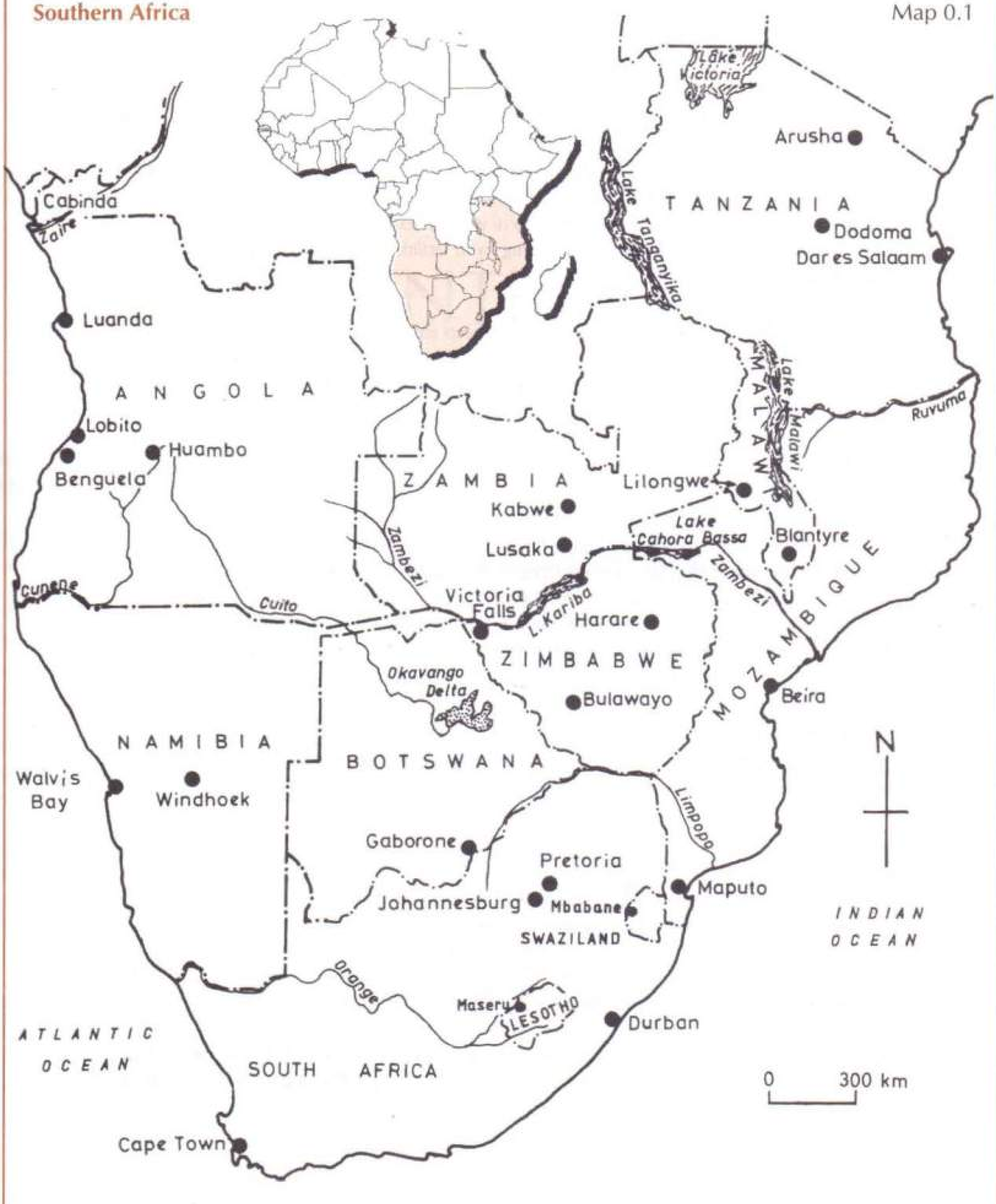
The CEP project would not have been realised without the generous financial support of: the German Federal Ministry of Economic Cooperation (BMZ), who helped us to transform an idea into reality; the John D. & Catherine T. MacArthur Foundation through their Collaborative Studies programme, the regional office of OXFAM (UK), and the Canadian International Development Agency (CIDA).

Together we hope we have contributed in some small way to environmental awareness and sustainable development in southern Africa.

July 1994

Southern Africa

Map 0.1



SOURCE: Maruziva, Robert, University of Zimbabwe Department of Geography, for SARDC, 1994

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. SARDC's objective is to improve the base of knowledge about economic, political, environmental, gender, cultural and social developments and trends, and their implications by disseminating information to a wide regional and international audience. SARDC is also a documentation centre containing over 3,000 subject files on regional issues, a library of books and periodicals, and computerised database of select material with reading room facilities for researchers and others studying issues with a regional perspective.

Under CEP, SARDC has produced environmental fact sheets and established a new environment resource centre with a comprehensive computerised database and library on southern Africa. The library and database are at the core of SARDC's ongoing reporting and analysis of regional environmental issues. SARDC is also able to undertake consultancies on environmental and other issues.

IUCN
The World Conservation Union

IUCN is the only union whose members include both governments and non-governmental organisations (60 in southern Africa) providing a medium for effective conservation and development action on the ground. The Regional Office for Southern Africa (ROSA) based in Zimbabwe, and its country offices in Botswana and Zambia, act as focal points for IUCN's conservation and development programmes in the region. IUCN's aim is simple as manifested in the Union's Mission Statement which is to "influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature to ensure that any use of natural resources is equitable and ecologically sustainable."

Among other activities in the framework of the CEP programme, IUCN-Rosa has awarded investigative reporting fellowships for journalists in the region and facilitated training workshops for environmental writers.

SADC
Southern African Development Community

SADC, an intergovernmental organisation, is structurally organised into several development sectors, whose respective coordination is entrusted to the government of a specific member State. The Government of Lesotho is responsible for coordinating activities within the SADC Environment and Land Management Sector (ELMS) and, to that effect, has established a Coordination Unit within its Ministry of Agriculture, Department of Conservation, Forestry and Land Use Planning.

Environmental reporting and information activities are key components in the SADC ELMS programme of work and, for nearly two years now, ELMS has been collaborating with SARDC and IUCN-ROSA in this area.

INTRODUCTION

The *State of the Environment in Southern Africa* is a book for people who want to increase their understanding of environmental issues and processes in southern Africa — one of the most ecologically rich and diverse regions of the world.

The book looks at the resources shared by the current member countries of the Southern African Development Community (SADC) — Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. It reviews both the opportunities and the problems.

Southern Africa's environment is presented here as it occurs in nature — without national boundaries. This environment is shared by everyone in the region regardless of history, nationality, ethnic origin, gender, religion or class. The main focus is on ecological zones (ecozones), which transcend the countries they cover, and how they are affected by human activities.

The countries of southern Africa are interdependent, and an understanding of this factor is critical to an appreciation of the environment anywhere in the region. The solutions to many environmental problems in any country lie in the cooperation of all countries in the region.

The purpose of the book is to give a balanced and accessible overview of the state of the environment in the region as it is today. The contents are intended to inform, motivate and empower southern Africans at different levels of decision-making to enhance various conservation programmes already in place, and to build upon the good land-use practices passed down through generations. The text also identifies bad land-use practices that have contributed to land degradation in some parts of the region.

While concerned primarily with environmental impacts in southern Africa, the book recognises that this region is not an island. It is influenced by trends and decisions in other parts of the world which have a bearing on whether southern Africa will be able to achieve sustainable development. In responding to the challenges of sustainable use of resources in southern Africa, the people of this region are looking also at a much broader picture.

THE FORMAT

There has been a deliberate attempt to avoid technical language and explanations in this presentation, 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.

The book is presented in three parts. Part One sets out background information on southern Africa, its physical environment and the way it has been managed throughout history to the present. The first chapter in this section gives a regional overview in the context of related socio-economic issues, such as population growth and economic development, which affect people's interaction with the environment. The chapters on history and policy deal respectively with traditional environmental management techniques and the laws, policies and institutions that regulate the southern African environment today. The next chapter describes the different ecozones in the region — large natural units which are controlled by a set of common processes, mostly climatic, and dominated by life-forms with similar physical adaptations to those processes. The chapter on climate reviews the role of weather patterns, particularly drought, as an important context for understanding environmental issues.

Part Two of the book sets out a series of environmental issues of interest to southern Africa. The issues covered here are the most serious faced by the region, chosen after discussions with literally hundreds of people in the environmental field throughout southern Africa. These are the topical issues that were mentioned as foremost during visits to all 11 countries, and further highlighted at a conference of environmental personnel from all countries in the region. These issues are broad — ranging from soils and land use, woodlands and forests, and wildlife and protected areas, to freshwater and marine resources, pollution and armed conflict. The "issue" chapters focus on how people in southern Africa interact with the environment, the various measures used to protect and conserve resources, and the factors which contribute to overexploitation of resources.

The last section of the book, Part Three, looks toward the future. The chapter on global atmospheric changes considers the possible impact on the region of global warming and depletion of the ozone layer, and reviews the actions being taken, regionally and internationally, to contain this. The final chapter on regional trends and scenarios takes the major trends identified in the overview and projects them into the future. These scenarios were developed at a workshop which considered the region's environmental strengths and weaknesses, opportunities and problems. The question was deceptively simple: *What road are we on, and what major decisions can affect this course?*

In addition to the compilation of information and building of scenarios, we have tried to give a human face to environmental issues. A number of journalists in the region were commissioned to talk to, and write about, people and their environment. Their stories — ranging from the fuelwood shortage in Tanzania and efforts to solve it, to the accumulation of junk in Angola as a result of war — are placed throughout the book. The purpose is to show the environment not as an abstract issue, but as a reality which affects people in their daily lives. The stories 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.

All chapters have a "linkages" section at the end, to direct the reader to chapters with more information on a related issue. For example, the linkages section of The Climate Factor, which deals with drought, signposts the reader to the Soils and Land Use chapter for additional information on the relationship between drought, soil degradation and agricultural productivity.

THE PROCESS

This book on the *State of the Environment in Southern Africa* has been three years in the making, and many thoughts and contributions have come together to give it substance. It has been as much a process as a product. Part of the ongoing Communicating the Environment Programme (CEP), it involves the Southern African Research and Documentation Centre (SARDC) and the World Conservation Union Regional Office for Southern Africa (IUCN-ROSA) together with the Southern African Development Community's Environment and Land Management Sector (SADC ELMS).

This is a unique partnership between SADC, an inter-governmental organisation; SARDC, a non-governmental organisation; and IUCN, whose membership includes both governmental and non-governmental participation.

The process began in late 1991 with the collection of information — studies, books, reports, research papers and articles — from hundreds of organisations and individuals around the region. SARDC's contribution was to assemble those studies and reports into a reference library with a massive computerised data base, using CDS/ISIS, a bibliographic software programme developed by the United Nations Educational, Scientific and Cultural Organization (UNESCO). The data base has three subject areas:

- a bibliographic reference of environmental information on southern Africa;
- contacts for environmental organisations and individuals; and
- over 7,500 notes from library documents used in the preparation of this book.

The bibliographic data base, which can be searched using Infoterra key words, will be available on disc as a PC-based information product, and a CD-ROM production is being considered if a funding source can be identified. The data base contained 3,500 bibliographic references by early 1994 and is regularly updated. This information is available to governments, NGOs and other organisations and institutions working on environmental issues in southern Africa, and to journalists and media workers through the Environment Resource Centre at SARDC in Harare.

For purposes of this report, the information assembled was distilled into a list of major points on each of the issues covered in the individual chapters. Five environmental specialists from each country in southern Africa were then invited to attend a conference to examine these outlines, to determine the direction being taken and the accuracy and breadth of the information contained. Following the conference in June 1993, a Scientific Advisory Committee (SAC) was established from among the delegates to set out a detailed direction for the book and to monitor its progress. Twenty-four expert contributors from the region were identified to provide additional information and analysis of the various issues. SARDC staff wrote chapter drafts, which the SAC members and other specialists reviewed for errors and omissions.

After the chapters were assembled into a whole manuscript, the SAC met again to digest the data and to forecast future scenarios for the environment in southern Africa. The Southern African Environmental Scenarios Workshop in February 1994 attempted to examine the region's environmental future.

The result is this book — an interesting, accessible and well-illustrated document which has been rigorously examined for its scientific accuracy in content and approach. It is not an academic or policy study, but is intended to give an overview of the current "state" of the environment in southern Africa. This should be a tool for decision-makers to use in developing appropriate agendas for action, and a reference for media workers and non-governmental organisations who communicate information to the public. It will be available in English and Portuguese (1995) editions.

The book is also aimed at the decision-makers of the future, and is presented in a way that should make it a useful resource for teachers and school librarians throughout the region. A teachers' manual is one of the options being studied by SADC ELMS as an educational guide to this volume.

The *State of the Environment in Southern Africa* is the first report of its kind on southern Africa, including South Africa. The partner organisations believe it fills a gap, provides valuable information in an accessible form and is a useful contribution to environmental education and decision-making tools.

ENVIRONMENTAL INFORMATION

The overall intent of this publication is to challenge people, governments, organisations, researchers and the media to strive for the sustainable utilisation of resources.

The project which led to the development of this book is based on the principle that information is a key to transformation. When people have access to information about the ecological processes that affect their lives, their resources and their future, and the environmental problems they face, they are able to respond — and may even feel compelled to respond.

This philosophy of information sharing appears in documents of environmental organisations at the grassroots and at the global level. The United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro, Brazil, in June 1992, set out a series of principles for bringing together environment and development in a sustainable way. These principles, called the "Rio Declaration", recognise the pivotal role of environmental information. Principle 10 states:

> "Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities. ... States shall facilitate and encourage public awareness and participation by making information widely available."

Among the objectives set out by the 103 heads of state who attended UNCED, were:

> "Countries should cooperate with each other and with the various social sectors and population groups to prepare educational tools that include regional environment and development issues and initiatives using learning materials and resources suited to their own requirements."
>
> and
>
> "Countries and international organisations should review and strengthen information systems and services in sectors related to sustainable development, at ... international levels. Special emphasis should be placed on the transformation of existing information into forms more useful for decision-making and on targeting information at different user groups."

In line with the UNCED principles, the partners to this report believe southern Africa can use its environment for sustainable development 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 environmental policy and management, and that an informed population will not only widen and enhance the discussion, but will take positive action to achieve sustainable development.

Sustainable development Box 0.1

" ...development to be sustainable must meet the needs of the present without compromising the ability of future generations to meet their own needs."

The World Commission on Environment and Development (WCED), chaired by the Norwegian Prime Minister, Gro Harlem Brundtland, defined sustainable development in their report, *Our Common Future*, published in 1987.

"... a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations."

SOURCE: WCED, *Our Common Future*, Oxford University Press, Oxford, 1987

1

Regional Overview
PEOPLE AND ENVIRONMENT

The future of the environment in southern Africa is in the hands of its people — numbering about 136 million and expected to double in the next 24 years. The physical processes described in the following chapters do not simply happen; they are directly and indirectly affected by the human context (political, social and economic). People are not only an ecological disruption. We are part of the environment in which we live, make decisions, and take actions that determine the state of the environment now and in the future.

Increasingly, there is the realisation at national and international levels of decision-making that a healthy society needs a healthy environment as well as a healthy economy. The World Commission on Environment and Development (WCED) in 1987 drew attention to the need for a new developmental path to sustain human progress, not just in a few places and for a few years, but for the entire planet into the distant future. The WCED (often called the Brundtland Commission because it was chaired by Norwegian prime minister Gro Harlem Brundtland) defined *sustainable development* as meeting "the needs of the present without compromising the ability of future generations to meet their own needs."[1]

POPULATION

Most people look forward to a new baby. It may be a family's first child, a new brother or sister, or a grandchild. Each new life is a symbol of the potential of the human race to excel — a successful business person, a religious leader, a brilliant scholar or a politician, a good husband or wife. Every baby represents the future in some way.

Over five million babies were born in southern Africa in 1993.[2] These babies need food and water, shelter and warmth. As they grow older they will need land for farming, or jobs for wages, and they will want to have children of their own. Governments will have obligations to these babies throughout their lives, providing health care, education, social services, roads and infrastructure, and the many other supports which citizens need. When all these needs are added together they can create a sizeable draw on natural and financial resources. Sooner or later, however, the resources cannot be stretched any further.

Population growth

In southern Africa, the population grows at three percent annually, on average, although the growth rate for different countries ranges from 2.2-3.8 percent. At this rate, the region's population will double by the year 2018. The Southern African Development Community's Environment and Land Management Sector (SADC ELMS) has stated that the increasing population is multiplying the effects of all environmental problems in the region.[3]

It is not easy to reduce population growth-rates, and the process is slow. If all the people living in the region now bear only enough children to replace themselves, the population will still increase before levelling off. The United Nations Population Fund (UNFPA) calls this the "low fertility scenario".

Most people in southern Africa are of child-bearing age, or younger. In most countries, over 40 percent of the population is under 14 years of age.[4] Although quite high, popula-

Photo 1.1 MINFO-D Chinamo

Population growth in southern Africa Table 1.1

Country	Population (millions) 1994	Average annual growth rate (%) 1990-5	Population (millions) 2025	Density per sq km (persons) 1994	Population in urban areas (%) 1970****	Population in urban areas (%) 1990	Annual urban growth rate (%) 1990-5
Angola	11.2	2.8**	24.7	9.0	-	28	5.4
Botswana	1.5	3.5**	3.4	2.6	8	28	8.3
Lesotho	2.0	2.9**	4.4	66.0	9	20	6.3
Malawi	10.1	3.6**	24.7	107.3	6	12	6.3
Mozambique	17.5	2.7*	35.4	22.3	6	27	7.6
Namibia	2.0	3.1*	4.7	2.4	19	28	5.2
South Africa	38.5	2.2**	65.4	32.5	48	59	3.2
Swaziland	0.9	3.6*	2.2	53.0	-	33	7.0
Tanzania	31.3	3.8*	84.9	33.3	7	33	7.0
Zambia	9.8	3.8*	26.3	13.0	30	50	5.6
Zimbabwe	11.0	3.1*	22.6	28.2	17	28	5.4
TOTAL	135.8		298.7				
AVERAGE		3.0***		17.7		42.7	6.5

* growth-rate increasing ** growth-rate decreasing or stable *** regional population doubles in just under 24 years
SOURCES: UNFPA, *State of World Population 1992*, Nuffield Press, London, 1992
The 1994 populations, and densities and other statistics beyond 1994, are extrapolations by UNFPA.
**** World Bank, *World Development Report 1993: Investing in Health*, Oxford University Press, New York, 1993

Population growth — the global picture Box 1.1

World population growth is expected to stabilise in about 45 years, declining gradually after the year 2025, with no significant slowdown until 2050. The UNFPA has projected global population increases from the current 5,700 million, for the years 2050 and 2150, using low, medium and high scenarios:

- rising to about 8,000 million in 2050, but dropping to just under 5,000 million by 2150 if effective family planning leads immediately to low fertility throughout the world;
- rising to just over 10,000 million in 2050, and stabilising at around 12,500 million in 2150 if family planning leads to low fertility globally in about 10 years; and
- rising to 12,500 million in 2050 with a 500 percent increase to 28,000 million in 2150 if family planning is unsuccessful.

UNFPA considers the middle projection the most likely to happen, and predicts that 97 percent of this population growth will occur in developing countries.

Working with a 2.49 percent average population growth rate, UNFPA's medium projection for southern Africa shows the region's population increasing to 539 million by 2050.

SOURCE: UNFPA, *State of World Population 1992*, UNFPA, New York, 1992

tion growth-rates are stable or decreasing in six of the region's 11 countries. Southern Africa, 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.

Slowing down the population growth would take some pressure off natural resources and give some "breathing space" to tackle environmental problems.[5] The conventional policy for slowing population growth is through family planning, although success stories in reducing birth rates are almost invariably tied to an increase in standard of living.[6] It is generally accepted, therefore, that the best way to decrease population growth is to reduce poverty and increase standards of living.

Infant mortality rates in southern Africa have dropped dramatically in the last 20 years, and now, on average, less than 1 in 10 babies born in the region die before the age of one year. Young children do not fare as well, with an average mortality of 2 in 10 for children under five years, although this rate has also improved.[7] Infant mortality rates are also linked directly to birth rates — where one is high, so is the other.

Literacy and education

While education can have a direct impact on behaviour toward the environment through particular topics and courses or outreach programmes, its main impact may be less direct. Several studies show that higher levels of education attained in a society correlate with higher economic growth. Education levels, especially among women, also relate directly to lower fertility rates and greater use of family planning methods. So, in theory, higher levels of education also reduce population growth. Children from smaller families tend to perform better in school because they spend more time individually with their parents.[8]

In southern Africa, literacy rates have improved considerably in the post-independence period. The number of students enrolled in secondary institutions has also risen sharply, although the highest rate achieved by any country in the region is 50 percent.[9]

The role of environmental education in raising awareness, improving understanding of issues and encouraging positive action is receiving greater attention in southern Africa. Environment is included in most school curricula in one form or another and environmental magazines and other

Social development indicators Table 1.2

Country	Adult literacy (%)*		Births attended by health personnel (%)***	Infant mortality per 1,000**		Under 5 (years) mortality per 1,000*		Population with access to health services (%) ***	Population with access to safe water (%)*	Life expectancy (years)*		
	1970	1990	1983-90	1970	1991	1960	1990	1987-89	1988-90	1960	1990	1992
Angola	12	42	15	-	127	345	292	30	35	33	46	46
Botswana	41	74	78	101	36	173	85	89	53	46	60	60
Lesotho	-	78	40	134	81	208	129	80	48	42	57	60
Malawi	-	47	45	193	143	366	253	80	56	38	48	45
Mozambique	22	33	28	171	149	331	297	49	24	37	48	47
Namibia	-	40	-	118	72	262	167	-	-	43	58	58
South Africa	-	70	-	79	54	192	88	-	-	49	62	62
Swaziland	-	72	-	-	107	226	167	80	53	40	57	57
Tanzania	-	65	60	132	115	249	170	81	56	41	54	51
Zambia	52	73	39	106	106	228	122	75	59	42	54	46
Zimbabwe	55	67	60	96	48	181	87	72	74+****	45	60	56

SOURCES: *UNDP, *Human Development Report 1992*, Oxford University Press, New York, 1992 and UNDP, *Human Development Report 1994*, Oxford University Press, New York, 1994
**World Bank, *World Development Report 1993: Investing in Health*, Oxford University Press,;New York, 1993
***UNFPA, *State of World Population 1992*, UNFPA, New York, 1992 and Oxford University Press, 1994
****Government of Zimbabwe, *Zimbabwe National Programme of Action for Children: Our Second Decade of Progress and Development*, Government of Zimbabwe, Harare, 1992 (For rural areas = 74%; resettlement areas = 83%; urban areas = 100%)

publications are produced for children and adults. Non-governmental organisations (NGOs) are directing more energy into this area, and some have been formed specifically to implement environmental education. The media are becoming better informed, and more stories on environmental issues are appearing in print, on radio and television.

ECONOMIC DEVELOPMENT

Economic growth in southern Africa is among the lowest in the world. Gross Domestic Product (GDP) (the value of all goods and services produced by all factors of production resident in a country in one year) is growing at a slower pace than population in virtually all southern African countries. In more than half the countries, economic growth declined during the 1980s, largely because of defence expenditures to counter South Africa's military action. Job creation has not kept pace with the increasing labour force[10] and per capita income declined by an average of 1.1 percent annually during the decade 1982-92.[11]

Per capita incomes in southern Africa are very low by world standards, although the large proportion of rural subsistence farmers means that people are generally able to support themselves, in whole or part, through their own production. This is not measured when compiling national economic statistics. For example, statistics suggest that economies are in doldrums in much of southern Africa, but these figures mask what really takes place. A significant proportion of the citizens of this region work in the informal sector — unrecorded, untaxed and regulated only by a common desire for a livelihood. This sector spans activities ranging from operating a home-based dressmaking shop or tilling the land, to selling used cars across borders. Thus, many of the economic indicators used to measure a country's wealth may mean little. The point is that both the formal and informal sectors in the region are drawing heavily on the local environment.

Rapid population-growth commandeers a large share of investment to maintain the same amount of capital per person, handicapping, but not preventing, economic growth.[12] Studies since 1975 show that income growth is slower in countries with faster population growth, and better economic performance is correlated with slower population growth, although the factors are very complex and dynamic – and the effect is relatively modest.[13]

Women count — but are not counted Box 1.2

Much of the work that women do is "invisible" in national accounting and censuses, despite its obvious productive and social worth. The reason is that women are heavily involved in small-scale agriculture, the informal sector and household activities — areas where data are notoriously deficient. ...

Women have shouldered a large part of the adjustment burden of developing countries in the 1980s. To make up for lost family income, they have increased production for home consumption, worked long hours, slept less and often eaten less — substantial costs of structural adjustment that have gone largely unrecorded. The low value attached to women's work requires a fundamental remedy: if women's work was more fully accounted for, it would become clear how much women count in development. To do that requires much better gender-specific data on development. There is a need to redesign national censuses, particularly agricultural surveys.

SOURCES: UNDP, *Human Development Report 1990*, Oxford University Press, New York, 1990
OAU and UNICEF, *Africa's Children, Africa's Future*, Background Sectoral Papers prepared for the OAU International Conference on Assistance to African Children, Dakar, 25-27 Nov 1992, p. 156

Historical perspective

Southern Africa's economic stagnation can be traced back to colonial times, when economic policy distortions and inefficient, unregulated exploitation of resources was rampant. Much of the population was not allowed to develop past subsistence level. Education levels were kept low, leading to a shortage of skills. The result was limited, fragmented markets and a small production base, often relying on out-dated equipment and technology, and depending on external inputs.

Sharp increases in petroleum prices began with the global "oil crisis" in 1973 and the subsequent recession hurt global trade. Commodity prices began to decline in world markets in the late 1970s and have been going down ever since, further harming the export-based economies of southern Africa.[14] Foreign loans taken to support sagging economies in this period carried high interest on repayments and increased pressure on foreign exchange reserves.

Many southern African countries responded to the need for post-independence social and political change by installing economic systems intended to be more equitable, especially in supporting the poor and disadvantaged. Economic policy, however, tended to favour urban residents at the expense of the rural majority by keeping food prices low through agricultural marketing regulation.[15] In addition, most southern African countries have had high levels of military expenditure during the 1980s due to the confrontation over *apartheid* in South Africa.

Such pressures led to southern African governments cutting imports to save foreign exchange, while trying to expand exports to repay the debts. Consequently, internal investment and government expenditure dropped, especially for education, health and social welfare. As debt increased and commodity prices fell, developing countries around the world tried to produce more agricultural and mineral commodities to acquire foreign exchange, leading to over-supply and further price drops.[16] The tariffs and import ceilings in industrialised countries also hampered exports from developing countries.

Structural adjustment

In the early 1980s, commercial credit to southern African and other developing countries, which had been fuelled by huge petroleum profits, dried up. The World Bank stepped in to provide assistance but insisted on strict Economic Structural Adjustment Programmes (SAPs). They proposed to improve government economic management, increase economic efficiency and stimulate growth through exports (largely raw materials or agricultural products). The main components of the programmes were cuts in government spending, removal of import controls and subsidies, devaluation of currency, tight money and credit supply, and privatisation of state-owned enterprises.[17] One assumption, which has proved to be incorrect, was that the world economy would improve, providing the impetus for economic growth in those countries which chose the adjustment process.[18]

Governments and NGOs around the world condemned the impact of SAPs, especially on the poor and vulnerable. These criticisms culminated in the 1990 report *Adjustment with a Human Face*, by the United Nations Children's Fund (UNICEF), which was able to have some effect on World Bank policy. Following this, the United Nations Economic Commission for Africa (UNECA) developed an alternative framework based on the idea that adjustment should concentrate on developing human resources and institutions.

While there is general agreement on the need for economic structural change, the UNECA noted that the SAP approach has not provided the desired results in Africa. They felt this resulted from:

- an approach geared to free-market economies and market forces which did not exist in the poorly structured economies of many countries;
- the high levels of debt which severely strained the developing economies;
- protectionist import policies in industrialised countries; and
- lack of sufficient capital to develop.

The World Bank insists that SAPs have had positive effects on the economies of countries which implemented them, compared to those which did not, although the economic improvements rarely met predictions.

In environmental terms, SAPs have not been aimed explicitly at putting countries on a path to sustainable development. A recent study of the environmental effect of SAPs in Ivory Coast, Thailand and Mexico revealed that environmental impacts had not been considered, and that unintended impacts (both positive and negative) had occurred. For example, the removal of subsidies, such as those on commercial energy, has usually resulted in more efficient use of resources; but export incentives have led to clearing of forests and other natural vegetation for cultivation, as well as farming of increasingly marginal land.[19]

Reductions in government programmes have harmed environmental infrastructure and services, and, in some cases, cuts in these areas are disproportionately high compared to other sectors.[20] There is also evidence that SAPs have perpetuated or increased existing patterns of overexploitation of natural resources.

Poverty alleviation

While economic growth is necessary to improve incomes, it is also critical that poverty be alleviated; in other words, fairer distribution of wealth is also needed.[21] Unless poverty is reduced, population growth and pressure on resources will continue to increase. Information on numbers of people in absolute poverty (those unable to meet essential needs) is difficult to get but statistics are available for Botswana, Lesotho, Malawi, Namibia and South Africa. For those five countries the figures ranged from 49-78 percent.[22] A recent study in southern Africa also concluded that SAPs lead to wider gaps between rich and poor.[23]

Less than half of the population in the region has access to clean water, health services and sanitation. Most countries experience high levels of infant mortality and not enough young people attend college or university, or even secondary school. Government priorities and limited resources will focus on these basic human needs until the level of available resources allows for improved environmental management.

Debt burden

Foreign debt continues to climb, at least doubling in most SADC countries between 1980 and 1991. In some cases, the debt burden increased by three or even six times in that period,[24] although economic research shows both positive and negative connections between debt levels and income growth depending on the countries studied.[25] Two countries have foreign debt greater than GDP — Mozambique by four times and Tanzania by two.[26] It is notable that the Mozambican government, in its official report to the UN Conference on Environment and Development (UNCED), said bluntly that it cannot achieve sustainable development in the short-term because it could not yet meet the human needs of its population.

Debt service has risen to more than 25 percent of Gross National Product (GNP) (the value of all goods and services produced by citizens within and outside the country in one year) in four countries of seven for which statistics are available.[27] Inflation rates between 1980 -1991 are also high and continue to rise in some countries.[28] Low global commodity prices have cut export earnings, requiring greater production of materials to earn sufficient foreign exchange to pay the interest on the debt.

Economic indicators Table 1.3

Country	GDP growth (%) 1970-80	GDP growth (%) 1980-91	GDP per capita (US$)* 1991	Average annual inflation (%) 1980-91	Foreign debt ratio (US$m) 1980	Foreign debt ratio (US$m) 1991	Debt service (% of exports) 1980	Debt service (% of exports) 1991	Terms of trade (1987 = 100) 1985	Terms of trade (1987 = 100) 1991
Angola	-	-	1,225**	-	-	-	-	-	-	-
Botswana	14.5	9.8	4,080	13.2	133	543	1.9	3.4	-	-
Lesotho	8.6	5.5	1,890	13.6	71	428	1.5	4.6 -	-	
Malawi	5.8	3.1	570	14.9	821	1,676	27.7	25.0	104	87
Mozambique	-	(0.1)	600	37.6	0	4,700	0	10.6	91**	-
Namibia	-	1.0	-	12.6	-	-	-	- - -	-	
South Africa	3.0	1.3	4,958**	14.4	-	-	-	-	105	86
Swaziland	-	-	2,405**	10.3	-	-	-	-	-	-
Tanzania	3.0	2.9	640	25.7	2,476	6,460	19.6	24.6	101	84
Zambia	1.4	0.8	1,010	-	3,261	7,279	25.3	50.3	90	116
Zimbabwe	1.5	3.1	2,580	12.5	786	3,429	3.8	27.2	100	101

* means it is based on purchasing power
SOURCES: World Bank, *World Development Report 1993: Investing in Health*, Oxford University Press, New York, 1993
** 1989 figures from UNDP, *Human Development Report 1992*, Oxford University Press, New York, 1992

The need to increase economic output will intensify pressure on southern Africa's resources, doubly so because economic growth will not only have to meet the needs of people today, but also the expanding population over time. Much of the economic growth strategy is export-driven, with a sizable component dedicated to cash crops from (tobacco and coffee to bananas or roses), which can earn considerable foreign exchange.

Many volumes have been written about the debt burden and possible solutions to it, but it is unlikely that most southern African countries will be able to advance in the areas of environmental regulation and management until the debt burden is reduced.

The two most obvious resources which will be affected by the pressure to increase economic output are land and water. Land will be needed to grow food, support industry, graze livestock and, of course, as a place to build houses and cities. Water will be needed for basic survival, and it is also essential to each of these land-based activities.

LAND USE

Land is still relatively accessible in most countries in southern Africa, although population density and the number of people an area can support varies dramatically from place to place. While people need land for agriculture, the percentage moving to cities is higher than the birth rate in most of the region. Urban land requirements for housing are much less than in rural areas, and industrial demand for land is still relatively low.

Land distribution

The demand for agricultural land is increasing rapidly. The use of marginal or unsuitable land for farming is increasing, while intense pressure on some existing farmland often leaves it completely exhausted. Large areas of forest are being cleared and cultivation of very steep, or very dry, land is becoming common. The demand for land for cultivation is not only due to population pressure, but also to land distribution, where large expanses are farmed commercially, reducing the amount available to small-scale, subsistence farmers. This problem can be compounded by inequitable distribution of high productivity farmland. Programmes for redistribution of land in a more equitable way are being planned or implemented in most countries where this is a problem.

Traditional farming methods

Traditional forms of agriculture have been able to provide for large numbers of people on small areas, using intensive but ecologically sound methods, on a sustainable basis. Ukara Island in Lake Victoria was already supporting a population of more than 500 people per square kilometre in the mid-1800s, but even today their soil is not degraded. They use a labour-intensive system in which every available nutrient (including leaves and human waste) is "integrated with irrigation and a complex system of crop rotation".[29]

Traditional cropping systems, such as slash-and-burn shifting cultivation, are well-adapted to the local ecology. These systems involve clearing and burning the land to fertilise the soil and kill pests. The cleared area can be farmed for two or three years before weed growth and declining productivity stimulate a move to a new location. If the land is given 20-30 years to recover, as in the past, this form of cultivation is sustainable. But today, with so many people trying to earn a living from the land, this is no longer the case. Long fallow-periods are not possible and the trees do not have

Urbanisation Box 1.3

The movement of people from rural areas to towns and cities, known as urbanisation, has been a constant feature of the 20th century. In southern Africa, the rate of urban growth is now more than double the rate of population growth. The proportion of people living in towns and cities increased dramatically between 1970 -1990, with more than 40 percent of the region's population now living in urban areas.

Urbanisation was once considered to be a pre-condition for reducing population growth and increasing economic development, but recent trends have shown that this is not necessarily the case. The rate of urbanisation is higher in countries with rapid population growth, in other words, cities absorb a larger proportion of people when populations are rapidly expanding.

The reasons for urbanisation are many. Young people move in search of jobs; incomes are often higher in urban areas; drought or other disasters draw rural people to urban centres in search of relatives who can provide food and shelter. Services tend to be better and more available, with urban dwellers having double the access to health care, clean water and sanitation of rural people. Government policies tend to favour urban dwellers. For example, food price regulations keep prices down, benefiting urban food-buyers, but hurting rural farmers who sell food, and generally depressing the agricultural sector.

Urbanisation at today's rapid levels can cause tremendous problems. Housing and other services are often unable to keep up with demand, leading to squatter settlements and unsanitary conditions. Infrastructure (such as roads, or water and sanitation services) designed for specific population levels, breaks down under the strain of trying to serve too many. Towns and cities place difficult demands on water and fuel resources. Cities also produce huge amounts of waste in the form of sewage and industrial pollution, rendering water in rivers and lakes dangerous. Urban areas are the largest and most concentrated pollution sources in the region. While there is no obvious way to improve these problems immediately, slowing down urban "drift" would allow city governments time to improve services and build or upgrade infrastructure.

SOURCES:UNFPA, *State of World Population 1992*, UNFPA, New York, 1992
UNECA, *Africa Alternative Framework to Structural Adjustment Programmes for Socio-economic Recovery and Tranformation — A Popular Version*, UNECA, Addis Ababa, 1991
Reed, David (ed.), *Structural Adjustment and the Environment*, Earthscan, London, 1992

enough time to regenerate. Then, because there is less wood to burn when establishing plots, the soil-heating and ash production are not sufficient to make the soils fertile again.

However, some studies indicate that population density does not seem to have a universal cause-effect relationship with land degradation, because so many other factors play a role.[30] In some cases, high population levels are needed to support productive agriculture. In the Kilimanjaro region of Tanzania, a hectare or less of land intercropped with coffee and bananas, and with stall-fed cattle, provides enough food and cash to support an average family, if they are able to provide the labour — 2,000 work-hours per year for coffee, 1,500 hours for bananas and livestock, and another 900 hours for cultivating grain in the lowland.[31]

Grazing

Grazing is the most extensive form of land-use in southern Africa, and about two-thirds of the region is estimated to be suitable only for grazing. Pastoralism has been practised for centuries over large portions of the region, especially in Tanzania, in harmony with the environment.

With technological developments, such as farm dams and boreholes, more marginal areas have been opened up. Livestock populations now amount to about 45 million cattle and 71 million sheep and goats. However, over the last 10 years, cattle populations have dropped slightly in seven countries, while sheep and goat populations have increased substantially. This may be an indirect indicator of farmers' assessments of rangeland degradation. Sheep and goats are often brought in when land is too degraded to support cattle, because they are less selective feeders and are able to eat leaves as well as grass.

Reversing degradation

About 20 percent of southern African soils needs some degree of rehabilitation, and the degradation and loss of productivity is continuing. Most of the degradation is caused by overgrazing, although where the degradation is strong, cultivation is equally to blame. Poverty compounds the problem because farmers can't afford to fertilise, leading to less vigorous plant growth which leaves soil more exposed to eroding rainfall and runoff. Although fertiliser use is growing at a faster rate than new land being brought into production,[32] a 1990 UN Food and Agricultural Organisation (FAO) study showed that soil in the region is being "mined" for its essential nutrients. Each hectare of cultivated land loses an average of 22 kg of nitrogen, 28 kg of potassium and 6 kg of phosphorous annually.[33]

Many communities are developing strategies to combat land degradation, based on local conditions. These strategies include:

- strips of grass alternating with strips of cropped land;
- no-plough techniques relying on use of mulch and crop residues to protect from erosion-causing rainfall; and
- agroforestry, the use of multipurpose trees in cultivated areas to improve productivity.

These locally developed techniques are not widespread, but they seem to hold great promise, and are far more effective than many of the established soil conservation methods such as terracing.

Some areas which are not cultivated or grazed have been kept that way by tsetse-fly infestation. Successful tsetse-control programmes are allowing the opening up of some of these areas. Although the land appears to be under-utilised, there are some concerns. Tsetse zones tend to be in nutrient-poor areas which quickly become infertile under cultivation. In addition, they are often on fragile soils which have been protected by bush and grass cover. Clearing this for agriculture will almost certainly lead to heavy soil-loss.

Another complicating factor in the land equation is a possible sea-level rise due to global warming. A significant amount of coastal land could disappear under water in the next 50-100 years, decreasing the total amount of southern Africa's land and flooding some very productive areas.

There are few available areas left for agricultural expansion outside of protected areas and forest reserves. As more land is brought under cultivation, land available for grazing decreases, forcing pastoralists onto smaller, less productive areas. Rapid urbanisation also takes land out of agricultural production. In southern Africa, the amount of land cultivated (largely marginal land) has increased by only 0.2 percent each year in the last decade or so. If population growth is considered, the amount of cultivated land per person has actually dropped by 20 percent, from 0.4 hectares per person in 1980 to 0.34 hectares in 1989.

FOOD SECURITY

To meet the food requirements of a growing population in southern Africa, supplies will have to increase by four to five percent a year.[34] This will be a challenge, since food production per person decreased in all countries in the region by anywhere from 0.7-3.7 percent each year between 1979 and 1991 — a total drop ranging from 8.4-44.4 percent.[35]

Agriculture and food indicators Table 1.4

Country	Food production per capita index (% of food produced 1979-81 = 100)*		Daily calorie supply (as % of minimum needs)*	Food import dependency ratio (%)*			Average annual net trade in cereals (1,000 tonnes)**	Food aid (US$m) * ***	Cropland (1,000 ha) **	
	1987-89	1991	1988-90	1969/71	1986/8	1988/90	1987-9	1988	1980	1989
Angola	84	79	80	10	-	36	273	11	2,950	3,600
Botswana	68	68	100	48	84	75	90	20	1,360	1,380
Lesotho	80	70	93	31	52	59	122	5	292	320
Malawi	85	75	87	4	3	6	59	14	2,300	2,409
Mozambique	83	77	77	7	-	22	434	86	2,850	3,100
Namibia	95	-	-	36	-	31	-	0	655	662
South Africa	90	82	128	7	9	10	(2,612)	-	12,440	13,174
Swaziland	93	85	105	26	36	31	43	1	185	164
Tanzania	90	78	91	5	4	3	73	13	4,100	5,520
Zambia	97	96	87	22	14	7	125	19	5,100	5,628
Zimbabwe	90	78	94	5	5	5	(235)	2	2,465	2,810

Food import dependency ratio is the ratio of imports to the food available for internal distribution.
SOURCES: * UNDP, Human Development Report 1992, Oxford University Press, New York, 1992
** World Resources Institute, World Resources 1992-93, Oxford University Press, New York, 1992
*** UNDP and World Bank, African Development Indicators, UNDP and World Bank, New York and Washington DC, 1992

Measured as daily requirements for food consumption, people in eight countries receive less than they should, ranging from 70-99 percent of the minimum.[36]

Domestic production

A number of countries are close to self-sufficiency in food production, measured by the food-import dependency ratio (the amount of food imported compared to the amount available). Such statistics are not available for all countries, but half the countries measured are more self-sufficient in food production than 15 years earlier.

Although many southern Africans are not eating minimum daily food requirements, the region could be self-sufficient in food production. Total net cereals production for the region (excluding Namibia) amounted to a surplus of about 1.6 million tonnes during the period 1987-89. This was accounted for by large surpluses from South Africa and Zimbabwe, while all other countries were net importers.[37] The overall level of cereal surplus declined by six percent from a surplus of about 1.7 million tonnes between 1977-79.

According to SADC's report to UNCED, current data is insufficient to assess the land's capacity to support future growth in food production.[38] A factor affecting domestic food production will be competition with cash crops, which are needed for foreign exchange earnings.

The only countries achieving adequate growth in food production have either brought new land into cultivation or intensified production through irrigation.[39] Irrigation has been badly managed in some cases, leading to salinisation and alkalinisation, which poison the soil so crops have difficulty growing. Unless the soil is treated, this eventually removes more land from production. Only Angola, Mozambique and Zambia have significant areas of land they could bring into production, much of which is presently forested or infested with tsetse-fly.

Drought-resistant crops

Recent advances in the development of drought-resistant crops may be an important part of increasing food production. Many farmers plant maize even in areas considered marginal or unsuitable.

Traditional crops such as sorghum, rapoko and millet are more appropriate, but most people prefer maize, which is easier to process and more valuable. It is, however, much more vulnerable to poor rainfall. New varieties of sorghum and millet show vastly increased production over traditional varieties during droughts, and programmes are underway to encourage their use as a less risky food source.

Fish protein

Fish protein is in high demand, but projections indicate that production will have to increase by 550,000 tonnes by the turn of the century to meet the increasing demands of the growing population.[40] Several marine areas, such as the Angolan and Namibian coasts, have suffered from overfishing and there is localised overfishing inland as well.

Management will have to improve if the production goal is to be met, as in the case of Namibia which has set low limits on allowable catches to increase stocks, while dealing very strictly with illegal offshore fishing by foreign boats. There is insufficient information to assess the maximum sustainable inland and marine fish-yield, a requisite for proper management, so it is not clear whether fish demand can be met from existing resources.

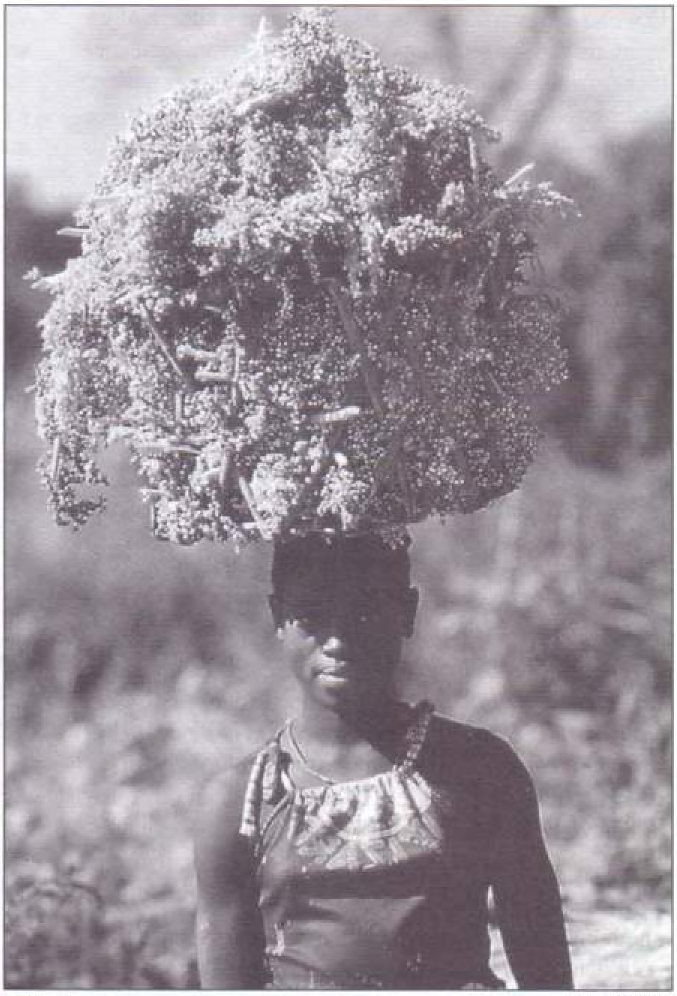


Photo 1.2 IUCN-D REED

Traditional food crops such as millet are more drought-resistant than maize, and new varieties are being developed to increase production.

Regional sustainable yields could be increased through fish farming. There are several pilot projects and many operating fish farms throughout the region, but the cost of farmed fish tends to be prohibitive. As more dams are constructed for water supply they can also be stocked for fisheries, as has occurred at Kariba, Zimbabwe.

WATER

Inadequate supply of water, which is needed for domestic, industrial and agricultural use, and flushing away of wastes, could be a limiting factor on development in southern Africa.

Availability and use

The diminishing land area available for agricultural expansion means production growth will soon have to be achieved by increasing the amount of yield per hectare, rather than increasing the number of hectares available. While new seed varieties, agricultural chemicals and fertilisers, and farming techniques can increase yield, irrigated farming is the method that surpasses all others in potential production per unit area, in the low rainfall parts of southern Africa. However, this requires huge amounts of water. About 60 percent of the total amount of water used in the region — almost 20 cubic kilometres of water in 1993 — is used for irrigation.

By world standards, current water consumption per person in southern Africa is low. In many countries in this region, people get by on much less than the UN World Health Organisation (WHO) target of 50 litres per person per day.

However, larger amounts will be required in southern Africa in future, with more and more dams constructed, and continued (and possibly increasing) over-pumping of aquifers. Trade in water has been discussed in a SADC document. For example, Mozambique has considered giving up rights to some Zambezi river water in return for access to more water in its drier southern part.[41] Water transfers from one part of the region to another, such as the Lesotho Highlands Water Project, are likely to become more commonplace and countries with low economic growth may be tempted by the possibility of profits from sale of water.

Dams and storage

Aside from their clear benefit as sites for water storage and generation of electricity, dams have a number of disadvantages. They seriously disrupt downstream ecosystems through decreased, but more regular, water flow. Dams also cause sedimentation and lose storage capacity through eroded soil carried by rivers and deposited at the dam bottom. As more land, especially marginal land, is brought into production, this problem will increase, unless management of land-use and control of erosion is improved. Not only does sedimentation cost the region vast amounts of money in lost water-storage capacity, but many areas are quite flat, with few good potential dam-sites left, so replacing silted dams may be difficult or impossible.

Pollution

Another problem concerning water supplies is the relatively poor standard of pollution control. Pollution from sewage is a growing problem as urbanisation increases the strain on water-treatment facilities. Unplanned settlements such as shanty towns, and densely populated rural areas, usually have inadequate or non-existent sanitation and waste facilities, exposing people to diseases such as diarrhoea and cholera. Agricultural pollution by farm chemicals, particularly pesticides, contaminates drinking water. Improper irrigation has made freshwater rivers salty in some areas. Industrial pollution, subject to little enforcement or monitoring, effectively decreases the amount of available fresh water by making supplies unfit for use.

Conservation

One area which needs attention is water conservation. Urban water infrastructure loses a large amount of water and irrigation is a notoriously inefficient user. There is potential for domestic and industrial recycling of water, with some major cities, such as Harare and Windhoek, already recycling a significant part of their waste water.

Water is also used in hydroelectric power-generation. The water that pushes the turbines is not consumed, but the water that fills the reservoir behind the power dam up to the level of the intake is unavailable for other uses. Yet it must be maintained to allow electricity production. This "dead storage" amounts to huge quantities of water. Lake Kariba alone contains more than three times the quantity of water consumed annually in the entire region,[42] yet little of it can be used without jeopardising power generation.

ENERGY

Many countries in southern Africa promote electrification through hydroelectric power-generation and/or coal power-stations to meet their long-term energy demand. However, the majority of people still rely on wood, charcoal or coal for most energy needs — largely heating and cooking. Although energy consumption in southern Africa is quite low by global standards,[43] per capita fuelwood consumption in the SADC region is among the highest in the world.[44]

Supply and consumption

The fuelwood demand in the region is seen as unsustainable, due to the growing number of people and the clearing of forests and woodlands for agriculture. As fuelwood becomes scarcer, its value rises, a situation that may make it economical in future to plant fuelwood trees to sell. The value of food crops is increasing at least as quickly as fuelwood, however, which mitigates against the planting of fuelwood plantations.

Some countries are planning an alternative fuel source through rural electrification, although this has far to go before it can be easily accessed or used by the rural majority. Poverty often prevents rural and urban people from buying electrical appliances, even if electricity is connected to their dwellings. The township of Soweto, near Johannesburg, South Africa, was partly electrified a decade ago, but most people continue to use coal, since they cannot afford to pay for electricity or electrical appliances.

At the national level, the cost of power-generating facilities is an additional burden for countries already under heavy debt-loads. Competition for water for hydroelectric power has already created tensions in some areas and is becoming an issue for some of the Zambezi river states. As demand for both electricity and water increases, choices will become harder to make.

Mozambique's Cahora Bassa, the massive hydroelectric project on the Zambezi river downstream of Zimbabwe's Lake

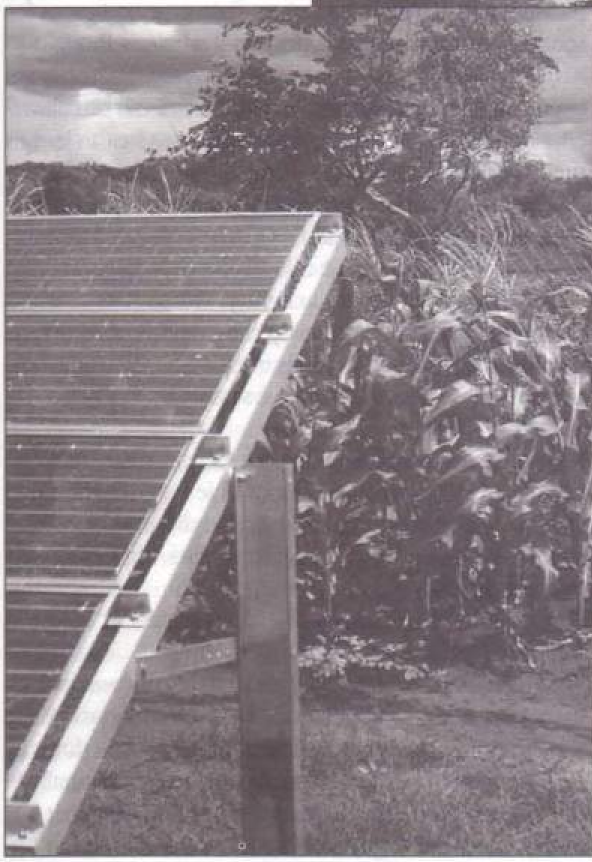


Photo 1.3 GTZ-D Hancock

The sun is an appropriate energy source for southern Africa because its power is plentiful and renewable.

Photo 1.4 GTZ-D Hancock

Solar power is harnessed by these panels and used to heat water, and cook food, even to irrigate fields.

Kariba, is expected to come back on stream soon to boost the region's generating capacity. It became operational in 1974 but was sidelined by armed conflict. While this dam already holds a tremendous amount of "dead storage" water, it will not take more water away from downstream sources to fill it, or more capital to build it, as new dams would.

The southern African region has very large coal reserves, which are mostly unused except in South Africa and, to a lesser extent, Zimbabwe. These could provide fuel for electricity generation, although the environmental cost of mining and burning coal is high. Already this is causing localised pollution problems in Zimbabwe and large-scale air pollution is evident in South Africa's eastern Transvaal.

Environmental impact

Production and use of all forms of energy has environmental consequences. Fuelwood burning contributes to deforestation and causes pollution. Electrical production can cause serious pollution problems and environmental degradation. Hydroelectric dams cause widespread environmental degradation through flooding and regulation of downstream water flows. Nuclear power-stations create nuclear waste, the disposal of which is very dangerous. Nuclear waste remains highly dangerous to all living creatures for many thousands of years. Petroleum products, needed to run virtually all forms of transportation, produce pollution when burned. Burning of fossil fuels such as coal and petroleum also produces carbon dioxide, which adds to global warming.

Nevertheless, energy is needed for economic development. Electricity is required in many industrial processes, while others may simply require heat from electricity, petroleum, coal or wood. Transportation requires petroleum products. The question will be how to provide energy without degrading the environment.

Renewable sources

Renewable energy sources, such as wind or solar power, may provide a long-term answer to energy needs. The latter is particularly applicable to southern Africa which receives large amounts of sunlight all year round. Electricity production from these sources has received disproportionately little research-and-development funds world-wide, and will not be ready for large-scale consumption for some time. However, several pilot projects have started in this region. Solar water-heating has been used for a number of years, although there is little information as to the amount of energy involved.

Another energy source with high potential is biogas — a gas such as methane, produced by fermenting animal dung and vegetable waste. But again there are few pilot projects in the region. The potential for energy conservation in the urban and industrial sectors is high, but does not seem to be a significant policy focus.

WILDLIFE HABITAT

The demand for land, water, food and energy has reduced the wild plant and animal life in southern Africa. The use of land for agriculture has decreased the amount of space available to wildlife. In addition to clearing, forests are being chopped down for fuel and building materials. There is a direct connection between increases in the human population and loss of wildlife habitat, so this trend will most likely continue until such growth stabilises.

Wildlife, including fish, has been overexploited for food and commercial gain. Loss of animals to subsistence poaching does not pose a significant threat at present but commercial poaching, with its targeted species, is threatening some with extinction. Scientists estimate that planetary species loss ranges from 2-11 percent of the total each decade.[45]

Protected areas

In most countries in southern Africa, wildlife is largely confined to protected areas or private game-reserves and nature conservancies. As demand for land grows, national protected areas are beginning to feel the pressure. There is a growing sentiment that parks will have to prepare for the day when they must provide sufficient benefits to local people to outweigh the loss of potential cultivation or grazing. At the same time, farmers in some countries are moving toward game-ranching, with government support, increasing the amount of private land available for wildlife.

The philosophy that wildlife and other natural resources must "pay their own way" is being implemented in several different ways in southern Africa. It is a new approach, and while initial results are positive, its effectiveness over the long-term is still to be determined. However, it shows a desire to innovate and find solutions to problems. Innovations will be critical to the success of future environmental and resource management in southern Africa.

Wetlands

Wetlands, and the wildlife which lives there, are also under pressure as population increases. There are no figures for southern Africa alone, but Africa as a whole is thought to have lost about 30 percent of its wetland area.[46] Wetlands are important sources of dry-season grazing and can be cultivated, although care must be taken or this pressure can lead to their breakdown and loss. Wetlands can also be seen as potential sources of water. For example, vast quantities of water flow through Botswana's Okavango delta. The delta, which is a World Heritage Site, is the only large internal source of water in this arid country. While Botswana has committed itself not to develop this wonder of nature, as populations and water demands increase, it may be the only place to look. Other wetlands face similar dangers.

Such pressures contribute to species loss, although no one country or region is solely responsible for extinction of a species. It is the loss of habitat around the world, or global supply and demand for particular species, that eventually claims its victims.

POLLUTION AND WASTE

The environment has a natural ability to break down biological wastes and put them back in the ecosystems. Many wastes are food for some creatures, or are broken down by sunlight, water or other chemicals which occur naturally in the environment. This is part of the cycle of life that has evolved since the origins of life on earth. Plants absorb carbon dioxide to produce food, and give off oxygen to the air as a waste. People and animals breathe the air and absorb oxygen as a fuel for life's processes, breathing out carbon dioxide as a waste.

Natural systems have limits as to the amount of waste they can process beyond which the systems break down, with potentially disastrous environmental consequences. Pollution can stress natural systems to the breaking point. In lower amounts, pollution can decrease the productivity of ecosystems as well as having serious impacts on human health.

At present, the levels of air and water pollution in most parts of southern Africa are low by world standards, largely due to relatively low levels of industrialisation. As standards of living increase in the region, consumption will increase, and so will industrialisation. The impact of increased consumption will be felt through pressure on natural resources, and emissions associated with production. To avoid environmental impacts associated with increased consumption, the impact per unit consumed must be lowered. Such a decrease can be effected through improved technology for using resources and producing goods.

Monitoring pollutants

Systematic monitoring of environmental quality is lacking, above a very basic level of testing drinking water. Some municipalities monitor a few substances in local air and water, but this is largely *ad hoc*. Surveys of industrialised areas of Botswana in 1991 and Zimbabwe in 1992 revealed that many firms did not know whether the waste they produced was toxic, or even what was in the waste. Agricultural chemical use is monitored in a few countries. Several compounds which are banned or strictly controlled for reasons of toxicity in most developed countries are freely available to the commercial and small-scale farming sectors in this region, as well as for household use.

People produce waste as part of their everyday lives — product packaging, vehicle exhaust, sewage, industrial emissions and burning, to give a few examples. Most industries in southern Africa are unable or unwilling to properly treat their wastes. While the amount of industrial pollution produced is low when compared with industrialised nations, the most poisonous waste often makes its way into drinking water, air and land. Legislation to prevent such pollution is often in place, but governments cannot afford the personnel and analytical equipment to enforce it.

Hazardous waste

A related area of concern is international trade in toxic and hazardous waste. The industrialised countries of Europe, North America and Asia have developed stringent controls over toxic waste which make disposal complicated and expensive. Fewer controls in regions such as southern Africa make them attractive destinations for companies managing toxic waste. Only a handful of cases of toxic-waste dumping have emerged in southern Africa, but a recent memo by a senior World Bank official may indicate a worrisome trend. The memo suggested that it would be economically advantageous to allow shipment of toxic waste for disposal in developing countries.

Health conditions

The health impacts of pollution are a growing concern in southern Africa. The relatively low level of industrialisation means that sources of such pollution are still not numerous, and largely confined to cities or mine-sites. Numerous poisonings take place each year from improper use of agrochemicals, which include deadly pesticides. The chronic health effects of exposure to such chemicals, which are in wide use, are far more difficult to see, but generally decrease resistance to disease and undermine health. These effects are largely unmonitored in the region. Health problems related to drinking untreated water, which contains sewage or untreated industrial waste, include outbreaks of gut diseases such as cholera and diarrhoea, or poisoning.

Another serious health problem is respiratory damage caused by smoke from heating and cooking fires. This smoke, although a relatively minor pollutant in terms of total volume produced, has many poisonous substances in it, which people gathered around the fires breathe in directly. Research shows that this smoke, breathed every day by a majority of southern African residents, produces serious health effects, especially in children.

ARMED CONFLICT

Armed conflict has caused some serious environmental problems in southern Africa, many of them indirect. In a war situation, government funds are directed almost entirely to defence instead of environmental and social spending. Lack of security makes environmental management difficult. During an armed conflict people congregate in safe areas, either inside or outside the country, putting tremendous pressure on relatively small areas.

South Africa has been one of the most violent countries in the world and Angola is still at war. With the removal of institutionalised *apartheid* (racial separation) and the holding of the first all-race elections in April 1994, South Africa has passed a milestone, but still has to repair the mistrust and inequity built up over much of this century. As South Africa's regional policy of destabilisation has been curbed, Mozambique has entered a negotiated peace, and a peace settlement is under discussion in Angola. However, it will take time for the legacy of internal strife and violence to vanish.

The seeds for further armed conflict or instability exist in this region as in other parts of the world — often related to dwindling supplies of various natural resources in relation to ever-increasing populations. Tensions over access to water and other shared resources already exist. However, regional structures such as SADC are establishing mechanisms to deal with these concerns.

Peace dividend

Many of southern Africa's governments have had high defence expenditures for the past decade which have

The new South Africa Story

Johannesburg (SAR)—Undoubtedly the most significant feature of the ANC's position on ecology is how it is integrated into their broader reconstruction programme. It is not just policies in the narrow sense of writing up new rules — it is a notion of ecology that goes hand-in-hand with a fundamental restructuring of *apartheid's* socio-economic inequities.

Apartheid created one of the most environmentally degraded countries of the world. Soil erosion and desertification in the over-crowded homelands have been coupled with similar erosion on the mono-culture, profit-oriented white farms. Dirty, coal-fired electricity has been provided at reduced rates to white industry, while two-thirds of South Africans have been denied this basic amenity and forced to cut down trees for cooking and heat.

Water distribution, perhaps South Africa's most precious resource, is similarly skewed. Millions of litres of water a day are squandered in white suburban gardens, while entire African communities may depend on one unreliable tap. The lack of proper sewage facilities in squatter areas makes the water situation even worse. Contaminated puddles are breeding grounds for disease, and the runoff pollutes rivers and groundwater supplies.

There will be enormous environmental benefits merely from the scrapping of the previous *apartheid* absurdities and the implementation of basic reconstruction plans (housing, sewage and sanitation, land redistribution, etc). These brown environmental issues (and I use the term "brown" because it so vividly conjures up images of sewage and treeless townships) are the core of ANC environmental policy.

Without an effective plan to deal with grinding poverty that exacerbates the environmental degradation of this already beleaguered ecology, then all of the fences, anti-poaching squads, and water-purification tablets in the world will do nothing to save South Africa's natural resources for future generations.

— **David McDonald**, excerpt from "It's Not Easy Being Brown — ANC Environmental Policies", *Southern Africa Report*, Toronto, 1994, Vol 9 no 4, p. 31

strained their economies. SADC has expressed the hope that with the reduction of hostilities in the region, government resources can be redirected to environmental management, among other things. This so-called "peace dividend" has yet to make its impact felt, and given the weight of debt in many countries, it may not be possible to increase environmental and social spending. Many countries continue to spend high proportions of national budgets on defence,[47] although this will be reassessed in view of the changed situation of South Africa.

While statistics vary broadly from country to country, defence spending ranges from about 5-16 percent of annual budgets.

Environmental security

Security considerations have changed over the last decade. As concern over a nuclear holocaust has diminished and understanding of the threat posed by global warming has grown, a balance has been tipped. The existence of the Brundtland Commission, and more recently UNCED, serve to underline the seriousness with which world governments now treat the environment. The realisation that the future of our species depends on the continued good functioning of environmental systems, and that some of these systems are threatened, has evolved into the concept of "environmental security".

Environmental security obliges governments to safeguard citizens from the ravages of environmental destruction at the global, regional, national and local level. This includes:

- emergency response to environmental disasters;
- ratification and acceptance of provisions of global

environmental conventions;
- development and enforcement of integrated environmental policy and legislative frameworks;
- conservation of renewable and non-renewable resources; and
- commitment to sustainable development for the people of today and the generations to come.

BREAKING THE POVERTY CYCLE

Poverty and environmental degradation are linked in a vicious circle[48] in which people cannot afford to take proper care of the environment. A degraded environment produces less, so people become more vulnerable. As population increases, the next generation must spread the limited resources even thinner.

In southern Africa, many areas have resources which are communally held and to which there is open access. Traditional management systems have been able to protect these "open-access" resources, but increased population, coupled with a free-market approach, has eroded traditional practices. This has often created disruptions with open-access resources such as grazing land, water, fish and trees. In some areas, the wealthier livestock-owners have fenced off areas of communal land and have begun digging private wells. When grass or water begin to run short, they move livestock to these fenced areas or water them at their wells,[49] essentially "privatising" communal resources.

There is no easy answer to overexploitation of open-access resources. Private ownership would give an incentive to manage such resources carefully. However, this would impact on traditional values and culture, and the patchwork of holdings resulting from privatisation could create a set of different, and perhaps worse, problems. There are also concerns that privatisation would reduce the amount of land available to the rural population, while land would concentrate in the hands of a few wealthy individuals or companies, or be repossessed by banks if used as collateral to get loans. People manipulate their environment, sometimes on a very large scale, for their own gain. Agriculture, water wells or industrial production all involve manipulating the environment and natural resources. Water-points allow livestock to exist where it could not naturally survive. The development of new seed varieties increases food production. Cities need large quantities of resources from surrounding areas to support them. In all of these ways people have been able to change the environment to their advantage.

Often there is a long-term cost to human ingenuity, as shown throughout this book. An increase in the efficiency of fishing to feed more people may result in overfishing, leaving less food later on. Improvements in farming methods may allow more people to live on a piece of land, but there may be too many people for the amount of water available, putting strains on another resource. Many resources are being depleted and renewable resources are often used much faster than they can be replaced. The exhaustion of renewable resources (such as soil, trees and water) is the primary environmental concern facing southern Africa.[50]

Ill 1.1 NEW GROUND-A Pienaar

Linkages to other chapters Box 1.4

2 HISTORY

People have made a living from southern Africa's environment for longer than written records have been kept. Some traditional management practices are still used today, while others may have potential for adaptation to present conditions.

3 POLICY

The policies of governments, private sector, regional and international organisations — even individuals — affect how the environment is managed and determine how well environmental considerations are integrated into the overall decision-making process.

4 ECOZONES

The characteristics of each ecological zone affect how productive it can be, how easily it is degraded and how many people and livestock it can support. Successful environmental management policies and programmes take these factors into account.

5 CLIMATE

Climate is a major determining factor in the ability of southern Africa to be self-sufficient in food production, and frequent droughts often thwart this objective.

6 SOILS

Soils and land-use are generally considered to be the most pressing environmental issues in southern Africa. Land-use impacts directly on food production and the well-being of people, plants and animals.

7 WOODLANDS

Woodlands and forests provide many of the resources people use — construction poles, firewood for domestic and industrial purposes, and materials for crafts and other retail goods.

8 WILDLIFE

A major challenge is to find ways to increase the value of wildlife to people who share the habitat and see it as a threat, a pest or a competitor for land.

9 FRESH WATER

Access to fresh water is fast becoming a critical issue in some countries in southern Africa. Demand is increasing and ground water is being overused in some areas. Competition among water uses is starting to occur, and water storage or transfer projects can have negative environmental impacts.

10 MARINE

Marine resources are an important source of food but fish are being overexploited in some areas. Marine environments are suffering abuse, such as large amounts of sewage from coastal cities.

11 POLLUTION

Air and water pollution is an emerging health issue in southern Africa, although levels are still low and concentrated in cities and industrial areas.

12 ARMED CONFLICT

Some parts of the region have been subjected to destructive conflicts, with damage to people, wildlife and their habitat.

13 GLOBAL

Global atmospheric changes will affect southern Africa's environment, although assessments and studies are still in early stages.

14 TRENDS

Population growth, consumption patterns and industrial development can all impact on overuse of resources, and degradation and pollution of the natural environment. Information and awareness are tools which can be used to define positive approaches to economic and environmental development.

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2 Learning from HISTORY

From years of experience, farmers across southern Africa understand the mechanics of soil erosion. The relationship between rainfall and erosion was described in surprisingly simple terms by one farmer — a village elder in Zimbabwe:

> "If I fall from where I'm sitting now, I won't hurt myself. But if I fall from the top of my house I will be bruised."[1]

Where he lived, rainfall over the years came in fewer, yet heavier, storms. Big raindrops hit the ground hard and ran away with the precious soil. The storms only scratched the surface of his parched *deve,* a fragile ecological system traditionally reserved for wildlife and occasional grazing but now used for the centralised human settlements of Mazvihwa in Zimbabwe's Midlands province. Less rainwater now enters the soils — which means less plant cover, more soil erosion and gullies.

The elders of Mazvihwa know the problem as well as the scientists and government officials do, but they perceive changes in their lands differently from most scientists and bureaucrats.

Half the region away, in Tanzania, Iraqw farmers settled on the Kainam hills southwest of Lake Manyara during the late 18th century, initially to escape raids from Maasai pastoralists roaming the plains below. Here, the sedentary farmers developed a system of intense and permanent cultivation on steep hills, using terraces protected by storm drains and planting on ridges along the contour.

Few modern farming systems can rival the capacity of these terraces in healing worked land and conserving soil moisture and fertility. Even now, after almost 200 years of cultivation, the Kainam hills remain well-conserved and feed some 20,000 inhabitants. People still live in ridge communities where land is communally managed through work parties, which maintain the structures on the hillsides and drainage channels in the valleys. Domestic animals are not allowed to graze crop residues, which are ploughed into fields instead. The soils are further enriched by manure on carefully rotated cropland. Fallowing is practised, though for shorter periods now than in the past.

These are not isolated stories. The people of southern Africa have a rich heritage of managing and living with the environment. Some of the knowledge lives on, seasoned with thousands of years of communal practice. Other lessons of past successes and failures are evident in traditional farming and range-management practices still in use throughout the region. Still more of this knowledge remains locked in the hills, mountains and valleys of the African landscape, awaiting archaeological analysis. African history is often told in fables and legends, and is also couched in the physical environment, because most societies were not literate when such descriptive systems evolved.

The history of environmental management in southern Africa cuts across many cultures, and often defies present political boundaries. Farming systems developed by sedentary communities in Zambia, for example, were also in use on the rolling plains of Ufipa in southern Tanzania, just as range-management systems were similar among pastoral and nomadic societies. The region largely falls within the Bantu culture, which accounts for a measure of uniformity. Differences emanate from environments — hence the situation in the arid Kgalagadi area of Botswana and Namibia is different from the mountain wetlands of Malawi, Mozambique, Tanzania and Zimbabwe. There are also great varieties in the methods of conservation applied by different cultures, often expressed in a unique African idiom for which modern science has little time.

Naming is living

The Wasukuma of western Tanzania have soil names which define land potential more effectively than any modern classification. The region of Shinyanga where most of them live was in fact named after the tree which thrives there, the *inyanga*. The issue of what trees to plant is so central among the Wasukuma that they once refused to plant certain species during a government-sponsored operation because they knew those trees would provide nesting grounds for *quelea* birds which eat vast amounts of grains. The scheme eventually collapsed, not because peasant farmers did not understand the importance of trees, but because they realised they would be creating an equally serious problem in an attempt to solve another.

Among the Barbaig pastoralists of northwestern Tanzania, many place names carry an environmental message. The Barbaig graze their herds on the "milk grass" where the ecology is suitable for increased milk production when the cows bear calves. They avoid the "balding hills", where treeless pastures lie bare and exposed to wind erosion, for fear of further degrading the land.

Soil scientists in Zimbabwe report that the Shona and Ndebele peoples classify soil in two ways.[2] The first involves using specific names for specific soil types, usually based on colour and texture. These and other indigenous communities have a comprehensive system of recognising and describing soils — down to finer details about its chemistry. In determining the presence of salts and other organic matter contained in soils, traditional knowledge has often relied on taste, smell and the general appearance to tell the difference between quality and poor soils. These are sound parameters, even by modern standards, and are frequently used by scientists in field descriptions of soils.

A bountiful land Box 2.1

The first written descriptions of the fertile and productive African farming lands in the southern part of the continent date back over 300 years, from Portuguese traders and explorers. Cultivation and cattle-keeping were, for example, the chief sources of wealth that sustained the Munhumutapa empire which spanned central Mozambique and Zimbabwe for over 500 years — from 1400-1902.

During the 17th century, Antonio Bocarro noted that the people of Munhumutapa

> "will not exert themselves to seek gold unless they are constrained by necessity for want of clothes or provisions,which are not wanting in the land, for it abounds with them, namely millet, some rice, many vegetables, large and small cattle, and many hens. The land abounds with rivers of good water, and the ... [people] are inclined to agricultural and pastoral pursuits, in which their riches consist."

Two hundred years later, the first English-speaking traders and settlers to reach the same area also wrote of the successful and varied local agriculture:

> "... fields of mealies, millet, rukweza, sweet potatoes, pumpkins, peanuts and then across rice beds in the marshes."

SOURCES: Mudenge, S.I.G., *A Political History of Munhumutapa c 1400-1902*, Zimbabwe Publishing House, Harare, and James Currey, London, 1988, p. 162
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WHAT'S IN A NAME

In their ordered fields of study, research scientists often miss the real gems woven into place names and in the traditional names of animals and plants. Names carry profound meaning and an understanding of the living environment among alcultures in southern Africa.

The second classification system developed by Shona and Ndebele communities uses ecological zones to describe soils in terms of what other life-forms are found in the environment, such as *mopane* soils which derive the name from the *mupani* tree in Shona. Again, this sound approach is borne out in scientific writings. "The most reliable indicators of the agricultural possibilities of a region are found in the native vegetation," a scientist testified back in 1938.[3] In fact, available records show that early visitors to southern Africa found surprisingly detailed criteria used by indigenous communities to identify mineral deposits well before the advent of European interaction with the region.

Sign-posting ecologies with the life-forms found in them also shapes the way people draw their living from that environment. Quite often, peasant farmers will suggest alternative uses or benefits where soils are not good for normal arable agriculture — such as licks for livestock in salty pans.

Among Ndebele communities in Zimbabwe, there are fewer names describing wetlands than there are among their Shona-speaking compatriots. This does not mean that Shona has a richer vocabulary, but merely reflects differences in the living environment in which either language evolved. Much of the area where siNdebele is spoken is arid — an environment which shaped their historical links with livestock-keeping as opposed to the arable farming common in Mashonaland.[4]

Traditional values in perspective

Shared beliefs provide a strong sense of group solidarity, even if its members come from different backgrounds. In the case of traditional African community organisation, a shared pattern of beliefs has always affected decisions about the use of the natural environment. Cultural taboos, for example, put restrictions on the use of certain plants, animals or areas. This helps to curb the depletion of natural resources considered important for continuation of the larger community.

Traditional beliefs also embody a common interest among rural communities to conserve resources which play such an important role in subsistence economies. A study carried out in 1958 showed that 614 of 740 ethnic groups in Africa and Madagascar derived their livelihood from the wild woods around them. While few communities showed a major dependence, more than half gave some degree of importance to hunting, fishing and gathering of wild-plant products.[5]

Of a total of 5,000 known plant species, researchers in Zimbabwe were able to identify 500 plants as being useful to people after interviewing 240 traditional healers throughout the country. Botanist Stephen Mari said, "I found that every plant with a vernacular name had a use."[6]

Today, cash income derived from the collection and exchange or sale of wild products continues to be of great value to rural people. Use of wild resources, including consumption by local people in controlled areas, was estimated to contribute a gross annual value of more than US$120 million in Tanzania in 1988.

Inventories of wild species utilised by rural communities indicate great opportunities for improving food security. In Swaziland, for example, over 200 wild plants are routinely collected for food. Throughout Saharan and sub-Saharan Africa, at least 60 wild-grass species are harvested for food.

Wild resources as nutrition Box 2.2

Southern Africa: Seventy percent of the people eat the fruit of the marula tree which is a seasonal staple in local diets. The kernels of the marula fruit are rich in oil and protein, and contain eight times more vitamin C than oranges. Without this fruit many people, particularly children who are most vulnerable, would suffer dietary deficiency diseases such as kwashiorkor and pellagra.

Tanzania: In a study of one village, wild vegetables and plants appeared in 32 percent of all meals. Although this village cultivated vegetables, they preferred wild leaves which are seen as replacements for meat and fish. These wild leafy vegetables contain high quantities of protein, calcium and vitamin A.

SOURCE: Makombe, K. (ed.), *Sharing the Land: Wildlife, People and Development in Africa, Issues Series No. 1*, IUCN-ROSA, Harare and IUCN-SUWP, Washington DC, 1993, p. 12

TRADITIONAL ENVIRONMENTAL MANAGEMENT

Hunter-gatherers

Prior to the appearance of farming communities in southern Africa, the region was occupied by people commonly referred to as hunter-gatherers. They depended entirely on a mode of subsistence that was either nomadic or semi-nomadic. Archaeological work in Botswana and Zimbabwe shows that communities of hunters and gatherers, particularly the San, did not cause any significant changes to the environment. The populations were small, and the daily needs relatively simple. Records from sites more than 2,000 years old show that their use of the environment often revolved around procurement of food, firewood and raw materials for weapons.[7]

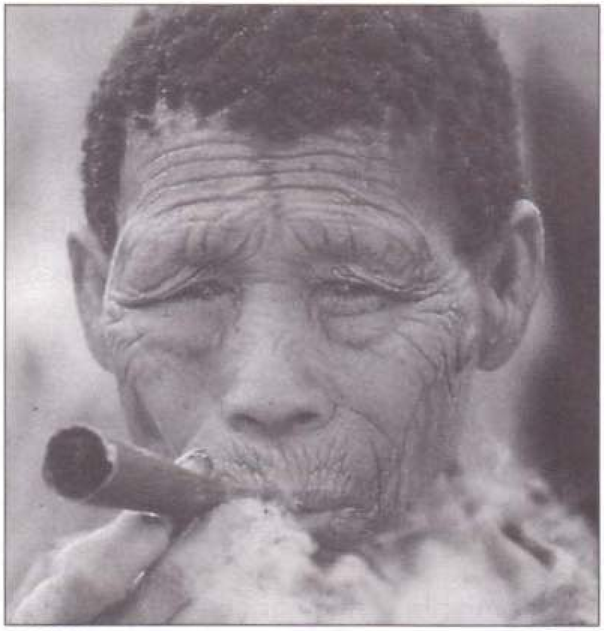


PHOTO 2.1 IUCN-D Reed

The San made use of seasonal fluctuations in resources.

Land was collectively "owned" by whole communities where nobody had exclusive rights to resources. In the western Cape, as in many parts of southern Africa, it has been shown that hunter-gatherer groups moved with the seasons between mountains and the coast because this was the best way to make use of seasonal fluctuations of resources in different ecozones — coastal plain, mountains and karoo.[8]

Pastoralists

The use of livestock as an economic and social mainstay started in southern Africa more than 4,000 years ago. The landmark economic shift from hunting and gathering to pastoralism probably took place first among the nomadic groups of the Khoisan, popularly referred to as "Khoi Khoi" or "Hottentot" pastoralists.[9] They moved their animals about the countryside and lived in temporary open-air camps relying on hunted and gathered foods in addition to domesticated stock.

Pastoralism assumed greater significance, especially in parts of Botswana, Namibia and Tanzania , where the land was not suited to cultivation. Although local people had learned to exploit in a sustainable way the variations in the ecosystems such as rainfall and soil fertility, the colonial administrators who came later often viewed indigenous systems of pastoral production as destructive to the environment.

Emergence of farming communities

At about the same time as pastoralists were spreading out, sedentary communities with knowledge of agriculture and metal-working emerged in southern Africa. They gradually covered entire regions where conditions were favourable for a mixed farming economy. However, Botswana and southern Namibia could not support a southward expansion because of the dry desert environment which proved too hostile for farming.

Unlike hunter-gatherers and pastoralists who spread over large areas, farmers exhibited patterns of shifting cultivation in favoured localities only. This placed a greater demand on the environment as a result of increased population densities, food production, metal-working and permanent human settlement. The exploitation of forest and riverine resources expanded into a much wider variety of uses than their hunter-gatherer and pastoralist neighbours could employ. As a result, they began to build up complex economic systems and agricultural techniques adapted to the local conditions.

These agricultural communities evolved a varied mode of subsistence that resulted in a sustained traditional pattern of shifting cultivation. At the same time, pastoralists began losing their grazing lands to farmers as the practice became more specialised, relying on ecological variations such as rainfall and soil fertility.

Land-use rights vested in chief

The pattern of land-use was established on a clan system in which rights of cultivation and other agricultural land-use practices originated with chiefs to their people. Cultivation and other use-rights were granted by the chief who had power over all productive resources, including wildlife. No land could be sold or given away, because rights to land rested with the creator. Consent to individual use of land was granted by the chief, through whom a system of land inheritance by kinship developed.

This system represented a form of land-holding, vested in the chief as custodian of the people's cultural heritage and land. And it was greatly respected.

Ill. 2.1 IUCN-C Bass

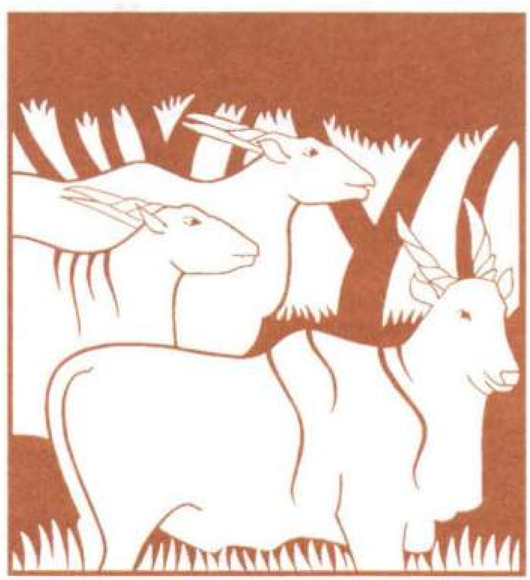
The authority of the chief was diluted by colonial administrations. At the time, governments created the impression that the chief had full control over African tradition, when in fact it was not always so. In Shona culture, for example, the spirit mediums, as representatives of the founding ancestry of specific clans, had stronger control over proper resource-use. The chief was the secular political leader whose powers were counter-balanced by the spiritual leadership of the medium — although in some cases one person served both functions.

As an important productive resource, land formed an essential cultural link between members of a community and the chief. Available studies show that in Malawi, Zambia and Zimbabwe, this link was not simply a matter of political allegiance but was based on beliefs that the spirits of the chief's ancestors controlled the productivity of the land through rainfall or pests and plagues. The chief was believed to have powers to summon these. Any problem in the productivity of the land was interpreted as a form of punishment from the ancestors of the chief.[10]

The centrality of the chief in having absolute control over resources varied greatly across the region. In general, however, equity in land distribution was common and built on kinship, except that most systems did not give equal rights to men and women. Equity was built on the understanding that when a male was allowed residence in an area, he was entitled to a set of rights, such as those of land for cultivation and grazing. With those rights to use land came rights of access to waterholes, wells and trees — which carried a duty to protect them.

In the well-established chiefdoms, the chiefs enjoyed executive powers over natural resources under their jurisdiction. Among the Lozi, for example, the *Litunga*, or king, had territories that were exclusively reserved for his hunting.[11] Tshaka, the Zulu King, also had special hunting reserves.

These were basically the royal family's hunting grounds, but chiefs were not provided with such resources simply to satisfy personal needs. In most cases, the system was part of the traditional distribution of wildlife products, particularly during drought periods or at times of communal ritual. In Zambia, it was only the *Litunga* who, under customary law, could hunt large animals such as elephant, hippo, eland and lechwe. In the event that a commoner strayed into those areas and accidentally killed one of the prohibited species, the *Litunga's* advisors had to be informed immediately and all trophies such as tail, skin and tusks had to be surrendered. This was the case with all major chiefdoms in the region where rules and regulations governing hunting and exploitation of resources helped to conserve the environment.



Ill. 2.2 IUCN-C Bass

TRADITIONAL MANAGEMENT SYSTEMS

From customary laws, people developed traditional management systems that were effective mechanisms in environmental conservation. The creation of institutional curbs such as sacred areas for purposes of worshipping ancestral spirits, spirit mediums and rain-making oracles served to regulate societal attitudes toward the natural environment.

Spirit mediums, particularly, controlled large ritual groves and protected forests where no one was allowed to hunt, graze livestock or cultivate. The management of resources under customary law endured for centuries due mainly to this strong link with the ancestors and the low population densities which helped to maintain a sound ecological balance. Today, territorial cults remain significant among cultural groups of Malawi, Mozambique, Tanzania, Zambia and Zimbabwe.

PHOTO 2.2 SPLASH-M Segerros

Specialised agricultural techniques

From long experience, southern African peoples developed locally appropriate and sustainable systems for cultivation and grazing. Common throughout the region were strategies to deal with environmental limitations such as unreliable rainfall.

Farmers would spread the risk by cultivating several widely separated fields or by distributing their cattle to relatives. Intercropping was widely used, with seeds of grains, beans, pumpkins and root crops mixed together and broadcast over the land. The benefits were soil protection and improved soil structure, moisture conservation, suppression of weeds and pests, and, especially, lower risk of crop failure.

They also made use of *dambos* – the grassy, seasonally waterlogged areas common in moist savanna and found in the headwater zones of streams and rivers. The margins of *dambos* were favoured for cultivation in Angola, Malawi, Mozambique, Zambia and Zimbabwe because they were

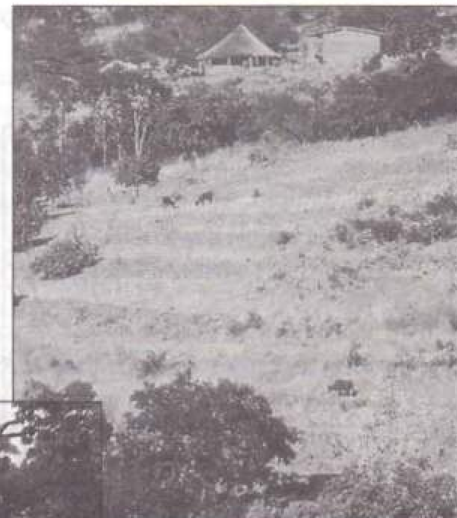


PHOTO 2.3 IUCN-D Reed

Above: Terracing, at Chimanimani in Zimbabwe, has contributed to local sustainability for centuries.

Left: Traditional agroforestry has increased crop-yields in Malawi.

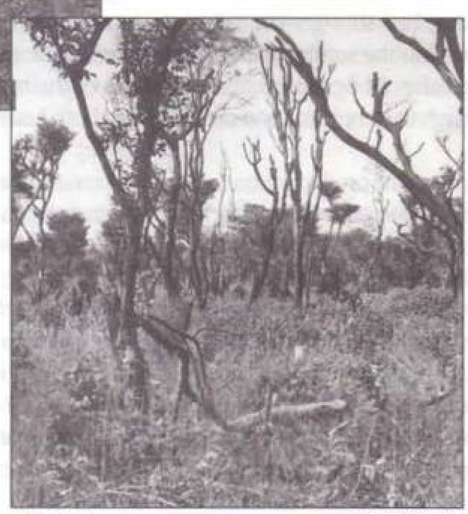


PHOTO 2.4 IUCN-Zambia

Chitemene involves cutting down branches from trees and burning them in large piles, shown here in northern Zambia.

Tree gardens of Kilimanjaro Box 2.3

The villages of Kilimanjaro region in northern Tanzania are the most populous in the country — or anywhere in the region. At 500 people per square kilometre, these villages are like cities in rural areas.

To stem the pressure on the land, the WaChagga of Kilimanjaro practise one of Africa's most intensive agricultural systems, based on agroforestry — the use of trees in agriculture. The "tree gardens" of Kilimanjaro, or *kihamba* in the local dialect, were designed to conserve the soils on the slopes of Mount Kilimanjaro well before the arrival of Europeans.

The tree gardens feature permanent cropping and irrigation, in a multi-storey arrangement of trees and plants. At the lowest level are food crops such as taro and beans, interspersed with grass for animal fodder. Above these are cash crops and medicinal plants, followed closely by a zone of bananas, the staple food of the WaChagga. Standing above the rest are tall timber trees such as teak, which crown an age-old farming system unique among Africa's surviving soil technologies.

WaChagga gardens are labour intensive and extensively managed. Trees and crops are transplanted to ensure better growth. At the right time of year, foliage is cut to let more sunlight into the coffee plants below the towering teak — all designed for better fruiting. The WaChagga also use a lot of manure for fertiliser, and grow certain crops which repel pests. All these were developed before modern science brought other biological pest-control methods to the area.

The irrigation system used in Kilimanjaro is an extremely sophisticated and complex system of furrows which carry water for long distances. At times, furrows cross other furrows, and even rivers, in hollow tree-trunks.

Community participation ensures the success of this labour-intensive form of cultivation. All labour comes in the form of work parties. Farmers using the irrigation system belong to a board run by elders, and take turns in maintenance work.

SOURCE: Maro, Paul S., "Agricultural Land Management Under Population Pressure: The Kilimanjaro Experience, Tanzania," *Mountain Research and Development*, 1988, Vol 8, no 4, p. 273-282

moist enough to provide dry-season crops without irrigation, and clearance of woodland was not required. *Dambos* are also suited to dry-season grazing. While *dambo* cultivation and mixed cropping were fairly widely used, a variety of other specific techniques were developed to deal with a range of conditions.

Terracing

Terracing the land is not new to southern Africa, and has made a distinct contribution to local sustainability for centuries. It was a management tool long before any significant contact with the outside world. The terracing of hillsides of Nyanga in eastern Zimbabwe and those of Kainam in northern Tanzania are a case in point.[12]

The Nyanga terraces were constructed in the eastern parts of Zimbabwe, by Shona people,[13] to reduce loss of soil from slopes and preserve soil fertility. The system involved ridging and mounding of hillsides and valleys. Large numbers of people were supported by this specialised exploitation of land, a practice often described as a finely balanced and integrated agricultural technique.[14]

The success of this agricultural practice depended on labour and good social organisation. If there was threat of war or conquest, the agricultural system either collapsed or faced a re-orientation in its implementation. The fact that the system remained in use for centuries, and continued to support a large population, indicates that it was not very vulnerable to environmental problems.

Slash-and-burn agriculture

People across much of southern Africa relied on shifting cultivation to produce food. Local variations were developed to suit different local conditions.

In high rainfall areas of northern and central Zambia, for example, where leached and acidic, nutrient-poor soils could not support permanent cultivation, the Bemba people developed a system known as *chitemene* (slash-and-burn). This involves cutting branches from trees and burning them in large piles. The ash fertilises the soil, while the burning destroys weeds, cutworms and other pests as well as bacteria in the soil that normally eat up the nutrients.[15]

The ash gardens, also known as *swidden fields*, are cultivated for one to three years. Nutrient levels remain high for a number of years after burning. The excessive weed-growth and reappearance of pests means the plot must be abandoned and left fallow before being cleared again for cultivation, depending on land availability, forest re-growth and population density in the area.

This was an efficient farming system which operated successfully under the established traditional mode of subsistence. The people understood that it was necessary to leave the land fallow for a long time to allow enough tree growth to provide sufficient ash and heating of the soil.

Generally, traditional shifting cultivation has two important characteristics that minimise soil degradation, according to recent studies:

- cultivation is confined to small, detached plots for a limited period (due to loss of fertility and weed-growth); and
- the force and amount of runoff is minimised while the disturbance to soil structure under the impact of hand tools is small and temporary.

Mound cultivation

Mound cultivation was another successful traditional farming method practised by, among others, the Tabwa in Zambia[16] and on Ufipa plateau in southwestern Tanzania.[17] The practice involves incorporating grass into the soil so that it rots and fertilises the soil. This method has the advantage of allowing people to settle and work the same land for a long time. The mound system is able to sustain a larger population than shifting cultivation, with a carrying capacity of about 30 persons per square kilometre against 5 persons/sq km under shifting cultivation.

PHOTO 2.5 SPLASH-M Segerros

Mound cultivation in Malanje province of Angola is ideal for planting sweet potatoes.

Mound cultivation provides a sustainable solution for agriculture in treeless environments as it allows crop rotation and fertilises the soil after the mound is broken up. Terracing and mound systems of cultivation were based on use of the hoe, which has proved to be an effective farming tool up to the present day. Many farmers maintain that hoe-cultivation ensures even distribution of water over the land. The introduction of the plough during colonial days often produced rapid, unitary drainage systems which concentrate water and cause gullies.

Fire and resource-management

Traditional societies found burning a useful tool, and depended on it for centuries in their day-to-day activities. Hunters used it to drive game and sharpen wooden weapons for hunting. Among agriculturists it was (and still is) used to clear bush for settlements and gardens. Fire was also used to improve grazing and eliminate ticks, notably during wildlife breeding seasons. This strategy was designed to increase wildlife numbers by maximising production of food supplies. Traditional hunters in Angola, Malawi and Zambia used fire not only as a hunting weapon to force animals out of hiding

Photo 2.6 IUCN-D Reed

Fire was a useful tool in day-to-day activities.

but also to increase concentrations of wildlife. Fire is still used to burn the bush, destroy cover for certain animals, and create patches for certain vulnerable species of animals, such as duikers, which hide in thickets. By leaving some vegetation untouched in preferred ecological zones where hunting can be carried out, animals are attracted and their concentrations maximised for exploitation.

Wildlife conservation

Traditional societies developed wildlife conservation strategies that helped to regulate exploitation of wildlife, and ensure that the communities had adequate natural resources readily available. These strategies were deliberately aimed at the preservation of living resources for the benefit of the present and future generations, and were deeply enshrined in the traditional values of the societies.

Traditional societies in southern Africa practised and enforced wildlife conservation measures with varying degrees of effectiveness, through seasonal hunting and trapping of animals and birds for home consumption. This practice discouraged indiscriminate hunting, and encouraged selectivity in capturing wildlife.

There was a widespread cultural belief in abstinence from unwarranted killing of wild animals, especially those which society held in contempt such as hyenas and monkeys, and also the young of all species. Fish were also protected, with some sites held sacred. Family totems, whereby some groups of people were prohibited from eating certain fish, animals or birds, also offered protection. There can be little doubt that these strategies emanated from people who had concern for their environment and its ecosystems, an attitude which enabled societies to conserve their resources without written legislation.

The Ila-speaking peoples of Zambia had a traditional wildlife management system well-known in the region — the *chilla*. This was a system of seasonal hunting expeditions organised to hunt lechwe, particularly in the Kafue flats, either once a year or at intervals of two to three years, depending on the population of the animals. According to eyewitness accounts, *chilla* was a communal hunt in which a large number of animals were killed. There were strict rules governing such hunts. Chiefs and elders were the only people with authority to sanction *chilla* and they could do so only after ascertaining that animal populations were not being hunted to extinction. Oral history suggests that there was an element of selectivity in the actual hunt, with females and juveniles spared while males were targeted.[18]

IMPACT OF COLONIALISM

Restrictions and regulations

The growth of anti-colonial grievances in southern Africa was in most cases the result of restrictions and regulations aimed at curbing African practices. Colonial prohibitions were particularly severe on agricultural practices such as use of wetlands for cultivation and grazing, and hunting and fishing.

The onset of colonialism in southern Africa disrupted the delicate balance that existed between traditional communities and their environment, and triggered a process of change in all spheres of development. The influence of colonialism on traditional environmental management varied from one African society to another, depending on social organisation, environmental and cultural factors. For example, before Europeans invaded the Transkei in South Africa in the 19th century, Sarili, the paramount chief of the Gcaleka nation, exercised a strict policy of banning the felling of saplings for huts. Nor was the collection of firewood allowed from the Dwesa and Manubi forests along the coast. But soon after Sarili's conquest in 1878, these forests were overrun by woodcutters. By the time a forest service was established in the territory 10 years later, much damage had been done. The new authorities did not have as much control as the traditional chief in regulating the use of the forests, so much of the area was reduced to scrub.[19]

Sarili's conquest, and the subsequent changes imposed on his land and people, was repeated many times across southern Africa, particularly during the last decade of the 19th century and the best part of the current one. In Sarili's time, traditional values overshadowed all other competing interests for the common good of the larger community. When he was eased out, as many of his peers were, the land's productivity assumed a new definition — in rands, pounds or US dollars.

Religion was of primary importance in influencing a change in traditional practices. As people converted to Christianity, they began to change or severely curtail their traditional roles relating to certain practices, such as worshipping ancestral spirits. African traditional values were either suppressed or so much discouraged that they changed in response to influences such as Christianity, imported values and technocratic approaches to development.

The fundamentals of African knowledge and values gained over centuries still remain. Often these seek compromise with external systems and are now expressed in Christian behaviour and ritual. Swaziland has examples of where this has happened, as do some Lozi traditions in Zambia. Sacred areas such as Wedza Mountain, Nyangani and *Mosi-oa-tunya* (Victoria Falls) remain significant to the social landscape in Zimbabwe.

African cultures and traditions have bestowed a lasting legacy on southern Africa's environmental landscape. But much of the knowledge of traditional management systems is expressed in various forms often difficult to decipher, even in the country of origin. This includes:

- planning and location of local spaces, including sacred areas within villages;
- traditional technologies, such as food processing and storage methods handed down the generations;
- wildlife management, including selective communal hunts, customary bans on hunting female animals and ritual-hunting;
- ecological arrangements and classification systems based on dominant plant or animal life and importance to the community;
- knowledge of plants and their benefits to society, including food and medicine;
- knowledge of land forms, such as rivers and valleys, their attributes and importance to the welfare of the community; and
- farming methods, such as the seasonal moving of livestock to more suitable pastures, and terracing in mountainous areas.

Division of land

British colonial administrations in Malawi, Zambia and Zimbabwe created land divisions that marginalised Africans to infertile communal areas which they could not legally own while at the same time strengthening the settlers' grip on fertile land by giving them freehold. Africans were expelled from their traditional areas and their resettlement in native reserves eventually led to overpopulation, overstocking and overcultivation.[20]

Despite the fact that the food staples the European settlers ate after their arrival in southern Africa were produced by African farmers under traditional systems of land tenure, the recipients condemned subsistence agricultural practices and instead introduced policies that disadvantaged African farmers. In some areas, traditional cultivation techniques were discouraged and in others, simply displaced.[21] Due to lack of understanding of the way land was used by Africans, laws were enacted that enabled settlers to seize fertile agricultural land from Africans who were deemed to be "wasting" it.

Chitemene (slash-and-burn) was condemned as destructive even though the practice was viable and environmentally sound as long as population densities remained low. The traditional mound cultivation system, which for centuries had proved to be an appropriate and sustainable land-use system in the treeless parts of northern Zambia, was condemned by colonial administrators who said it increased gully erosion and reduced water storage.

Colonial administrators condemned traditional hunting practices such as the *chilla* (seasonal expeditions), which were subsequently banned. They realised too late that the practice had very important ecological implications for the lechwe, and provided for rational utilisation of available animal and plant resources. Hunting weapons such as spears, bows and arrows, and assorted traps were substituted with muzzle-loading guns which were more destructive. Realising the rapid decimation of wildlife and the increase in human populations, and under pressure from some sectors of the international community, colonial administrators resorted to creating game reserves and national parks in preference to traditional hunting areas.

Major changes took place in the patterns of social organisation and resource exploitation among southern African populations in the early 20th century due to the dictates of colo-

Colonial parks Box 2.4

Joao Serodio de Almeida, Angolan environmentalist, from an interview with senior Angolan journalist, Jose Ribeiro, in February 1992:

"In my view the war was not the most important element of the current state of the environment in Angola. Much more important than the war was the period of Portuguese colonial rule. Then there was no understanding, no preparation of people to face environmental problems. The issue was not even raised in Portuguese education. The proof of this is that Portugal itself was never the subject of environmental concern.

"But why, you might ask, did the Portuguese then set up national parks in Angola? They did so because the United Nations forced them to. When the UN established the principle of nature conservation in the 1940s, and urged governments to set up parks to conserve some special ecosystems, Portugal did so to shut up the rest of the world so it could continue with its colonies. So they set them up, but never really supported them. The little they did was to control hunting of wild game. That was strictly a repressive activity. The wardens were there to impose fines. They never tried to educate people, to explain why it was important to protect certain species and to protect the forest.

"Therefore, after independence and the dismantling of Portuguese authority, Angolans thought, 'Now the land is ours. We can do what we want. There are no longer any parks, that was just an obsession of the settlers.' This was how people thought."

SOURCE: Sogge, D., Sustainable Peace: Angola's Recovery, SARDC, Harare, 1992, p. 68

nial administration. Africans were portrayed as poachers ignorant of wildlife management, and rules and regulations were imposed which severely restricted their hunting.

After dismantling traditional systems of African land-tenure, policies were introduced to impose permanent cultivation within a cash economy. This was considered more efficient than bush fallowing or shifting cultivation. In some areas, African farmers were compelled to grow marketable crops such as rice, tobacco and cotton to provide fast-growing industries in Europe with raw materials. This emphasis on commercial production led to cultivation of large areas, resulting in greater runoff, destruction of soil structure and risk of soil degradation.

In northern Mozambique, compulsory farming of cotton disrupted rural production systems and almost caused desertification of the area.[22] Due to lack of food crops, there was a famine in the area in 1951. In other areas, Africans were discouraged through unfair pricing policies from producing cash crops, beef and dairy products to favour European farmers. In Zimbabwe, destocking was made compulsory,[23] while in Malawi fines of up to 50 pounds and prison sentences were imposed on those who failed to adopt the European mode of agricultural production through the Natural Resources Ordinance passed in 1946.

Soil-conservation measures

Soil-conservation measures enforced throughout most of the region can be traced to February 1938 when a circular letter was sent to all British colonies, demanding that they submit an annual account of all the conservation work undertaken by their various departments. As the fat files containing colonial soil-erosion reports got fatter from 1938 onwards, resentment grew against coercive enforcement of soil-conservation measures in several British colonies. This was so intense in several British colonies that it fuelled the initial agitation for independence.[24]

Few environmental disasters of that period had such global consequences as did the *Dust Bowl* phenomenon in the United States. At its height in 1935, the *Dust Bowl* galvanised international action to make soil conservation a truly global agenda. Measured in square metres of topsoil blown hundreds of kilometres across the country, the impact of the *Dust Bowl* did much to encourage the colonial office in London to change their view of recurrent cycles of drought in Africa. There were fears that much of the continent was "drying" up, and that the welfare of white settler farmers was at stake if roaming herds of African livestock were not controlled.

False starts, wrong directions Box 2.5

Events of the past half century have greatly shaped the southern African landscape. Just 50 years ago, the beauty of Lesotho's Mobu valley was legendary and people said "it could make the heart beat nonstop". The main dialect, Sesotho, did not even have an appropriate vocabulary for soil erosion.

Basotho elders aged over 65 years recall a countryside full of grasses on the hills and in the fields. From these oral accounts, researchers have pieced together a fairly elaborate landuse pattern at the time. Livestock stayed in mountain pastures until the crops were gathered from the fields. Milk cows had separate grazing places from oxen, which were in turn distinct from areas reserved for horses. In lowlying wet areas grew the reeds for roofing and fencing. Crop fields were punctuated by wide bands of thatching grass which, together with the reeds, formed the community's commons. Harvest and use were regulated by the chief. Such was the ideal setup which governed Lesotho's unwritten environment and development policy for ages.

This changed drastically during the 1930s when cycles of drought swept across Africa. Almost simultaneously, the United States had the worst drought on record, the Dust Bowl. Pushed for answers to resolve an apparently similar problem in Africa, the British colonial office looked to US soil scientists for advice.

The US experience with the Dust Bowl created such profound, yet misleading, confidence that some South African and British administrators visited various US research institutions and projects for observation and training. South African officials, then contemplating an ambitious soil-conservation programme for Basutoland, sent staff members on study tours. On their return, extension officers were deployed to oversee an extensive system of contour banks superimposed slapbang on the existing local conservation measures.

Generally receptive to constructing contour banks at first, the Basotho soon noticed that water at shedding and distribution points was instead concentrating and forming gullies. One elder summed up the frustrations of his peers when he said: "If the water came spreading down, there is no way it would gather and move with such force ... harm is being done by contouring. ..."

The Basotho became the first people in the world to use a largely untested and little understood soilconservation technology. They suffered immeasurable soillosses as a result.

SOURCES: Anderson, David, "Depression, Dust Bowl, Demography, and Drought: The Colonial State and Soil Conservation in East Africa During the 1930s", African Affairs, 1984, Vol 83, no 332, p. 321343
Showers, Kate B. and Gwendolyn M. Malahleha, "Oral Evidence in Historical Environmental Impact Assessment: Soil Conservation in Lesotho in the 1930s and 1940s", Journal of Southern African Studies, Jun 1992, Vol 18, no 2

The economic and environmental crises of the 1930s brought the first set of policies "from above", implemented with force, which ignored local conservation measures already in place.

In Malawi, Zambia and Zimbabwe, the Federal Government of Rhodesia and Nyasaland in the 1950s created soil conservation measures which were more applicable on estate farms than small-holder farms and were inappropriate for African traditional farming. In Swaziland, African farmers were prohibited from ploughing up and down the slope, which decreases soil loss but increases water loss,[25] and forced to maintain grass filter strips. In Tanzania, force was used only when persuasion failed.[26]

There were instances when colonial authorities recommended conservation techniques which Africans themselves preferred, and which did not require much extra resources to adopt. The failure of these management systems was not because they were unsuited to local conditions, but often because they were viewed as an imposition.

Many studies now suggest that the best approach to rural-development planning is to improve on what already exists, such as the role of traditional leaders in the management of agriculture.

Photo 2.7 SOUTHLIGHT-P Grendon

Local knowledge and control was supplanted by apartheid control in South Africa. This woman, outside her reed mat house in Namaqualand, faced eviction from her communal land which was being sold to private individuals.

Apartheid

In South Africa, *apartheid* stratified society based on colour, advocating territorial segregation. A version of southern African history was propagated in which white settlers laid claim to the land. The creation of homelands or "bantustans" for the rural African population exacted profound social and cultural consequences on the environment as a result of overpopulation.

Even with the changes now taking place in South Africa, the black majority, who constitute about 75 percent of the population of that country, still occupy a mere 14 percent of the land while 80 percent is occupied by white-owned commercial farms — a legacy of decades of *apartheid*.

In QwaQwa, one of the homelands which existed under *apartheid* in South Africa's Orange Free State, the black majority are so crowded that, on average, three people share a hectare. This includes using the land for purposes such as cultivation, livestock and infrastructure. Only 10 percent of the population that lived there in 1990 could be adequately supported by the land through subsistence farming. People forced to subsist in rural areas, without adequate resources and infrastructure, have no choice but to strip the environment just to survive. In QwaQwa, forests have disappeared entirely.[27]

Once land-holding by chiefs was disturbed by settler invasion, there were massive displacements of people. This

Use women's knowledge for sustainable development Box 2.6

Empowering Women: The process of development may have liberated a small minority of African women able to gain an education. But at the same time many women with an intimate understanding of how to manage their environment on a sustainable basis have become more powerless, losing even the limited control they had as resource managers at the household and village levels.

For African women to gain the degree of equality commensurate with their responsibility for social wellbeing and the care of natural resources will require a transformation from within each society, more than just women-centred aid projects, which can sometimes be counterproductive.

SOURCE: OAU and UNICEF, *Africa's Children, Africa's Future*, Background Sectoral Papers prepared for the OAU International Conference on Assistance to African Children, Dakar, 25-27 Nov 1992, p. 157

caused very difficult adjustments to new environments. The disruption caused by *apartheid* could be felt across the borders of neighbouring countries through the establishment of a system of compulsory seasonal labour in South Africa. Able-bodied men from these countries were forced to seek employment in South African mines and elsewhere outside their communities. This intra-regional drain of human resources disrupted families and traditional communities, resulting in a deterioration in the standard of living and abandonment of traditional environmental management systems.

Despite the successful conclusion of South Africa's first all-race elections in April 1994 and the inauguration of Nelson Mandela as that country's first black president, it will take years, probably decades, before the impacts of *apartheid* can be corrected.

BUILDING ON TRADITIONAL MANAGEMENT SYSTEMS

Africans managed the environment and its resources quite successfully for a long time through well-designed, productive and sustainable farming practices. Even under the pressure of colonialism some traditional practices, such as mound cultivation and terracing, have survived. Indigenous technologies may not be very significant now but African traditional social organisation remains. The question, therefore, is why traditional practices are being abandoned. What has made it difficult for people to maintain these practices?

While traditional rules for use of the environment are still well-known in many parts of the region, they are not observed due to the transfer of power from traditional leaders to colonial administrations and then post-independence governments. In countries such as Angola and Mozambique, war and political conflict have been responsible for the abandonment of some indigenous techniques. Rural-urban migrations have disrupted communities and depleted populations of able-bodied men and women needed to maintain the traditional methods of land management. Traditional systems of communal land-management have been eroded, originally because of new forms of governance but, more recently, because of population pressure and displacement of people.

The *chitemene* (slash-and-burn) system of shifting cultivation is now under the pressure of increasing population densities, but has survived because of adjustments which have taken place. The fallow period of woodlands has been shortened to 12 years or less, and the large ash-circles have become smaller to compensate for scarcer wood. These adjustments will not be enough on their own to allow shifting cultivation to survive as a technique for much longer,[28] and there is research now to find other ways to adapt *chitemene* and make it sustainable — through tree-planting and other modifications.

Another workable alternative to *chitemene* is mound cultivation, which is sustainable and indigenous to parts of the region. The *kanchomba* farming system, which stresses the use of dung, crop rotation and weed-control to maintain soil productivity, is still practised in Zambia. It could be introduced in other areas where pastoralism is practised. This would reduce the use of expensive chemical fertilisers. Despite the expansion of commercial cattle-ranches in the region, the subsistence pastoral patterns of cattle-raising are still viable in some areas and cause little rangeland degradation compared to commercial ranching.

Photo 2.8 SAMSO-D Deudney

Robert "Treeman" Mazibuko explains a point about traditional management practices at Edendale African Tree Centre, Natal, South Africa.

Rural people in some areas have been able to develop new methods to cope with new pressures. For example, the people in Shinyanga district, a long-settled part of Tanzania, dealt with a steady decline in crop production for almost 50 years from the 1940s. In 1982, a World Bank-financed Shinyanga Regional Integrated Development Project survey found that some areas of the district were at least 20 times overstocked. Grazing lands had the severest erosion and greatest quantities of sediment, according to the survey. With innovative leadership and without assistance, they developed contour ridging using an ordinary ox-plough, intricate systems of intercropping on ridges mixing legumes with grain crops, and simple management procedures for their cattle. Today the area shows no signs of erosion and has a relatively prosperous group of villages.[29]

The quality of local leadership can determine the difference between success or failure of these modern adaptations. In the Lozi society in Zambia, for example, the environment of the Zambezi river plays an important role in regulating the economic life of the people, centred on the river's floodplain. Even today, the traditional chief still determines when people and their animals have to leave the flooded area for higher ground in an annual ceremony known as *kuomboka*. This ceremony has a long history and continues to be an important environmental management practice. The lessons learnt from activities of the past can assist in future planning to enable us to manage the environment sustainably.

Perhaps the most important question now is what options the average farmer in southern Africa has — in view of the shortage of good land, adequate credit and extension services.

The movement patterns of pastoralists and their livestock have for many centuries depended on environmental indicators such as presence of forage species for good pasture and availability of water. This is an African environmental ethic which remains little understood and is not properly catered for in current policy initiatives. Traditional environmental indicators are still in use today and have become more pertinent with the resource shortages. The absence of a strong cultural base in the formulation of conservation measures has resulted in traditional management methods being discarded in preference for imported methods.

Much of African traditional methodology is passed down the generations orally and is, therefore, not easily accessible, not only within one country but others in the region. Further research is needed to capture this indigenous knowledge and traditional practices so that they can be accessible, improved upon or adapted to suit current conditions.

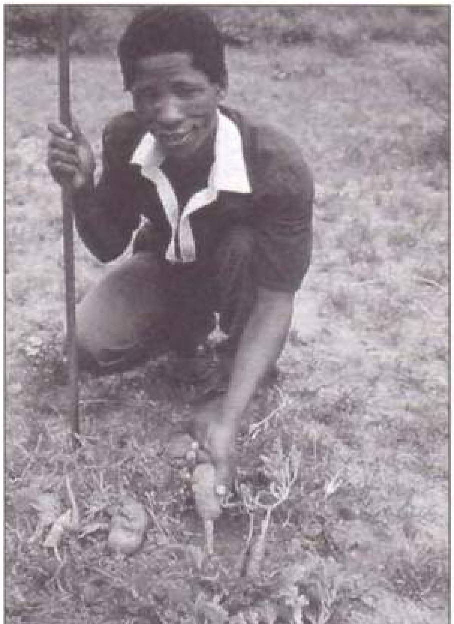


Photo 2.9 IUCN-D Reed

Wild roots, bulbs and tubers provide food and medicine in rural areas.

Photo 2.10 NAMIBIA REVIEW

Marula (maroela) is a popular wild fruit, often prepared as juice.

Linkages to other chapters Box 2.7

1 PEOPLE
Many aspects of traditional environmental management remain relevant today, but more research is needed to adapt this knowledge to current conditions.

3 POLICY
Policy takes up where the history chapter ends, reviewing current environmental policy initiatives and tracing progress since colonial times.

4 ECOZONES
The different ecological zones are the physical processes paramount in each part of the region, differences for which indigenous people developed appropriate management technologies over several centuries.

5 CLIMATE
The history and role of weather patterns in the region, characterised by drought, provide good background on developing policies aimed at minimising environmental impacts.

6 SOILS
Traditional agricultural techniques are examined in more detail, reviewing their sustainability and environmental suitability to various conditions.

7 WOODLANDS
The use of woodland and forest resources for subsistence and other purposes is explored, showing the major cause of deforestation in the region today as clearing of agricultural land, not subsistence use of woodland resources as often claimed.

8 WILDLIFE
The wildlife management systems employed today and in the recent past have given rise to current attempts to involve rural communities in formal wildlife management.

9 FRESH WATER
Water availability and quality has been a factor in human development for centuries, with rural people developing their own water conservation methods. Freshwater fish have been a significant source of food in parts of the region.

10 MARINE
Marine fisheries have been exploited by people for hundreds of years, and were essential to many subsistence economies.

11 POLLUTION
Though still insignificant when compared to world figures, both domestic and industrial pollution pose serious threats to human health, which are increasing with the pace of urbanisation and industrialisation.

12 ARMED CONFLICT
The colonisation of southern Africa resulted in armed conflicts but the impact on the environment was not as severe as it is today due to the increased use of arms of destruction.

13 GLOBAL
Many environmental issues examined are common across southern Africa. Although impacts are still highly localised, they may have dire global implications, such as the impact of grass and woodland fires on climate change.

14 TRENDS
More people are becoming aware again of the relevance of the environment in their daily lives. Opportunities and challenges are examined, from traditional management and usage to new institutions and new threats.

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3

Evolution of POLICY

Before the emergence of modern nation-states in southern Africa, a strict code of conduct determined how much, and when, people could draw from the natural environment. The system of policy-making was defined, for example, by the *kgotla* among the Batswana, the *lugiko* in Sukumaland (northwestern Tanzania) and the *lipitso* of the Basotho.

Today's policies are defined by the set of government and/or corporate objectives and guidelines deliberately chosen to influence future decisions. Some policies are specifically targeted; others are just plain statements of ideals. All policies should be written down and formally approved by government or corporate authority, but many are informal and lack legal backing.

In much of southern Africa, government policies often involve a long process of consultation between people and their parliamentary representatives, analysts and research scientists, civil-service bureaucracies and the legislature. All countries in southern Africa now have representative forms of governance, using legislative assemblies and legal instruments, modelled on English Common Law or Roman Dutch Law, to formulate policies which later become Acts of Parliament. The Acts are legally binding, but policy-making is not a function of legal instruments alone.

Most policies in the region are implemented through legislation or through programmes enforced by established institutions. Implementing many policy initiatives remains difficult due to a combination of factors, such as lack of resources, inadequate skills or lack of political or popular support. Different policies often overlap or even contradict each other, since they may represent the objectives of individual government departments with differing approaches and goals.

POLICY-MAKING PROCESS

Until the early 1960s, there was hardly any written, holistic environmental policy anywhere in the world. The environmental vogue was preservation rather than the current context of sustainable development. Soil conservation and wildlife management were major policy issues in southern Africa at the time, as was water conservation, particularly for South Africa and Zimbabwe.

The global environment movement, which began with the 1972 Stockholm Conference on the Human Environment, pushed the ideals of *sustainable development* into the world's development agenda. It has since overshadowed the quest for *economic growth* even among neo-classical economists.

If the 1980s were "the lost decade" as described by the United Nations, they were also a turning point in Africa's development thinking. Cycles of drought, famine and large-scale starvation, particularly in the Horn of Africa, ushered in a new environmental ethic from their combined effect on human suffering.

Yet the 11 southern African countries are well-endowed with the basic resources of soil, water and air — and all the life-forms on the earth's outer crust called the biosphere. The SADC region (excluding South Africa) covers some 5.7 million square kilometres, most of it in the form of rangelands (41 percent) and forests and woodlands (32 percent). Only 5.5 percent of the land is arable.

The critical question which southern Africa must grapple with is how best to use its resources to develop the lives of its people, while ensuring future generations will also have access to these resources for their own development needs. The region's recent colonial history passed on to present governments a legacy of alien policies and rules alongside a range of institutions and mechanisms for implementing them. These were largely driven by forces and personalities outside southern Africa, and were often developed for a minority of the population. Many of today's governments, some tempered in the heat of armed struggle, have inherited such frameworks with which to achieve sustainable development and put right the many wrongs of past policies. This is happening against a backdrop of economic hardships, often perpetuated by trade and aid policies of the northern economic divide.

Ill 3.1 IUCN-D Reed

Public awareness

The World Resources Institute identifies two factors as critical indicators of a country's commitment to environmental protection:

- its effective participation in relevant international agreements; and
- its collection and dissemination of information.[1]

In southern Africa, participation in international agreements has been selective, and is dictated mainly by common regional positions and national priorities. What is relevant elsewhere may be regarded as inconsequential when weighed against other regional or national priorities. During the 1992 United Nations Conference on Environment and Development (UNCED), or Earth Summit, in Rio de Janeiro, Brazil, national position papers were greatly influenced by what came to be known as the *African Common Position*. This African position paper devoted only half a page in its 76-page report to the Convention on Biological Diversity. It steered clear of any direct reference to the convention on climate change, which was so central to the UNCED process in the eyes of Northern governments and non-governmental organisations (NGOs).

In southern Africa, the collection and dissemination of information on environment-and-development issues reflect these differences of approach and emphasis. In a region where some people still die of starvation, a public-awareness campaign may fail miserably at the sheer stroke of wrong emphasis. Efforts to communicate the environmental message effectively also depend on the strengths and weaknesses of institutions at different levels of society —whether grassroots, national or regional. But the process of public awareness and the issues of concern do not differ much from those generated by the global environment movement. In southern Africa, real opportunities now exist to refine the region's environmental agenda through emerging networks of organisations bringing together people engaged in the communications media and policy research.

Process of awareness-building

The fact that the environment and human development are inexorably linked is hardly debatable today, though this was not the case two decades ago. Such evolution is best illustrated by an episode at the Stockholm conference in 1972 when a Central American delegate said he "wouldn't mind a bit of pollution" if that meant more economic growth to his country. At the time, few countries which sent delegates to the historic conference were aware of the real issues. Environmental matters had received little publicity, with a few notable exceptions, such as Rachel Carson's *Silent Spring*, written in 1962, which galvanised world attention on chemical pollution and exposed to a wide audience the dangers posed by pesticides.

In southern Africa, environmental awareness has been achieved at great cost. The socio-economic crises which ravaged the continent from the early 1970s to well 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. Change in attitude among policy-makers became the most important aspect in the slow process of public awareness. Change has been slow in this region, as in many other developing countries, because governments have had a virtual monopoly on policy-making during the evolutionary two decades since Stockholm. Governments often had other pressing priorities, particularly post-independence governments. Several countries in this region were not yet independent at the time of the Stockholm conference. In contrast, policy initiatives of the industrialised North often result from public pressure and involvement.

Apart from pushing their own governments toward new policy directions, Northern NGOs also play a leading role in the ongoing debate about the future of the global environment and its perceived impacts on developing countries.[2] Through carefully planned and targeted media campaigns and institutional networks, the environmental message is probably the most widely advertised commodity anywhere — perhaps rivalled only by war and related political conflicts.

The sheer volume of environmental information and its scope of coverage is unprecedented in recent history, but the impact on public awareness in southern Africa is mixed. Many of the issues raised by Northern think-tanks (research organisations) and media are valid but, like their political leaders at UNCED, people in southern Africa have more pressing things to worry about.

Dissenting views on areas of immediate concern have done little to stem the flow of environmental information from North to South. However, differences in definition and emphasis have brought about a healthy exchange of information on South-North perspectives. The inherent challenges in the overall process of awareness-building now lies in the quantity and quality of information that national and regional institutions can generate to define the global environmental debate in local terms, and to inject local concerns back into the global debate.

International cooperation on environmental policies is gaining momentum across southern Africa, as are regional networks striving to enhance communication of public information on common environmental issues. To sustain the process of environmental awareness-building, regional and international partnerships will rely heavily on institutional frameworks already established in the region. All countries in southern Africa now have national environment councils or commissions to define their priorities and enhance cooperation on the environment. The semi-autonomous councils and commissions are supported by government ministries or departments of environment — most established during the 1980s. The establishment of these institutional frameworks has greatly improved the collection and dissemination of environmental information.

CURRENT POLICY FRAMEWORKS

The path to sustainable development in southern Africa is thorny. Many of the environmental problems facing the region can no longer wait for tomorrow's solutions but call for painful choices now — between managing them on tight budgets and meeting day-to-day needs.

The link between environmental issues and the poverty of people at the cutting edge of such issues is now better understood than before. In the struggle for food, shelter, warmth and water, the values of the poor are tied to immediate use of the land and its resources to meet their pressing needs. Such values are not necessarily matched to national policy objectives. In many cases, people still remember oppressive measures of colonial governments and see little point in cooperating today. Diffusing such mistrust is central to the success of current policy directions. Many governments in southern Africa are making genuine attempts to develop home-grown policies that meet the needs of their people while pursuing economic reforms.

Silting up community water sources Story

Domboshawa (IPS) — Streambank cultivation could cost a vibrant Zimbabwean community its water source as the Nyaruwanga river progressively dries up.

Largely dependent on market gardening for their livelihood, the people of Makumbi village in Domboshawa, 50 kilometres north of the capital, Harare, carry out their farming practice on river banks.

"This is the only place where we can get some water for our vegetables," says 40-year-old Muchaneta Munemo. "As you can see the rest of the land is rocky and dry.

"But our main worry now is water. There is very little water left in the stream," complains the mother of four.

Munemo has been farming in the area for more than 10 years now, but since the 1992 devastating drought the streams feeding the Nyaruwanga river are no longer perennial.

"In many cases legislation is inadequate in terms of coverage and relevance. In many instances it is outdated," says Davison Gumbo, agricultural researcher for a local non-governmental organisation, Environment and Development Activities (ENDA). There are over 20 environmental Acts of parliament in Zimbabwe, but conservationists say that they are sectoral, and tend to overlap.

The lack of clear-cut policy on the country's waters has resulted in competition between the gardeners and a local Catholic mission sharing the Nyaruwanga river.

The mission complex has had to drill its own boreholes as it can no longer rely on the river. With a population of nearly 2,000 people, the mission provides this rural community with a primary and a secondary school plus a hospital.

The villagers have resorted to damming up the streams with mud, preventing further flow of the remaining water. Some have begun digging wells on the river bed to source the valuable resource. "People come to tell us that we may cause the river to dry up in 10 years time and we should stop," says Annie Mashumba. "But they do not offer us any alternatives. Should we starve?"

—adapted from **Gumisai Mutume,** Inter Press Service (IPS), *Africa Rural Development* Bulletin, 16-31 Jul 1993

Imposition of bureaucratic, centrally managed programmes is now being replaced by a process of consultation. All countries in southern Africa are now putting in place policies, laws and regulations which seek to reconcile the conflicting interests of environmental conservation and development needs. Zimbabwe's report on the country's response to the Rio Earth Summit is a case in point. The report identifies, among other key issues, the need to:

- link the environment to the broader economic development process;
- initiate a broad-based and multi-level participation;
- empower and enable groups which carry out environmental conservation and management activities, particularly at the local level;
- harmonise environmental activities;
- initiate broad consultation in the formulation of policy,

legislation, plans and activities for environmental conservation, (and) accountability; and
- undertake effective prioritisation of environmental activities.[3]

Several countries, notably Botswana, Tanzania, Zambia and Zimbabwe, have prepared National Conservation Strategies (NCSs), modelled on IUCN's World Conservation Strategy, to guide national environmental policies. Lesotho, Malawi and Mozambique use National Environmental Action Plans (NEAPs) for the same purpose, associated with World Bank-sponsored economic structural adjustment programmes (SAPs) as a precondition for aid.

Namibia was the first country in the region to enshrine in its constitution a clause on protection of the natural environment. The Constitution of the Republic of Namibia says, in Chapter 11 on "Principles of State Policy", under Article 95, "Promotion of the Welfare of the People", that the State will adopt policies aimed at:

> "maintenance of ecosystems, essential ecological processes and biological diversity of Namibia and utilisation of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future; in particular, the Government shall provide measures against the dumping or recycling of foreign nuclear and toxic waste on Namibian territory."

Institution-building

Effective implementation of policies at the national level largely depends on effective institutional mechanisms. Most countries in the region have established central environment agencies, such as Zimbabwe's Natural Resources Board or Tanzania's National Environment Management Council. The specific roles of these agencies vary from country to country, but generally they:

- coordinate environmental programmes and activities;
- formulate legislation and other legal instruments; and
- implement national environmental activities.

Occasionally, these institutions also take on responsibilities that require coordinating regional and international assignments on behalf of their governments. Quite recently, they played pivotal roles in preparing country submissions to the Rio Earth Summit, and continue coordinating follow-up activities to date.

Evaluating how effective they have been so far is difficult, partly because many are engaged in intangible activities, such as coordination, which are difficult to measure. Assessing direct links between the efforts of these centralised agencies and their impact on the environment is even more difficult. Yet two potentially positive impacts are already apparent. First, general environmental awareness across the region is greater now than it was a decade ago and, second, cooperation within countries and between nations is increasing. The combined effect of both is providing real opportunities for strengthening national and regional environmental institutions and agencies.[4] In fact, the United Nations Environment Programme (UNEP) calls the 1980s a "decade of environmental atonement" mainly because of such positive developments in the recent past.

Environmental impact assessments

Environmental impact assessments (EIAs) are management tools to predict and mitigate negative environmental impacts and promote positive ones. Already, EIAs on huge hydroelectric schemes have been done in Angola on the Kapana hydro-project, in Botswana on the Bokaa dam, and jointly by Zambia and Zimbabwe in the Zambezi valley. Preparations are underway to incorporate EIAs into law in Botswana, Zambia and Zimbabwe, while South Africa has tabled a white paper for an all-embracing environmental ethic.

Such efforts notwithstanding, serious gaps remain in policy, law and practice throughout southern Africa. Laws in most countries are deficient and do not, for example, distinguish between toxic and other substances in respect to municipal dump-sites. This effectively erodes control over safe handling of such substances, which are often burnt alongside household wastes, releasing toxic fumes into neighbourhoods. Likewise, sewage and industrial effluents are disposed of together in the same sewers, sometimes without treatment.

Existing laws are often poorly enforced. Even where elaborate pollution controls exist in law books, enforcing them remains difficult because of inherent weaknesses in law enforcement mechanisms and shortage of money. Lack of coordination between the different sectors which deal with pollution is another weakness, often compounded by poor dialogue between those polluting the environment and those trying to prevent it from happening.

In much of the region, there are few measures to control air pollution and existing ones remain *ad hoc* at best. Studies carried out by SADC indicate that local and national companies do not necessarily observe such controls where they

National environmental institutions and their responsibilities Table 3.1

Country	Institutions	Responsibilities
Angola	Min. of Agriculture and Rural Development	Land husbandry
	Min. of Fisheries	Marine resources management
	Secretariat for Environment	Policy development and coordination of environmental activities
Botswana	National Conservation Strategy Coordinating Agency	Implementation of conservation strategy
	Min. of Agriculture, Local Government and Lands	Land management
	Min. of Commerce and Industry	Wildlife management
	Natural Resources Board	Multi-sectoral environmental issues
Lesotho	National Environment Council	Implementation of National Environment Action Plan
	Min. of Natural Resources	Natural resources management
	Protection and Preservation Commission	Protected area management
Malawi	Dept. of Research and Environment Affairs (President's Office)	Policy development, programme implementation and coordination
	Min. of Agriculture, Forestry and Natural Resources	Natural resources management
Mozambique	National Environment Commission	Coordination of environmental activities and organisations
	Min. of Agriculture	Land, wildlife and forest resources management
Namibia	Min. of Wildlife, Nature Conservation and Tourism	Coordination of environmental activities and organisations
	Min. of Agriculture	Land husbandry
	Min. of Fisheries and Marine Resources	Marine resources management
South Africa	Dept. of Environment Affairs	Development and coordination of environmental policy
	Dept. of Water Affairs and Forestry	Freshwater and forest resources management
	Dept. of Public Works	Pollution monitoring and control
	Dept. of Agriculture	Land management
	Dept. of Transport	Marine resources management
Swaziland	Min. of Natural Resources and Energy	Water resources and wildlife management
	Min. of Agriculture and Cooperatives	Land husbandry
	National Trust Commission	National park and monuments
Tanzania	National Environment Management Council	Coordination of environmental bodies and activities
	National Land Use Planning Commission	Land husbandry
	Zanzibar Commission for Lands and Environment	Natural resources conservation
	Min. of Tourism, Natural Resources and Environment	Forest, wildlife and marine resources conservation
Zambia	National Environment Council	Coordination of environmental programmes
	Min. of Environment and Natural Resources	Natural resources management
Zimbabwe	Min. of Environment and Tourism	Forests and wildlife management
	Natural Resources Board	Advise on natural resources conservation
	Min. of Agriculture and Water Development	Land and water management

SOURCE: SADC, *Regional Policy and Strategy for the Environment and Land Management Sector*, SADC ELMS, Maseru, Lesotho, 1993

Environmental Rights Box 3.1

The *Bill of Environmental Rights* — POLICY GUIDE developed by the African National Congress (ANC), in preparation for their leading role in the government of a democratic South Africa after the April 1994 elections, contains an Article on "Land and Environment". This article begins:

> "The land, the waters and the sky and all the natural assets which they contain, are the common heritage of the people of South Africa who are equally entitled to their enjoyment and responsible for their conservation."

The Article contains a section on "Environmental Rights" which reads:

"(14) All men and women shall have the right to a healthy and ecologically balanced environment and the duty to defend it.

(15) In order to secure this right, the State, acting through the appropriate agencies and organs shall conserve, protect and improve the environment, and in particular:

a) prevent and control pollution of the air and waters and degradation and erosion of the soil;

b) have regard in local, regional and national planning to the maintenance or creation of balanced ecological and biological areas and to the prevention or minimising of harmful effects on the environment;

c) promote the rational use of natural resources, safeguarding their capacity for renewal and ecological stability;

d) ensure that long-term damage is not done to the environment by industrial and other forms of waste;

e) maintain, create and develop natural reserves, parks and recreational areas and classify and protect other sites and landscapes so as to ensure the preservation and protection of areas of outstanding cultural, historic and natural interest.

(16) Legislation shall provide for cooperation between the State, non-governmental organisations, local communities and individuals in seeking to improve the environment and encourage ecologically sensible habits in daily life.

(17) The law shall provide for appropriate penalties and reparation in the case of any damage caused to the environment, and permit the interdiction by any interested person or by an agency established for the purpose of protecting the environment, of any public or private activity or undertaking which manifestly and unreasonably causes or threatens to cause irreparable damage to the environment."

SOURCE: ANC, *Bill of Rights* - POLICY GUIDE, ANC Department of Information and Publicity, Marshalltown, Mar 1993 exist. Transnational companies are often subject to international standards instituted by their holding firms abroad, but they can often flout most of those due to lack of monitoring and enforcement in their countries of operation.

REGIONAL PRIORITIES

In November 1981, the SADC Council of Ministers requested Lesotho to coordinate regional activities on soil, water conservation and land utilisation. Eight sectoral coordination units have since been established, including the Environment and Land Management Sector (ELMS), entrusted with overall responsibility for environmental issues since 1990.

SADC ELMS is a three-tier programme developed to define priority areas of concern to the region. Sustainable use of resources and, by extension, environmental issues, are an overriding factor in all three sub-sectors — land management, water-resources management and environmental management, monitoring and assessment. Seven areas of concern have so far been identified, namely:

- securing sustainable water supply and quality;
- preventing and reversing desertification;
- combating coastal erosion and pollution;
- ensuring sustainable industrial development;
- making efficient use of energy resources;
- maintaining forests and wildlife resources; and
- managing demographic change and pressures.[5]

All these priority areas, except water supply and quality, are the same as those adopted at a meeting of African ministers of economic planning and development in May 1993, as part of the continent's strategy to implement Agenda 21 of the Rio Earth Summit. The scale of impacts exerted by all seven environmental concerns differs from country to country, but is already severe and needs immediate attention.

Most environment-and-development challenges in southern Africa mirror similar challenges faced by other developing regions of the world — which call for both national and collective regional action. Each country in southern Africa has been moving to improve its environmental policy and legislative framework, but the limits to what can be achieved by each individually provide sound reason for joint action. SADC, as a political entity, is in itself a powerful commentary on how little each member state can do alone — and provides compelling reasons for a new resolve to work together in southern Africa.

Though much of the region is ecologically fragile, it is exceptionally rich in biological diversity, providing a home to all basic life-forms and their habitats. The region's wildlife is so diverse that over half of Africa's 84 known species of larger herbivores are found here.[6] In the face of increasing conflict between wildlife populations, human settlements and the region's development effort in general, opportunities exist to chart new development paths.

Across the region, there are as yet no clear, long-term land-use policies to address increasingly conflicting user interests. In much of southern Africa, wildlife has been pushed out of its range and replaced by cattle. More recently, cattle are being displaced by expansion of cultivation.

Even where alternatives to crop farming exist, the priorities are often misplaced. Past range-management science, for instance, was heavily influenced by beef ranchers, who assessed rangeland "carrying capacity" for beef production. A whole range of development opportunities are pegged to a single economic goal, even today. But in southern Africa, the management of pastoral rangelands is geared not only to producing meat but also to fulfilling entire lifestyle objectives. Milk, blood, traction-power and transport are just a few examples of goods and services from livestock which do not require animal slaughter. Current development policies and

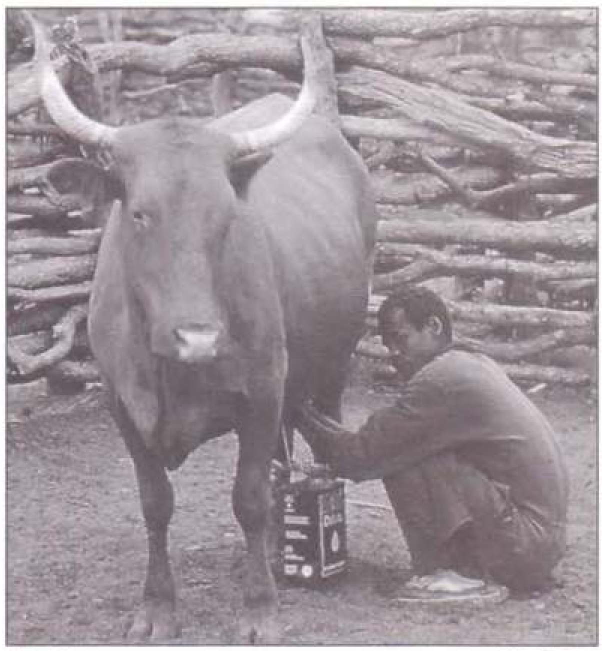

Photo 3.1 IUCN-D Reed

Sustainable use of cattle can fulfill lifestyle objectives.

interventions geared at boosting a single economic output such as beef are unlikely to be sustainable, and may have to change to meet new priorities.

Southern African countries share a host of common environmental problems created in the name of development during the colonial past, and carried forward after independence in the name of modernisation. The combined backlog of such problems now threatens the region's common joy of independence. A sample checklist of unresolved challenges provides only part of the regional picture:

- soil degradation is a serious problem across the region. Deforestation is common, due to clearing land for agriculture, although annual savanna burning, overgrazing and fuelwood-collection play a role.[7] In Botswana, South Africa and Zimbabwe, soil degradation is most severe in the communal lands, into which the majority of the indigenous population was consigned during colonial rule;
- large tracts of land suitable for human settlement and grazing are still home to the deadly tsetse-fly which causes sleeping sickness to people and *nagana* to their herds. Control programmes in Botswana, Tanzania, Zambia and Zimbabwe have made some headway over the years;
- poaching for the pot and for cash has far-reaching implications to the future of wildlife, especially in Tanzania and Zambia. But even where elephant populations were healthy at the height of carnage elsewhere, dealing with elephants is now a thorny policy issue for Botswana, Namibia and Zimbabwe;
- compared to other regions, southern Africa is among the least urbanised. Only South Africa and Zambia, where more than 50 percent of the people live in cities and towns, face real urbanisation problems. Industrial pollution is already severe in South Africa. Low population densities in some countries of the region mask the underside story of deprivation and associated environmental ills. On paper, every Namibian lives on about 690 hectares of land, the world's lowest population density. Yet most of that land is extremely dry and cannot support meaningful economic life; and
- poverty, the worst "polluter" in the words of a Chinese delegate to the 1972 Stockholm conference, is still the hallmark of environmental problems in southern Africa.

Distortions in the name of caring for the living environment are perhaps best summed up by a Tanzanian peasant, who said: "When I kill a buffalo, I get arrested. But when an elephant tramples on my fields, nothing happens." The call for new definitions and a new development ethic is on.

Opportunities and constraints

Government policies and priorities differ greatly across the region. Zimbabwe is noted for its environmental consciousness, especially in the area of wildlife conservation.[8] Botswana has a superior air-quality monitoring system, while Malawi and Tanzania are noted for agricultural expertise. Newly independent Namibia has the best marine-protection programme in the region. The environment has not been a priority in Angola or Mozambique due to the disruption caused by armed conflict.[9]

A number of environmental regulations exist in all countries across the region, but are more elaborate in some (Botswana, South Africa, Zambia and Zimbabwe) than in others. Practice still falls short of lofty theories everywhere, and there is a shortage of reliable information to guide implementation of both policy and legislation. Lack of coordination among ministries, or even among departments within ministries is common, compounded by serious shortages of trained staff.

In South Africa, democracy is firmly on course. The African National Congress (ANC), which won the first all-race elections in April 1994, has promised to make the environment a constitutional issue.[10] Yet, even with the best intentions from the ANC, the legacy of South Africa's *apartheid* past, such as politically enforced high population densities in the former homelands, will define the direction of its development and, by extension, its environment policy.

The strength and influence of NGOs will vary across the region. A new crop of fairly influential environmental NGOs has been established in Botswana, Namibia, South Africa and Zimbabwe, followed by Angola and Tanzania. Mozambique is developing some, but their presence is yet to be felt.

The opportunities and challenges facing southern Africa are part of the region's collective past in separate ways. But they provide a rich regional perspective from which either national or collective regional actions are already taking place, albeit modestly.

GENERAL POLICY DIRECTIONS

Wildlife and protected areas

Researchers have identified three factors to explain why large herds of wild animals roamed the African plains before the

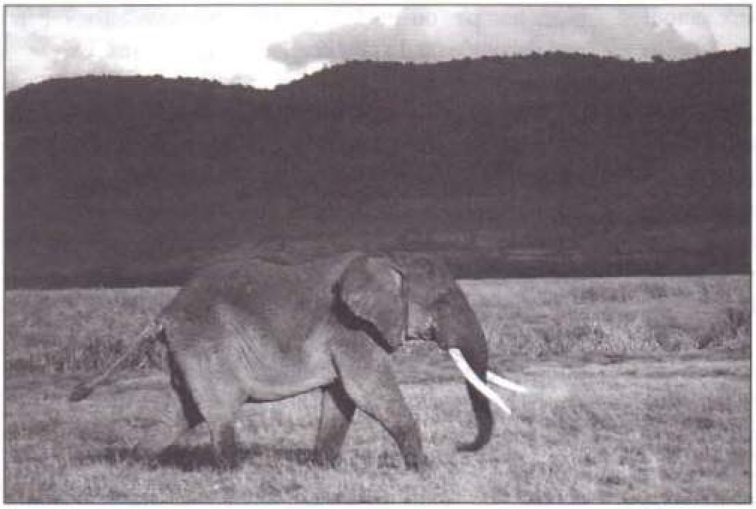

Photo 3.2 SARDC-P Johnson

An elephant's tusks (ivory) makes it vulnerable to commercial poaching which has reduced numbers dramatically in some areas. In other areas, the elephant population exceeds the carrying capacity of its range.

advent of commercial hunting and colonialism. First, only those individuals believed to have protective medicine against harm from wild animals could get permission from chiefs to engage in occasional hunting. Second, hunters were forbidden to kill totem emblems; and third, traditional hunting policy strictly banned the killing of animals around sacred groves.[11] This code of conduct, applied by many hunting communities across the region, is what a foreign researcher once described as "the African method of preservation of fauna".

Toward the end of the 19th century, however, commercial hunting of elephants began to replace traditional hunting practices, a process which came full cycle after white-settler communities formed colonial regimes. With the establishment of colonial governments, all wildlife became state property, accessible exclusively to white hunters. In several countries, not only did wildlife become the exclusive property of the white settlers, but so did prime farmlands in well-watered, high-altitude zones. This "double expropriation" of both land and wildlife pushed most indigenous communities into marginal agricultural lands, often into fragile lowlands.[12] In the face of diminished land resources, local populations were also denied any legal access to wildlife utilisation. What once belonged to all people now became "crown" property — a euphemism for state ownership. Traditional hunting became "poaching" almost overnight, a stigma which remains at the centre of controversy between wildlife conservation managers and rural communities even today.

To strengthen wildlife protection measures against alleged "illegal" poaching, most governments established national parks and hunting areas. These were often carved off residential lands occupied by already displaced indigenous communities. Often adjacent to the national parks where the government-controlled hunting grounds. Sport-hunting was, in fact, increasingly restricted because most wildlife had been virtually eliminated from areas designated for white commercial farms. But the most serious cycle of conflict between wildlife conservation and utilisation began when farmlands, both commercial and communal, expanded into traditional wildlife range, along with increasing human populations in need of yet more farmland.

The conflict over land-use was more acute in communal than commercial areas. One communal-land resident in Zimbabwe echoed the sentiments of many in southern Africa when he told a national parks official: "Your animals are eating our crops." Such is the scale of alienation that, even now, villagers believe wildlife belongs to someone else. In the words of a Malawian researcher, early attempts to preserve wildlife were largely "irrational" because they did not encourage full public participation.[13]

Conservation through utilisation

So who gets the benefits from consumptive tourism these days? That is a question many policy-makers are unable to answer easily. Beyond conservation rhetoric, the question of who owns the land, and the resources it holds, will largely determine the future of wildlife in southern Africa. The same question will also determine the future of this region's development effort, sustainable or otherwise.

Zimbabwe (then Rhodesia) was among the first countries in Africa to adopt a policy of "conservation by utilisation" on private lands. The Parks and Wildlife Act of 1975 transferred effective control of wildlife on private lands from state to private ownership. The rewards were immediate as increasing numbers of ranchers turned to wildlife for cash from game-hunting, sales of live animals, meat and other animal products. The transition from cattle to wild animals led to massive increases of wildlife under private control.

Positive as this may sound, conservation by utilisation is only part of the larger resource-management policy debate. Taken during the last decade before independence, it largely

SACIM: Will ivory ever sell again? Box 3.2

In October 1989, the Convention on the International Trade in Endangered Species of Flora and Fauna (CITES) put a provisional ban on trade in ivory to curb a widespread decline of elephant populations in Africa. But in much of the region, elephants still roam the savannas in large numbers, sometimes exceeding the carrying capacity of their range.

In response to the blanket ban, the elephant-range states of southern Africa mapped out a strategy to ensure the continued survival of elephants in large numbers, and continued economic benefits from elephants without supporting the illegal ivory trade. Five countries — Botswana, Malawi, Namibia, Zambia and Zimbabwe — established the Southern Africa Centre for Ivory Marketing (SACIM) to implement these broad policy objectives, and to demonstrate how conservation and development needs could be reconciled. Basically, SACIM sought "a farsighted, tightly controlled elephants management programme", to be achieved by strict management of elephants in the bush and control of trade in elephant products.

Elephants are culled only when they are overcrowded and destroying their habitat and that of other wildlife. The sale of ivory and other products can help cash-strapped countries recoup the costs of management and protection.

SACIM showed the difference in policy between different world cultures, and how international conventions and decisions can challenge, and even undo, the policies and practices of southern Africa. But SACIM also exposed the lack of a common stand on the issue, even among countries in southern Africa. Some wildlife managers in African countries where elephant populations have been decimated by poaching strongly opposed SACIM proposals.

At the 1992 CITES meeting in Kyoto, Japan, SACIM's attempts at persuasion failed. Under pressure from Northern and other African countries, SACIM member-states withdrew their proposal to have the ban on trade in ivory partially lifted.

Within SACIM itself, cooperation is critically wanting, a factor which, prior to the 1992 CITES conference in Kyoto, led to the withdrawal of Zambia, a founder member. Zambia's about-turn on the elephant policy issue was demonstrated not just by words but also by burning all the eight tonnes of ivory it had in stock. Zambia cited continued decline in elephant numbers as its reason for abandoning SACIM.

The remaining four members — Botswana, Malawi, Namibia and Zimbabwe — have been unable to change international opinion on the issue. But South Africa, which observed the SACIM deliberations two years earlier, strongly supported SACIM states at the CITES conference in Kyoto, and is poised to join the SACIM team and lend weight to the group's proposals. Some countries in the Far East — including some of the world's major importers of ivory from Africa — are considering changing their stand on a complete ban on ivory sales. The world's conservation managers will have to decide whether this policy needs international support when CITES meets again.

SOURCES: Townsend, M., "The CITES File: Resolutions That Will be Presented to CITES by Zimbabwe and Other States", Zimbabwe Wildlife, 1991, Vol 65
Governments of Botswana, Malawi, Namibia, Zambia and Zimbabwe, "Agreement for the Establishment of the Southern African Centre for Ivory Marketing", Lilongwe, 1991
SADC, "Southern African Centre for Ivory Marketing", *SADCC Natural Resources Newsletter for the SADCC Inland Fisheries, Forestry and Wildlife Sectors*, 1992, Vol 2

ignored the interests of the African farmers in the communal lands. To date, it is still difficult to develop policies which would allow indigenous communities to farm wildlife for profit as do their white neighbours on commercial farms. The problem, in the words of a University of Zimbabwe lecturer, is not one of "transition from domesticated livestock to wildlife", or even a mix of both. Rather, it is a question of changing the whole structure of governance and administration in communal lands — which goes beyond the concept of conservation by utilisation of the 1970s.

After years of mistrust between wildlife managers and villagers living adjacent to national parks, Zimbabwe has taken the lead in steadily, if slowly, turning the tide of mutual resentment. This is being made possible through a rural-based programme known as Communal Areas Management Programme for Indigenous Resources (CAMPFIRE). Similar programmes have been adopted in other countries, notably Namibia, South Africa, Tanzania and Zambia, a clear sign that a new African perspective on resource conservation and the empowerment of local communities is emerging.

New directions are being taken. But key to all this is the change in attitude among the people who once thought wildlife resources belonged to the government and, by extension, to white hunters and tourists. The concept of CAMPFIRE goes well beyond wildlife conservation. Fundamentally, the programme seeks to develop a sustained, renewable resource-base for both present and future generations. In the final analysis, the programme is inexorably linked to the question of land ownership and who gets what from it.

Ill 3.2 IUCN-C Bass

In Tanzania, wildlife found in game reserves and game-controlled areas is classified as "government trophy" even though the wildlife habitat in them is designated as commons. This contradiction is crucial to the future of environmental policy because Tanzanian villagers and their local governments are becoming increasingly vocal about who should manage and regulate the use of wildlife. In 1992, a group of six Maasai villages in Loliondo, a rich wildlife confluence on the eastern shoulder of the Serengeti National Park, contested a government permit giving an exclusive hunting concession over their area to an Arab sheik. The concession has not been nullified, and the larger issue of who owns and controls the disputed resource remains.

Photo 3.3 IRIS-C Thege

Maasai pastoralists in Tanzania reap the benefits of community game-management.

For Tanzania, which has the singular privilege of strong village governments established under *ujamaa*, resolving these contradictions will demand hard questions and painful choices. Under the Villages and Ujamaa Villages Act of 1976, all land and the re-

Who is a poacher? Story

Arusha (EPF) —In a well-rehearsed drama episode, graduating park-rangers gave a powerful message to conservation managers in Tanzania's Serengeti National Park recently. "Your Lordship, I am not a poacher," one belated actor argued in a mock court case. "I am only doing what my father, and his father's father before him, did to feed the family."

A few minutes hop by light aircraft from where the play was staged, a real drama unfolds. There are 12 permanent human settlements on the fringes of the Serengeti where just 10 years ago there were fewer than three villages. Poaching for the pot and for cash has become serious over the years. Game meat from the park sold in the lakeside town of Musoma, near the border with Kenya, has gained a significant share of the market in recent years.

A 1991 conservation strategy for the Serengeti is changing all this. The strategy encourages villagers to conserve wildlife resources and involves them in making decisions about sustainable harvesting of the resources. Once "poachers", the villagers are now a vital part of Tanzania's conservation approach — an approach which is slowly replacing the game-ranger's gun with consultation.

Changes brought about by the Serengeti conservation strategy do not mean animals will stop being killed for meat and cash. Quite simply, the strategy shows that orthodox conservation policies can be hopelessly out of tune when hungry people living adjacent to a vast source of meat are barred from harvesting it. It is an eloquent definition of what workable conservation ought to be not who the poachers are.

In much of southern Africa, orthodox conservation policies are being replaced with new, more holistic approaches. The new policies seek to guide the conduct of particular activities and channel the efforts of those participating in such activities to achieve desired goals.

—**James Mpinga**, Environment Press Foundation, Arusha, for SARDC, 1993

sources belong to the villagers under whom they are registered. Newcomers to such rural settlements can get land on which to work only after the village government has scrutinised and passed a written application to join the community. Absentee landlords are not permitted. In fact, nobody can own land as such. With such vast powers in the hands of village governments, the six Maasai villages could not understand the presence of "government trophy" in their midst — let alone the reason why some government official faraway in the capital city, Dar es Salaam, should allow foreigners to hunt in their area.

Chief among a backlog of policy issues to be resolved is how community-based environmental management can really work. Even in Zimbabwe, where a lot of pioneering work has been done in the past decade, it took a long time before communities could receive direct benefits for their participation in curbing wildlife poaching. In one case in southeastern Zimbabwe, the local government could not decide whether cash incentives derived from sport hunting should go to the district council or directly to the village of Mahenye. Most councillors argued that since the animals killed were state property, the money should be "pooled" and disbursed to all villages in the district. It took the intervention of an elderly chief from another village to resolve the issue in favour of Mahenye. His words remain an epic testimony of traditional African justice, and are worth quoting:

> "My children, what we have heard is the truth.
> We have no claim to this money. We did not
> sleep in the fields to protect the crops from the
> elephants, as the people of Mahenye did. The
> elephants are theirs, not ours."[14]

Forest resources and woodlots

Most governments in the region have identified deforestation as a major environmental issue. But the temptation to over-simplify the causes and effects of deforestation on the environment and on rural livelihoods has led to some inappropriate policies and programmes. The lack of understanding of the use of woodland resources in rural areas, and the focus on fuelwood shortages, has led to an emphasis on planting village woodlots of eucalyptus which provide few benefits and, on the whole, have been a costly failure.[15]

Photo 3.5 IRIS-C Thege

Tractor carrying timber in Malawi.

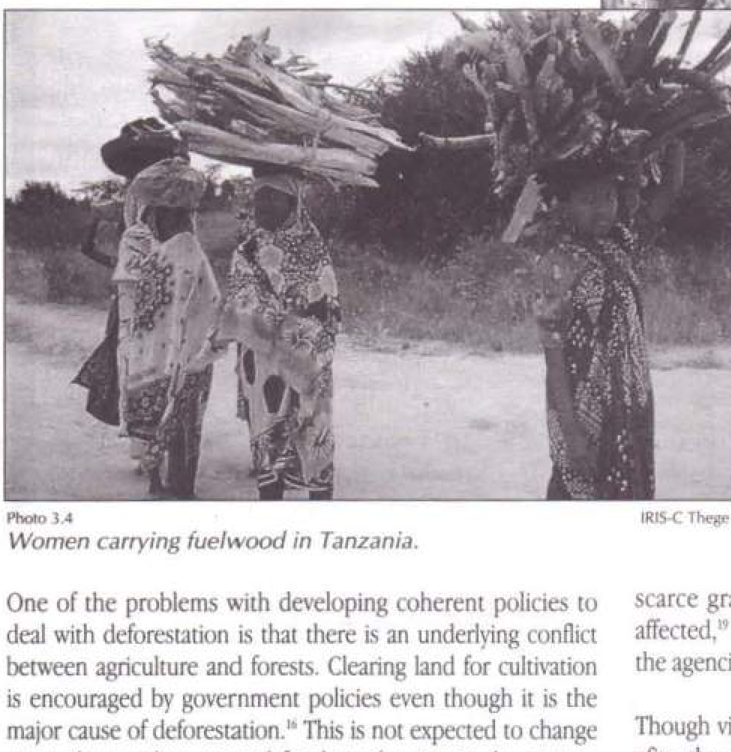

Photo 3.4 IRIS-C Thege

Women carrying fuelwood in Tanzania.

One of the problems with developing coherent policies to deal with deforestation is that there is an underlying conflict between agriculture and forests. Clearing land for cultivation is encouraged by government policies even though it is the major cause of deforestation.[16] This is not expected to change given the need to expand food production in the region. However, forestry policies are changing with the times, becoming more multi-faceted and moving away from woodlot planting of foreign, fast-growing tree species alone.

Village woodlots

Studies show that to succeed, village woodlots should be a community initiative, run by community members or a committee chosen by them, to avoid misunderstandings later about who makes decisions and who owns the trees.[17] In practice, the planting of village woodlots has been controlled from outside, sometimes coercively, without much recognition of the real needs of the local people and without building on existing knowledge and practices. As a result, it is never clear who should maintain the woodlots, leading to poor survival and growth of the trees in the absence of proper care.

In Tanzania, the Village Woodlot Programme, intended to establish a fuelwood woodlot in each village, did little to improve the country's parched landscape because people did not like the choice of tree species available from the government — and did not feel they needed a fuelwood woodlot in the first place.[18] In other countries, village woodlots were equally unpopular because most of them were established on scarce grazing land without compensation to the people affected,[19] building resentment between the community and the agencies that enforce the change in land-use.

Though village woodlots involve shared work for shared benefits, the distribution of the benefits is often perceived to be unfair. In the Morogoro area of Tanzania, for example, villagers were intensely suspicious that revenues from the sale of wood would be embezzled by members of the village government.[20] In South Africa, a survey of attitudes found that in areas where a woodlot had recently been harvested for the first time, respondents were emphatic that woodlots were *not* a good idea. They had waited a long time with heightened expectations — only to be let down by the way the benefits were distributed. This negative attitude toward woodlots makes future tree-planting efforts more difficult.[21]

The process followed in Ciskei, South Africa, requires a person wanting wood to pay for it in advance then go with the receipt to the ranger's house, perhaps to find that he is out — leave a message, walk home, return to the ranger's house the next morning, walk with him to the woodlot, cut the wood and carry it home on her head. Two days' effort and it costs money too.

While village woodlots have been unpopular, rural people have a history of conserving the most useful indigenous trees and are extremely interested in planting trees for their own use. Today's forestry policies build on this initiative, with a trend toward "social forestry" supporting farmers to plant their own trees for their own use so that they can have a stake in protecting and managing them.[22]

Afforestation

Tree plantations of eucalyptus and pine occupy huge portions of land in Swaziland, Tanzania and, particularly, South Africa. Paradoxically, large-scale tree plantations themselves have resulted in considerable deforestation in the region, by replacing natural forests and woodlands. Plantations are cash crops. They supply timber and pulp, not fuelwood for energy-starved rural communities.

In the past few years, the amount of new land being afforested has decreased. Instead, the same areas are cut and replanted. This is a sound, sustainable practice often the result of government policy reacting to the impact of plantations on water supplies and the shortage of good land. South Africa, for example, no longer issues permits to plant exotic species close to some water courses.[23]

Management of indigenous forests and woodlands

Policies related to management of indigenous forests and woodlands have been more patchy than tree-planting efforts. Large portions of the region's good hardwoods have been "mined" by inadequately monitored commercial woodcutters, with a corresponding permanent change in woodland structure and composition.[24] Recently, there has been a lot more interest in improving management of existing indigenous forest and woodland. Utilisation systems are also improving generally. A range of techniques, such as cutting trees in a way that encourages dense regrowth, are being tested to increase the productivity of natural woodlands.

Land allocation

Environmentalists and policy-makers now believe that there is a direct link between inequitable land allocation and environmental degradation, many of them tracing current problems to colonial land policies. These policies institutionalised destructive land-use practices such as overgrazing, overcultivation and deforestation by confining African farmers to marginal land with limited capacity to support growing populations.[25]

In South Africa, the division of land along racial lines was altered several times. Blacks were confined to "homelands", with about 14 percent of the land, although they account for over 75 percent of the country's population. Most of this land is not suited to farming, and in most of the former homelands agriculture accounts for less than 10 percent of total household income.[26]

In the past few decades, newly independent states have moved toward a more equitable distribution of land, coupled with better support and incentives to African farmers. Land

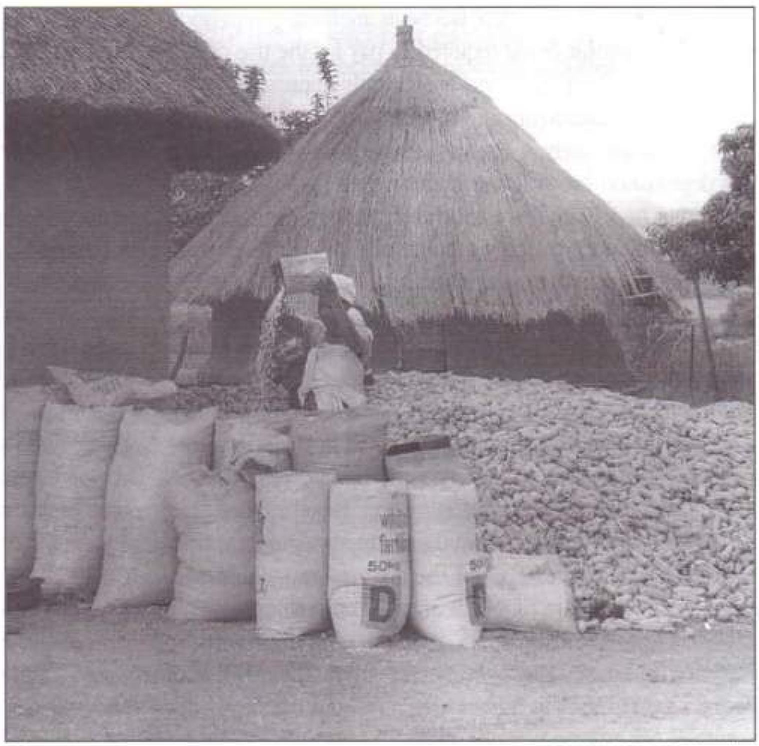

Photo 3.6 DAILY GAZETTE-K Kamashu

The process of reallocating land to meet resettlement needs, while maintaining food security, has been difficult due to political and economic constraints — and lack of infrastructure for irrigation for small farms.

allocation defines people's access to credit and other resources, and is largely seen by governments as an equity issue, although the land question has serious environment dimensions as well.

Each country's approach has been unique, but generally the process of reallocating land has proved difficult. A combination of political constraints and economic interests is holding back widespread transfers of land. In addition, shortage of productive land, and land purchases and associated development infrastructure have all made land more expensive than expected.[27] As a result, much of the land that has been resettled is marginal, without real potential for productive, sustainable agriculture.

Tanzania, which gained independence in 1961, led the campaign to introduce land reforms. Between 1970 and 1975, 85 percent of the rural population moved into villages of 250 people or more under the policy of *ujamaa*, a voluntary resettlement scheme which was intended to create communities which could be given land and social services. While land distribution changed, land tenure remained customary.[28] However, in some cases there has been unofficial privatisation of land with people being required to pay for the use of customary land. The programme significantly improved the the provision of infrastructure and services such as education and health. Unfortunately, it has also resulted in some significant soil degradation by changing land-use patterns through concentrating people and livestock in straight-line settlements. Tanzania continues to apply a policy of villagisation, or compulsory resettlement, to pastoralists and hunter-gatherers.

In Zambia, there is no private ownership of land. Some lands are under customary tenure and others leased from the government. This has not presented a huge equity problem because the Zambian population is small in relation to the size of the country, and over half the people live in urban areas. Much of the commercial agriculture is on land designated as "customary tenure" located near appropriate infrastructure such as major roads and the state railway. However, some soil degradation problems are now cropping up, particularly on leased lands. There is little incentive to protect the resource base as the land is essentially "free". The privilege of access to land-leases by a few citizens without cost is neither equitable nor environmentally sound.[29]

Namibia has considered various options, including expropriation of land owned by absentee landowners and foreigners, but does not intend to expropriate lands productively used by citizens. The government recognises the need for building on the knowledge and practices of rural people, and its 1992 report to UNCED says in part: "If commercial farms are to be allocated to groups of communal area livestock-owners, it would be better to amalgamate several adjacent farms, take down the internal fences, retain only the minimum number of water points needed for the herds and flocks, and leave them to manage the farm as a communal area."[30] The land-reform programme in Namibia has not yet begun in earnest and the government is still engaged in consultations to establish suitable institutions and funding mechanisms. Debate has centred on whether commercial ranchers should be allowed to continue using communal lands for grazing as a stop-gap measure while their own degraded farms recover.[31]

Zimbabwe's resettlement programme is perhaps the best-known and most studied,[32] yet it is being implemented at a much slower pace than originally envisaged.[33] This is due in part to difficulties in securing suitable land and providing adequate infrastructure such as water supplies and equipment. The programme's original focus on overcrowded communal lands is being expanded to include relatively better-off farmers with technical skills or a proven ability to farm the land as a commercial venture while conserving the land. This should help maintain food production levels through the period of resettlement, and ensure that resettlement schemes do not require long-term assistance from government.[34]

Across the region, the major problem hindering resettlement is that governments have attempted to deal with two different policy issues — equity and agricultural production — both at once. Inequitable land distribution has had serious impacts on agricultural production in communal lands, but it will not be possible to resolve this solely by improving land equity. At the same time, resettlement programmes alone cannot be expected to solve soil degradation problems.[35] Research in the region by the Land Tenure Centre in the US shows that "it requires much time and investment to develop an agricultural system that is both productive and equitable".[36]

Marine resources

Five countries in the region (Angola, Mozambique, Namibia, South Africa and Tanzania) have direct access to the sea. The sheer length of southern Africa's coastline renders protection by individual countries almost impossible.The length of the coastline is estimated at 9,600 kilometres, with 200 nautical miles of exclusive economic zones (EEZs) offshore. As a result, several regional networks are being developed to address marine conservation issues jointly.

Photo 3.7 UNEP/IUCN Educ.

Namibia has reduced total allowable catches now so the fishing industry can become sustainable.

Water

Southern Africa will not immediately run out of water, even though three countries (Botswana, Namibia and South Africa) will face serious difficulties in meeting their needs shortly after the turn of the century. Growing populations will increase pressure on the limited water resources. Already, discussions have begun on how to share water equitably within SADC, along with South Africa. Numerous water storage or transfer projects are in the planning or proposal stage, with several already complete or under construction.

As people realise that water is a finite resource, and that many areas of the developing and developed world face imminent scarcity, the move for cooperative management of water resources is growing world-wide. With the increasing demand for water throughout the region, water-poor countries are looking to cross-border sources to secure future water-supplies. Namibia has negotiated access to 180 million cubic metres (mcm) per year from the Cunene river in Angola and at least 500 mcm/yr from the Orange river on the border with South Africa.[38]

Both individually and collectively, all coastal states except Angola have policies establishing protected marine and coastal areas. Mozambique and Tanzania have yet to devote adequate resources to control overfishing and curb illegal dynamite fishing which continue to deplete fish stocks and destroy habitat.

Namibia has succeeded in curbing fish-poaching by foreign trawlers. At independence in 1990, Namibia's fish stocks were extensively overfished, notably hake and pilchard, and the future of these two species was threatened. Less popular species, such as the Cape horse-mackerel, almost replaced declining stocks of pilchard and hake. Namibian authorities have now cut by half the annual allowable catch for hake of 400,000 metric tonnes, which the International Commission for the South East Atlantic Fishery (ICSEAF) set before independence. The move has had drastic implications for fishing companies and threatens to throw many Namibians out of employment in the short-term, but stocks are recovering rapidly and will support a more sustainable fishing industry within a few years. Namibia has also cut back on the total allowable catch (TAC) for lobster from 2,000 mt before independence to a mere 100 mt two years after independence.[37]

Current regional efforts to improve the status of protected marine and coastal areas also 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 other countries in the region.

Sharing agreements

The question of equity in international water-management arrangements will continue to increase in stature. In the case of Swaziland, all but two of the country's major rivers rise in South Africa, flowing either to Mozambique or back into South Africa. Swaziland has little bargaining power in water-sharing negotiations both because of its small size and the flow of the rivers leaving its borders, which requires the provision of downstream flow to neighbouring countries.[39] South Africa has already built several dams on the rivers flowing into Swaziland, two as part of a water-transfer scheme. The flow of two major Swazi rivers, the Usutu and the Komati, will be cut by hundreds of millions of cubic metres each year when the projects are fully implemented. This is doubly difficult for Swaziland, which has given guarantees of minimum flow to Mozambique.

Southern African countries are beginning to take steps to establish management agreements and structures for shared water-bodies, the most notable being SADC's Zambezi River Action Plan (ZACPLAN). This involves the eight countries of the Zambezi river basin, and focuses on ways to guarantee the

Controversy rages over St Lucia Story

Richards Bay, (New Ground) — The controversy over mining St Lucia's eastern shores has generated over 1,000 pages of Environmental Impact Assessment (EIA) and many more pages of newspaper reports, press releases, petitions and broken friendships.

The Wildlife Society of South Africa, St Lucia's Action Group (SLAG) and the Zululand Environmental Alliance (ZEAL) have been at the forefront of the fight against mining the shores. The dunes of South Africa hold concentrations of heavy minerals such as titanium and rutile — especially the sand-dunes of Natal's St Lucia Park, a potential World Heritage Site. The dilemma is whether to mine these dunes for the immediate economic good or to preserve them for their ecological importance.

The minerals are in demand for use in the production of leadfree paint, chips for making computer parts and control rods in nuclear reactors.

Barry Clements of Richards Bay Minerals (RBM), one of the mining companies, said, "We want to mine titanium in the dunes. It's jobs for 2,500 people for five more years. And I tell you, it will be mined at some stage." The company also promises to rehabilitate the mined dunes.

The sand-dunes are fragile and, according to the results of an EIA, mining causes irreparable damage.

The dunes are crucial to life in the coastal lake which depends on the shifting balance between sea and fresh water. They act as a watershed — deflecting some water eastwards into the sea and the rest westward where it seeps out first into the low-lying wetlands and later into the lake. During the dry years, they act as a sponge, retaining and gradually releasing water into the lake.

The area has diverse flora and fauna, including birds, butterflies, mangroves, sand-dune forests,reed-beds, orchids, grasses and mosses, many of them rare. Over 100 threatened plant and animal species are found in and around the lake.

Mining of the dunes causes soil erosion, silting the lake and disturbing the delicate balance between the fresh and sea water in the lake to the detriment of its inhabitants.

In 1986, the St Lucia system was named a wetland of international importance under the Ramsar Convention. In 1989, the EIA was initiated following an RBM application for mining rights. In 1990, proposals for a greater St Lucia Wetland Park were announced.

The highest priority for the scientists on the EIA team is to get everything right — so they welcome criticism, says Dr Alex Weaver, project manager.

He agrees with critics that the environmental side was given more weight than economics and rural development, and says it was unfortunate that "the mining option was not presented starkly, so that mining plus conservation would be seen more clearly as a compromise."

—Adapted from **Victor Munnik** in *New Ground*, Environment and Development Agency Trust, Newtown, Winter 1993

Lessons from St Lucia Box 3.3

- public opinion now has to include all South Africans, and conservationists will have to seek support beyond their traditional white, middle class base;
- issues and politics of land ownership — a legacy of *apartheid* land alienation — are central to the conservation debate;
- economics is an intrinsic part of the environmental debate whether it concerns rural development, adding value to mining products or the role of multinationals;
- the claims of ecotourism as a saviour for conservation have to be argued in realistic terms — which may come as a disappointment to many;
- the government, especially the present one [1993],is the wrong body to make environmental decisions like these;
- science cannot solve everything; and
- real public participation is an ambitious ideal and takes a long time.

SOURCE: Munnik, V., *New Ground*, Environment and Development Agency Trust, Newtown, Winter 1993

quantity and quality of water crossing borders — through sharing arrangements and compensation. ZACPLAN's principles come from the SADC Treaty itself, which provides for cooperation in the area of natural resources and the environment.

At a 1993 SADC/IUCN conference in Kasane, Botswana, delegates recommended that the ZACPLAN be broadened to take in all river basins in the SADC region[40] ZACPLAN was initiated in 1985 by UNEP, SADC ELMS and the Zambezi basin states, except Namibia, which was not yet independent. The revised ZACPLAN, now the "Protocol on Shared Watercourse Systems in the SADC Region", was tabled in July 1993 at the SADC summit and is expected to be signed at the 1994 summit. ZACPLAN is one of many ongoing regional negotiations. Namibia is keen to develop joint river-basin management agreements with Angola and Botswana on the Okavango river, and with Angola on the Cunene river. Botswana, Mozambique, South Africa and Zimbabwe have also set up a joint committee on the Limpopo river.

Other water agreements have tended to be short-term and simply follow the "Helsinki rules", which say 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. The rules further stipulate that one state cannot be prevented from using water just so another can have it available in the future; and that existing reasonable uses can continue unless it is shown that the use must be modified to accommodate a competing, incompatible use. Treaties on the use of Lake

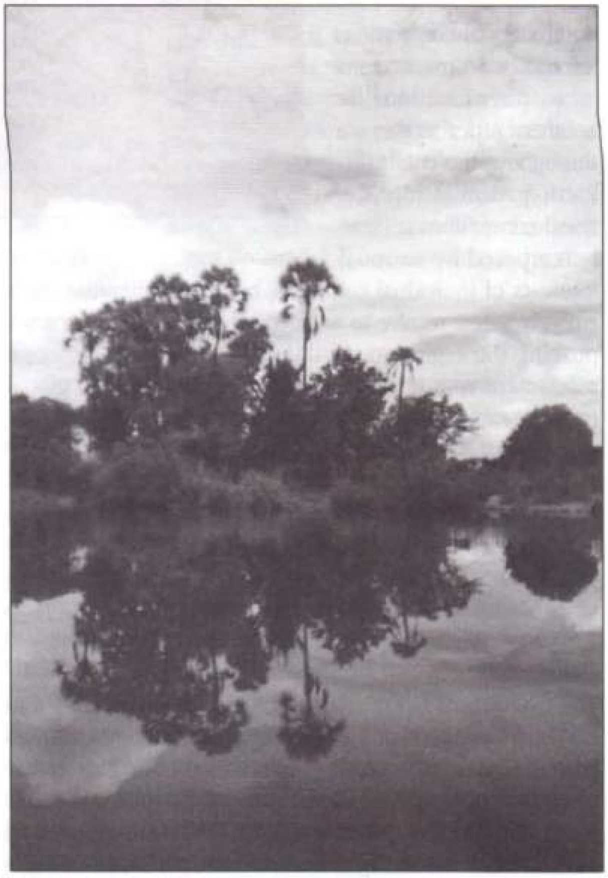

Photo 3.8 SARDC-P Johnson

The Zambezi River Action Plan involves eight countries and focuses on ways to guarantee the quantity and quality of water crossing borders.

Victoria and the Nile are a case in point, and have existed since early this century, though now outdated.

CONVENTIONS AND TREATIES

Southern African countries are party to several international treaties and conventions, some of which shape the region's policy thinking. There are also regional conventions which reflect collective efforts to set up institutional arrangements to solve common problems.

Participation in international conventions on conservation Table 3.2

Country	Wetlands (Ramsar) Convention	World Heritage Sites	Convention on International Trade in Endangered Species (CITES)
Angola	no	no	no
Botswana	no	no	yes
Lesotho	yes	no	yes
Malawi	no	yes	yes
Mozambique	no	yes	yes
Namibia	no	no	yes
South Africa	yes	no	yes
Swaziland	no	no	no
Tanzania	no	yes	yes
Zambia	no	yes	yes
Zimbabwe	no	yes	yes

NO means the country is neither a signatory nor a contracting party to the convention
YES means the country is either a signatory or a contracting party to the convention
SOURCE: World Resources Institute, *World Resources 1992-93*, Oxford University Press, New York, 1992

International conventions on the environment are a new phenomenon for southern Africa, as they are throughout the continent. Participation in international conventions is clearly tempered by national interests of individual countries, but regional conventions embody a new resolve to work together. All conventions are pushing the region to yet unknown directions, although assessment of international debates which lead to global treaties looks positive.

International conventions

Most international conventions provide "frameworks" within which governments can work together in implementing new policies and programmes. The UN Framework Convention on Climate Change (UNFCC) signed by over 150 states in June 1992 at the Rio Earth Summit, is a case in point.

The UNFCC has galvanised a lot of high-profile global attention because many world governments believe climate change poses "a common concern of humankind". The convention carries with it serious implications to the economies of developing regions such as southern Africa, which are expected to switch to new technologies because old ones based on fossil fuels are likely to be phased out in the near future. Many questions remain on the science and chemistry of climate change, and researchers are working hard to answer them, but world governments have already decided the risks are too big to wait for research findings.

The switch to new technologies will be too costly for most developing countries. At UNCED, many countries argued that there was need for concessionary technology transfers to deal with environmental problems. This was contested by industrialised countries with the argument that intellectual property rights and patents belong to the private sector. No significant concessions were gained in this field, and technology will still come to developing countries through normal commercial markets.[41]

While the UNFCC enjoys enormous political support globally, other conventions remain hotly debated. Most African countries, for example, refused to ratify the Basel Convention on Transboundary Movement of Hazardous Wastes, and instead launched their own in Bamako, Mali, in 1990. Africa's refusal to accede to the Basel convention was prompted by cases of illegal dumping of hazardous wastes on the continent — which fuelled fears that the Basel treaty was not strong enough to stop dumpers from using Africa as a landfill for dangerous chemicals.

Participation in international conventions on pollution and toxic waste control Table 3.3

	Nuclear Test Ban	Montreal Protocol	Biological and Toxic Weapons
Angola	no	no	no
Botswana	yes	yes	yes
Lesotho	no	no	no
Malawi	yes	yes	yes
Mozambique	no	no	no
Namibia	no	yes	no
South Africa	yes	yes	yes
Swaziland	yes	yes	no
Tanzania	yes	no	yes
Zambia	yes	yes	no
Zimbabwe	no	yes	yes

SOURCE: World Resources Institute, *World Resources 1992-93*, Oxford University Press, New York, 1992

Regional conventions

UNEP's regional seas programme divides southern Africa into two parts, hiving off Mozambique and Tanzania, and joining them with eastern African coastal states. Angola and Namibia are linked to the western African coastal states. South Africa stands alone because of its long history of isolation from the region's mainstream political alliances.

The West Coast is covered by two UNEP-brokered regional conventions:

- the Convention for Cooperation in the Protection and Developmentof 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, in addition to a third on Protected Areas and Wild Fauna. UNEP facilitates all these agreements.

South Africa is party to the London Dumping Convention, which controls indiscriminate dumping of wastes at sea. This was ratified in 1978 and the convention's principles incorporated into local statutes under the 1980 Dumping at Sea Control Act. According to this Act, all dumping at sea is regulated under a permit system, but the dumping of toxic substances such as mercury, cadmium and organohalogen compounds is prohibited. Other substances, such as lead, arsenic and copper, may be dumped only under specified conditions. Namibia is not party to the convention but has very strict domestic pollution laws.

In addition to regional seas conventions, there are several other joint projects including networks to combat poaching of fish by foreign trawlers 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 in pollution monitoring.

There are 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.[42]

Participation and negotiation

An increasing number of countries have signed international conventions over the past 30 years although some still hesitate to ratify conventions which are deemed not to be in the national interest. Governments are working increasingly with NGOs to improve environmental policy and practice. Since the last amendment to CITES, for example, there has been heated debate within government institutions, among NGOs and communities affected by certain policy decisions. The establishment of the Southern Africa Centre for Ivory Marketing (SACIM) is a test case in the ongoing debate about the future of ecologically sensitive natural-resources. Furthermore, institutional frameworks have been established to handle certain environmental issues. Some of these institutions carry out environmental monitoring and assessment programmes, paving the way for serious debate on likely impacts of certain government decisions.

The level of participation and the quality of input into international conventions are determined by the level at which negotiators understand the issues at hand and their relevance to national or regional interests. This in turn presupposes the existence of a strong science and technology back-up. In much of southern Africa, this has not been the case.

Real scientific backing can be found within the region for almost all conventions affecting the fate of southern Africa — from plant protection to high seas, and from CITES to biological diversity. But much of this expertise is scattered in universities, public research institutions and in the private sector, and is not fully utilised by governments in the region. During the UNCED process, Asian, Latin American and Northern delegates brought many such experts with up-to-the-minute information on current debate. They were frequently consulted by political delegates. In contrast, such support was absent from African delegations. The link between scientific support and negotiated positions is clearly one of making a convention relevant.

Convention processes involve detailed, and often lengthy, negotiations. Delegations given the task must have the skills to know when trade-offs can be made, or where compromises to national interests can lead to greater regional gains. All these require a deep understanding of the issues on the table and their context. The growing number of institutional frameworks, both governmental and non-governmental, are clearly laying the foundation for evaluating the true nature and implications of the various conventions.

Photo 3.9 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO-R Rangel

Policy definition for southern Africa must consider a broad spectrum of human requirements — urban and rural, rich and poor, men and women, and past, present and future. Mozambique has perhaps the widest divergences in human need, with the "concrete city" of Maputo seen here from the "reed city" on the outskirts.

Linkages to other chapters Box 3.4

1 PEOPLE
Policies aimed at enhancing public awareness of environmental issues can have a significant impact on behaviour. Rapidly increasing urbanisation requires revision of policy initiatives.

2 HISTORY
Traditional management systems, and the impact of colonisation on those systems, set the scene for the current policy framework.

4 ECOZONES
Plants and natural systems do not stop at boundaries, and activities in one country can affect another. This is a compelling argument for the management of resources on a regional basis.

5 CLIMATE
Government policies largely determine the region's ability to respond to the extreme weather conditions, including droughts and floods, described as the "climate factor".

6 SOILS
The main causes of soil degradation include political and socio-economic factors which restrict access to land, together with physical factors such as marginal soils and drought.

7 WOODLANDS
The main cause of deforestation in this region is clearing of land for agriculture, although commercial cutting and subsistence-use play a role.

8 WILDLIFE
Wildlife management has been dominated by outside initiatives until recently. The current and emerging status of conservation within the various ecozones highlights community-based wildlife-management approaches.

9 FRESH WATER
Water supply and quality is becoming a major policy issue throughout the region. An assessment of the water resource-base highlights some areas of possible regional cooperation.

10 MARINE
Policies for the protection and management of marine resources are a priority, as is international cooperation in curbing pollution and related threats to living organisms and habitat.

11 POLLUTION
Pollution, while not a major problem throughout the region, is locally severe and hazardous, largely due to poor management and policy enforcement.

12 ARMED CONFLICT
Armed conflict makes any kind of concerted environmental policy or management unworkable. This chapter explores the policy roots of conflict in the region and reviews the environmental impacts.

13 GLOBAL
Global warming is occurring at a time when southern African economies are already under stress from a number of internal and external pressures, so it is difficult to prioritise it as a policy issue. This chapter reviews the predicted impacts, and highlights international and regional actions.

14 TRENDS
Regional trends show movement toward more environmental awareness and involvement at the grassroots, with increasing policy cooperation at regional and international levels.

NOTES
CHAPTER 3

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4

Southern African ECOZONES

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. Those who see it without understanding what makes it work not only miss the pleasure of a deeper knowledge, but risk interpreting it in misleading ways. Since colonial times, many administrators and managers from elsewhere have looked at southern Africa and boldly made observations and drawn conclusions without understanding the ecological processes. Despite decades of ecological research in the region, this work has started to influence policy-makers only recently.

The natural units which make up the environment are called ecological zones, or "ecozones". An ecozone is a large natural unit, controlled by a set of common processes, mostly climatic, and is dominated by life-forms with similar physical adaptations to those processes. A project that pushes against these processes can disrupt natural cycles and functions, and risks failure.

Local people, who have lived within an ecozone for generations, adapt farming and grazing techniques to take advantage of the characteristics. Yet ecozones are not easily identified without a map (Map 4.2). Scientists use geology, rainfall, vegetation and soil to define ecozones, but attach different importance to various combinations of factors. Scientists who study ecozones do not agree on exactly where they are, or even how to define them. Yet it is essential to understand ecozones in order to understand the environmental problems and opportunities in this region.

The transition from one ecozone to the next is gradual, so there is no easy line to draw on a map to show exactly where one ends and the next begins. Any ecological unit can be grouped with others, or sub-divided. Some are much less studied than others and tend to be lumped together. In addition, there are many site-specific conditions within a zone which do not conform to the overall processes in the zone itself, such as wetlands, special soil conditions or slopes.

Ecozones also exist in the ocean, and some compare easily to land systems in terms of productivity and diversity. These marine ecosystems are discussed in a later chapter.

Vegetation is a good criterion for defining ecozones because it embodies all the conditions in which it lives. Soil provides nutrients and stores water which plants use. Sunlight, temperature and rainfall patterns affect the plant's ability to grow and survive. Animals which graze on grasses or browse on leaves affect the plants, and fire can stimulate vegetation growth or clear an area, making room for other plant species. Since conditions differ from place to place, the vegetation best able to thrive will also differ. Plants stay in one place and respond more slowly than animals to changing conditions, but more quickly than rocks. They show what is happening in a particular place on a time-scale which allows people to observe and plan.

A number of factors must be considered in order to have a basic comprehension of the number of people who can make a living from a particular area of land, and how good a living. These factors include:

- sustainable level of production;
- quantity of plants and other resources which can used or removed without harming the ecozone;
- critical functions which must not be tampered with;
- functions which can be used to benefit people;
- limits, and how far the system can be pushed before failing;
- ability to recover, and the period required.

None of the above can be determined without studying the characteristics of the different ecozones and associated processes.

Photo 4.1 SARDC-P Johnson

Geology, rainfall, vegetation and soil are factors used to define an ecozone, which is a large natural unit controlled by a set of common processes, mostly climatic.

FACTORS AFFECTING SOUTHERN AFRICAN ECOZONES

Ecozones change with the fluctuation of conditions which affect them. A particularly good rainy season could produce an exceptional growth of plants. When the plants die there could be an intense fire, fuelled by the quantity of dead-plant material. This fire could burn much of the plant life and threaten the animals that feed on it. New plant species might come up in the fire-cleared area and new animals arrive to feed on them. Different species of plants and animals flourish at one time or another, depending on which conditions dominate.

In southern Africa, there are several main factors which affect ecozones: water, soils and soil nutrients, fire, animals and climate, including rainfall and its seasonality and temperature, and frost.[1] In addition, human activities can have a marked effect on ecozones through local developments such as agriculture, and at a global level through processes such as global warming. The various factors combine, and as one or more change, so do the ecozones.

Rainfall and water

Water is the most important factor influencing southern African ecozones. Water affects the soils, vegetation and wildlife, and largely determines the type of land-use possible in an area. The availability of water affects the ability to grow crops, raise livestock, produce consumer goods, develop socially and economically, and sometimes even survive.

Rainfall in southern Africa originates largely from the Indian Ocean, although several weather systems combine to produce the rainfall pattern. Generally there tends to be more rain in the north and east (Tanzania, northern Mozambique) and less toward the south and west (Namibia). 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 the northeast (Tanzania) is quite dry.

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.[2]

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, in the northeast of the region, experiences two rainy seasons. A small part of the extreme southwestern tip, centred roughly on Cape Town, gets rain in winter. The northwest and some eastern coastal areas have rainfall year-round. These rainfall patterns, especially the long dry season, affect agricultural and grazing practices as well as ecozones.

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 cool 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 word for a fine-leaved bush) at the region's southwestern tip results from the reverse — with moisture in the cool 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 a full desert.

The variation in rainfall from year to year also 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.[3] In dry areas it is difficult to determine the difference between drought-induced fluctuations and permanent changes in vegetation, because, as rainfall becomes erratic, there are large changes in productivity. The vegetation is continuously disturbed and has a very high resilience, or capacity to recover.[4]

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. Potential evaporation is often measured by keeping a pan of water continuously full under the sun's glare to see how much water evaporates over a certain period of time. In many areas of the region the amount of rainfall over the year is less than the potential evaporation.

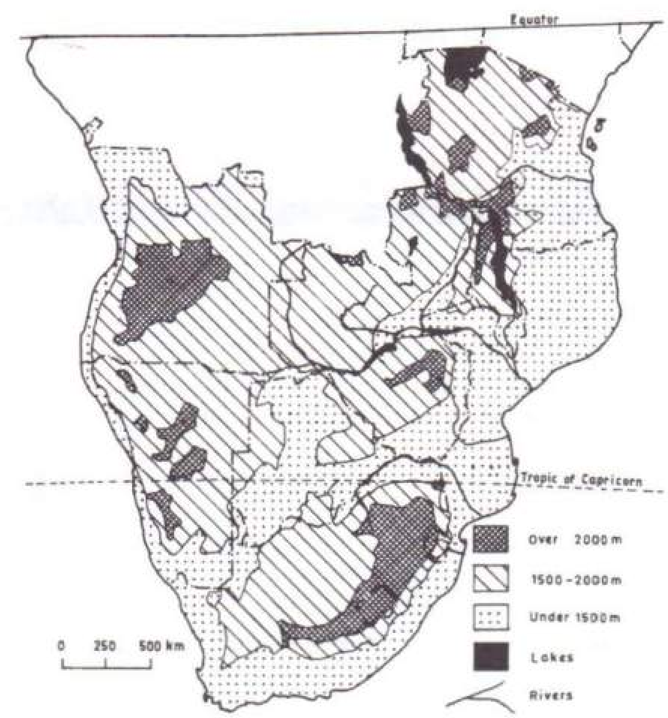
Plants adapt to heat and lack of water in a number of ways. Their leaves are cooled by a process known as evapotranspiration, where water vapour moves through the leaves to the air, similar to the effect of human perspiration. Generally, hotter temperatures mean more evapotranspiration. To save water 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.[5] 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. 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.[6]

Soils and geology

Rainfall also affects soil fertility. Lower rainfall areas can have low soil-nutrient levels because little vegetation can grow there, and this is the main source of nutrients when it dies and rots. Soils in high rainfall areas lose nutrients through leaching, when the water dissolves and carries nutrients away. Soil and vegetation in drier areas, therefore, tend to have more nutrients than wet areas.[7]

Other aspects of soils also affect vegetation. Soil nutrients originate from the breaking down of rock. Chemicals and nutrients in the rock slowly end up as part of the soil. The geology in southern Africa has resulted in many soils being low in phosphorous, an essential element for plant growth. Soils with high levels of toxic chemicals or minerals make it difficult for plants to grow. The original geology controls the chemical make-up of the soil.

Major geological features of southern Africa Map 4.1



SOURCE: Chabwela, H., *Wetlands: A Conservation Programme for Southern Africa*, IUCN and SADC, Harare, Nov 1991

Event-driven ecozones Box 4.1

A fundamental principle of ecology is equilibrium — the idea that an ecological system will return to a particular state after being disturbed. This principle of equilibrium is based on the idea that the forces outside the system are relatively stable over time, allowing the system's internal processes, such as competition between species, to regulate it. Certain aspects of this principle have been challenged since the 1970s, stressing the role of random events. If the system is controlled by random droughts and downpours, rather than stable, predictable forces, then it rarely operates at equilibrium.

Ecozones with highly variable rainfall are said to be "event-driven". An "event" is a certain minimum amount of rain, which causes a significant level of vegetation growth. This means that an especially large rainfall or series of rainfalls, or an exceptionally long dry-spell, can have impacts for many years. These "events" can happen several times annually, or only a few times per decade, so production of vegetation can swing wildly from year to year.

"Events" can also affect species composition of vegetation, for example droughts can favour short-lived species (ephemerals) which quickly seed and die, over perennials, those plants which grow through the dry season. In event-driven systems, once the change in species composition has occurred, it will usually remain in the new state until another event of sufficient impact changes it again.

Fires or grazing can also trigger a change in state, or the change may result from a combination of rain or drought, fire and/or grazing. In savanna such a combination may change the system to one dominated by trees or grass. The ecozone response to "events" is still not completely understood.

SOURCES: Stafford-Smith, Mark and Geoff Pickup, "Out of Africa, Looking In: Understanding Vegetation Change", in Behnke, Roy H. and others (eds.), *Range Ecology at Disequilibrium: New Models of Natural Variability and Pastoral Adaptation in African Savannas*, ODI, Nottingham, 1993, p. 203
Skarpe, C., "Dynamics of Savanna Ecosystems", *Journal of Vegetation Science*, 1992, Vol 3, p. 293-300

The major geological land-forms also have distinct effects on the ecozones. Over 70 percent of the southern African region is at an altitude above 1,000 metres. This elevated region is the Great African Plateau, the edge of which is called the Great Escarpment. There are coastal plains, which are extensive in the eastern part of the region.

A major geological influence on the region is the Kgalagadi basin, which extends from the Orange river to the southern extent of the Zaire watershed and is almost entirely covered in sand. Another is the Rift valley, which extends from Beira in Mozambique, northwest through Zimbabwe, then north through Malawi and Tanzania, and on through Kenya and Ethiopia to the Red Sea.

The type of soil particles also makes a difference. Plant production tends to be higher in soils with high clay content, and lower on sandy soils.[8] This is due to clay's ability to hold nutrients and water. But a heavy layer of clay can stop water from draining away, drowning tree roots, allowing only grass to grow. This results in a grassland.[9]

The depth of the soil affects ecozones as well. Very deep soils, such as the Kgalagadi sands, can have large amounts of rainfall which will simply drain into the sand. This can also cause the water to drains to great depths, too far down for roots to use. Shallow soils cannot hold very much water and are easily waterlogged, which can drown tree roots. This low capacity also means that the water stored there is used up quickly by plants.

Fire

A high level of plant growth may lead to large amounts of dead leaves and branches at the end of the growing season.

Left alone this will eventually rot into the soil, but it can also serve as fuel for fires. Many fires occur in southern Africa every year, caused by lightning, especially at the start of the rainy season, and by people in the dry season. Paradoxically, in areas that are normally fairly dry there are few fires because little vegetation is produced to fuel them.[10] Thus, an unusually wet season can lead to an increased risk of fire.

Fire-prone areas tend to have more grass and fewer trees. Fire damages trees more than grasses because grasses can often regrow from underground root systems, while trees, especially saplings, can be killed or severely damaged. Some tree species are thought to show adaptations to regular burning by moving nutrients out of their leaves prior to the fire season, and into their roots and trunk where they can't be lost through burning.[11] Some plant species have seeds that must go through a fire before they are able to sprout.

Animals

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. The quality of vegetation is directly related to the soil nutrients, so dry areas (which are less productive but have higher soil nutrients) are preferred by wildlife and livestock.[12]

Wild animals also affect other ecological functions. Trampling by many animals kills plants and exposes and hardens soil so that water runs off, causing erosion. However, livestock grazing can have far greater impacts than wildlife. Wildlife numbers are naturally controlled by available water and food, but livestock can be supported in dry areas by artificial waterholes and protected from attack. Their pasture can be improved by planting more nutritious plants and they can be fed in times of scarcity. All of this can allow their numbers to increase to the point where they overgraze an area.

In some areas the overgrazed types of plants die leaving less nutritious plants which cattle cannot eat,[13] although other livestock, such as sheep and goats, are less selective.

Serious concern has been expressed by various governments, organisations, academics and others about overgrazing, soil degradation and desertification in southern Africa for at least 100 years. Some ecologists, agriculturalists and other researchers now question whether this concern was based on rigorously gathered evidence[14] and are re-examining the scientific bases for these concerns. There is a major re-evaluation of how ecozones function in southern Africa to determine when grazing becomes overgrazing, or when apparent degradation really is degradation.

ECOZONES OF SOUTHERN AFRICA

The land-based ecozones chosen for this book are loosely based on the work of several ecologists, since no one study has divided the region into a universally accepted system based on ecological processes. This includes the seminal work of Mike Rutherford and Rob Westfall (South Africa), who divided the southern third of the region into a widely accepted set of biomes (ecozones) in 1986,[15] and Brian Huntley (South Africa) on moist and dry savannas.[16] Peter Frost (Zimbabwe) assisted in expanding these systems to cover the rest of the region.[17]

Southern Africa covers roughly seven million square kilometres — divided here into a system of eight ecozones and a ninth transitional zone:

- Lowland Tropical Forest
- Afromontane and Temperate Forest
- Grassland
- Savanna
- Nama-Karoo
- Succulent Karoo
- Desert
- Fynbos
- Transition between Forest and Savanna

A tenth type — Wetlands — is also discussed, although it is not a formal ecozone. Wetlands include rivers, lakes and swamps, and change the immediate area due to the presence of abundant water.

Each zone results from a particular mix of the factors described, the most important being the amount of water available. These zones are not all clearly separate but mix into one another as the various factors change, just as rainfall does not suddenly cross a line and drop from 600 to 500 mm/yr. In some cases, sub-divisions of the zones are described.

While ecozones are a useful tool in studying the region, they also must be viewed with caution. When looking at a map of southern Africa, ecozones help in understanding why certain types of plants grow better in one area than another. But just as the scale of a roadmap makes it more useful for driving across the country than navigating through a city, so ecozones are better for looking at very large areas of land. It

Re-evaluation of ecozone degradation Box 4.2

In southern Africa, the most prominent environmental problem is soil degradation, sometimes called desertification. It has been a serious concern since the colonial period when vast amounts of money were spent on large-scale conservation works. Yet scrutiny of the evidence reveals that little was actually known about the real extent and seriousness of the problem or even how it occurred.

Today, scientists are taking a closer look at the various forms of land degradation and concluding that little of the so-called "evidence" reveals anything that could be considered scientifically valid. Erosion studies have shown inconsistent methodology from place to place and were often poorly designed. Observations of changes in vegetation due to overgrazing have often been short-term, and not correlated to rainfall trends. Calculations to determine livestock carrying capacity, which show severe overstocking in some parts of the region, have been made on the basis of methods developed for completely different areas, ecological processes and agricultural methods. Therefore, little is known about the extent and degree of the problem, or how to solve it.

Recent studies from Botswana and Zimbabwe ask why areas which have been overstocked, according to conventional calculations, have maintained the same or higher numbers of cattle for several decades. In South Africa, range scientists are now questioning the "advancing karoo" maxim which stated that karoo-type shrubby, semi-desert vegetation has been steadily advancing into the productive grassland ecozone, taking away valuable farm and grazing land. This theory has been widely held for almost 40 years by range managers, yet may have been little more than a series of observations during a dry cycle. Recent work suggests that this advance may have been part of a cycle of vegetation response to wet and dry periods, and that grassland expands back into the nama-karoo during wet periods.

The main difficulty in determining land degradation relates to the dependence of southern Africa's ecozones on water, and the extreme variability of rainfall from year to year, or even within a year — so-called "event-driven" systems. An area could look completely different depending on the time of year and the previous year's rainfall. Long-term systematic observation and correlation of such factors has been rare or non-existent. Moreover, an area only a few kilometres distant could experience a completely different situation. When grazing is added to the equation, the difficulty increases. The question which has not been answered is when does apparent degradation become permanent and irreversible?

A 1990 Commonwealth Secretariat workshop on savanna development produced a list of indicators of degradation including:

- decreased fertility;
- decreased water-holding capacity;
- decreased infiltration (of rainwater);
- soil loss significantly in excess of formation; and
- changes in vegetation productivity over time, unrelated to rainfall.

Lack of rigorously collected evidence is no reason to say that soil degradation doesn't exist, but it may show why so many of the projects and programmes designed to "solve the problems" have not had the expected results. There is a real need to find out what makes soil degradation happen in its many forms, and what works effectively to stop it.

SOURCE: Behnke, Roy H. and others (eds.), *Range Ecology at Disequilibrium: New Models of Natural Variability and Pastoral Adaptation in African Savannas*, ODI, Nottingham, 1993 is entirely possible, though unlikely, that at any given spot in one ecozone an observer might be surrounded by vegetation typical of a zone 100 km or more away. In addition human activities (especially agriculture) have disturbed large parts of all the ecozones, so the existing vegetation is often a reaction to such impacts.

Lowland Tropical Forest

- high continuous rainfall
- maximum two months of low rainfall
- temperatures high and regular

The inland portion of this zone is not particularly important from a development perspective, being remote and difficult to cultivate, but it contains a variety of species (biodiversity) not found elsewhere in the region. The coastal forest, however, is quite productive. This part of the zone has been extensively cleared, with large numbers of people making their living from it. There has been little apparent connection between the rainforest and coastal forest in terms of species, at least for the last million years, although both have species adapted to similar conditions and processes.

Rainforest

- covers northern Angola's Zaire-river basin
- rainfall average, 1,200-2,000 mm/yr
- mean annual temperature, 22°C
- trees evergreen, up to 30 m high and deep-rooted, no access to ground water[18]
- soils deep, nutrient-poor, Kgalagadi sands

Some rangelands in this region have been developed or expanded by human-caused fire for grazing. The natural grasses are generally unpalatable, low in nutrition and avoided by livestock and wild animals.[19] So grazing requires planting of suitable grasses. This ecozone extends several hundred kilometres beyond the north of the region and is still fairly sparsely inhabited and not very developed throughout.

Coastal Forest

- eastern coastal areas
- average rainfall, 800-1,250 mm/yr
- two rainy seasons, with a clear low-rainfall season[20]
- trees evergreen, most 20 m, but can grow to 40 m.

Coastal forest is a form of lowland tropical forest which once extended along almost all of the region's eastern and southern coasts. Low altitude and high humidity from the warm ocean currents compensate for the relatively low (in tropical forest terms) and seasonal rainfall in this zone. This type of forest is now found in smaller patches throughout the region, in suitable areas: along rivers, penetrating from the coast as far inland as southern Malawi and eastern Zimbabwe, and along coastal eastern hillsides which receive rain from warm, moist, Indian Ocean air which rises over the mountains.

These forests have been devastated in many places by clearing for agriculture, largely in areas of high population.[21] Where forest has returned it is usually in the form of wooded grassland mixed with shrub forest, bushland and thicket, rather than a fully covered forest of tall trees. So there is little true coastal forest left.

Afromontane and Temperate Forest

- scattered throughout the region
- minimum rainfall, 700 mm/yr
- mean annual temperature, below 20°C, average 10°C in cold months
- vegetation changes with elevation

The main differences between afromontane/temperate forest, and lowland tropical forest, result from the more seasonal rainfall with a longer dry season, and the lower and less regular temperatures. The lower rainfall areas (down to 700 mm/yr in places) are more southerly, so these are cooler with lower evaporation rates and less water demand. These are in an area that receives light rain year-round. Mists may also provide some moisture. While the rainfall seasonality and greater variation in temperatures prevent the growth of lowland forest, the rainfall is too high and the temperatures too regular to allow the savanna ecozone to exist here.

The afromontane zone is tiny and fragmented. It is important, for its size, because of the high levels of biodiversity and its use for agriculture. Another important aspect is that since rainfall increases with altitude to an elevation of about 3,000 m, then gets drier above that,[22] the afromontane zones lower than 3,000 m can provide substantial water to lower ecozones through runoff and groundwater as well as river flow.

The afromontane zone is like an island chain of mountain areas extending from Tanzania, more or less along the sub-continent's eastern escarpment to South Africa. As elevation increases the various ecozone factors change rapidly. Below afromontane, there is a transitional zone from lower ecosystems which tends to be forest grading into smaller bush, but throughout the region this transitional zone has been largely destroyed and is now a fire-maintained grassland, or farmland.[23]

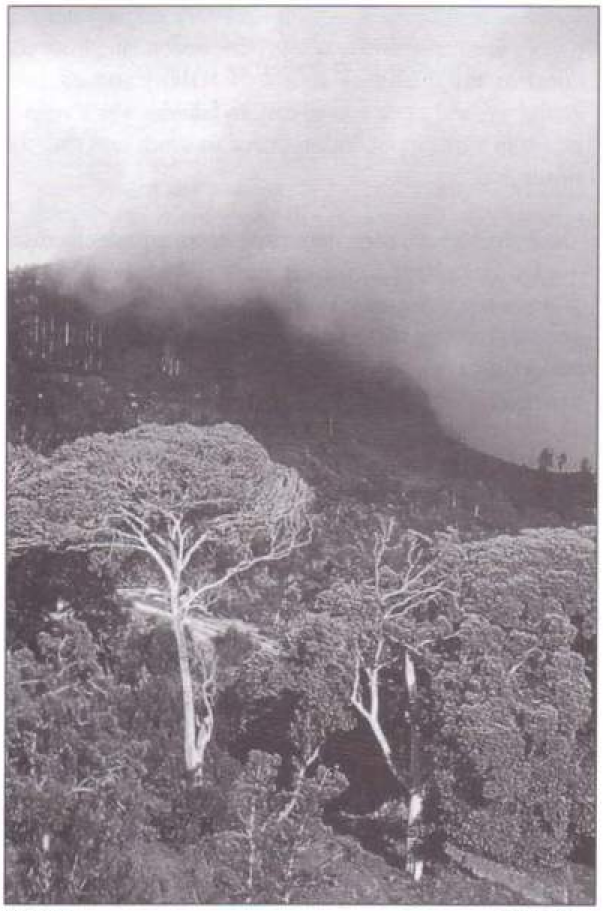


Photo 4.2 IRIS-C Thege

Afromontane and temperate forest, shown here in the Usambara mountains of Tanzania, has more seasonal rainfall and lower temperatures than the tropical forest.

The zone generally occurs at altitudes above 2,000 m, but drops down to the coast in the southern part of the region[24] where temperatures are cooler. It includes the Bailundu highlands in Angola, the Drakensberg/Maloti in Lesotho and South Africa, Eastern highlands of Zimbabwe, Swaziland's highlands, the mountain belt through Malawi, and the Usambara and Uluguru mountains in Tanzania. There are many small parks and forest reserves in this zone throughout the region, and logging and agriculture are significant threats.

Grassland

- mostly east-central South Africa and parts of Lesotho but other countries have smaller areas, altitude 1,350-2,000 m
- rain falls in summer, average 400-800 mm/yr
- mean annual temperature, below 17°C, ranging from 25-30°C in summer to 10°C to sub-zero in winter
- soils variable, generally silty to sandy

Grassland is found mainly on the interior plateau of South Africa and Lesotho, although Swaziland, Malawi, Tanzania, Zimbabwe and, particularly, Zambia have smaller areas. These result from a number of ecological factors including climate, fire and soil conditions, and are, or may become, quite important for agriculture and biodiversity.

This area is generally known as a climate-controlled grassland because the combination of temperature and rainfall determines grass as the dominant vegetation.[25] Fire-controlled grasslands can also occur where tree seedlings are unable to survive due to regular burning. Soil-related grassland is found in areas with shallow soils or a layer of clay, causing waterlogging of soil in the rainy season, drowning tree roots.

Grasslands tend to have a distinct growing season, followed by a period of dormancy when the above-ground vegetation dies. This dormancy occurs when the grasses have used all the available water, which happens during the dry, cold season. Studies show that climate-controlled grasslands occur in much the same conditions as savanna, but where the temperatures are lower during the dormant period. Grass can tolerate lower temperatures than trees, including the often severe winter frosts which occur.[26]

Photo 4.3 SOUTHLIGHT-P Weinberg

Grassland covers most of east-central South Africa, and human population and livestock are above carrying capacity.

The grasslands are sometimes divided into "sweet" and "sour" denoting their nutritional quality and palatability to livestock, although there is no clear division between them. Sour grasslands occur where rainfall is above 600 mm/yr and have lower nutritional quality. Overgrazing, which can lead to soil degradation, does not generally occur because vegetation grows quickly and livestock avoid the unpalatable plants.

Sweet grasslands receive more variable rainfall, ranging from 400-600 mm/yr, and are found on heavier clay soils with higher nutrient levels. They occur interspersed among sour grass in the lower rainfall areas.[27] Sweet grasses are more nutritious and palatable throughout the year, so are often overgrazed, leading to bush encroachment, erosion and land degradation. A quarter of Lesotho's grasslands are in poor condition due to overgrazing.[28] Shrubby Karoo vegetation has been invading the western parts of the zone for many years due to overgrazing. The damage from overgrazing is irreversible in over 20 percent of the zone (over 66,000 sq km), [29] although some scientists now say this may be part of a long-term natural cycle.

Biodiversity Box 4.3

Biological diversity, or biodiversity, is the richness and vast variety of forms of life on earth. The term is commonly used by biologists and environmental organisations. The 1992 Earth Summit in Rio de Janeiro, Brazil, finalised a global Convention on Biodiversity which came into effect at the end of 1993. But most people have no idea what biodiversity is, or why it is important.

There are almost 1.5 million species on earth which have been classified and named, including insects, birds, fish, mammals, plants and other life-forms. Scientists don't know exactly how many species there are but estimates range from 5-30 million — at least three times as many as we already know about. And this says nothing about the huge range of differences within each species.

We live in a world where species go extinct every day, and with them the whole range of possibilities that once existed within that species. When people talk about conservation of biodiversity, they really mean prevention of extinction — and efforts to maintain the huge range of differences among and within the species of the earth.

Why preserve biodiversity? Some people feel that moral reasons should suffice. If human beings hold the fate of a species in the balance through overutilisation or destruction of habitat, there is a moral obligation to preserve that species. Others make more pragmatic arguments. Since all of our crops and livestock originally came from the wild, if an undiscovered disease were to wipe out all the commercially grown maize, we could turn to some wild variety to develop new seed. Many life-preserving drugs have been developed from wild plants and the loss of a particular species or variety might destroy a possible cure for cancer. Ecologists point out that the more we know about ecosystems, the more we understand how every species has a relationship with all the other species, and that each of these "building blocks" we remove brings the whole system a step closer to falling in on itself.

No one knows how many extinctions is too many. What we do know is that the "normal" rate of extinction was about 10 per year until recent history, but by 1992 the extinction rate had accelerated to one every 12 minutes — over 40,000 each year.

SOURCES: Huntley, B.J. (ed.), *Biotic Diversity in Southern Africa: Concepts and Conservation*, Oxford University Press, Cape Town, 1991
UNEP, "Protecting the Diversity of Species on the Planet", *Earth Summit in Focus*, Mar 1992, Vol 7, p. 1

This zone receives a very high number of lightning strikes per square kilometre compared to the other zones. Fires, often caused by the lightning, can occur annually in higher rainfall areas where sufficient vegetation grows and dies to provide fuel. Veld managers say burning is essential for good grass production, stimulating the plants to produce more, although it is best not to burn more often than every two years, in late winter when the grass is still dormant, rather than annually.[30]

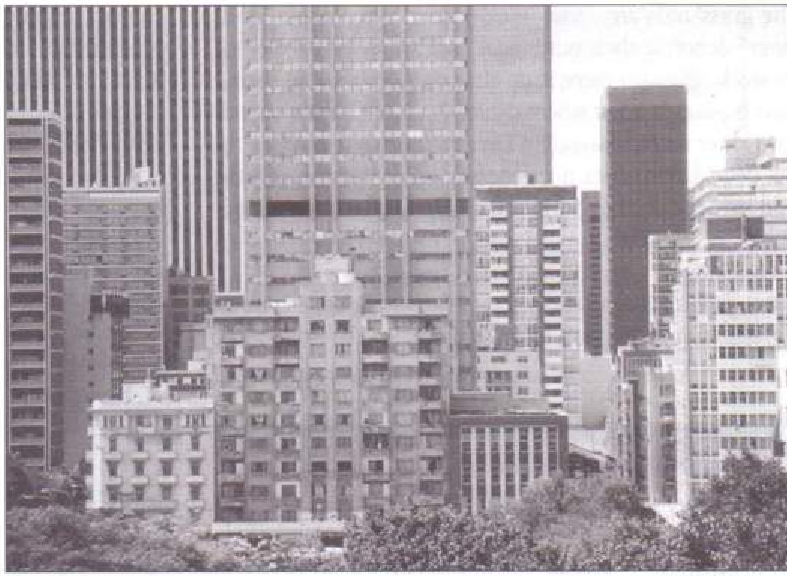


Photo 4.4 SAMSO-T Davies

The grasslands zone contains the PWV province of South Africa, and the highest concentration of urban centres in the country.

This ecozone supports a great deal of grazing-related agricultural activities including beef and dairy cattle, and sheep for wool. Pasture has been planted in some moister areas. It is also important for crop production. The largest maize-producing area in the region is in the grasslands — South Africa's "maize triangle". This area also has the highest concentration of urban centres in South Africa. Human population and livestock numbers are above carrying capacity.[31]

Savanna

- found in all countries except Lesotho, on high plateau ranging from 800 m in the west to 1,700 m in the east
- rainfall seasonal, falls in summer, 400-1,400 mm/yr
- vegetation, mix of grass and trees, proportions vary depending on conditions

Half of Africa is covered by savanna and it is by far the biggest ecozone in southern Africa taking in large parts of all countries except Lesotho. Savannas occur in areas with a dry season of at least five to seven months resulting in a long period of water shortage, with one or two wet seasons. Fire and animal-feeding are critical factors affecting savannas; without them, either grass or trees would dominate.[32] Theories about why grasses and trees occur together in savannas are still developing. The usual explanation is that there is a surface layer of soil where grasses out-compete trees for most of the rain-water and a lower layer where deep-rooted trees have exclusive access to the water. The amount of water getting to the sub-soil is enough to support the trees, but not enough to allow them grow big enough to shade out the grasses. Topsoil that holds water favours grass, while deep, well-drained soils where water reaches the sub-soil, favour trees.

Savannas are changeable, and may not automatically return to a previous condition if left alone after a major impact, such as overgrazing, fire or drought.[33] Open rangeland can change into woodland under conditions of decreased fire, increased feeding or water availability. Woodland can change to rangeland if trees are killed and fire, combined with browsing, slows the development of trees to the point where grasses dominate. This process may be part of a long-term swing back and forth between the two conditions.

Trees can assist nutritious grass growth by providing nutrients and higher soil moisture. Their roots pull in nutrients and water from deep in the soil, much farther out than the reach of their branches, and concentrate them in leaves which fall and fertilise the ground. When they die they also leave patches of additional nutrients which slowly rot into the soil, enriching the immediate area.[34] Recent studies show that the best production of nutritious grass occurs with a specific number of trees per hectare, varying from about 10-25 percent.

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.[35]

Moist Savanna

- rainfall ranges from 500-1,400 mm/yr, falls in summer (November to April)
- mean annual temperature, over 18°C
- broad range of soil types, generally nutrient-poor, due to leaching by rainfall and low-nutrient base rock
- trees mostly *miombo*, growing to 20 m, with a mix of shrubs and grasses below

The high rainfall leads to higher plant production than dry savanna, but the plant material is of lower quality due to the low nutrient levels. Moist savanna cannot support as much grazing wildlife or livestock as an area of similar rainfall and higher soil fertility. The mix of plant species depends on available water, largely rainfall, with the north moister and more tropical. There are a few other moist-savanna types of more limited range, such as the Zambezi teak forests on the deep Kgalagadi sands, especially in southern Zambia and the Angola-Namibia border area.

The high plant-production provides more fuel at the end of the season when plants die, so there are many fires (every one to three years). Generally, the very wet savannas burn only in exceptionally dry years, while those in the middle-moisture range burn more frequently and intensely.

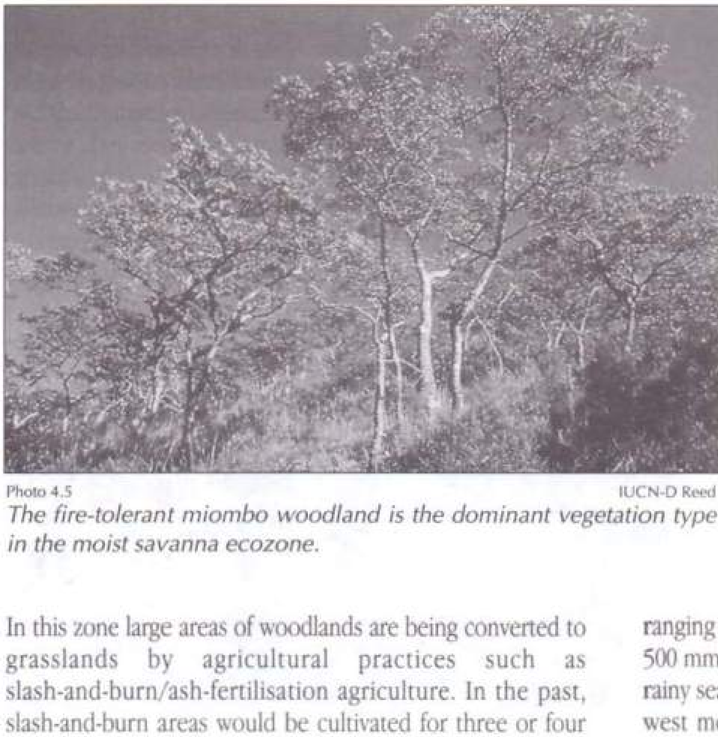


Photo 4.5 IUCN-D Reed

The fire-tolerant miombo woodland is the dominant vegetation type in the moist savanna ecozone.

In this zone large areas of woodlands are being converted to grasslands by agricultural practices such as slash-and-burn/ash-fertilisation agriculture. In the past, slash-and-burn areas would be cultivated for three or four years, then left fallow, returning to their original state after 10-25 years. Many parts of this zone have climatic conditions which could support more tree cover but for the influence of human-caused fire.[36] Clearing can reduce rainfall infiltration, lowering the water table.

While soils are generally infertile in moist savannas, modern farming practices using chemical fertilisers have led to high yields in some places. There is, however, concern that high-input systems can acidify or otherwise degrade the soil. There are some naturally fertile soils in the zone, but these are unusual.

Dry Savanna

- covers the southwestern part of the region, also north-eastern Tanzania
- rainfall erratic, 200-500 mm/yr, Tanzanian portion has two rainy seasons
- soils generally fertile, due to less leaching
- vegetation sparse, mixed grass and trees (*acacia, mopane*)

Dry savanna covers a large part of the region, mostly in the southwest. Another area begins in the northeast of Tanzania and continues on up to include much of Kenya, Somalia and Ethiopia. The two appear to be linked by a narrow section through Zambia's Luangwa valley.[37] While these two areas are similar ecologically they cover different geographical areas and have undergone distinct development patterns.

There is less vegetation than in moist savanna due to lack of water, but it tends to be higher quality and has more species because of higher levels of soil nutrients.[38] This is an important ecozone for grazing and wildlife due to high relative fertility. It can be productive agriculturally where sufficient water is available, either naturally or through irrigation. In the southern part of the zone, the population is generally low, although it is growing rapidly, with rural dwellers living near secure water-supplies, usually wells, boreholes or pans.

In the southern part of the ecozone rainfall occurs erratically during a five-month season ranging from an average of 200 mm/yr in the southwest to 500 mm/yr in the northwest. The Tanzanian portion has two rainy seasons related to the calm periods between the southwest monsoon in summer and the northeast monsoon in winter, although significant amounts of rain can also fall in

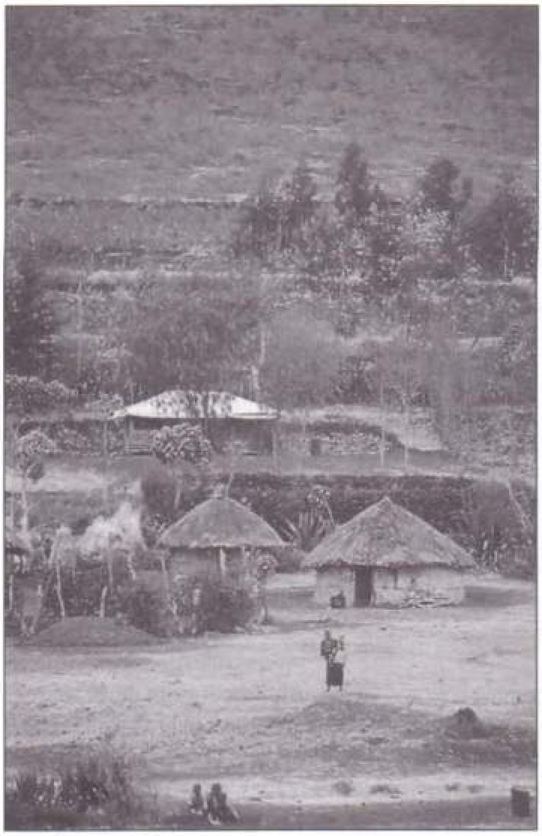


Photo 4.6 IRIS-C Thege

Erratic rainfall, sparse vegetation, and fertile soil mark the dry savanna zone. Human population is generally low, and concentrated near secure water-supplies.

the "dry" season outside these rainy periods.[39] Evaporation usually exceeds rainfall for all but one or two months each year.

As much as half can runoff into rivers during the heavy rainstorms leaving only a small amount available for vegetation. The dry savanna, and the other dry ecozones — nama-karoo, succulent karoo and desert ecozones described later — are controlled largely by "events" of rain, rather than average rainfall over a season.

Much of the southern part occurs within the Kgalagadi Basin, including the so-called Kgalagadi desert. The basin is filled with sand, with a few rock outcrops, and drainage is largely internal. The Kgalagadi sand area is largely wooded grassland, though it has been replaced over large areas by desert grasses and karoo shrubs. There are fewer trees as it approaches the nama-karoo zone.

The main type of vegetation associated with southern dry savanna is the thorny *acacia* woodland. *Mopane* are also found extensively in lower altitude areas on heavy soils where they are one of few species able to tolerate the range of soil water conditions from virtually waterlogged to extremely dry.

Large parts of the southern dry savanna are severely affected by overgrazing and underbrowsing due to high cattle populations, as well as by too-frequent burning. Such removal of grass gives more soil water to trees, while lack of browsing allows bushes to spread and thrive, leading to bush encroachment. This is a particular problem in Namibia, Botswana and parts of South Africa, with Namibia changing from being a major exporter of dairy products to an importer due to loss of grazing land to bush encroachment.[40]

In the northern part, the altitude is generally 900 m or less, with islands of afromontane emerging above in the higher parts. Plant species are largely in the form of deciduous bushland and thicket with many acacias, usually less than 3.5 m tall. Much of the vegetation has been damaged or destroyed by fire and clearing. There are major problems of erosion and loss of soil fertility.

Where soil nutrient levels are high, dry savanna can support large numbers of many different animals. The Serengeti plain, in particular, is a unique savanna ecosystem which has the largest concentration of large wild mammals in the world. There are 23 species of large *herbivores* (plant-eating animals). Animals such as wildebeest, Thomson's gazelle

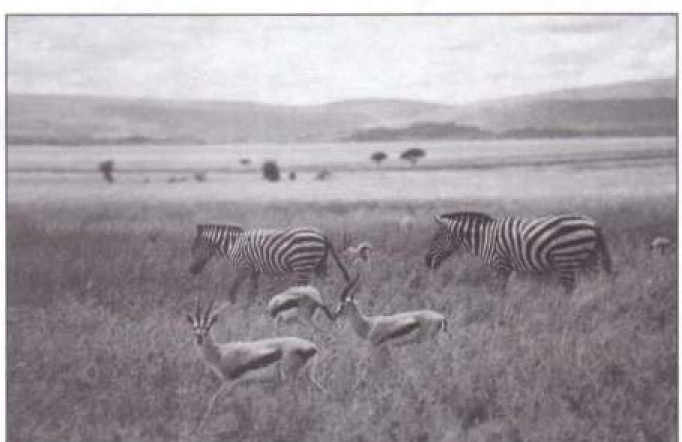


Photo 4.7 SARDC-P Johnson

Thomson's gazelle and zebra on the Serengeti plain, which has the largest concentration of large wild animals in the world.

and zebra migrate through the area with the rains and the fires. The Serengeti soils result from an ash layer laid down about 150,000 years ago by volcanic eruption, which strongly affected the soil leading to nutritious grassland.[41]

Nama-Karoo

- covers west-central South Africa, the Namibian coast into southern Angola
- average rainfall, 100-400 mm/yr, increasing from west to east, 60 percent falls in summer
- mean annual temperature, over 30°C in summer, sub-zero in winter
- soils shallow and alkaline, vegetation predominantly shrubs

Nama-karoo, like the dry savanna, is largely event-driven. Potential evaporation is very high, greater than 2,000 mm/yr —more than eight times the average annual rainfall. This zone also experiences extreme temperatures over the year. Daily temperatures can also vary by up to 25°C.

Water is the main constraint in this zone resulting in low vegetation production. Fires are rare due to small amounts of fuel in the form of dried vegetation. The zone is a dwarf open shrubland, although some studies show there was a grass layer before farmers fenced large parts of it, introduced sheep and other livestock, and developed artificial water sources to allow the animals to live year-round in large numbers. Areas protected from grazing produce a lot of grass in high-rainfall years. Agriculture is possible only under irrigation.

The soil is easily eroded and has been severely degraded due to overgrazing, leaving bare subsoil where grassland used to be. In some places it now resembles a desert.[42] Bush encroachment is also a serious problem. The major threats are agriculture and invasive plants. This ecozone has been abused and does not yield much agricultural produce on a per hectare basis; it is used largely for very extensive grazing (from one to five hectares is needed for each sheep).

Succulent Karoo

- flat coastal strip south of Luderitz, Namibia
- rainfall varies from 20-290 mm/yr, over 60 percent falls in winter
- plants sparse with thick, fleshy, water-retaining leaves (succulent)
- soils poor

Areas close to the west coast receive moisture from fog during summer. The annual growth period is short, between 15 and 50 days, because rainfall occurs only when occasional winter storms go further north than usual.[43] 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.

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.

Large mammals would rarely have lived permanently in such areas because of the extreme shortage of water and low amounts of grass or leaves. However, artificial water points have allowed livestock to live there year-round, resulting in severe local overgrazing.[44] The very low rainfall, coupled with the flat landscape have minimised water erosion, although the soil is easily eroded and a lot of soil has still been lost by wind erosion. This area has even lower agricultural potential than the nama-karoo, with some areas requiring nine hectares for each sheep.

Desert

- true desert (Namib) runs from north of Lüderitz in Namibia along narrow coastal strip extending well into Angola
- rainfall ranges from 10-85 mm/yr, fogs can increase annual average rainfall threefold at times
- daily temperature range is very high
- soils, poor, vegetation sparse with annual grasses

This is true desert, as opposed to the so-called Kgalagadi desert which has a tree-and-grass layer and falls in the dry savanna ecozone. The Namib has a low carrying capacity and little plant cover.

The cold Benguela ocean current limits maximum rainfall on the coast to 50-85 mm/yr. The cold current cools the air above, severely limiting its ability to hold moisture and resulting in little or no rainfall. The current also provides moisture by cooling warm offshore air, condensing the moisture in it and producing sea fog. The Namib Desert gets most of its moisture from sea fog, which can occur 150 or more days each year. Fogs increase precipitation by 30-180 mm annually and regularly penetrate up to 40 km inland, occasionally up to 100 km from the coast.[45] Plants, animals and insects are adapted to getting their water requirements from the fog.

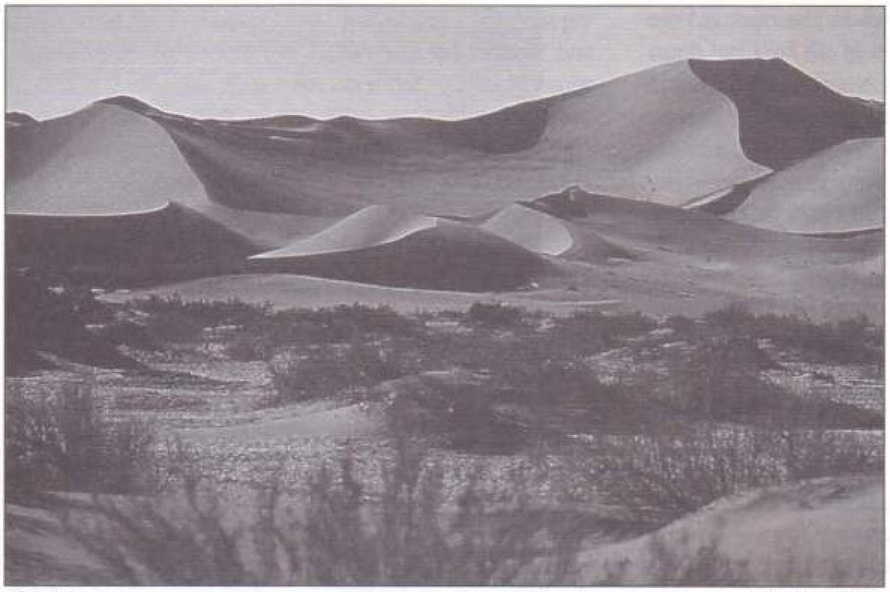


Photo 4.8 NAMIBIA REVIEW

The Namib, a true desert, has a low carrying capacity and little plant cover. Plants, animals and insects are adapted to getting water requirements from sea fog.

Vegetation throughout the Namib Desert is sparse, except along rivers fed by water flowing seasonally from the highlands in the east. Annual grasses are abundant on the plains after good rainfall years. Most plants survive in the form of seed, growing quickly after rain, then leaving seed to wait for the next sufficient rainfall.

Fynbos

- covers the extreme southern tip of South Africa including a coastal belt and adjacent slopes
- rainfall ranges from 250-2,500 mm/yr, with cool, wet winters and hot, dry summers
- mean annual temperature, about 17°C, varies with altitude
- soils, infertile
- vegetation, largely dwarf shrubs, plant species diversity, high

As with other ecozones, most growth occurs in the wet season, the difference being that this occurs in winter with lower temperatures and resultant slower growth. Fynbos soils are exceptionally infertile and particularly low in phosphorus, due to the chemical make-up of the base rock and the heavy leaching that has occurred through time.

The fynbos has a huge number of plant species, over 7,300, and 5,000 of them are found nowhere else on earth.[46] 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.

The low-nutrient soils produce nutrient-poor vegetation which is largely unpalatable to animals. Generally the plants are dwarf shrubs or shrub woodland. Leaves are usually thick and leathery, not only due to lack of nutrients but lack of water, and this discourages feeding. The result is generally low diversity and densities of mammals and birds. Insect diversity may be quite high, although there is little information on this.

Fires, though not frequent, are usually very intense. A great deal of fine, easily burned material collects, usually igniting during the hot, dry summer and killing the existing vegetation. These fires start a new cycle of growth, with certain species dominating immediately after fire and a gradual taking over by shrubs and eventually plants, until the next fire. However, if the fires are spaced too closely, plant species can be locally exterminated. Fynbos is said to be well adapted to, and dependent on, fires.

This is one of the most highly cultivated areas in South Africa. Its winter rainfall allows production of certain deciduous crops, particularly fruits such as grapes which need a cool, moist growing season, as well as winter wheat. Agriculture and urbanisation have removed more than a third of the natural vegetation and much of the rest is declining due to overgrazing and too-frequent burning.[47] The lowland part of the fynbos has been hardest hit, where about 80 percent has been cleared for agriculture.[48] The area also suffers from severe wind and water erosion due to overcultivation.

Transition between Forest and Savanna

- rainfall ranges from 1,500-2,000 mm/yr
- dry season is much less severe than the savanna zone
- rainfall is too seasonal to support forests, not seasonal enough for savanna
- vegetation is largely scrub forest, bushland and thicket[49]

Acacia saligna: resource or invader? Story

Khayelitsha, South Africa (New Ground) — Jackson Gannes does not use the words "sustainable harvesting of natural resources" but he chops only the dead wood from the Port Jackson stands outside Khayelitsha. Even if it takes longer and is harder work.

The reason is simple: the Port Jackson *(Acacia saligna)* is his only source of income and he does not want to destroy it. Every day he cuts a trolley full and sells it for R10 to the vendors who barbecue meat on the shantytown's sidewalks.

He is angry when he hears that a fungus has been released to kill all the acacia trees from Port Elizabeth in the east to Saldanha on the West Coast. *Acacia saligna,* an exotic tree, is very unpopular among conservationists.

Acacia woodcutters, who use the tree for cooking and building, say they like it because "after you have cut it, it grows back again."

They agree that white farmers eradicate the acacias because "they don't make them money", unlike the fynbos (the native vegetation) with its wildflowers that attract tourists and wildflower-buyers.

The wildflower industry in the Cape is worth R30 million (about US$10 million) a year. Interestingly, the informal firewood industry is worth just about the same — R28.5 million, according to researcher Estenban Azorin of the University of Cape Town.

But the value of the fynbos goes beyond generating cash. It has an unusually high variety of species by world standards. *Acacia saligna* invades the habitat of these fynbos plants, out-competing them.

Thys Greeff, a part-time wildflower farmer who uses fungus to kill the acacia on his farm because it "invades the fynbos and destroys it", shows little concern for the people who use the acacia. "I am afraid it is very difficult to combine my ideals of conservation with keeping the Third World fed, warm and happy. I had to make a choice and the veld came first."

But Gavin Armstrong, his neighbour, thinks otherwise, "You have a heart of stone, Thys."

The acacia survives these conditions by "fixing" nitrogen from the atmosphere. In addition, the roots bring nutrients from the clay to the surface.

Armstrong intercrops the acacia with grass. He uses the fodder to feed Damara sheep and Nguni cattle — both indigenous breeds. He reckons destroying the acacia will bring dustbowls not fynbos.

Another farmer, Freddie Rust, says the decision to eliminate acacia lacks wisdom as the trees could be commercially raised in Khayelitsha. He criticises importing electricity for heat or chemicals for fertiliser when both could be effectively provided by using the acacia.

The acacia species was introduced from Australia in 1877 to stabilise the Cape Flats sand dunes which had lost cover under the impact of wagon traffic and the growing settlements on the outskirts of Cape Town.

Although the acacia "met their brief", they became a threat to biodiversity in the Cape Province but a blessing to the poor people of Khayelitsha.

—Adapted from **Victor Munnik** *New Ground*, Environment and Development Agency Trust, Newtown, Spring, 1992

The transition between the lowland tropical forest of the Zaire Basin and the savanna zone covers a very large area, and has a set of characteristics which do not fall directly into either zone. Rather it is a complex mixture of both, also affected by geographical factors. The main reason for the transition is rainfall, which begins to become too seasonal to support a real forest. The forested areas are under pressure due to expanding agriculture and most evidence suggests savannas are expanding at the expense of closed forest.[50]

Although the whole transitional area is not shown on the map, one particular area deserves some special attention — the Lake Victoria Mosaic. This once-forested area surrounds Lake Victoria. Five distinct vegetation systems meet here, so it is a complex mixture.[51] There has been a lot of destruction of vegetation by fire and clearing, and small forest areas are now found only in reserves. There are many plantations of exotic tree species not native to the area.

The highland areas have very fertile soils, resulting from the volcanic activity in the past which deposited a nutrient-rich ash layer. This is one of the most important agricultural zones in the region for its size. Crops include coffee, cotton, tea, maize, cassava and plantain. While agriculture is important here it is also threatened by major problems of soil degradation and loss of fertility due to poor agricultural practices and overuse, coupled with the steep slopes and high rainfall. Some areas have become denuded despite the high rainfall because the soil is unable to retain moisture for growth.[52]

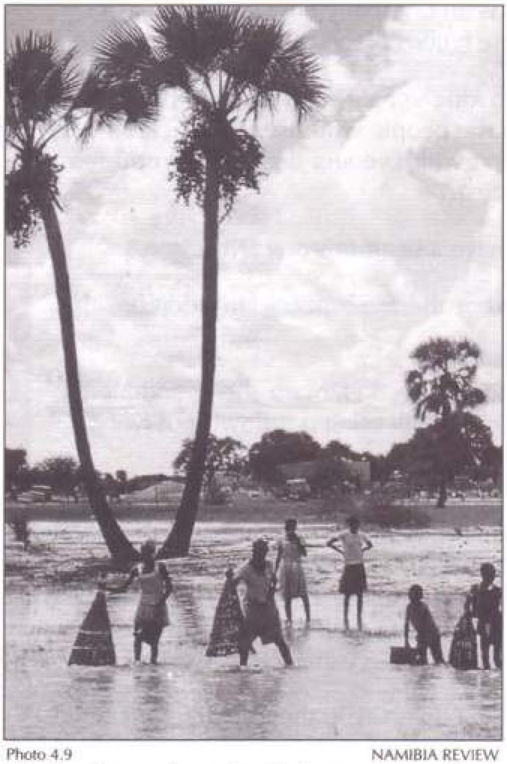


Photo 4.9 NAMIBIA REVIEW

Wetlands, such as the Oshanas in northern Namibia, have a significant impact on the immediate environment.

Wetlands

- cover 13 percent of the region
- include rivers, lakes, swamps, estuaries and coastal areas
- vegetation varies from grasses to trees

Wetlands are not an ecozone on their own because they do not cover a sufficiently large, contentious area — but they have a significant impact on their immediate environment. Wetlands are important both as habitat for wild species and for agriculture during the dry season because of the additional water availability. Rural populations in the region tend to be found around wetlands. Wetlands also provide temporary habitat for migratory species, including birds which fly long distances between the southern and northern hemisphere, and are a refuge for some wildlife during droughts. Wetlands change over the year due to evaporation and run-off, and from year to year due to rainfall variation.

Many wetlands dot the southern African landscape. Examples such as the Okavango delta in Botswana are like an oasis in the middle of arid savanna — a huge inland swamp area with grassy floodplains and woodlands. The lesser-known *oshanas* in northern Namibia/southern Angola are occasionally flooded lands that support far more life than the land around them, as do the Bangweulu swamps in northeastern Zambia.

Dambos are wetlands commonly found in the central part of southern Africa where groundwater discharges into low-lying areas. They provide grazing and natural crop irrigation during the dry season.

Dambos also provide sanctuary for wildlife during drought. They tend to be more productive than the surrounding area because they receive organic matter and nutrients from erosion of the surrounding uplands. Unfortunately *dambos* are often highly vulnerable to erosion themselves.[53]

Other types of wetlands are also important regionally. Lakes furnish fish habitat and supply much fish protein, as do most rivers. Floodplains — such as Wembere in Tanzania, Kafue Flats in Zambia or Marromeu in Mozambique — provide breeding for fish as well as wildlife habitat, grazing and specialised agriculture.

Many wetlands in southern Africa are drying up or breaking down due to overuse, especially overgrazing and/or lowering of the water table. This will be a great loss, if allowed to continue.

PLANNING WITH ECOZONES

Southern Africa's ecozones are a complex interaction of all the natural processes outlined in this chapter, and each creature's activities take from, and give back to, the system. If too much is taken and not enough replaced, the system fails, as will happen if more waste is produced than can be assimilated. Since all living things, including human beings, depend on the natural environment for food, shelter, energy and other needs, it is our interest to manage ecozones properly. This is where the idea of sustainable development originates — use of the environment for economic activity must ensure the environment remains healthy. Many human activities have an environmental cost and provide little environmental benefit. If the costs become too high the environment cannot survive.

Ecozone planning means understanding the cost of human activity and making sure it is not higher than the system can tolerate. It ensures that ecological processes and limits are understood and that the effects of particular activities in relation to those processes and limits are known. Each ecozone in the region has developed in response to a particular set of external factors. Some zones are far more productive than others, and some are better able to recover from ecological stress. Each can be manipulated to benefit humans, within certain limits. If the limits are exceeded, the ability of the ecozone to keep producing will decrease, and could eventually be unable to support human life.

A few studies have provided some insights into managing southern African ecozones. The dry savanna has been researched by ecologists, soil scientists and economists because of concern over high numbers of livestock and the possibility of resultant range degradation. Because the dry savanna is an event-driven ecozone, standard range-management techniques which set the number of livestock for a given area, known as carrying capacity, are not the best approach.[54] Since vegetation production can fluctuate from year to year, studies show that livestock management should be "opportunistic", with livestock numbers increasing and decreasing in response to availability of palatable vegetation. This calls for a system that allows herds to be moved quickly to areas of high quality vegetation, and where there can be quick de-stocking and re-stocking of livestock in response to changes. There may be large die-offs of livestock during severe droughts. Small individual ranches would disrupt such a system. The system outlined is one which describes the traditional pastoral systems which involved moving livestock over large range areas.

The major concern in any livestock management is to ensure that the grazing area is not degraded to the point where it cannot recover. While it has been shown that southern African dry savannas have been able to support livestock numbers far in excess of predicted carrying capacity, researchers are less clear about whether the ecozone is being degraded. A lot of work is now going into measuring the amount of degradation in dry savanna, whether the ecozone is, or is not, being permanently degraded, and whether the present livestock numbers are sustainable.

A simple analogy might be people who give blood to help others. They may feel a little weak for a short time but their bodies create new blood to replace that given away. However, if a person gives too much blood, or does it too often, the body is unable to keep up and ill-health, or even death, could occur. If this happens there is no more blood supply and everyone is poorer.

To plan for an ecozone, we must know how much "blood" can be taken, and how often, and how much is produced. Signs of deterioration must be recognised and understood. Planners, policy-makers and politicians must know how to respond to the information, and have sufficient resources and political will to do so. As populations increase, resources in southern Africa will feel increasing pressure and more stress will be placed on the ecozones. Ecozone planning is part of the recipe to avoid their degradation or collapse.

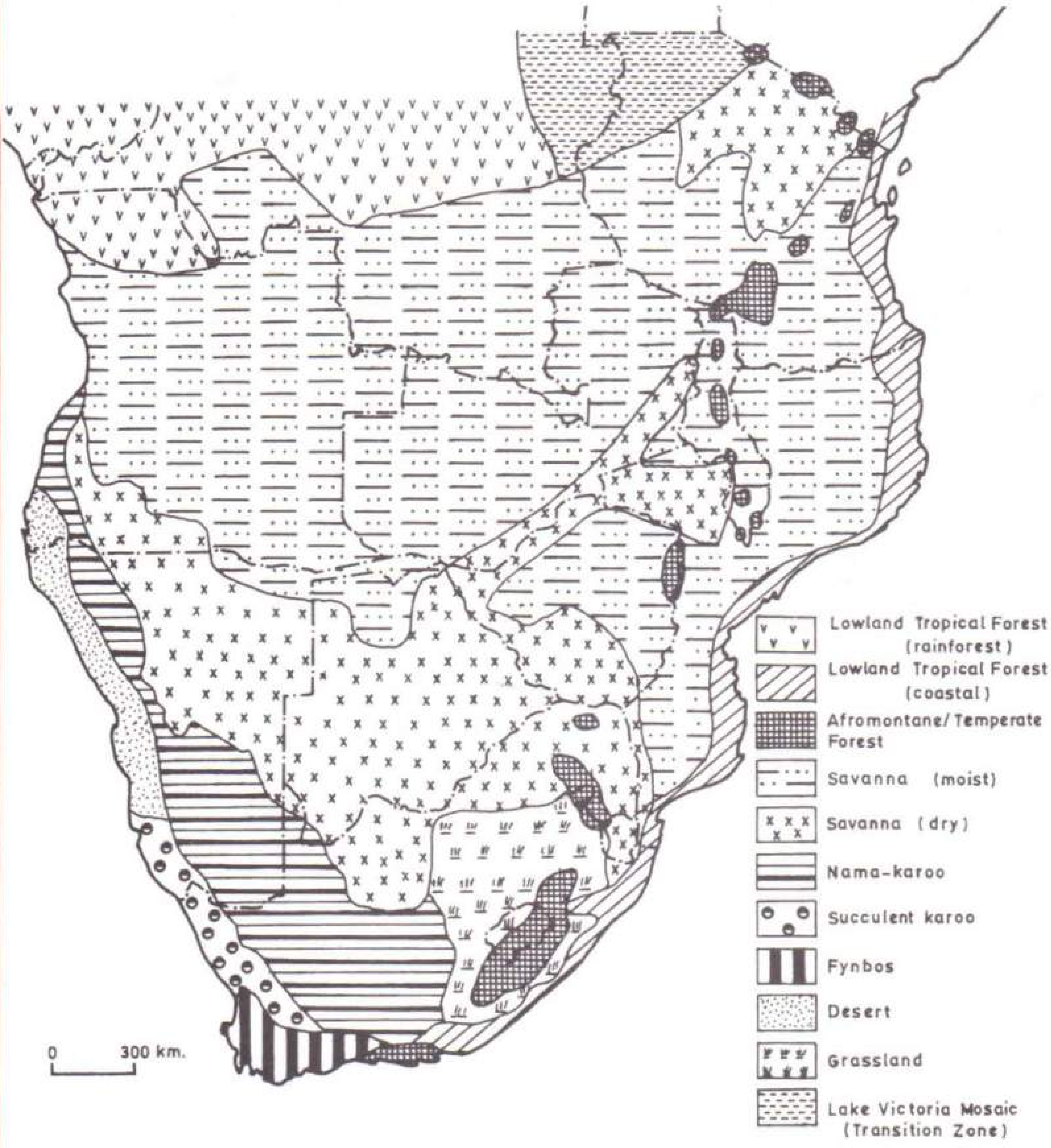
Characteristics of southern African ecozones Table 4.1

Ecozone Factor	Lowland Tropical Forest	Afromontane/ Temperate Forest	Grassland	Moist Savanna	Dry Savanna	Nama-Karoo	Succulent Karoo	Desert	Fynbos
Rainfall	high	high to medium	medium	medium	low	very	very low	very low	low, very low
Evaporation	high	high	medium to high	medium to high	high	high	high	high	medium to high
Dry season (in months)	no	2in winter	5-7in winter	5-6 in winter	6-7 in winter	event-driven	event-driven	none	summer
Average °c temperature	20+	20-	17-	18+	varies	varies	varies	varies	17
Minimum °c temperature	20	10	varies	varies	varies	varies	varies	varies	varies
Occurrence of frost	none	none	frequent	varies	medium	frequent	medium	medium	medium
Altitude	low	medium	medium	medium	medium	medium	low	low	low
Soil fertility	low	varies	low to medium	low	medium to low	low	low	very low	very low
Graze and browse	low	low	medium to high	medium	medium to high	low	low	very low	low
Occurrence of fire	none	rare	frequent	medium to frequent	rare to medium	rare	very rare	very rare	medium
Plant production level	high	high	low to medium	medium to high	low to medium	low	very low	very, very low	medium
Threat of bush encroachment	very low	very low	high	low	medium to high	medium	low	low	low
Threat of erosion	low	low to medium	low to high	low to medium	medium to high	medium to high	medium to high	low	medium to high
Agricultural development potential	low	medium to high	medium to high	medium to high	medium to high	low	low	very low	medium

Note: "varies" means the factor varies a great deal over the ecozone and is not critical to ecozone functioning.
SOURCE: Frost, P.G.H., "Determinants of structure and funtion of southern African biomes", for SARDC, 1993

Ecozones of southern Africa

Map 4.2



SOURCE: Frost, P.G.H., "Determinants of Structure and Function of southern Africa Biomes", for SARDC, 1993
Rutherford, M.C. and R.H. Westfall, "Biomes of Southern Africa: An Objective Categorization", *Memoirs of the Botanical Survey of South Africa*, Department of Agriculture and Water Supply, Pretoria, 1986, no 54

Linkages to other chapters Box 4.4

1 PEOPLE

People can disturb the ecological balance in various zones through their lifestyles and patterns of consumption.

2 HISTORY

Traditional societies had well-developed methods of conserving the natural resources in these zones.

3 POLICY

Modern policy development and implementation will be effective only if based on an understanding of ecozones and their characteristics.

5 CLIMATE

Drought is a regular and natural occurrence in southern Africa, more in some ecozones than others. Climate has both regular and episodic impacts on ecozones, and plays a key role in determining distribution of plants and animals.

6 SOILS

The features of each ecozone determine how easily the land can be degraded by agricultural activities. Cultivation has different impacts in each ecozone and can increase or decrease soil degradation.

7 WOODLANDS

Natural forests and woodlands align closely with ecozones. Deforestation has had a dramatic impact in some ecozones where the clearing of land for agriculture and too-frequent fires are transforming whole areas from one predominant type of vegetation to another.

8 WILDLIFE

Wildlife affects, and is affected by, ecozones. Most species can be found in more than one ecozone but there are areas more suitable to some species than others.

9 FRESH WATER

Water is the key factor in every ecozone. Its availability, shortage or abundance has direct influences on each ecozone. Various activities have an impact on water supplies and wetland habitats.

10 MARINE

While the land ecosystems and marine ecosystems are quite different, they do interact. Marine conditions affect weather and moisture. Coastal ecosystems (including mangroves, estuaries and beaches) are at the border between land and ocean, having elements of both.

11 POLLUTION

Pollution affects people as well as the ecosystems on land or in water, poisoning various components and disrupting the ecological balance.

12 ARMED CONFLICT

Armed conflicts affect ecozones in various detrimental ways, but often the movement of people away from certain areas also allows those areas to recover.

13 GLOBAL

Global warming is expected to have significant impacts on the various ecozones. Some may cease to exist, or change in unexpected ways to adapt to the new conditions, so the whole association of vegetation could look completely different.

14 TRENDS

Savanna is expanding at the expense of closed forest, and human activity is changing the conditions in some ecozones in various ways.

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5 The Climate Factor

Rainfall is the lifeblood of southern Africa. Much of the region is arid or semi-arid and rainfall is extremely variable, often unreliable. A poor year can result in large-scale crop failure, food shortages and, in extreme cases, famine. Trees and grasses wilt and die, and animals perish from hunger and thirst. Subsistence farming, which provides most people of the region with their food, depends on sufficient rainfall. Any signs of drought are received with dread. Drought is associated with suffering, and loss of valued crops, livestock and wildlife. 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.

Droughts are not easily predicted and most of the region has long, dry spells every year. If the rains do not come by a particular time, this may be a sign of drought; early rains may hide an impending drought.

The 1980s saw an increase in the severity of the impacts of droughts. The 1982-83 drought in Mozambique was considered the worst in 50 years and led to many thousands of deaths.[1] But the worst drought in the region was experienced a decade later, in the 1991-92 season. The areas surrounding the Kgalagadi — the savannas of Angola and Botswana, and the pastoral areas of southern Africa — were the most affected. Drought left most of those areas parched and gasping for elusive rains.[2]

DROUGHT DEFINED

The word "drought" is derived from an Anglo-Saxon word *drugoth*, which means dry ground. However, meteorologists, hydrologists, agriculturalists and economists define drought differently.[3] 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, groundwater). Agriculturalists link drought to agricultural impacts, focusing on precipitation shortages, the differences between actual and potential evaporation, and factors such as soil water deficit. Economists associate the supply and demand of goods and services with elements of meteorological, hydrological and agricultural drought.[4]

Central to all definitions is the shortage of water. Drought denotes dryness and should not be confused with aridity even though both are characterised by a lack of water. Aridity is a permanent climatic condition. Drought is temporary. Drought occurs when there is a protracted shortage of water. A dry spell has to last long enough to cause damage, otherwise it is not a drought.

Drought is a relative, rather than an absolute, condition. An area normally receiving 1,000 millimetres (mm) of rain annually would experience drought if it received 700 mm per year, but would not have serious problems from an agricultural perspective. An area normally receiving 700 mm would experience crop losses if it received 400 mm. Yet each area would have lost 300 mm. In drier areas, even small reductions of rainfall can have significant economic effects. Although we tend to associate droughts with areas of low rainfall, they can also occur in areas that normally enjoy abundant rainfall.

Shortage of rainfall is always the "trigger", but it is the lack of water in the soil, rivers or reservoirs which causes the hazard.[5] Plants do not use rain as it falls, but rely on the moisture available after the rain seeps into the ground. Similarly, rainfall does not supply water directly for irrigation or domestic use. It is harnessed from rivers and reservoirs, and from underground.

When the duration of a drought is short, the impact is minimal as long as the previous season was wet enough to provide adequate food and water reserves. If a dry spell lasts for a longer period of two or three years, then the impact can be severe on the environment, people and their crops, and livestock. Meteorologists refer to the frequent but short dry-periods, often lasting for less than a year, as "normal drought". It is not uncommon for a "normal drought" to occur in the middle of a wet spell.

CLIMATIC CAUSES OF DROUGHT

Although climatologists have produced a number of plausible explanations as to why droughts occur, a single conclusive answer is yet to be found. Past occurrences of drought have been linked to certain events such as *El Nino* and volcanic eruptions.

El Nino and the Southern Oscillation (ENSO)

El Nino is a weather condition which begins with the warming of waters in the western Pacific ocean, eventually affecting global climate.[6] This condition has an effect on weather over a quarter of the world's surface. *El Ninos* develop 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 Nino* occurrence.[7] Again, when the devastating 1991-92 drought occurred, *El Nino* lasted until the end of February 1992.[8] Some experts say that about one-third of the droughts in the region could be attributed to *El Nino.*[9]

El Nino is a component of another global weather phenomenon, the Southern Oscillation, and 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 Nino* 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 Nina* or (anti-*El Nino)* is experienced. The occurrence of *La Nina* results in unusually heavy rain in southern Africa. At this time the Pacific is cooler than the Indian ocean and wind moves from the Pacific toward the latter. *El Nino* means "the boy-child" in Spanish, so-named because it occurs around late December, when Christians are celebrating the birth of Christ. La Nina means "the little girl".

Volcanic eruptions

Volcanic eruptions elsewhere in the world have been linked to drought in southern Africa. Climatologists believe that the eruption of Mount Pinatubo in the Philippines in June 1991 could also be linked to the drought that devastated southern Africa in 1991-92.

Dust spewed by the volcano could have interfered with southern Africa's Intertropical Convergence Zone (ITCZ), which brings rain to much of the region, and other weather systems. Mount Pinatubo's volcanic dust reached the stratosphere (a layer of the atmosphere 10-60 km above the earth's surface) over the Indian ocean and partially blocked the sun's radiation. As a result, the ocean and the air above it did not warm as much as is usual. Thus, the rain-bearing wind, which drives moist air toward the region from the north-east, was not strong enough to reach southern Africa and was pushed up north of Zimbabwe.[10] Rain associated with the ITCZ fell further north than usual — over Zambia.

Global climate change

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 pre-historic times makes it difficult to assess the role of global atmospheric change.

SOUTHERN AFRICA AS A DROUGHT-PRONE REGION

Southern Africa's climate and rainfall patterns have been highly variable for at least the last three centuries,[11] leading to recurrent droughts of varying severity.

Droughts lasting between one and five years may occur in isolated areas or on a regional scale.[12] The region experiences regular wet and dry spells, that is, several years of abundant rain followed by periods of little rain. Theories about the cyclic nature of rainfall in the region were first put forward 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.[13]

A 77-year study done in the upper Vaal catchment, South Africa, reveals two distinct patterns of rainfall cycles. First, the cycles of drought followed by high rainfall are a common feature in the Vaal catchment. Second, the length of droughts in the area varies considerably, while there is also variance in the quantity of rainfall received in each wet period. South African experts believe that this has some significance for the region. If the trend continues, the rest of the 1990s could be relatively wet.[14]

Generally, arid and semi-arid areas are most prone to drought, especially toward the southwest, in Botswana and Namibia. The erratic and unpredictable rains in Botswana make that country more susceptible to water shortages than some of its neighbours. The poor sandy soils, which retain little water, coupled with high evaporation rates, exacerbate the problem. However, a plant that can root deep into the ground has access to moisture for a longer period. The camel thorn and Zambezi teak are good examples. In Botswana, only three years between 1959-1972 had abundant rains; six received inadequate rain and the other five received very little rainfall.[15] While Botswana has recently received above-average rainfall on a national scale, the distribution remains erratic and there are large variations, which cause severe localised crop failure.

Like Botswana, Namibia is an arid country. The northern parts and coastal areas, in particular, are the most severely affected by drought. Parts of the Namib desert record virtually no rain in some years. Evidence of drought and degraded land is particularly strong across northern Namibia. Years of abnormally low rainfall and overuse have turned savanna grass to straw, and dried up creeks and water holes, leaving cattle thin. Dust devils dance over the plains, and sudden bursts of wind can bring a blizzard of white dust, dense as mist.

Photo 5.1 SOUTHLIGHT-G Tillim

Drought often means a daily trek for water, several kilometres longer than usual, as local supplies dry up, shown here in Lesotho.

David Livingstone's journal Box 5.1

British missionary David Livingstone recorded a drought in Botswana between 1845-1851.

Livingstone was living among the Bakwena at Kolobeng, not far from Gaborone. His letters and diaries described a number of events related to the drought, including the summoning of rain-makers. So bad was the drought that some people had to emigrate. In January 1849, Livingstone wrote that the famine was so acute that the people had survived the previous six months entirely on locusts.

Ultimately, the local people began to blame Livingstone's mission for the drought. The criticism became more vocal when the Kwena chief, a renowned rainmaker, converted to Christianity and gave up rainmaking.

"We know a great difference in him since we came to him. He was a rain maker and had the reputation of being a wizard .... He has nothing now to do with the rain making incantations and it was by his own desire that we began prayer meetings in his house."

(Letter from David Livingstone in Kolobeng to Dr. J.R. Bennett, 23 June, 1848)

Soon after Livingstone's departure from the area, the drought broke.

SOURCES: Hitchcock, R.K., "The Traditional Response to Drought in Botswana", in *Symposium on Drought in Botswana*, Botswana Society, Gaborone, 1978, p. 92
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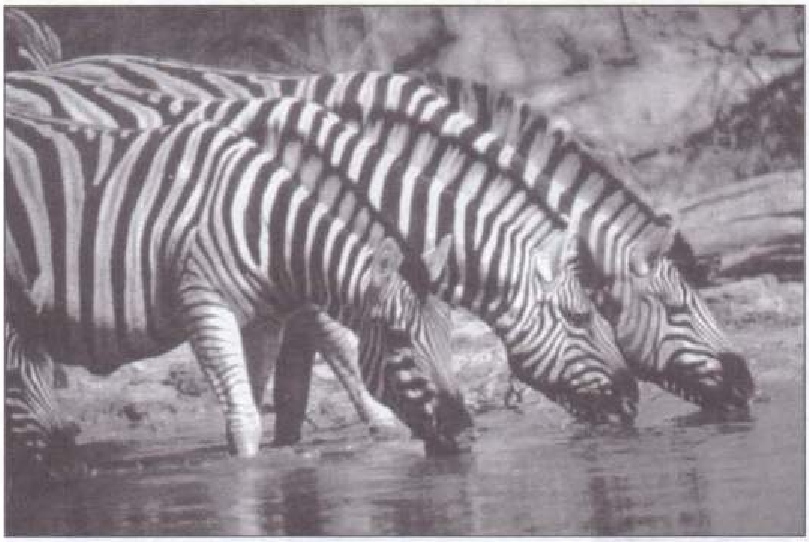


Photo 5.2 NAMIBIA REVIEW-National Parks & Wildlife

Namibia's Etosha pan, now a dried-up lake, supports a large population of wild animals, with ample waterholes in the wet season.

One of the areas that has been severely impacted by drought is Namibia's Etosha Pan, which has attracted the attention of US scientists from the University of Virginia. They are probing air and soil around the pan, now a dried-up lake. In wetter years, it was one of Africa's major breeding grounds for flamingos. When the lake last held ample water, in 1979, more than 200,000 flamingos nested on its islands.

Even in Tanzania, which gets more reliable rains than elsewhere in the region, rainfall can be low and uncertain in parts of the country. For example, in the capital city of Dodoma, in the central part of the country, the rainfall is extremely variable.[16] Tanzania experienced droughts from 1943 to 1993. Recent research in central Tanzania indicates a serious drought and famine in every 10 years, characterised by years ending with the number 3 or 4 in every decade.[17]

Trends and patterns in regional rainfall

Southern Africa's rainfall is variable, but there has been no evidence of long-term change in rainfall patterns. Nor is there any indication that the region's climate is becoming drier overall.[18] A 100-year study (1880-1980) of weather patterns in East Africa — based on air temperature, rainfall, mountain glaciers and lake levels — detected no long-term climatic change.[19] Only short-term climatic fluctuations were noted. Similar studies of long-term records have been car-

Climatic change 1800-1992 — Table 5.1

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

❖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.

SOURCE: Tyson, P.D., *Climate Change and Variability in Southern Africa*, Oxford University Press, Cape Town, 1987 ried out in other countries in the region, with the same conclusions being drawn.

Regional weather systems

The Intertropical Convergence Zone (ITCZ) brings most of the rain that falls in the region. 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. This movement is linked to the position of the sun in relation to the region, which marks the seasons. During summer, when the sun is directly overhead between the equator and the Tropic of Capricorn, it heats the ocean and other water bodies. This causes warm, moist air to rise into the atmosphere, often resulting in substantial and rain-bearing clouds. During the summer months, the ITCZ is the main rain-bearing system over most of southern Africa.

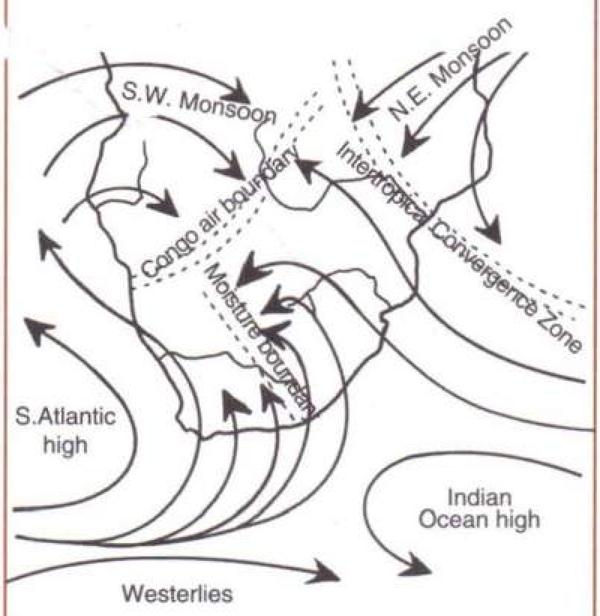
One indicator of how well a season is performing is to monitor the position of the ITCZ, and compare this to its "normal" position at different phases during the rainy season. In a normal year, the ITCZ can fluctuate between mid-Tanzania and southern Zimbabwe, bringing good rains to most of southern Africa.

The ITCZ and other main rain-bearing systems have often been inactive in recent years and less effective in promoting rainfall. An atmospheric condition known as the Botswana Upper High also creates unfavourable conditions for heavy rainfall.[20] Its frequent occurrence almost always results in drought in some countries in the region. 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.

Rainfall variations across southern Africa

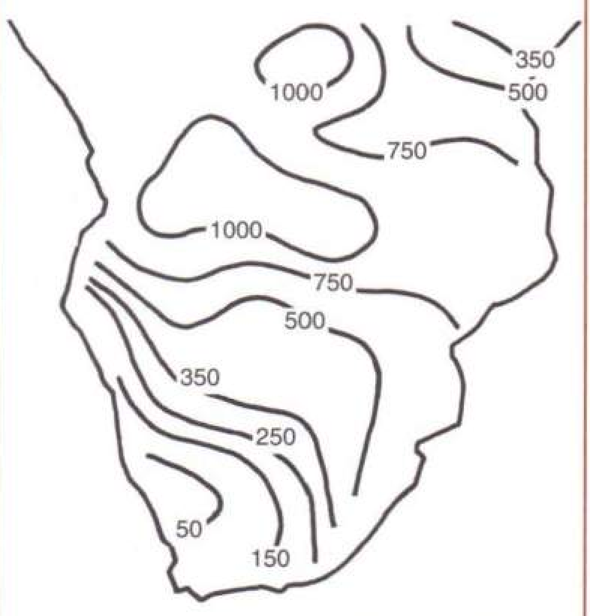
Rainfall in southern Africa comes almost entirely from evaporation over the Indian ocean. During winter and drought periods, the Botswana Upper High, along with the eastern mountain belt stretching from the Drakensberg in South Africa right up to Tanzania, blocks moist air from entering the region. The Botswana Upper High is a high pressure cell centred over Botswana (hence the name) between three and six kilometres above sea level. Its establishment is unfavourable to widespread rains across southern Africa.

Basic movements of air masses over southern Africa in summer Map 5.1



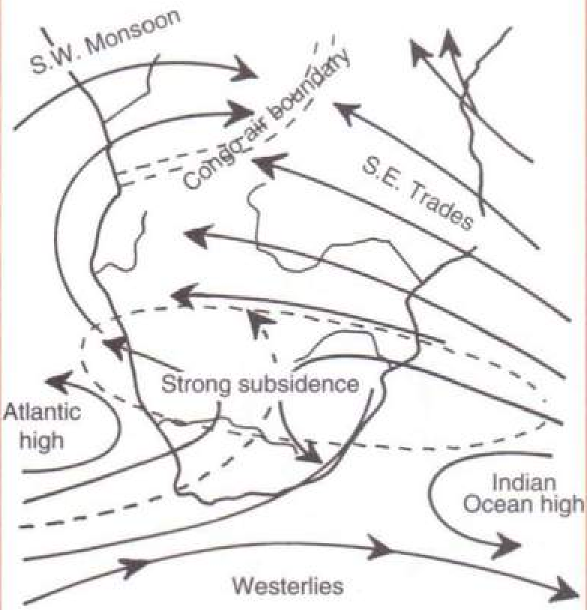
SOURCE: Van Heerden, J. and L. Hurry, *Southern Africa's Weather Patterns: An Introductory Guide*, Acacia Books, South Africa, 1992

Mean summer rainfall (mm) over southern Africa Map 5.2



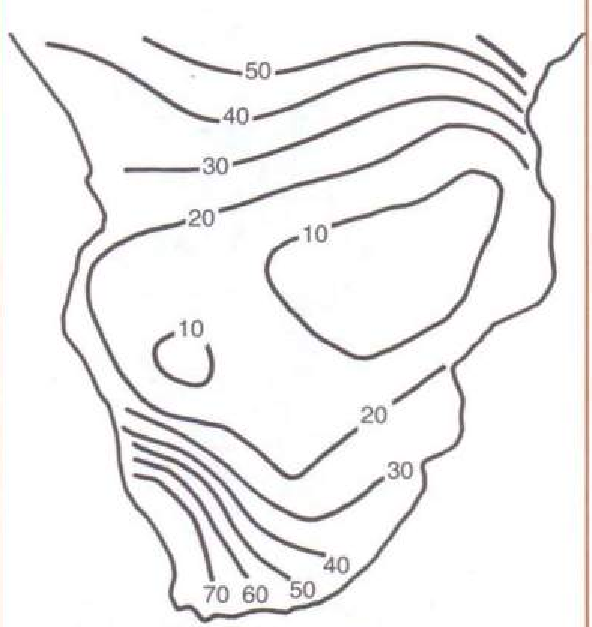
SOURCE: Rocha, A.M.C., "The Influence of Global Sea Surface Temperatures on Southern Africa Summer Climate", Phd Thesis, Meteorological Department, University of Melbourne, 1992

Basic movements of air masses over southern Africa in winter Map 5.3



SOURCE: Van Heerden, J. and L. Hurry, *Southern Africa's Weather Patterns: An Introductory Guide*, Acacia Books, South Africa, 1992

Mean winter rainfall as a percentage of the annual total Map 5.4



SOURCE: Rocha, A.M.C., "The Influence of Global Sea Surface Temperatures on Southern Africa Summer Climate", Phd Thesis, Meteorological Department, University of Melbourne, 1992

Moisture in the air generally increases from southwest to northeast in the region. Rainfall increases toward the equator, with the south and west of the region being arid or semi-arid.[21] 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.[22] Examples are the nama-karoo, succulent karoo and desert. The dry savanna and fynbos zones have slightly more rain and less variation.

Malawi, located within the moist savanna zone, experiences fewer droughts because of the mountains which stimulate rainfall. The country's relatively good rains have made it a natural refuge for migrants from drought-prone areas.[23]

RAINFALL AND ECOZONES

Rainfall patterns, and the frequency and intensity of drought cycles, negatively affect the region's ecozones on a regular basis. The drier ecozones (the nama-karoo, succulent karoo, desert and large parts of the dry savanna) are particularly affected. 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. It is particularly so in areas where the amount of rainfall differs on a yearly basis from the average by more than one-third.[24] As the variation increases, so does the amount of change. The length of the drought seems to have a much stronger effect than its intensity. Plants and animals can survive a short, very dry spell more easily than a longer spell which is not as dry.[25]

Plants need water to survive and grow. Research has shown that in dry grasslands, the amount of grass cover can increase by up to seven times during a wet period.[26] In the desert ecozone, rainfall can vary by 100 percent from year to year, with the vegetation produced varying by up to 50 percent. During dry periods, some plants become extinct in their local areas while the same species thrive in areas of abundant rainfall. This may prevent the species from becoming extinct. The dry and wet periods also lead to changes in composition of plant species. Studies on dry grassland have shown variations of species composition directly related to dry and wet changes.

In areas which fall between the summer and winter rainfall areas, there seem to be opposing wet and dry cycles. When the winter rainfall area is in a dry cycle, the summer rainfall

Photo 5.3 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO-R Rangel

People and wildlife adapt to rainfall patterns, changing their habits to suit the weather conditions.

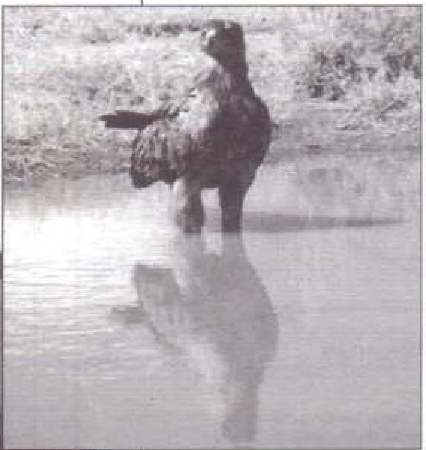


Photo 5.4 SARDC-P Johnson

area is in a wet cycle. Parts of the nama-karoo area which fall between these two zones are affected by these cycles. Summer rainfall tends to favour grass, so during periods of high summer rainfall grasses dominate. But grasses go dormant in winter, so when winter rainfall is higher the shrubs are the winners.[27]

Animals which feed on plants are affected by these cycles. Their numbers increase and decrease dramatically in response to rainfall, which determines the amount of food available. Animals such as the wildebeest experience a population explosion during wet periods, followed by near-extinction during drought years — particularly where normal movements are restricted by fences and people.[28] This is also true for cattle, although artificial water-holes have helped many through a short drought.

The type of animals found in an ecozone also changes with the plant species composition. More grazers (grass-eaters) move into an area during a period of abundant grasses. Browsers (leaf-eaters) take over during times when leafy shrubs are dominant.[29] Large mammals tend to roam over large areas in search of food and water during drought. Elephants, which require large amounts of food, migrate in search of food and dig for water in dry river beds.

The vegetation in such regions has adapted to dry and variable environments. Some plants have specialised roots which store large amounts of water. Deep-rooting plants can obtain moisture at great depth and for longer periods. Examples of such plants are found in the Kgalagadi sands of Botswana, southern Zambia and western Zimbabwe where species such as the Zambezi teak remain in leaf throughout the year. Succulent plants, which have thick fleshy leaves or stems which store water, are also common in the region. Other plants are deciduous, shedding their leaves during the dry season to cut water loss through leaves. Still others can lie dormant for a long time until the next rains come, even a couple of years later.

FACTORS THAT WORSEN DROUGHT

Though droughts in southern Africa are regular climatic events, there is some question as to whether human activities may adversely affect weather patterns. Some scientists argue that severe deforestation or overgrazing over large areas may result in dry rather than fairly moist, warm air rising, enhancing the chances of drought. This view is contentious, as explained by a Canadian climatologist, who wrote in 1984 that while Africa's droughts are considered by most researchers to be aspects of natural fluctuation:

Weather monitoring and reporting in southern Africa Box 5.2

The World Meteorological Organisation (WMO) and the United Nations Food and Agricultural Organisation (FAO) assist southern Africa with weather monitoring.

The WMO project "Drought monitoring for eastern and southern Africa" consists of the drought-monitoring centres in Nairobi and Harare. FAO's involvement is mostly through the National Early Warning Units (NEWU) of SADC as well as through the Regional Early Warning Unit (REWU) based in Harare. Member countries send raw weather data to the centres. The centres in turn prepare bulletins such as the *Ten-Day Drought Watch for Southern Africa* and the monthly *Drought Monitoring Bulletin.*

Meteorological data is exchanged among member countries and the drought monitoring centres through WMO's Global Telecommunications system, by fax and telephone, but the performance of some modes of communication has not been satisfactory. Poor communication remains one of the major constraints to effective exchange of meteorological data in southern Africa.

Publications such as *Impact,* a magazine published by Climate Network Africa, inform on rainfall and distribution in southern Africa. Their information is supplied by the drought monitoring centres. REWU regularly publishes weather information of interest to farmers, policymakers, donor agencies and others concerned with food security.

While information and weather forecasting is available in the region, there has often been a lack of appreciation by government officials of the value of such information for planning purposes. Prior to the widespread drought of 1991-92, the drought monitoring centres advised all national weather services about the possibility of drought due to persistent anomalous atmospheric and oceanic behaviour, nine months before the eventual calamity. But some governments in the region did not act quickly, and were found wanting when the drought eventually came.

The challenge ahead is to ensure that weather information is translated into management decisions if crises are to be avoided.

SOURCE: Maurice Muchinda, "Global Weather Patterns in Relation to Southern Africa", Drought Monitoring Centre, Nairobi, Sept 1993

"... it is conceivable — though still unlikely in the view of some professionals — that human interference may be prolonging and intensifying the dry spells natural to the climate."[30]

There is no conclusive evidence linking poor land-use with decreased rainfall in southern Africa. Human activities do, however, increase the impacts of drought. There is agreement that the impacts are becoming more severe in southern Africa, and the environment more susceptible to irreversible damage as a result. Rapidly increasing numbers of people in southern Africa put more pressure on resources and lead to clearing of vegetation, use of marginal land, inappropriate land-uses and soil degradation, altering the landscape in the process. This has led to adverse environmental developments such as no groundwater recharge and flash floods.

Natural resource degradation

Droughts intensify land degradation and weaken the land's resilience — its ability to bounce back to full production after a drought episode. Overgrazing and poor cultivation practices in combination with drought can lead to the deterioration of pastures and arable land to the point where they must be abandoned.

There is little documented evidence yet to support the theory that overgrazing and expanding cultivation reduce the amount of rain that falls in the region. The more obvious result of overgrazing and overcultivation is soil erosion, floods, reduction of productivity and species shifts when the rains eventually return.[31]

Drought also directly results in the loss of trees and a lack of regeneration. Vegetation cover loss enhances the impact of drought in two major ways: the increase of rainfall runoff, and evaporation. Increased rainfall runoff affects many soil types, reducing nutrients, organic matter and moisture availability for the remaining plants. The increased daytime temperature range, because of the loss of vegetation cover, may also inhibit the regeneration or establishment of woody plants. In the end, woody plants using moisture from much deeper in the soil dominate at the expense of the more shallow-rooted grasses and trees which utilise moisture in the surface layers of the soil. All of this results in a significant change in species composition.

IMPACTS OF DROUGHT

Drought has its greatest impact on water supplies. Lack of water affects every aspect of environmental health and human activities, including agriculture, natural areas, industry and development projects.

Agriculture

Agriculture is the sector most directly affected by drought, and the impact can be extreme in dryland farming areas which rely on rain to provide water for crops. In Botswana, for example, where most cultivation is rain-fed, between 1979-1981 production fell from 60,000 tonnes to below 20,000 tonnes due to lack of rainfall. In 1984, production was as low as 7,000 tonnes. This represented a food decline from 715 to 100 kg per family as a result of drought.[32] In arable areas, problems of soil erosion are intensified and worsened during a drought. This is basically due to severe loss of vegetation during the dry spell.

Drought is the most important factor limiting livestock production in Africa. A single-season drought does not have a major impact on livestock numbers as the animals can survive, though they may not put on weight or breed. However, a drought lasting two or three seasons exhausts the available food sources, decimating herds. In Botswana, for example, drought reduced cattle numbers from 1.35 million to 900,000 in the dry years of 1964-67.[33] The 1991-92 drought, which ravaged most of southern Africa, killed more than one million cattle in Zimbabwe and many more in other coun-

Livestock and drought Box 5.3

Livestock can be severely affected during times of drought, and can die in large numbers under persistent dry conditions.

❖ During the 1980s drought, cattle in the Mopane area around Palapye and Francistown, Botswana, were in much better physical condition than those further south because *mopane* trees — which can be browsed — still had leaves.

❖ During the 1991-92 drought, Zimbabwe's commercial and communal farmers lost more than 1.5 million head of cattle, and agricultural experts believe it will be several years before the national herd fully recovers.

❖ In Lesotho, all livestock importation from South Africa is halted during a drought to give way to local sales of beasts. This is aimed at reducing grazing pressure on the rangelands.

❖ In Botswana, where cattle production constitutes a major economic base, a decrease in cattle population is a great loss. Rural people depend on their cattle for food and draught power. Loss of cattle forces them to hire tractors, which most cannot afford. In 1988-89, when the rains came, most communal farmers in Botswana had no draught power because their herds had been destroyed by the drought.

❖ Livestock numbers in the Kgalagadi have been flexible, adjusting to rainfall conditions. In the 1950s and 1960s, livestock increased rapidly. When drought set in, more than half of the livestock died. The 1970s brought another improvement in rainfall and an increase in livestock.

SOURCE: Zumer-Linder, M., "Botswana: Can Desert Encroachment be Stopped?", *Ecology Bulletin*, Vol 24, 1976, p. 179

Photo 5.5 SOUTHLIGHT-P Grendon
Intensive livestock farming can threaten fragile soils, especially in times of drought. Near Rietfontein in Northern Cape, 1990.

tries of the region. During a drought, overgrazing leads to further degradation of pastures and arable areas in cattle farming-areas. The deterioration of grazing capacity further reduces livestock numbers.

In drier areas, scanty rainfall for a few years can kill vegetation permanently and poor land-practices only make it worse.[34] In Namibia, for example, degradation of pasture is caused by interaction of overstocking and drought cycles.[35] Drought can also exacerbate deforestation, as some of those whose crops are lost attempt to make money by selling firewood.

Urban areas and industry

Drought also affects urban areas and industry. During the mid-1980s drought, the construction industry in Botswana was forced to reduce its activities after water reservoirs fell to critical levels. Beverage companies, which use a lot of water to wash bottles, had to change to non-returnable aluminium cans which require less water. The 1991-92 drought was no different. Botswana's construction and textile industries had to retrench workers after operations were scaled down because of a severe shortage of water. According to the Botswana Textile Manufacturers Association, 50 percent of the workforce in the sector was laid off during the drought.

Similar problems hit Bulawayo, the heart of Zimbabwe's industrial sector. Companies were almost forced to pull out and relocate elsewhere because of a lack of water, and half of the small businesses crumbled. In South Africa, Swaziland and Zimbabwe, sugar cane industries almost ground to a halt because there was no water for irrigation.

Rivers, lakes and groundwater

The drop in water supplies in dams and rivers also affects the quality of the water. Because of the reduced water volume, the concentration of sewage and other effluent in rivers increases, resulting in outbreaks of diseases such as diarrhoea, dysentery and cholera. The cholera outbreak that affected almost every country in the region during 1992 and 1993, claiming hundreds of lives, may have been compounded by the drought.

In many drought-affected areas in Zambia, streams and rivers dried up. Villagers, mainly women, had to walk long dis-

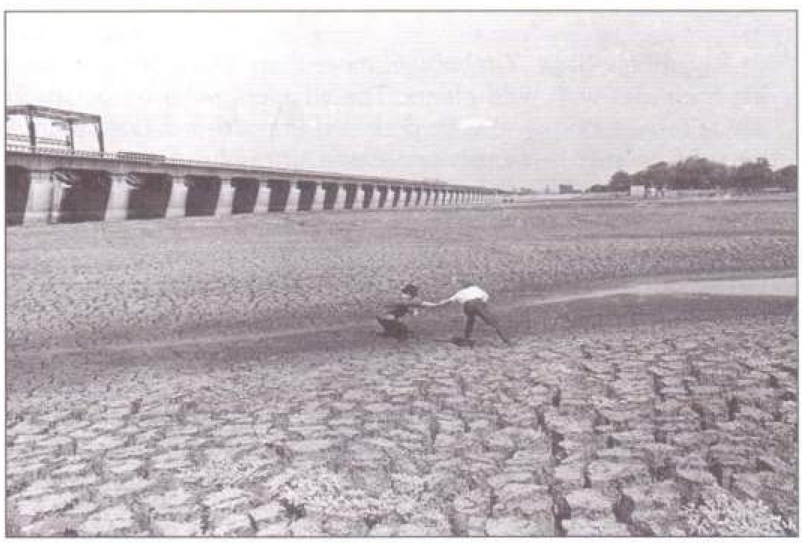


Photo 5.6 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO- R Rangel
The life-sustaining Limpopo river, almost dry in time of drought in southern Mozambique.

Indigenous responses to drought: food reserves

Box 5.4

Over hundreds of years, people in southern Africa have developed effective responses to alleviate the ravages of drought on their communities.

The Basarwa (or San people) of northern Botswana share food as a form of "risk insurance" in times of drought. The relatively well-to-do share with the less fortunate, thus ensuring that everyone in the community survives. The Basarwa also increase their hunting and foraging activities to obtain extra food reserves. They have adapted to their harsh environment, surviving on very limited resources. They can live in areas receiving an annual rainfall below 350 mm, a minimum amount considered essential for dryland agriculture. The Basarwa can go for long periods without surface water, relying mostly on food and dew that collects on wild plants.

Rural people in Botswana utilise over 250 species of wild plants and animals for food in times of drought. Most of these plants are not used during years of good rainfall, and this is vital because it gives the plants time to recover and regenerate before the next drought. The Batswana have also developed food preservation and storage methods to establish and maintain a reliable, nutritious food-base during long-running droughts. The methods include sun-drying, salting, parching and fermenting foodstuffs.

Elsewhere in the region, subsistence farmers are also turning to drought-resistant crops. Tanzanian and Zambian farmers have adopted cassava, sorghum and millet as drought reserves. During the 1991-92 drought, the Government of Zimbabwe called upon farmers to grow drought-resistant crops, most of which had been abandoned for the more commercially viable maize.

Many rural people throughout the region ate wild roots and fruits to survive. These were plants that indigenous people had known for many generations as an alternative source of food during times of hardship.

At Sagambe village, Zimbabwe, more than 1,000 families survived the drought by supplementing their diet with wild plants. The villagers, who on occasion, supplement their staple diet of *sadza* (maize porridge) with pounded flour from a bush palm known as *nyamutata*, had to rely heavily on this brownish substance throughout the drought period. Many of the villagers crossed into neighbouring Mozambique to collect this bush palm from the Tangwena mountains.

Desperate villagers in the Southern Province of Zambia also resorted to similar actions to survive the drought. The villagers collected roots, some of which were poisonous, and either boiled or soaked them in water to get rid of the poison before eating them.

During an earlier drought in 1982-84, many rural households in southern Zimbabwe generated income by harvesting, shelling and selling wild *marula* nuts, a species found in several countries in the region. The villagers used the income to buy basic foodstuffs.

SOURCES: Fluret, Anne, "Indigenous Responses to Drought in Sub-Saharan Africa", *Disasters*, Vol 10, no 3, 1986
Muir-Leresche, Kay, "Drought Relief Strategies: Some Ideas", University of Zimbabwe, Harare, n.d., p. 4

tances, only to settle for polluted water. In many cases, the villagers were forced to share the water with wild animals and their livestock, making it even more unsuitable for human consumption. This is thought to have led to widespread outbreaks of dysentery and cholera that killed hundreds of people in Zambia in 1992. It is worth noting that when a previous cholera outbreak occurred in several countries in southern Africa in the mid-1980s, the region had just come out of another drought.

Drought problems go deeper than just the availability of surface water. The water-table is usually lowered if an area is hit by recurrent droughts. The lowering of the Kuiseb water-table, in the Namib desert, resulted in the wilting and

Rural water management conquers drought Story

Gaborone (SARDC) — Peter Mosweu has no formal training but the skill he has acquired over eight decades qualifies him as a rural water-management expert and drought survivor.

The 84-year-old farmer from Botswana, who never went to college or university, today hosts groups of students from a Gaborone agricultural college at his 51-hectare farm in Dinkgwana communal lands, to show them his water-harvesting skills.

"I did not go to school to train as a water engineer," says the grey-haired, five-foot Mosweu, "but I have equally good knowledge on how to harness water and I have used those skills to build two dams."

Fed up with the 10km trek his family had to make almost every other day to and from a district borehole in Mochudi village about 40 km north of the capital, Gaborone, the farmer built his first dam using a spade. The dam, on a fast-flowing underground stream, took three years to complete. It now holds about 400 cubic metres of water, according to local estimates.

Since the dam was built more than 15 years ago, Mosweu, his family and livestock have escaped largely unscathed by the cycles of drought that grip Botswana almost on a regular basis. During the 1991-92 drought, described as the most severe in living memory, Mosweu's family and about 100 neighbours survived with their animals intact.

While many people in Botswana lost some of their animals or could not use them as draught power because they were too weak, Mosweu's livestock — cattle, donkey, pigs, goats and sheep — was in good shape.

He supplies his neighbours with water "because it's good neighbourliness to do so." His philosophy is simple: Love thy neighbour. He explains that while he may have abundant water supplies today, he may suffer shortages in other necessities tomorrow and believes his neighbours will come to his aid.

Mosweu's fame as a rural water expert has attracted the attention of the Forum on Sustainable Agriculture, a Gaborone-based non-governmental organisation. It has since invited him to participate in its farmer-to-farmer programme whose aim is to get Batswana farmers to learn from each other's experiences and share skills.

Richard Kashweeka, the Forum's co-ordinator, said Mosweu's water-harvesting skills are of great benefit to other rural farmers. "Even in dry, dry seasons he has managed to feed his family, livestock and neighbours," said Kashweeka.

— **Munyaradzi Chenje,** Southern African Research and Documentation Centre (SARDC), Jan 1994

Photo 5.7 SOUTHLIGHT-P Weinberg

Traditional crops such as sorghum and millet are more drought-resistant than maize, which requires predictable rains or irrigation.

dying of acacia trees — a valuable and vital component of the lower Kuiseb ecosystem.

Human population movements

Historically, droughts have provided an impetus for mass migrations of people in southern Africa. People tend to move from an adversely affected area to a relatively better one. In Botswana, where boreholes dried up during the 1991-92 season, people moved first from rangelands to arable areas — and eventually to urban areas. Drought has also been a factor in the movement of commercial farmers off the land. South African commercial farmers numbered 120,000 in 1982 but only 66,000 remain on the land today. The rest have abandoned their farms due to drought — moving to urban areas and creating pressure on services and employment.

Wildlife and fish populations

The migration patterns of wild animals, including birds and mammals, are determined by seasonal rainfall. In the event of a drought, migrations are disrupted and wildlife numbers decrease, particularly herbivores. Severe loss of wildlife leads to ecological imbalances and economic losses.

Fluctuations in wildlife populations are fairly common in drought-prone areas. During a wet period, numbers increase rapidly, peak and then decline when drought sets in. The 1962 drought, for example, killed nearly all the zebra in Botswana. Hundreds of thousands of wildebeest also died.[36] The 1991-92 drought, which ravaged most of southern Africa, killed a significant number of wild animals in most countries of the region.

Fish populations also tend to decline during drought. Rivers and lakes shrink, and food sources for fish decrease, resulting in low breeding and smaller catches for fishermen. The characid (a fish found in the Zambezi), for example, breeds well in a three-to-four-month period when the river flows fast. During drought, the river flows slowly and there is little breeding.[37] Inland rivers and deltas such as the Okavango Delta in Botswana are a source of food and income for villagers in surrounding areas so the loss of fish increases the hardship of the drought.

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.

Normal rainfall expected this year [1993] Story

Johannesburg (ZIANA-Reuter) — Normal rainfall levels are expected over southern Africa this year after two seasons of severe drought that hit agriculture in the region very hard, weather experts said yesterday.

"Just about all the signs we look at are close to normal at the moment," weather researcher Simon Mason said in an interview. "The implications for the next two-to-three months are that the prospects for close to normal rains are very good and the chance of a bad start to the season or a particularly wet start are rather low."

The rainy season runs from October to April, covering an area running from around 10 degrees of latitude — from northern Angola, Zaire, Malawi and southern Tanzania through Zambia, Zimbabwe and Mozambique to the southern tip of the continent.

The region's weather is primarily governed by a massive area of equatorial ocean stretching from the Peruvian coast 10,000 km westwards to the international dateline in the central Pacific.

Surface warmth in the area, a phenomenon known as *El Nino*, spells drought for southern Africa. Conversely, an unusually cold surface current, *La Nina*, heralds unusually heavy rain.

Mason said a particularly strong *El Nino* developed at the start of the 1991-92 rainy season, bringing the worst drought of the century to much of southern Africa. Crops withered and hard-pressed governments were forced to spend scarce foreign currency to import food for their people.

South Africa, the main import point for drought relief for much of the region, has just received a soft loan of $850 million from the International Monetary Fund to help pay for emergency grain purchases.

El Nino conditions weakened in the first part of 1992, but suddenly and unexpectedly strengthened again last December, bringing a second successive year of drought, although less severe, in the 1992-93 rainy season to last April.

"This persisted through the first half of 1993, but there are indications that it weakened in July this year," said Michael Edwards, deputy director of the South African Weather Bureau. "Statistically over the past 70 years there has never been a period of three consecutive drought years — less than 75 percent of average rainfall over the main rainfall regions of South Africa."

He said there had been only two instances of two consecutive drought years during this period — between 1925-1927 and 1991-1993.

Unusually cold water in the western equatorial Indian Ocean means good rains, while warm water indicates drought conditions. Mason said the ocean temperature was now about normal after two years of fairly warm water.

—The Herald, Zimbabwe Newspapers, Harare, 29 Sep 1993

Linkages to other chapters Box 5.5

1 PEOPLE
Human activities can increase the severity of short- and long-term impacts of droughts.

2 HISTORY
Climate change/drought is a recurring phenomenon in southern African history.
Over hundreds of years, people in this region have developed effective responses.

3 POLICY
Government policies and implementation largely determine the region's ability to respond to extreme weather conditions, including droughts, floods and other natural disasters.

4 ECOZONES
Climatic factors, particularly the amount and variability of rainfall, determine the distribution of animals and plants, and the characteristics of the ecological zones.

6 SOILS
Drought is an overriding factor in degradation of cultivated lands and rangelands in southern Africa, chiefly because of its impact on plant cover.

7 WOODLANDS
Drought has a similar effect to fire, killing trees and seedlings and reducing the ability of woodlands to regenerate. Fuelwood supplies increase during drought because trees die and provide more firewood, but its scarcity later is a lasting negative impact.

8 WILDLIFE
Wildlife populations decrease, sometimes dramatically, in times of drought because of reduced water and food supplies, and a greater vulnerability to predators. Weather and rainfall are significant factors in the distribution and abundance of wild animals in the savanna woodlands and other zones. Repeated severe droughts can reduce biodiversity by killing some species.

9 FRESH WATER
During periods of high rainfall, eroded soil causes siltation in rivers, damaging fish habitat and reducing dam storage capacities. During drought, there is less water available for natural systems and human activities, affecting the progress of development and construction projects.

10 MARINE
Occurence of drought in southern Africa is believed to be linked to a weather condition called *El Nino* which begins with the warming of waters in the western Pacific ocean.

11 POLLUTION
Weather patterns often have an impact on pollution levels. Flooding increases pollution from overflowing waste disposal sites. The drying of streams and rivers during drought increases the concentration of pollutants in surface waters. Groundwater quality deteriorates, becoming more saline (salty) and unsuitable for consumption.

12 ARMED CONFLICT
Drought can have serious impacts in a war situation where normal relief mechanisms cannot operate. Armed conflict together with drought can lead to serious environmental abuses as people struggle to survive.

13 GLOBAL
Global atmospheric changes are linked to releases of polluting gases, such as carbon dioxide. Global warming is expected to result in more frequent and extreme weather events including severe storms and droughts.

14 TRENDS
Climatic change and drought are recurrent cycles in most parts of southern Africa, but information systems and early-warning capabilities have improved. Government officials, NGOs and others are beginning to make use of this information for planning purposes.

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6

SOILS
and Land Use

Southern Africa's agricultural potential is extremely varied, with some areas exceptionally productive and others almost barren. The region has a wide variety of soil types, due to its complex geology coupled with more than 3,800 million years of weathering, the long, hot, dry season, and unreliable, but sometimes heavy, rainfall.

Less than half the region's soils are suitable for cultivation, being relatively infertile and difficult to manage. High temperatures quickly break down organic matter so nutrients are readily weathered away. Most soil nutrients are concentrated in the top few centimetres, so even a minor loss of soil to erosion can seriously affect productivity.

Water is another limiting factor. Southern Africa's rainfall is exceedingly variable and unreliable, and a large portion of the region receives insufficient rainfall to support cultivation without irrigation. Soils are often shallow, without much ability to absorb or store water, and are vulnerable to short-term declines in rainfall. Low levels of rainfall in Botswana, Namibia and South Africa have limited the agricultural potential despite areas of good soils. Portions of Mozambique, Tanzania and Zambia have better rainfall but poor soils.

These extremes of soil types and conditions demand astute and specialised management based on local conditions, as different soils respond differently to techniques aimed at preserving fertility or increasing crop yields.

Over the past 25 years, southern Africa's overall agricultural output has increased substantially, but most of this increase has been in high-value, horticultural exports from South Africa, Swaziland and Zimbabwe. Average crop-yields per hectare increased between 1950 and 1970, but production of basic foodstuffs such as maize and rice failed to keep pace with population growth. Based on a 1961-65 average production index of 100, food production per person rose in both Asia and Latin America from 100 to 115 while in Africa it fell from 100 to 80.[1] Only South Africa, Malawi and Zimbabwe have the capacity to export cereals to other markets in the region,[2] and this may not be sustainable over the long term.

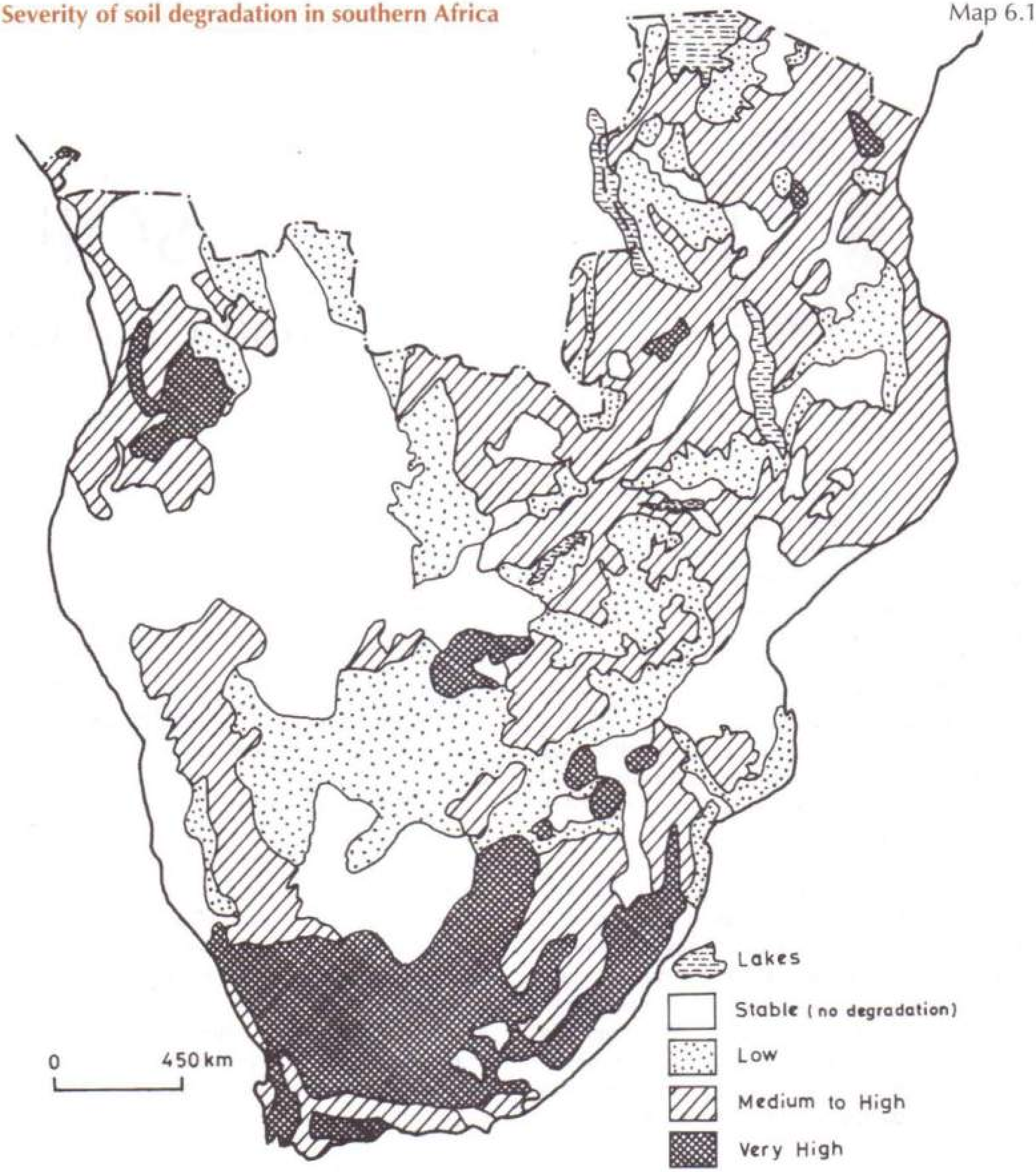
SOIL DEGRADATION

A combination of inequitable land allocations leading to high population densities in specific areas, and poor farming methods, have led to declining productivity of grazing lands, falling crop yields and diminishing water supplies. This has been aggravated by increases in livestock numbers without a commensurate increase in land area for grazing. Overgrazing causes more than half of the soil degradation in southern Africa, according to the United Nations Environment Programme (UNEP), with cultivation responsible for most of the remainder. Domestic subsistence use of trees for fuelwood, fencing and other purposes is a relatively minor cause.

Crop yields can be increased and maintained by using improved seed varieties and fertilisers for a time, but eventually real productivity declines due to soil degradation. Experts predict that crop yields in the region will be halved in 30-50 years if degradation of cultivated lands continues at present rates.[3] The effectiveness of fertilisers has already been cut in half in the most intensely cropped areas near

Severity of soil degradation in southern Africa

Map 6.1



Low degradation
The land has somewhat reduced agriculture suitability with part of the topsoil removed. On rangelands, restoration to full productivity is possible with improvement of the agricultural system at farmer level.

Moderate to high degradation
The land has greatly reduced agricultural productivity. Major improvements are required to restore it.

Very high degradation
The land is not reclaimable at farm level without major engineering works.

SOURCE: UNEP/ISRIC, CRU/UEA as in Middleton, Nicholas J. and David S.G. Thomas, *World Atlas of Desertification*, UNEP and Edward Arnold, Nairobi and London, 1992

The living soil Box 6.1

Soil is an ecosystem, formed by both physical and biological processes, and made up of hundreds or thousands of different species that behave much as they do in other ecosystems. When soil is degraded by overgrazing or overcultivation, the effect on the soil ecosystem is similar to disturbance of other ecosystems. It loses species in the same manner that species are lost from a forest ecosystem when trees are cut. Once the top layer of soil is removed by erosion, soil formation slows to insignificant rates because the key soil-forming organisms have gone. Soil is not a dead, inert material, but contains both living and non-living substances.

SOURCE: Senanayake, Ranil, "Feed the Soil, Not the Plant", *Ecoforum*, A Publication of the Environment Liaison Centre International, June 1993, Vol 17, no 3, p. 22

Lilongwe in Malawi, for example, following more than two decades of erosion.[4]

Many southern African economies depend on commercial farming, and more than two-thirds of the region's people are rural farmers and pastoralists who live with soil degradation and suffer from the effects. The loss of natural nutrients such as nitrogen and phosphorus is a massive drain on the region's natural resources and economies, estimated to cost as much as US$50 per hectare on cultivated land and US$80 per hectare on grazing lands.[5]

The loss in productivity set in motion by soil erosion is a self-perpetuating process. Soils that have been degraded become more vulnerable to further degradation. The process is difficult to control because it is complex, with a number of causes. Soils take a long time to renew themselves. In most parts of the region the amount of soil formed every year is less than a third of a tonne, depending on the soil type. At this rate, it takes 40 years to produce one millimetre of topsoil. If soil is lost faster than it is formed, there can be no sustainability.

The most extensive serious degradation is found in grazing lands in central and western South Africa. There are localised pockets of serious degradation between Luanda and Huambo in Angola, in northeastern Botswana, and in central and northeastern Tanzania. More than half of the region has little or no soil degradation.

Information reliability

Soil loss in southern Africa is commonly calculated on a national basis:

- Zambia's government estimated recently that the country loses three million tonnes of topsoil from cultivated land each year;
- Swaziland is estimated to lose 50,000 tonnes of soil per year through gully erosion alone;
- soil loss for the Save Catchment area in Zimbabwe is estimated at 96 million tonnes annually;
- soil losses for South Africa are estimated at 300-400 million tonnes annually.

These figures are interesting and perhaps alarming but, generally, soil erosion losses by volume or weight of sediments are poor indicators of productivity. Reductions in crop yields per unit of erosion are extremely variable, and sometimes the most badly degraded areas produce the least sediment. In South Africa, for example, much of the topsoil was washed away to sea during the early part of this century, and today erosion rates are lower, simply because there is less material to be eroded. As a majority of soil-erosion experiments do not report yield levels, it follows that in general they are not very useful for analysing productivity changes.[6] Statements about the threatening advance of soil degradation have tended to be overblown, without much basis in fact.[7]

Another problem in determining the extent and degree of soil degradation in southern Africa is that there is no single agreed way to measure it. Different methods of collecting soil-loss information mean that results are not necessarily comparable from country to country, or even from year to year. Most of the variation in erosion rates reported in different studies seems to have had more to do with the way soil loss was measured than with erosion itself.

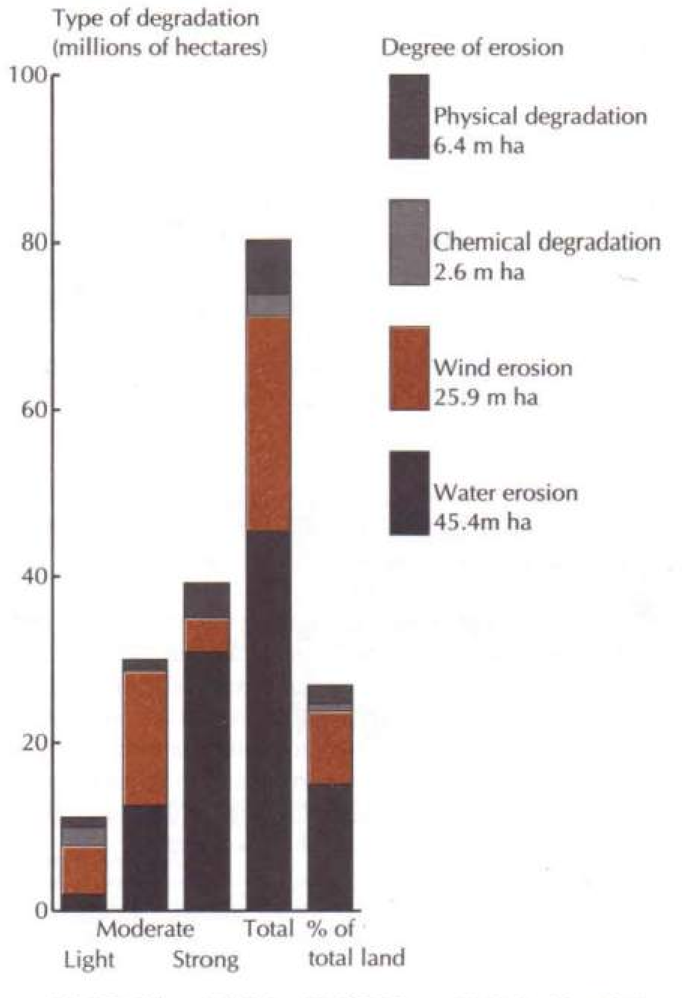
Given the importance of soil degradation, it is surprising how little is known about its extent, how it happens, or how to control it cost-effectively.[8] There are serious information gaps despite decades of warnings, research and legislation.

Without this information, it is impossible to say definitely how quickly soil degradation rates are increasing or how severe the regional problem might be.[9]

Types of soil degradation

The four main types of degradation are water and wind erosion, chemical and physical degradation. These are not mutually exclusive. Physical degradation frequently follows chemical degradation, for example, and wind and water erosion often operate together.

Southern African land affected by water and wind erosion, chemical and physical degradation, and degree of degradation Figure 6.1



SOURCE: Middleton, Nicholas J. and David S.G. Thomas, *World Atlas of Desertification*, London, UK, Edward Arnold, 1992

Water erosion

Erosion by water is probably the most important factor in the decline in agricultural productivity in this region. About 15 percent of southern Africa's land is degraded because of water eating away at the land.

Water erosion starts with the hammering action of raindrops. One raindrop does very little damage, but during a typical heavy rainstorm, millions of raindrops bombard each square metre of soil. One millimetre of rainfall per hectare weighs 10 tonnes, so an average rainfall of 40 mm is equivalent to 400 tonnes of water, with the larger drops striking the soil at about 20 km/hr. This powerful force breaks up the soil aggregates, or crumbs, at the surface. The fine loose particles are easily dislodged and washed away over the surface of the ground.

The damage from water erosion is greatest on slopes and hillsides. The runoff picks up a load of soil, sand and small stones which give it added abrasive power, like grit on sandpaper. A tenfold increase in the speed of runoff increases its ability to carry sediment by a million times.

How much soil is actually carried away is a function of how hard the rain falls and for how long, the type of soil, the slope of the land, and the plant cover. Extensive experiments in Zimbabwe show that rain is most erosive when it falls at more than 25 mm/hr. Europe and North America have rain throughout the year and rainfall intensities seldom exceed 25 mm/hr. In southern Africa, where most of the rain falls within a few days, rainfalls of 30 or even 40 mm/hr are common and bigger storms a fact of life. Over half of annual soil loss can occur during 10 minutes of the year's most severe storm. In eastern Zambia, for example, a single rainstorm in 1987 removed five centimetres of topsoil from a study area.[10]

Wind erosion

Wind erosion is less well-studied and documented than water erosion, though it is significant in some areas, accounting for about nine percent of the soil degradation in southern Africa. It is most severe in dry, flat areas where vegetative cover is poor and

Sheetwash Box 6.2

The most common and widespread type of erosion is sheetwash — rainfall washing soil evenly over the land. Globally, this accounts for about half of all soil degradation. It reduces the ability of the soil to hold water by removing the most productive top layer and making the soil more shallow. Gullies are the end result of sheet erosion, usually growing in years of above average rainfall, especially after a period of drought when the plant cover has died.

SOURCE: Oldeman, L.R. and others, *World Map of the Status of Human-Induced Soil Degradation: A Brief Explanatory Note*, ISRIC/UNEP, Nairobi, Apr 1991

winds blow strongly, such as the Kgalagadi desert in Botswana and Namibia, and parts of South Africa, Tanzania and Zimbabwe.

The amount of soil carried away depends on the gustiness of the wind and the stability of the soil. Raindrops make the soil more easily eroded by wind, as the fine soil particles dislodged by rain are easily picked up by wind. Soil structure is determined by the proportion of sand to finer silt and clay particles, and the amount of organic matter binding them together. Thus, removal of fine particles by wind degrades the soil structure, reducing its fertility and its ability to store water.

Wind-blown soil particles contribute to the sedimentation of dams and wetlands. Abrasion of soil by moving soil particles is another serious off-site impact. The bouncing particles bombard the soil, break down the soil structure and increase its vulnerability to erosion. Crops are buried, shredded and in extreme cases cut from their roots. Blowing sediment can blanket roads and buildings, reduce visibility and affects the health of people and livestock. Eroded soil from Africa blows many thousands of kilometres. It has been found as far away as South America and is said to contribute to the fertility of soils in the Amazon basin.

Physical degradation

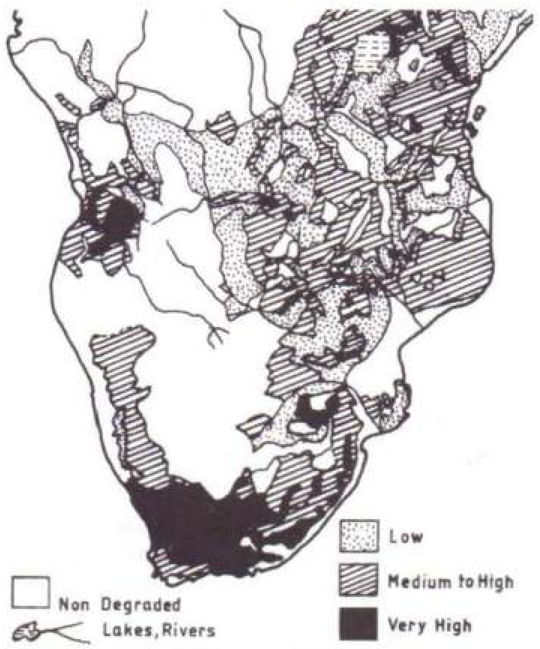
About two percent of southern Africa's soils are damaged by physical degradation, which includes changes in sealing and crusting of topsoil, loss of water-holding capacity, compaction of topsoil, waterlogging and aridification. Most physical degradation is related to rainfall. After heavy rains, the fine mud left on the soil surface dries, sealing the soil surface and making it hard for water to seep through. Crusting impairs oxygen and carbon dioxide exchange between the soil and the air, necessary for plant growth, and makes it difficult for seedlings to grow. Less water seeps into the soil, decreasing groundwater recharge.

Photo 6.1 IRIS-C Thege

Soil erosion from water, wind or chemicals can destroy a resource which has taken hundreds of years to develop.

Areas with water erosion

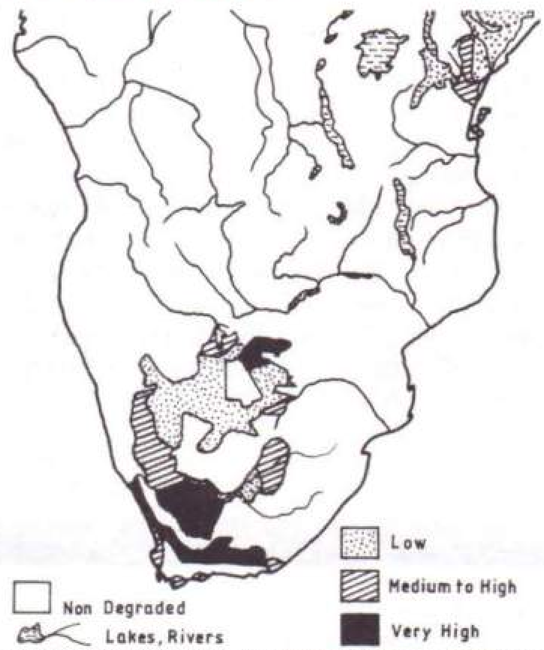
Map 6.2



SOURCE: UNEP/ISRIC, CRU/UEA as in Middleton, Nicholas J. and David S.G. Thomas, *World Atlas of Desertification*, UNEP and Edward Arnold, Nairobi and London, 1992

Areas with wind erosion

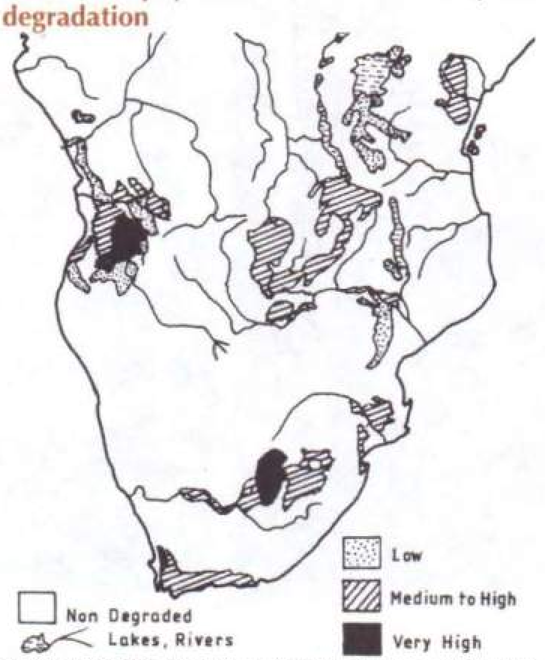
Map 6.3



SOURCE: UNEP/ISRIC, CRU/UEA as in Middleton, Nicholas J. and David S.G. Thomas, *World Atlas of Desertification*, UNEP and Edward Arnold, Nairobi and London, 1992

Areas with physical degradation

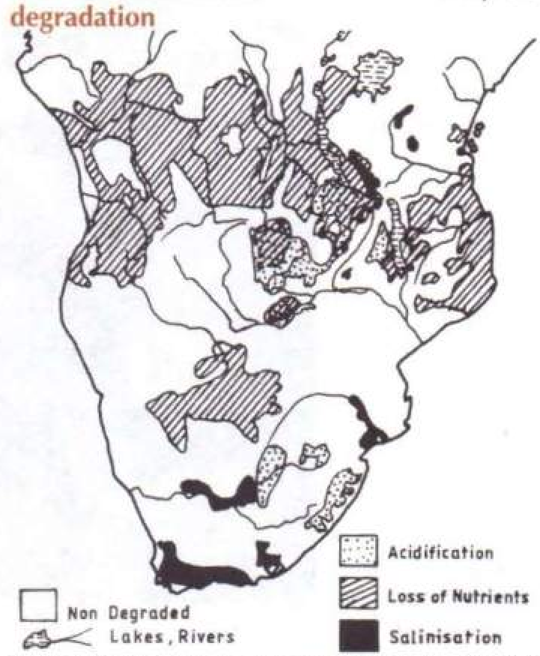
Map 6.4



SOURCE: UNEP/ISRIC, CRU/UEA as in Middleton, Nicholas J. and David S.G. Thomas, *World Atlas of Desertification*, UNEP and Edward Arnold, Nairobi and London, 1992

Areas with chemical degradation

Map 6.5



SOURCE: UNEP/ISRIC, CRU/UEA as in Middleton, Nicholas J. and David S.G. Thomas, *World Atlas of Desertification*, UNEP and Edward Arnold, Nairobi and London, 1992

Compaction of soil, caused by trampling cattle and heavy farm machinery, has similar effects to sealing and crusting. Mature cattle can exert a ground pressure of some 1.7 kg/sq cm of hoof-bearing area. This is comparable to the force exerted by heavy-wheeled tractors, which may affect soil densities to a depth of one metre[11] and cause a decline in crop yields of 30-40 percent. In dry savanna in east Africa, trampling by cattle was found to reduce water infiltration by as much as 40 percent.[12] This represents a large loss of water, equivalent to almost half the rainfall.

Waterlogging results from natural flooding and from over-irrigation which brings underground water levels to the surface. Air in the soil is displaced by water, with corresponding changes in soil processes and an accumulation of toxic substances which impede plant growth.

Aridification is a drop in local groundwater levels, the opposite of waterlogging, and results from crusting and compaction or overuse of water resources. Aridification can also follow the replacement of natural vegetation with a crop needing more moisture — the replacement of dryland grasses with wheat, for example. Aridification reduces the ability of the soil to store water and, over the long term, makes soil more susceptible to erosion.

Chemical degradation

Chemical degradation refers to changes in soil chemistry resulting from human activities — especially input-intensive agriculture and irrigation. It includes salinisation, nutrient and organic-matter loss, acidification and pollution. It is an unfortunate paradox that in water-deficient areas, use of too much water ruins agricultural lands. According to estimates, as much as half of the world's irrigated lands have been damaged by too much water.

Africa as a whole has approximately 9.5 million hectares (m ha) of cropland under irrigation, made up of 6.1m ha of modern schemes and 3.4m ha of small-scale and traditional schemes. Land under irrigation amounts to about five percent of Africa's agricultural land (compared to 20 percent in developing countries as a whole), but in some cases is higher. Irrigation in Swaziland, for example, takes up 1,465 sq km — eight percent of the country and about 75 percent of the arable land.

The main form of chemical degradation is salinisation — the surface or near-surface accumulation of salts. Salts are naturally present in soils and are normally found deep underground. When irrigation water is applied in amounts exceeding those used by plants, the extra water sinks into the soil and raises the level of the groundwater. This dissolves salts stored deep in the soil, and moves them up into the root zone or to the surface as the water evaporates. Where groundwater is used for irrigation the problem is increased because much of the region's groundwater contains dissolved salts.

Accumulation of salts in the pore spaces in soil reduces its ability to hold air, water and nutrients, all essential for plant growth. The presence of salts causes nutrients such as magnesium and calcium to become bound to clay particles and unavailable to plants. Excess salt accumulation makes it difficult for plants to take up moisture through their roots. Salty soil literally sucks the water out of plants, making it difficult for them to grow.

Nutrient depletion is another type of chemical degradation. Grassland nutrients are mainly stored in the plants rather than the soil and can be depleted by frequent fires. Nutrient depletion occurs where the replenishment of the soil's fertility by annual flooding has been prevented by dam construction. Erosion by water and wind also removes nutrients.

SOUTHERN AFRICA'S VULNERABILITY TO DEGRADATION

In undisturbed nature, the loss of soil through erosion is minimal. Only when natural processes are accelerated by human activities do they result in *degradation*.[13] Soil degradation arises from a combination of:

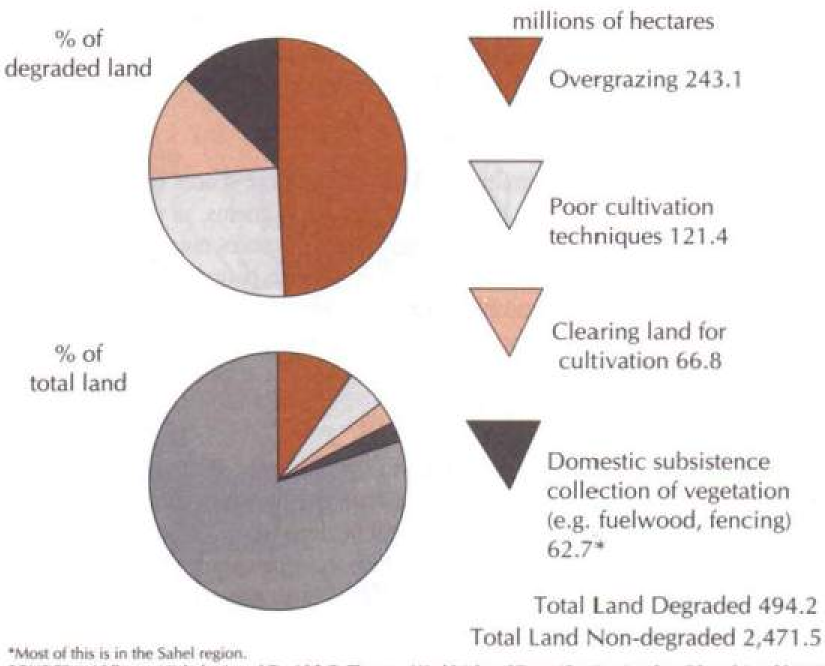
- physical factors (plant cover, fire, drought);
- management factors (grazing intensity, cultivation of marginal lands); and
- historical and socio-economic factors (inequitable land allocations, population densities and poverty).[14]

It can be difficult to distinguish the effects of human activities from physical factors.[15] The government of Namibia noted, in its 1992 report *Degradation of Agricultural Land*, that, "It is impossible to separate the effects of overstocking from those of periodic drought and high rainfall intensities."[16] Physical factors also play a large role in determining what uses people make of land.

Plant cover

Plant cover is one of the main determinants of the level of soil degradation. Plant roots hold the soil in place, and provide an environment for earthworms, ants, termites and other creatures which construct underground tunnels and

Main causes of soil degradation in Africa Figure 6.2



*Most of this is in the Sahel region.
SOURCE: Middleton, Nicholas J. and David S.G. Thomas, *World Atlas of Desertification*, London, Edward Arnold, 1992

improve water infiltration. Plants protect the soil from wind and direct sunlight, keep the soil cool and reduce evaporation of soil water. Dead plants rot and become part of the soil, adding organic matter which enables the soil to absorb water. Bare soils can experience very high soil-loss because plants (trees, shrubs and grasses) break the force of heavy rainstorms. In Tanzania, it was found that areas with plenty of grass and trees had rates of erosion of about 5 tonnes/hectare/year (t/ha/yr) while nearby areas, with similar topography and soils but not much plant cover, had erosion exceeding 100 t/ha/yr.

The type and density of the plant cover and its height makes a difference to the amount of protection it gives. Generally, closely-spaced, low plants provide good protection. The stems slow runoff like thousands of little dams, and the water sinks into the ground along the plant stems and down root channels. Rye grass and sorghum, for example, have more stems and provide better cover than maize and beans. Taller, more widely-spaced plants, such as trees, allow the raindrops to regain speed before they hit the ground. In savanna woodlands, the trees intercept only about a third of the raindrops, but in areas of dense natural forest the rain penetrates in a fine spray or runs down the trunks.[17]

Forest areas with little or no grass underneath do not protect soil from degradation. In some situations, trees can even increase soil loss by inhibiting the growth of grass.

Fire

Fire is a natural part of southern Africa's ecosystems and has been used throughout the region for generations as an agricultural tool — to encourage grass growth, improve soil fertility and kill insect pests and poisonous weeds.

Fire has been misused, however, and frequent fires at the wrong time of year can be extremely damaging. Burning the plant cover removes the soil's protection from rain, wind and sun. This can markedly reduce fertility levels and organic matter content, leading to soil deficiencies of various kinds. Burning also makes the soil surface hard for water to seep through.

"Hot" burns at the end of the dry season cause more damage than "cool" burns at the beginning. A study in Tanzania found that light burning produced no measurable change in runoff but heavy burning increased runoff by 11.6 percent.[18] Fire is least damaging when done after the grass seed has dropped but before it starts to grow.

Drought

Drought is an overriding factor in degradation of cultivated lands and rangelands, because it has a major impact on plant cover. During drought periods, the roots of perennial grasses (that grow every year from their roots) die and annual grasses (which grow new every year from seed) fail to seed.

There is a vicious circle between drought and soil productivity. Drought increases soil degradation problems, while soil degradation magnifies the effects of drought. Because of this, droughts can help to pinpoint areas of poor land-management. Prolonged droughts during the 1980s exposed poor cultivation practices in parts of the Kgalagadi, South Africa's Cape and Zimbabwe, for example.[19] During high rainfall years, the grass cover in Zimbabwe's dry communal rangelands in the southern part of the country is only nine percent below commercial rangelands, but during drought years the cover is 80 percent lower.[20]

During rainy periods, farmers tend to expand into marginal farming areas. Then, when a drought period follows, the marginal land is more vulnerable to degradation. Soil loss from water erosion slows down during drought periods, but when the rain returns erosion rates go up to three times higher than during dry years because the plant cover has died and the soil has turned to powder.

Overgrazing

Much of the dry savannas and semi-arid portions of the region are not suitable for crop production. The only way this land can be made economically viable is through grazing animals adapted to dry conditions. Cattle and other livestock are the basis of life and culture for a large portion of southern Africa's people, and contribute substantially to southern African economies. However, rangeland degradation has become one of the region's major environmental problems. There is a great deal of debate over the impact and permanence of degradation due to overstocking, how much degradation is actually taking place, and the implications for livestock production.

Currently, the concept of overgrazing is being re-evaluated. Rangelands do not appear to be as sensitive to stocking levels as previously thought and are being described more and more as "typically resilient" and able to regenerate themselves. While there may be changes in the types and numbers of plants growing on rangelands due to overgrazing, changes in vegetation do not necessarily indicate permanent

Desertification Box 6.3

The term "desertification" is much misused. First coined in 1949 by a French researcher examining soil degradation in tropical Africa, it has since become associated with inexorably marching deserts though little or no evidence exists to support the theory that deserts expand in this way. Two decades ago, an international conference pushed desertification onto the international agenda and launched an action plan to halt "land abuse" which the UN Environment Programme (UNEP) said created one-third of the world's deserts. In 1980, *The Economist* published an alarming article reporting that the Sahel was advancing at a rate of five to six kilometres per year, a story that has since been disproved.

Recent studies have not been able to verify a systematic advance of desert boundaries or any long-term change in productivity near deserts. Desert edges advance in dry periods, usually with a return to full vegetation when better rains return, but this is not *desertification.* Desertification encompasses changes in agricultural productivity, decreases in plant cover or the replacement of one type of vegetation with another. The critical point is that it takes agricultural land out of production, increasing the pressure on the remaining land. Desertification is now defined as *land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities.*

As a result of the United Nations Conference on Environment and Development (UNCED) in June 1992, an international negotiating committee was established to prepare an international desertification convention to marshal commitments and cooperation at all levels. The strategy focuses on sustainable development and appropriate technology. The Organisation of African Unity (OAU) is providing African expertise.

SOURCES: Colley, Marti (ed.), "Inter-Governmental Negotiating Committee for the Convention on Combating Desertification", *Desertification Control Bulletin*, 1993, no 23, p. 3-6
Panos, "New Desertification Convention May Help 99 Countries", Panos Media Briefing, no 8, Jan 1994
Nelson, Daniel, "Desertification: Fact or Fiction?" *Panoscope*, Mar 1992, no 29

Photo 6.2 IUCN-H Christen

Vulnerability to drought remains a constraint to sustainable development in much of southern Africa.

soil degradation,[21] and it is rare to find substantiated cases of irreversible vegetation changes.[22] Even when plant cover is completely removed, grass seed already in the soil or from nearby areas can help to recolonise such areas quite readily. Overgrazing can kill grass, but it can also stimulate grass growth because "shortened" grass needs less water.[23]

Others dispute this contention. "It can be categorically stated that the environment is degraded and that this can be attributed largely to excess livestock," argued several ecologists in 1989, referring to Zimbabwe's communal lands.[24] Another study concluded that soil loss from denuded grazing land is 20 times higher than for natural veld, with the rate of soil loss increasing dramatically if the vegetation cover is reduced by 35-40 percent. With more than 60 percent, the rate of soil loss does not change much with stocking rates.[25]

UNEP reports that about half of the world's rangelands have degraded soil, and another half have changes in vegetation only. Because of this debate over vegetation productivity, rangeland degradation is usually described in terms of the number of livestock that a given area can support, rather than the condition of the plants and soil.

Generally, rangeland scientists agree that the environmental impacts of overgrazing include:

- loss of overall plant cover with a corresponding increase in erosion by water and wind;
- decline in palatable types of grasses;
- increase in unpalatable grasses, poisonous plants and thorny shrubs; and
- physical degradation from trampling.[26]

Under heavy grazing, the grass suffers, mainly because the roots weaken when the leaves are removed and take time to recover. A study in western Botswana found that grass under moderately heavy grazing had only half the roots of the nearby ungrazed grasses.[27] When grass is grazed too frequently, the roots become exhausted and eventually die. Compaction from trampling makes it more difficult for the grass to regenerate.

Timing of the grazing is important. Grass growth begins with the onset of the main rains. At this time of year, grass plants are most dependent on energy reserves in their roots and communal farmers are most dependent on their livestock for draught power. Stock are allowed to graze freely on young grasses in order to regain their strength. If the root reserves of the grasses are exhausted, the plant[28] dies early and flowering and seed production does not take place. With fewer seeds, there is less grass the following season.

The type of soil also makes a difference. Studies in Zimbabwe found that high stocking rates on sandy soil did not result in significant changes in grass species composition even after 15 years. But clay soils were more easily compacted by trampling, with bare, degraded patches forming within a few years.[29]

Livestock are said to upset the balance of the southern African ecosystems more than wild animals do. The latter eat about twice as many different kinds of plants as cattle, and eat more shrubs and trees.[30] Livestock are concentrated in relatively small areas year-round, and protected from predators and disease. Though game-ranching has been touted as a more natural and appropriate use of land than livestock, this may not be the case. The management aspects, such as being confined to an area and protected from predation, are similar to livestock management.[31]

It should be noted that livestock numbers vary significantly between periods of drought and good rains, and these are not evenly distributed in each country. While subsistence livestock-owners are often blamed as responsible for the

Stocking rates Box 6.4

Stocking rates are based on the theoretical carrying capacity of the range and are calculated as an average number of animals over large areas for a long time. Carrying capacity varies enormously from place to place and year to year, depending on rain and how much grass there is. In a dry year, the carrying capacity may be close to zero. Actual stocking rates do not directly follow carrying capacity, because most farmers cannot afford to destock in dry years and restock in good, though it is not unusual to have half the cattle die in a dry period.

Part of the problem with determining stocking rates is that there is no consistent consensus on what the appropriate levels are, or how to calculate them. A survey in South Africa compared the views of cattle-owners with range-management specialists. Farmers estimated that more than half the land was in good condition, while the specialists calculated that only 12 percent was in good condition. The specialists believed the farmers were overestimating the grazing capacity of their land by as much as 50 percent.

One of the reasons they do not agree is that calculation of stocking rates assumes the grazing is uniform and of a certain quality, while in fact livestock depend on certain key grazing resources that occupy little space but provide most of the nutrients. Wetlands throughout the region, such as the Okavango, Linyati system, Caprivi, Kafue flats and Zambezi flats, provide important grazing in the dry season. Use of crop residues for fodder, feeding on contour ridges and areas around fields, and drainage areas and streambanks, also substantially increase grazing capacity. Another reason for the discrepancy is that range specialists normally calculate stocking rates on the basis of 450 kg animals, a standard size for beef cattle but larger than most cattle owned by subsistence farmers.

Mainstream ideas on carrying capacity suggest that average stocking rates should be below the maximum during good rainfall years, to avoid overgrazing and crashes of livestock populations during drought. Many farmers challenge this concept, as their experience with grazing shows that rangelands can and do carry increasing livestock populations. In Botswana, livestock numbers have increased greatly since the turn of the century. Occasional spectacular drops in numbers (such as in the 1960s and 1980s) were governed mainly by drought. The huge periodic herd losses under this "opportunistic" grazing strategy during droughts are more than offset by high production during the wet years. This provides an overall medium offtake, higher than what would be obtained with a more conservative grazing strategy. Instead of causing a productivity decline, increasing stock densities have brought about a higher overall yield from the land (though not without environmental consequences).

This explains why cattle-owners do not take warnings about overstocking seriously, despite dramatic changes in the vegetation. In fact the continuing ability of the land to support rising stock numbers suggests there is merit in rural people's skepticism about dire predictions based on calculated stocking rates. Livestock numbers recover rapidly after population crashes caused by drought and continue to increase despite proclamations about imminent collapse. Some areas in southern Africa have had 20 times the recommended stocking rates for more than 40 years. When rangelands can support stocking rates far in excess of carrying capacity for long periods, it is necessary to ask if there has been an underestimate of carrying capacity in the first place.

SOURCES: Abel, Nick O.J. and Piers M. Blaikie, "Land Degradation, Stocking Rates and Conservation Policies in the Communal Rangelands of Botswana and Zimbabwe", *Land Degradation and Rehabilitation*, 1989, Vol 1
De Klerk, C.H. (1986) cited in Scotney, D.M. and A.J. Aucamp, *Soil Science and the National Grazing Strategy*, Department of Agriculture and Water Supply, Pretoria, n.d.
Homewood, K.M. and W.A. Rodgers, "Pastoralism and Conservation", *Human Ecology*, 1984, Vol 12, no 4

region's soil degradation problems, large portions of southern Africa's degraded lands (particularly in South Africa, Namibia and Botswana) are occupied by commercial ranches.

Pastoralism

The movement of livestock to different grazing areas depends on flexibility and mobility. Pastoralists have learned to exploit erratic changes in rainfall and plant cover. They are skilled at getting their animals quickly onto new grass, which is more than twice as digestible as dry grass. There are two main types of pastoralists:

- sedentary pastoralists who are village-based, practising rainfed cultivation while keeping animals which graze near the villages; and
- nomadic pastoralists who do not cultivate, but move their livestock long distances from wet-season grazing in arid lands to dry-season grazing in semi-arid lands.

Pastoral people rely on livestock for milk and meat, and sell or exchange them as needed. In subsistence farming systems, cattle also have a key role pulling ploughs and providing manure for fertilising the soil. Many researchers have reported that farmers with more cattle also have higher crop yields, usually because of access to draught power. Ploughing with two oxen, instead of hoeing by hand, allows a family to cultivate seven times as much land (where land is available).

There are conflicting views of the effects of nomadic pastoralism. The conventional view has been that it is bad for the environment. The Management Authority for Ngorongoro District in Tanzania recently reported, for example, that, "there is much evidence of increasing desiccation associated especially with damage to the vegetation caused by overgrazing .... The signs of water loss due to over-grazing are very marked in areas used by the Maasai ... with the destruction of the existing grass cover and exposure to evaporation and erosion of the surface soil .... Ironically, cattle are destroyers of their own environment and enemies of their own survival."[32]

However, independent studies in the same area found that soil degradation was "negligible" and restricted mainly to cattle and wild-animal paths, and certain types of loose soils.[33] The only regular field measurements of erosion in Ngorongoro district found that vegetation cover was good and that terraces and wind hollows were stable.[34] An aerial survey showed the district had few severely eroded areas and, except for one section which was used as a major livestock route between the highlands and the plains, there was little evidence of livestock-induced problems.[35]

It is usually argued that pastoral systems are less productive than commercial ranches and contribute little to national economies. However, pastoralists make use of marginal lands that would otherwise not be used, and evidence from Tanzania suggests that pastoral systems can have the same or better offtake rates as commercial ranches and support as many as 15 percent more people per unit area.[36]

Nomadic pastoralism can actually be a means to protect land from degradation if it is used as an alternative to settlement and cultivation of marginal lands. Though plenty of evidence has accumulated which contradicts the notion that pastoralism causes widespread soil degradation, nomadic pastoralists have seen their grazing area reduced enormously in size and even more in value by the loss of their best grazing lands. In Tanzania, dry-season grazing areas have become a main focus of settlement by cultivating peoples. This will likely lead to severe degradation problems in future because the soils are not suitable for cultivation.

While there is debate over the soil degradation aspect, there is agreement that pastoralism today — under higher population concentrations — does impact on the vegetation. Several attempts have been made to improve on pastoral grazing management, but these efforts have not brought about the desired effects. The plans have been either too complicated to be adhered to, or too simple to bring about a significant change in range condition.

Wells and other watering points also have a bleak record in the history of African rangeland management. Development of water points had the good intention of bringing into production otherwise unused rangelands, but have interfered with traditional pastoralist systems which protected the environment. Providing permanent water points in dry areas disrupts normal movement patterns which safeguard the range. The result was inevitable: great numbers of livestock converging on the few water points and leaving the nearby land devastated. The 400 m area surrounding boreholes is known as the "sacrifice zone", where small-scale sand dunes (less than one metre) result mainly from trampling and local movement of soil.[37]

Destocking

There is ample evidence that overgrazing reduces grass cover, changes the types of plants that predominate in range-

Livestock in southern Africa Table 6.1

	Number of livestock (average 1988-90)	% increase since 1978-80	Pasture land* as % of total land	Total land (1,000 sq km)
Angola	3.13 million cattle	4	25	1,247
	1.25 million sheep and goats	9		
Botswana	2.52 million cattle	13	75	567
	2.18 million sheep and goats	199		
Lesotho	0.53 million cattle	9	80	30
	2.50 million sheep and goats	40		
Malawi	0.99 million cattle	27	50	94
	1.11 million sheep and goats	41		
Mozambique	1.37 million	1	55	784
	0.50 million sheep and goats	15		
Namibia	2.06 million cattle	23	—**	823
	9.08 million sheep and goats	14	—	
South Africa	11.86 million cattle	13	66	1,221
	36.91 million sheep and goats	1		
Swaziland	0.65 million cattle	0	80	17
	0.36 million sheep and goats	13		
Tanzania	12.96 million cattle	5	30	886
	13.23 million sheep and goats	43		
Zambia	2.77 million cattle	27	65	743
	0.61 million sheep and goats	85		
Zimbabwe	6.25 million cattle	11	60	391
	3.15 million sheep and goats	59		

*Pasture is rangeland improved for grazing by seeding with legumes or other livestock feed.
**Data not available
SOURCE: World Resources Institute, *World Resources 1992-93*, World Resources Institute, Washington DC, 1992

lands and exposes soil to erosion. But destocking is not necessarily the answer. Destocking is aimed at decreasing range degradation by reducing grazing pressure, and at improving the health and size of individual animals. Since most subsistence farmers already have too few cattle to meet their needs, destocking can cause great hardship and reduce the number of people the land can support.[38] For this reason, "voluntary" destocking does not seem likely. People are not willing to give up the social security livestock provides in the absence of a better system.

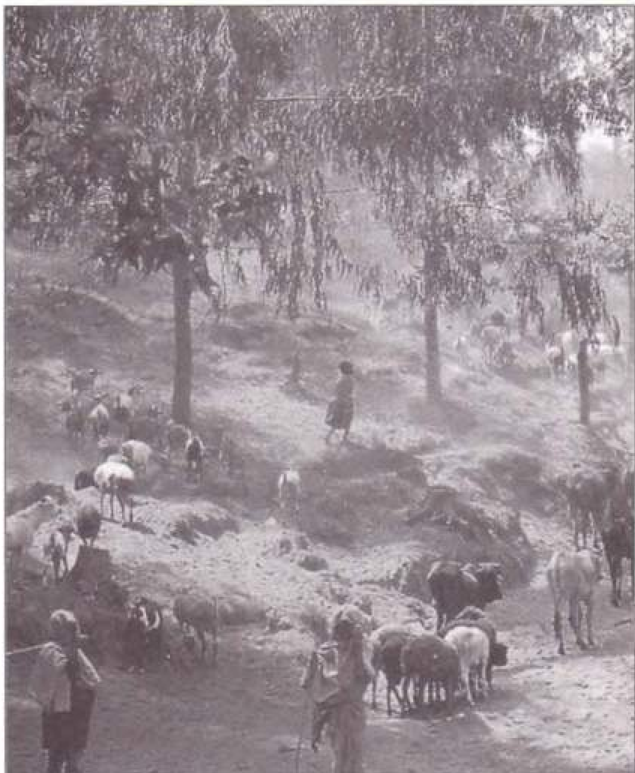


Photo 6.3 IRIS-C Thege
Overgrazed landscape near Mt.Meru, Tanzania.

An increase in cattle prices may not be the answer, either. In Lesotho, for example, instead of selling livestock when cattle prices are good, subsistence farmers try to increase their herd sizes.[39] Often, pastoral farmers are simply beyond the reach of markets. A study of pastoralists on the Pongolo Flood Plain in South Africa noted that while cattle were readily exchanged locally, only 19 percent were sold at markets. The researchers concluded that the cattle owners were in a better position to develop their own solutions to local overstocking.[40]

Cultivation

Southern Africa faces the challenge of increasing food production to keep pace with a fast-growing population. This is currently being done by bringing forested or grazing land under cultivation, or through intensifying irrigated production, but there is a limit to additional suitable land. The countries with the highest proportion of arable land are Malawi, South Africa and Swaziland with 24, 13 and 12 percent respectively. Angola and Botswana have the lowest proportion of arable land, with two percent each.[41]

Already, throughout the region, marginal lands not suitable for agriculture have been brought under the plough. Maintaining cultivated soils in good condition is difficult enough; it is nearly impossible when starting with the marginal soils. Large amounts of land have been permanently ruined by standard agricultural techniques and cannot support grazing anymore.

Modern agricultural methods, insufficient organic material being returned to the soil, and sheet erosion are fundamental causes of declining fertility of cultivated lands. Most cropping methods used in southern Africa today do not return enough organic matter to the soil. Crops are grown by "clean till", meaning that the weeds and crop residues are removed, leaving the soil bare for much of the year. Those areas planted to a single crop, such as maize, are most likely to suffer erosion because the soil is left bare and exposed after harvesting. On average, in South Africa, 20 tonnes of soil are lost for each tonne of maize, wheat, sugar or other crop produced.[42]

Photo 6.4 SAMSO-T Davies
There a~~e~~ conflicting views of the long term effects of nomadic pastoralism.

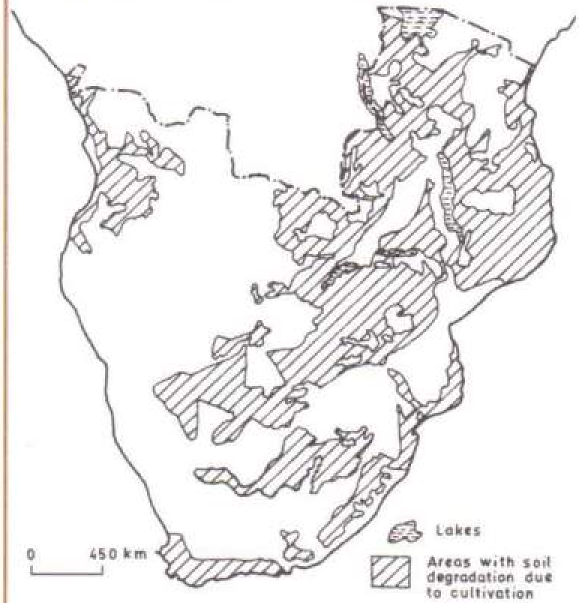
Ploughing

Ploughing is a standard agricultural practice used on both commercial and subsistence farms to kill weeds, reduce erosion and improve air and water infiltration. But ploughing has its drawbacks. When soil is broken and turned over, essential fungi which help to hold the soil together are destroyed. The extra air and warmth allows bacteria naturally present in the soil to eat up the organic matter at a faster rate, much of it turning into gases that disappear into the air.

Areas with soil degradation due to overgrazing Map 6.6

SOURCE: UNEP/ISRIC, CRU/UEA as in Middleton, Nicholas J. and David S.G. Thomas, *World Atlas of Desertification,* UNEP and Edward Arnold, Nairobi and London, 1992

Areas with soil degradation due to cultivation Map 6.7



SOURCE: UNEP/ISRIC, CRU/UEA as in Middleton, Nicholas J. and David S.G. Thomas, *World Atlas of Desertification,* UNEP and Edward Arnold, Nairobi and London, 1992

Photo 6.5 SOUTHLIGHT-P Weinberg

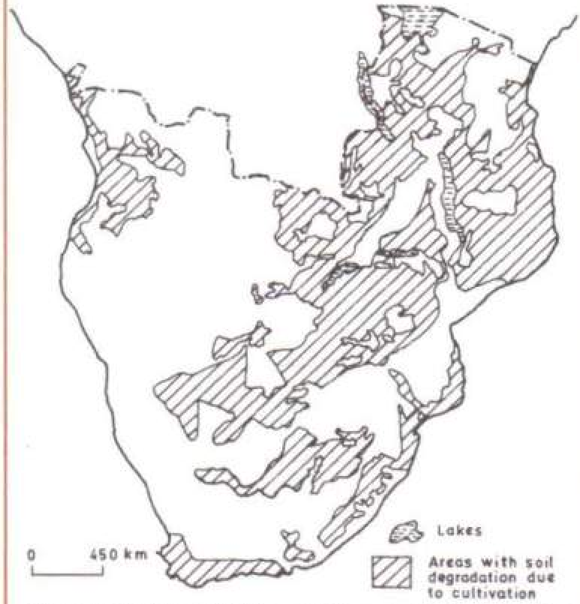
Photo 6.6 PHOTGRAPHIC TRAINING CENTRE, MAPUTO-R Rangel

Two views of cultivation in Mozambique. Farmers preparing the land near Beira, Sofala province, and ploughing at Taninga, in Gaza province.

Areas with soil degradation due to overgrazing Map 6.6

SOURCE: UNEP/ISRIC, CRU/UEA as in Middleton, Nicholas J. and David S.G. Thomas, *World Atlas of Desertification*, UNEP and Edward Arnold, Nairobi and London, 1992

Areas with soil degradation due to cultivation Map 6.7



SOURCE: UNEP/ISRIC, CRU/UEA as in Middleton, Nicholas J. and David S.G. Thomas, *World Atlas of Desertification*, UNEP and Edward Arnold, Nairobi and London, 1992

Photo 6.5 SOUTHLIGHT-P Weinberg

Photo 6.6 PHOTGRAPHIC TRAINING CENTRE, MAPUTO-R Rangel

Two views of cultivation in Mozambique. Farmers preparing the land near Beira, Sofala province, and ploughing at Taninga, in Gaza province.

As organic matter disappears, soil particles and nutrients are more easily washed away. The soil becomes more difficult to work, with drops in yield.[43] A compact layer called a plough pan is often formed in heavy soils which are regularly ploughed to the same depth, affecting water and root penetration.[44] Ploughing also damages soil by crushing it, producing large amounts of powdery material that block soil-pores and lead to increased soil-loss and runoff.

Research in Zimbabwe shows that annual ploughing is the major cause of the loss of organic material, exhausting productivity *within 10 years* of the land first being opened up.[45] Similar studies comparing cultivated and virgin soils in the Orange Free State in South Africa found that cultivated areas had lost 66 percent of their organic matter and 55 percent of their nitrogen from the top 15 cm of soil.[46]

Some agriculturalists argue that ploughing should be used only as a remedial measure to treat compacted soils and correct severe weed infestations. Ploughing is better, however, than cultivation techniques that combine no tillage with removal of all vegetation from the soil surface. Ploughed land absorbs more rainwater than bare, untilled land. A study in Mpwapwa, Tanzania, found that runoff on a hard-baked, bare, untilled surface began four minutes after the start of a rain, while a nearby roughly tilled surface was able to absorb rainfall for almost half an hour before any runoff appeared.[47] Tillage practices which leave the soil surface rough also reduce the likelihood of wind erosion.

Fertiliser use

As crops grow, they remove nutrients from the soil. A harvest of 5,000 kg of grain from a hectare of land removes about 100 kg of nitrogen, 20 kg of phosphate and 25 kg of potassium. In tropical regions this is equivalent to 10-15 percent of the soil nutrients.[48] Fertiliser is necessary to improve crop growth and make up for the lost nutrients, but must be used carefully.

Too much nitrogen fertiliser makes the soil more acidic, releasing toxic substances that make it difficult for plants to grow. In Natal, South Africa, acidification has been described as the most important factor limiting crop yields[49] with more than 5 million hectares severely affected by acidification and 10 million hectares moderately affected. This represents about 10 percent of South Africa's cultivated lands.

Manure as fertiliser **Box 6.5**

Application of manure to fields is a well-known technique to improve crop yields. While there is little doubt that manure can replace commercial fertiliser, its use is not very widespread because, paradoxically, there are not enough cattle.

Experiments at a Zimbabwean research station show that about eight tonnes of manure are required for each hectare annually to maintain high maize-yields on granitic soils. It takes approximately six cows to produce enough manure for one hectare of cultivated land. Six cows require 36 hectares of grazing land. However, average subsistence cattle-herd sizes are not enough to provide the basic minimum of 8-10 cattle per household, and grazing lands are not adequate to support more cattle.

Another factor is the quality of the manure, which varies considerably with the quality of feed available to the cattle. Manure from cattle on commercial ranches has double the nutrients of cattle from communal lands. Low quality manures actually depress growth in young maize plants. At the region's longest manure experiment, near Pretoria, there has been a slight but steady *decline* in productivity through more than 50 years of manure application, though researchers say the reasons for this are not clear.

SOURCES: Scotney, D.M. and F.J. Dijkhuis, "Changes in the Fertility Status of South African Soils", *South African Journal of Science*, Jul/Oct 1990, Vol 86
Tanner, P.D. and L. Mugwira, "Effectiveness of Communal Area Manures as Sources of Nutrients for Young Maize Plants", *Zimbabwe Agricultural Journal*, 1984, Vol 81, no 1, p. 31-35

Most farmers in the region, however, are effectively mining the soil by not applying enough fertiliser, manure or compost to make up for the drain on nutrients. Erosion increases, because the crops grow poorly and provide less plant cover for the soil.

Inequitable land allocation

Before colonisation, there was an abundance of land in southern Africa and population pressure was low, so very little damage was done to the soil. The colonial administrators did not recognise that traditional African forms of agriculture, such as pastoralism and shifting cultivation, were appropriate and sustainable uses of land over the long-term. They believed that Africans were wasting land, and used this as a justification to designate most of the best land for themselves.

Today's soil-degradation problems are largely a consequence of the inequitable, colonial land-allocations. The problem now is not solely the quality of the land but the high population densities. Historically, lands designated for blacks in some countries were insufficient to allow for population growth, and today are extremely crowded. High population densities drive farmers onto marginal lands which erode more easily, and do not produce much, while the decreasing grazing area has to carry increasing livestock numbers.

Population densities

Population is frequently highlighted as the all-important factor in soil degradation, but the relationship between population and soil degradation is not simple. In most cases, population must be considered in a particular environmental context. Low population densities may indicate that an area has never been occupied, or that people have left the area because of soil degradation. High population densities may indicate that the land is in good shape because intensive crop production with careful land husbandry supports a lot of people.

Tanzania provides a useful example. About 60 percent of Tanzania's population lives on a quarter of the country's land, concentrated near Lake Victoria and the northeastern highlands. The people who live there depend on intensive, innovative land-use, including agroforestry and irrigation, to grow a range of high-value and high-productivity crops that generate higher incomes.[50] Higher population densities are necessary to support this kind of labour-intensive agriculture.

The relationship of population to soil degradation is most clear where there is a conflict over access to land. In earlier times, in Lesotho, livestock was moved seasonally from winter-grazing in the lowlands near the owner's residence to summer rangeland in the mountains. These areas were allocated and controlled by principle chiefs. Now, with increasing human and cattle populations, more people live in the mountains year-round. This has interrupted the basis for grazing control and resulted in overgrazing in lowland areas.[51]

Poverty

Poverty is both a cause of soil degradation, and a consequence. People who lack adequate resources often have little alternative but to overuse their environment. Soil degradation makes their poverty worse because the land produces less. If people cannot feed themselves, they cannot purchase what they need or look after the land. A 1989 SADC ELMS report argues that most soil degradation occurs because there are no other options, not because of "recklessness" or a deliberate exploitation of the environment.[52]

The poor have been blamed unfairly for soil degradation caused by livestock. Livestock numbers are increasing in the region, but ownership is becoming restricted to fewer people.[53] Among pastoralists, the number of livestock per person is now too low to meet subsistence requirements, and levels of malnourishment are increasing. The minimum number of cattle needed by pastoralists to survive is 30-45 per family, but most have less than this.

In Malawi, though typical subsistence households do not have cattle, herd sizes have increased continually by about six percent a year since 1948. Government policies favour large commercial agricultural estates and have left more than half of rural families cultivating less than one hectare. Population densities exceed 300 people/sq km in the southern part of the country. Subsistence farmers crop their small holdings almost continuously, with some crop rotation, and often cannot spare any land from production to allow a fallow period. People have no cattle to supply manure or pull ploughs because there is no land for grazing or to grow fodder. They can barely afford to feed themselves, let alone purchase fertilisers and other inputs that would reduce soil degradation. Subsistence farming supplies only a third of their needs, and most support themselves by trading and, to a lesser extent, selling cash crops. They also depend on remissions from relatives working in towns.

In some highly urbanised countries, such as South Africa and Zambia, large "informal" settlements have put pressure on social services and housing, as well as land. Around the urban centres in Angola and Mozambique, the land pressure is acute due to movement of people displaced by armed conflict.

While human activity may be the immediate cause of soil degradation, the root cause lies in a range of economic and political parameters which are typically outside the farmers' control. Programmes to reduce environmental degradation will not accomplish anything if they do not address poverty as one of the causes.

SOIL DEGRADATION IN SOUTHERN AFRICAN ECOZONES

Except for the uninhabited desert, each of southern Africa's ecozones has localised areas of strong or moderate soil degradation, always related to the type of land-use.

Lowland Tropical Forest

Because of low populations, and good rainfall and plant cover, the northern Angolan portion of this zone is stable or has low rates of erosion, except for a strip parallel to the coast which has high water erosion resulting from agricultural clearing and woodcutting.

The tropical-forest zone on the east coast is vulnerable to erosion in higher population areas such as the Natal Province of South Africa, northern Mozambique and the border area extending up Tanzania's coast. Natal's coastal areas lose millions of tonnes of soil each year because of overgrazing and cultivation. Near Maputo there is localised degradation due to cultivation, overgrazing and fuelwood cutting. On the southern Mozambique coast, sand dunes are moving onto agricultural land following removal of the dune forest. Near the Mozambique-Tanzania border, overcultivation is causing soil infertility, and, up the coast, increased clearing of land for cultivation has caused erosion.

Afromontane and Temperate Forest

With steep slopes and higher rainfall, afromontane areas are easily degraded when the vegetation is removed. Between Lesotho and the Natal coast in South Africa, rapidly expanding cultivation and sheep grazing have caused loss of topsoil and gullying. In neighbouring Transkei and KwaZulu areas, overgrazing and wood collection on crowded subsistence farms has resulted in very high water-erosion, topsoil loss and gullying, affecting as much as half the land surface. North of Pretoria, portions of Lebowa and Gazankulu suffer from very high water-erosion due to heavy grazing. Gazankulu, particularly, has received many refugees from Mozambique who have increased pressure on the land.

Grassland

This zone is one of the most important agriculturally, but has the most complex and extensive soil degradation problems. Some of South Africa's best cultivated lands are in the grassland zone, but nearly all show signs of abuse. About 10 percent of the 1.8 million hectares under irrigation have been damaged by salinisation, sodification and waterlogging. Along the Orange river there are serious problems with erosion and with overirrigation. Soil compaction in the area has cut productivity of two million hectares of maize-fields by 30-40 percent.

About two million hectares of intensively cultivated areas in the Highveld region and in the Natal grasslands are also susceptible to wind erosion.[54] In the western part of the Orange Free State, wind erosion is estimated to remove some 40 t/ha/yr on an area of 100,000 cultivated hectares.[55] Southwest of Pretoria, the soil is contaminated by pollution, largely from mines, and overuse of nitrogen fertilisers on maize and wheat has acidified the soil.

Grassland researchers in South Africa estimate that only 10 percent of South African grassland has the high-quality mix of grasses best-suited for commercial beef-production, and that, because of overgrazing, as much as 60 percent of the grassland is in poor condition, "unable to meet sustained production requirements."[56]

In Lesotho, the average rural household has less than two hectares to cultivate, while a quarter of Lesotho's rural population has no land at all. Overgrazing and excessive browsing are major problems which have led to soil erosion and physical degradation. Lesotho's lowlands are overpopulated, so cultivation has spread up into former grazing areas with steep slopes, resulting in erosion.

Photo 6.7 IUCN-D Reed

Adequate drainage is an essential element of irrigation schemes, to avoid problems of soil salinisation.

Moist Savanna

Some parts of the moist savanna are largely unpopulated and unaffected by human activities, but there are a few areas with serious soil degradation due to cultivation and, recently, overgrazing has become a problem. Cattle are easily over-stocked and frequently malnourished in moist savanna because the grass is not very nutritious except for a short period at the beginning of the rains. Historically, the presence of tsetse-fly discouraged cattle-keeping, but in the past two decades the fly has been eradicated from large areas and cattle-herds have expanded considerably. Rangeland degradation is not confined to subsistence pastoralists, and some commercial ranches have suffered changes in productivity because of overgrazing.[57]

In the Kavango district of Namibia, the growing of millet along 300 km of the Okavango river has resulted in large numbers of livestock being confined to the floodplain to keep them out of the fields. River-bank erosion, grazing and trampling of reed-beds, removal of the trees and the consequent runoff and higher silt-loads are putting the long-term productivity of the fish-stocks (an important local food source) at risk.[58] It is feared that this trend could extend into the Caprivi district as well.

The fairly reliable rainfall in the moist savanna suggests the zone has high agricultural potential, but the predominate *miombo* woodlands have infertile soils which degrade rapidly under annual ploughing and heavy rains. In Tanzania, the Ismani valley was opened up for intensive maize cultivation using tractors in the 1950s and rapidly became the country's largest single maize-production centre. Today the valley is so eroded that production is a fraction of its previous level.[59] The eastern shores of Lake Tanganyika have lost fertility due to overcultivation, and about a quarter of the irrigated land surrounding Lake Rukwa has salinisation problems.

In the densely settled eastern and southern parts of Zambia, poor farming methods and irrigation of problem soils has caused degradation, compaction and gullying, and has reduced crop-yields.

Extensive forms of agriculture, such as shifting cultivation, were the tradition in moist savanna woodlands. Sustainable and appropriate under low population densities, today the fallow periods are too short to allow the woodlands' recovery. Shifting cultivation has largely been abandoned in most countries of the region because of high population densities. In Malawi, cultivation expanding at a rate of 3.5 percent annually is the most destructive force affecting the country's natural resources base.[60] In Angola and Mozambique, where populations are concentrated in urban and coastal areas because of armed conflict, serious soil degradation results from intensified cultivation. This is particularly evident in higher rainfall areas in Angola such as north and west of Huambo and southeast of Luanda.[61]

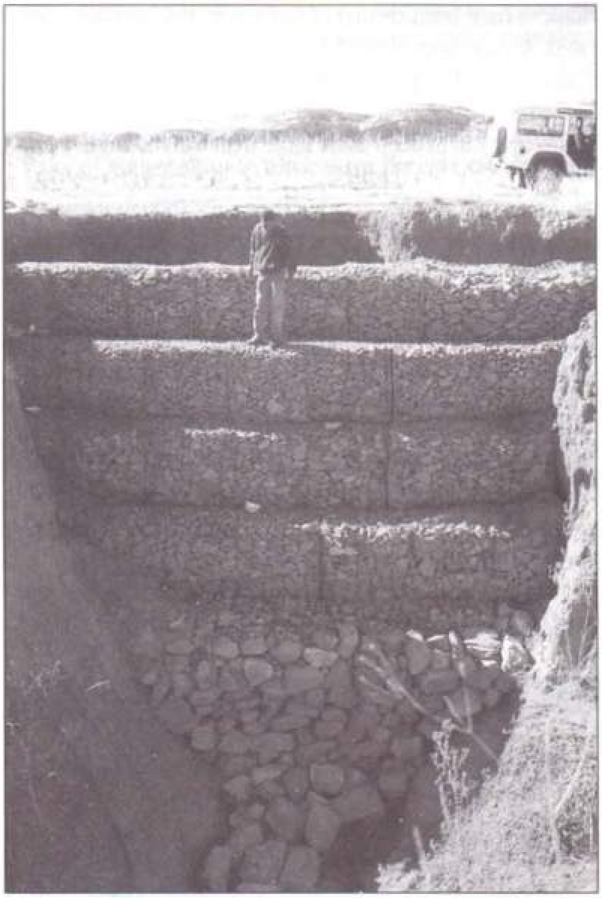


Photo 6.8 RED CROSS-D Sanger

Ben Sekone, Lesotho Red Cross youth soil conservation officer, inspects gully stabilisation works at Tlouoe community.

Dry Savanna

Dry savanna woodland is vulnerable to erosion by water and wind because there is often not enough rainfall to produce reliably good plant cover.[62] Soil degradation is a major problem due to overgrazing or where large areas have been cleared for cultivation.

The dry savanna's most extreme soil degradation is in central Tanzania, particularly Dodoma district. Most inhabitants are agro-pastoralists who depend on crops such as maize, millet, sorghum, cassava and groundnuts, and keep livestock.

Bush encroachment Box 6.7

In some densely populated parts of the region, bush encroachment provides a range of valuable materials to rural inhabitants. At least one chief in KwaZulu, South Africa, actively encourages his people to make use of encroaching bushes in degraded areas.

A study at Msinga, in KwaZulu, between Lesotho and Swaziland, calculated that encroaching thorn trees are worth the equivalent of at least R425 (US$129) per family of six per year — for fuelwood, grazing, fencing and other uses. Many types of thorn trees provide good-quality fuelwood. The nutritional value of thorn trees is comparable to good grass. Cattle avoid them because of the thorns, though goats relish them, and the pods and seeds are also good feed. Thorn-tree branches provide fencing material to protect gardens and confine livestock.

Lath frameworks for huts are constructed with termite-resistant varieties of thorn trees. The tough stringy bark is useful for binding roof-laths onto the frame. Bark and pods of some varieties are used to tan leather, and the tough, dense wood makes good tool handles.

SOURCE: Milton, Sue J. and Creina Bond, "Thorn Trees and the Quality of Life in Msinga," *Social Dynamics*, 1986, Vol 12, no 2, p. 65-76

southern Namibia are overgrazed near water sources, and severe bush-encroachment has reduced the carrying capacity of grazing lands by half.[70]

The average amount of land required to sustain a cow has increased from 10 to 40 ha, as grassy areas are taken up by dense shrubs.[71] Closer to Windhoek, central Namibia has very high wind-erosion due to overgrazing.

Though this zone is generally dry and poor for cultivation, the area between Lobito and Benguela in Angola has wetlands and several rivers creating rich alluvial deposits. However, the expansion of intensive agriculture and irrigation are causing salinisation and erosion.

Succulent Karoo

This zone is used largely for sheep-grazing and fruit-growing. Overgrazing is the main degradation problem. There is bush encroachment, wind erosion and gully erosion, especially along the flatter coastal areas where there is little topsoil left. Parts of higher altitude karoo have become desert due to overgrazing. Succulent thicket in the southeastern Cape has been eliminated by overgrazing.[72]

Fynbos

Much of the fynbos is high potential agricultural land but degraded by overcultivation and overgrazing by sheep. Because the fynbos is relatively flat and exposed to coastal winds, there is severe wind-erosion affecting wheat cultivation along the south coast. This zone also suffers compaction and salinisation. In fruit-growing areas, there is soil compaction and crusting.

REVERSING SOIL DEGRADATION

Three levels of interventions can be applied to problems of soil degradation:

- prevention (not allowing the degradation to happen in the first place);
- control (intervening before the problem becomes serious); and
- rehabilitation (a high level of technical input or radical restructuring of the land-use).

Prevention

Soil degradation can be prevented by maintaining the soil in good structural condition through boosting plant cover, growing healthy, well-fertilised crops, and avoiding annual ploughing and over-long fallow (bare) periods. Rotating crops and including cover crops such as forage legumes, grazing or hay-grasses are useful preventative measures.

Prevention of soil degradation is cheaper and easier than control. Rehabilitation is a last resort. Unfortunately, conservation is nearly always dealt with in the reverse order, tackling first the costliest interventions with the greatest technical difficulty. Control receives the next priority because it is visible and can be dealt with. Prevention is rarely done.[73]

Control

Erosion-control programmes have rarely worked in southern Africa, often because they were experimental or unproven when imposed — or did not consider the needs of farmers who were expected to put in a lot of labour without obvious benefits. Control was seen as an end in itself, with physical structures such as contour terraces treating the symptom rather than the cause of degradation. The importance of soil management and plant cover were not understood until quite recently. Farmers were rarely consulted during the planning stages to ensure the implementation of selected measures, and most programmes were never evaluated to see whether they had worked.[74]

Cultivated areas in southern Africa have often had different control measures imposed one after the other. In Swaziland, about 112,000 km of grass-strips were laid out in the 1950s protecting virtually the entire cultivated area, and were abandoned or destroyed 20 years later when contour terraces were constructed with heavy earth-moving equipment provided by USAID. Though the terraces were considered to be effective in reducing erosion, there were maintenance problems. Terraces broke down resulting in severe gullying. Terracing is now confined to flatter areas, with upland areas being protected again with grass strips which require little maintenance.[75]

Agricultural extension today concentrates more on locally appropriate tillage-practices and biological controls. In Malawi, trials of alley cropping have found that it improves soil fertility while producing high-quality fodder. This is the cultivation of annual crops between rows of trees or shrubs, which are pruned periodically to prevent shading of the crop and to provide leaf "manure", fodder and fuelwood. Maize-yields approach levels achieved with 50 kg of nitrogen fertiliser per hectare. Alley cropping does not reduce the amount of maize produced for a given area, and has added benefits of soil conservation, fodder and fuelwood.

In Zimbabwe, the Institute of Agricultural Engineering works with communal farmers to develop and improve a technique known as "no-till tied ridging" to reduce soil erosion, increase yields and reduce draught-power requirements. Permanent low ridges are constructed with a plough about 90 cm apart to act as mini-contours. Ties are constructed across the ridges like dams, to capture water and soil, fertiliser and seeds and prevent them from washing away. This system builds on local knowledge, as ridges are commonly used on Zimbabwean communal farms, though not permanent tied ridges. Weeding is the main problem, and must be done year-round by hand or with a combination of hand-hoeing and herbicides, with ploughing reserved as an emergency measure only. A major advantage of the system to subsistence farmers is that crop residues can be grazed.[76] Research results have attracted widespread interest throughout the region.

Rehabilitation

Attempts have been made to rehabilitate degraded land. Tanzania's Forestry Division started the *Hafadhi ya Ardhi Dodoma* (HADO) project in Dodoma in 1973 to rehabilitate 125,000 ha of badly eroded areas with extensive contouring and terracing. After five years they found that physical controls were not showing results, so in 1979 an existing bylaw prohibiting grazing was enforced by the district authorities. Some 90,000 cattle were cleared from 19 villages.

It was a desperate move and local people were very angry, particularly large cattle-owners. Then land previously grazed was opened up for cultivation and trees were planted. Within a few years of destocking, plant cover improved, water supplies became more reliable, streams flowed longer into the dry season than they used to, and wells which had dried up yielded water year-round.[77] Recently, cattle have been reintroduced but are confined to paddocks and are not allowed to free-range. Cattle-owners are required to cultivate grass to feed them.

There were several lessons from HADO:

- rehabilitation projects must be able to adapt to local conditions and have the strength to change their approach when needed;
- it takes time to build up popular support for a programme when the benefits are not immediate and deeply affect the way of living; and
- strength of political will and determination was the most decisive factor behind the eventual success.[78]

Moving forward

The SADC erosion-hazard mapping and equivalent exercises in South Africa have largely completed assessments of the vulnerability of the region's soils to degradation. These efforts provide a sound basis for action, but are not sufficient on their own. Studies predicting the degree of erosion risk have been of limited value where there was a poor correlation between potential and actual erosion. Improper land-use is more important than physical setting for determining the degree of erosion, and erosion-hazard mapping does not really consider population pressure on land, except indirectly, through plant cover.[79]

In 1986, SADC ELMS commissioned a detailed programme for obtaining uniform, dependable and comparable estimates of soil losses in the SADC countries (excluding South Africa), the important aspect being that everyone would use the same system. The programme, which has not yet been implemented, calls for two types of plot studies: normal runoff plots and other plots that would have the topsoil removed to judge the impact of the loss of topsoil on crop production.[80] This programme could go a long way toward providing a realistic assessment of soil degradation in the region. Information on physical and chemical degradation is also needed, so that the impact on crop-yields of loss of nutrients and water-holding capacity can be assessed.[81]

At present the precise costs of unchecked degradation and the benefits of conservation have not been calculated for southern Africa, but some economic analyses indicate that unless there are significant changes in crop-pricing and subsidies for erosion controls, farmers making use of existing forms of soil conservation will lose money.[82] Private incentives are not enough to pay for conservation measures, so investment in soil conservation cannot be expected without substantial subsidies.[83]

While South Africa is presently the largest producer of cereals in the region, it is unlikely that the country's cereal production can be significantly increased because little additional land is available. Land pressures are also high in Botswana, Namibia and Zimbabwe, with limited scope to put more land into production. The best potential for increasing food production is to move toward more intensive production in the small-holder sector, and greater use of high-potential land in northern parts of the region, including Angola, Mozambique, Tanzania and, particularly, Zambia.

Photo 6.9

SPLASH-L Sola

This sediment trap checks reservoir/dam siltation at Ntabazinduna, Zimbabwe. Economic analyses indicate that significant changes in crop-pricing and subsidies for erosion controls are essential to the viability of farmers who are using soil conservation measures.

The Green Crusade Story

Buhera (IPS) - A gully reclamation project in south-western Zimbabwe, in Buhera district has scored success in stemming the tide of land destruction.

Realising that a two-kilometre-long gully eating away four metres of valuable soils every year posed a real danger to the environment, 128 families in Garamwera village, located 150 km south of the capital, Harare, joined forces to redress the situation.

Discussions on reclaiming the gully started in 1983 when the community lost more than 30 head of cattle which fell into the gully and died. The gully was also threatening to swallow up homes, arable and grazing lands, and the community's main source of water. The gully originally formed in 1957 due to unprotected and "ungrassed" waterways, cattle tracks and badly built contours which were spilling into the gully.

The villagers — assisted by officials from conservation parastatals, the Natural Resources Board (NRB) and the Agricultural and Technical Extension Services (Agritex) — set to work on the gully in 1984. To stabilise the weak soil and prevent further soil erosion, they planted eucalyptus trees and a variety of fruit trees such as orange, tangerine, avocado, mango, guava and banana around the gully.

This approach has been proven successful and after almost a decade, says Phibion Murata, head of Garamwera's conservation committee, the gully is healing.

Garamwera is one of hundreds of conservation projects which have mushroomed in Zimbabwe's eight provinces following the introduction of a national conservation competition in 1985.

Dubbed "Green Crusade", the competition was initiated by a local publishing company, and is run in conjunction with NRB. "The competition is designed to promote conservation awareness, particularly in the rural areas where there is a severe depletion of resources due to population pressure," says Director of Natural Resources, Thomas Mpofu.

Projects for the competition include grazing schemes, woodlots, gully reclamation, land reform, vegetable gardens, tree-planting and tree nurseries. The winners receive cash prizes amounting to about US$100, fencing material and bulls for breeding.

The competition is run at provincial level every month and judged by NRB and Agritex officials, and attracts over 50 entrants from each province.

— Adapted from **Andrew Zhakata,** Inter-Press Service, *IPS Environment Bulletin*, November/December, 1992

Linkages to other chapters Box 6.8

1 PEOPLE

Agricultural activities such as cultivation and grazing can cause soil degradation, but the impact differs according to local conditions and population numbers.

2 HISTORY

Traditional methods of soil conservation and rehabilitation are still in use in many parts of the region, and provide a sound basis for agricultural improvements. Some methods are threatened by population density.

3 POLICY

Economic, as well as agricultural and environmental, policy affects soil quality and productivity, as does the access to land and type of land-use system chosen.

4 ECOZONES

Ecozone characteristics determine, to a large extent, which uses of land are sustainable and which are not.

5 CLIMATE

Weather patterns are linked to plant cover and soil degradation, and the effects of weather are sometimes difficult to separate from the impacts of human activities.

7 WOODLANDS

The major cause of deforestation in southern Africa is clearing land for cultivation. In some parts of the region, overgrazing resulting in bush encroachment provides a useful source of fuelwood.

8 WILDLIFE

Wildlife is also affected by overgrazing and the clearing of land for cultivation, often with loss of biodiversity, especially in the moist forests of the mountains along the east coast, and perhaps in riverine forests and coastal forests.

9 FRESH WATER

Security of water supplies is closely allied to soil degradation, which reduces the amount of rainwater infiltrating to recharge groundwater supplies. Agriculture impacts on water supplies, as does sedimentation of wetland ecosystems and dam-storage capacity.

10 MARINE

Sedimentation of coastal ecosystems reduces the ability of the water to support aquatic life.

11 POLLUTION

Soil degradation can result from direct contamination of land and water by industrial and municipal wastes, irrigation by sewage, inappropriate use of agricultural chemicals and careless disposal of agricultural wastes. Impacts are usually confined to a relatively localised area, but may be severe, long-lasting and difficult to reverse.

12 ARMED CONFLICT

Due to war in Angola and Mozambique, people have been concentrated in coastal areas, putting pressure on local resources. Unplanned settlements on islands and on unstable sandy soils along the coast have caused severe localised erosion. Refugee settlements in neighbouring countries have resulted in localised deforestation problems and soil degradation.

13 GLOBAL

Global warming could potentially change the distribution of rainfall over the region and affect agriculture positively or negatively. Coastal areas in Mozambique could be inundated by rising sea levels. Thinning of the ozone layer, which filters out harmful radioactivity, could harm plant growth.

14 TRENDS

Soil degradation is increasing and the growing numbers of people in southern Africa could cause more land — including marginal and ecologically sensitive areas — to be cleared for cultivation to meet the region's food needs.

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7

WOODLANDS

and Forests

Southern Africa's most common landscape is flat or rolling terrain with grass and scattered trees. About three-quarters of the land has tree cover, sometimes in dense forests but more often savanna woodland or grasslands made up of a mix of trees with grass. Most of southern Africa has a long dry-season, so rainforests, which require moist conditions year-round, are rare.

About a quarter of the region's trees are located in remote parts of Angola. Mozambique, Tanzania and Zambia each have about 20 percent of the trees. Botswana, Lesotho, Malawi, Namibia, South Africa, Swaziland and Zimbabwe share the remaining 15 percent.[1]

Part of this uneven distribution relates to natural factors such as rainfall and soil types but also, in large measure, results from human activities. The major cause of deforestation is conversion of land to non-forest uses such as agriculture, though thinning of trees due to fires, overgrazing, selective timber-cutting and fuelwood-collection also play a part.

Woodlands and forests fulfil a number of vital ecological functions:

- providing wildlife habitat;
- fertilising and nurturing the soil;
- cleaning the air by absorbing carbon dioxide and releasing oxygen; and
- soaking up rainfall and releasing it slowly into the air and surface or sub-surface waters.

These wooded areas are also an important source of natural resources for both commercial enterprises and subsistence farmers. Mining, manufacturing and construction could not have become established in the region without plentiful indigenous wood supplies. More recently, large-scale plantations supply wood for paper production, construction timbers and tanning extracts, and natural forest and woodland areas are valued as a draw for tourists.

Rural residents collect a range of essential products from forests and woodlands. Construction poles, agricultural tools and other implements are made from trees. Forests and woodlands supply some traditional medicines, and hundreds of different types of foods — fruits, seeds and nuts, leaves, gums and saps, edible roots, tubers and bark, mushrooms and wild spinaches, and insects, including caterpillars and honeybees.[2] Small animals found in woodlands and forests — such as certain antelopes, rodents, lizards and monkeys — supply animal protein as well. Forests and woodlands are also important culturally, as sacred and burial sites.

Information on the condition of the region's remaining forests and woodlands is often outdated, incomplete, fragmented, or misleading. Comparing estimates from the 1970s with present-day studies appears to indicate that there has been an increase in the rate of deforestation. However, it may be that the change has more to do with improved survey techniques which reveal old deforestation that was not previously detected. Moreover, deforestation is a sensitive issue, so even the most impeccable data are subject to considerable differences of opinion.

While precise details of the speed and extent of deforestation are not available, it is clear that deforestation is having a serious impact on subsistence farmers and the environment.[3]

Without trees, nothing grows Box 7.1

Most rural people appreciate the role of woodlands in protecting soil. One elderly Burungee resident of central Tanzania, recounting how the removal of almost all of the larger trees in his area to eliminate tsetse flies and allow for expansion of cultivation and grazing in the 1950s led to extreme degradation within 20 years, told a researcher:

"When we were children there was bush in that very place. People grew in numbers and they cleared the forest to cultivate. Without trees nothing grows. First the animals die, then people. The soil dies. It no longer has the strength to make grass and bushes grow. Nothing living will remain. The power of the sun turns the soil into ash. There will be no wind which is the breathing of the trees and the grass. God will remain, but his world is diminishing, he becomes alone. Well, where should he go?"

SOURCE: Ostberg, Wilhelm, *Land is Coming Up: Burungee Thoughts on Soil Erosion and Soil Formation*, EDSU, Stockholm, 1991

Ill. 7.1 IUCN-C Bass

Every country in the region has documented the increasing length of time required to collect building-poles and fuelwood. The environmental degradation following deforestation also affects the welfare of rural residents. When trees are removed, the exposed soil is vulnerable to erosion. Topsoil washes away into rivers and dams, reducing water-storage capacity and smothering fish-breeding areas. Water from storms washes off the surface, causing floods. With less water infiltrating the soil, streams dry up or become seasonal, ceasing to provide water year-round.

CAUSES OF DEFORESTATION

Agricultural expansion

Southern Africa has one of the fastest growing populations in the world and faces the challenge of trying to increase food supplies by some three percent a year. This is normally done by bringing large areas of wooded land under cultivation.

Farmers often remove trees from grazing lands as well as arable lands. The intent is to improve grass growth by reducing competition for water, but clearing away too many trees can have the opposite effect. A certain minimum number of trees benefits grass growth. Water infiltration rates and soil moisture are better with some tree cover, and the level of soil nutrients may be two to five times higher.[4] Ideal tree cover for palatable grass production is around 10-20 percent.

Commercial use of trees

Commercial use of indigenous trees for construction, furniture and flooring, rural industries, medicines and crafts contributes to the increased pressure on woodlands and forests by removing certain species, reducing the biodiversity and *quality* of the remaining areas.

Selective cutting for timber and hardwoods

Mechanised logging is the most damaging mode of commercial woodland-and-forest use. It is often sloppy and inefficient, with many trees crushed or destroyed during felling, cutting, loading and transporting of logs. In some cases only 15 per-

When the land is cleared Story

Lusaka (SARDC) — For 30 years, Dominic Chongo has practised subsistence shifting cultivation, known as *chitemene* in the local Bemba dialect.

The system has been in use since the Bemba settled modern Zambia more than four centuries ago, but Chongo is in trouble now. From his Mwamba village, tucked away in the hinterland of northern Zambia, the land looks barren and weather-beaten.

Chongo, now a 40-year-old father of six and a grandfather, has problems finding enough trees near his village for a good *chitemene* garden. For him to be able to grow crops in the infertile soils, he has to cut down trees and burn them in heaps on the ground before planting.

"The beneficial change in the soil lasts as long as 16 years," adds Zambian scientist, Emmanuel Chidumayo, "but plots are normally abandoned after a few years because of weeds and pests."

Traditionally, a new *chitemene* ash garden is made every year for sowing finger millet — which is often intercropped with a few other crops during the first year, and may be cropped for several years before it is abandoned.

"This system was not harmful to woodlands in the past," says Chidumayo, "because the area reverts to woodland soon after it is abandoned, as most of the trees are not removed altogether, but are cut at chest height and quickly grow back."

But population pressures, which have in the past been linked to towns and cities, are now being felt in some villages in northern Zambia, as elsewhere in the country.

"*Chitemene* is only environmentally friendly when you have less than four people to a square kilometre," says Chidumayo, who has studied the impact of increasing populations. "Too many people on too little land results in permanent deforestation. The trees do not have enough time to grow back.

"Then, because there is less wood to burn when establishing plots, the soil heating and ash production may not be sufficient to make the soils fertile again."

"Things are hard at home. Trees are finished because of too many people who cut them for their *chitemene* gardens," Chongo said.

— **Katongo Chisupa,** Environmental Forum of Zambia, Lusaka, for SARDC, 1993

cent of the timber cut in the forest actually makes it to market, while up to half the area's trees may be destroyed in the process.[5] It can be many years before forest soils recover completely from the impacts of mechanised logging. The heavy machinery rolling and skidding over the fragile forest floor compacts the soil so much that tree-root growth is reduced by almost 90 percent for about 20 years. Compaction reduces the amount of water that soil can absorb, increasing runoff and erosion. Poorly planned access-roads to logging sites also cause erosion, by removing topsoil and exposing fragile subsoils.

Even non-mechanised, selective cutting of particular trees can be problematic, with commercial woodcutters taking many more trees than their permits allow due to poor monitoring and enforcement. In the late 1980s, for example, some 500 pit-sawers employed in the East Usambara mountains in Tanzania were taking more than their licences permitted and exploiting sensitive areas such as riverbanks.[6] Recently the issuing of permits has been tightened up but there appears to have been a permanent change in the composition of the area's forest. When the forest canopy is opened up, a thick tangle of grass, shrubs and/or creepers fill in the gaps, making it difficult for tree seedlings to establish themselves, and also providing fuel for fires.

Commercial exploitation of medicinal plants from forests and woodlands is becoming an increasingly important component of deforestation as well. In many cases, especially in urban areas, demand greatly exceeds supply, and some medicinal plants have disappeared from certain areas because of overexploitation.

Commercialisation of particular crafts, such as basket-making, has also resulted in the decline of certain types of trees. The major source of weaving material in Botswana, Mozambique, Namibia, South Africa and Zimbabwe is fibre from palm leaves and brown dye from *Berchemia* bark. These trees have been overexploited in Botswana, South Africa and Zimbabwe.[7] In Botswana particularly, even though *Berchemia* trees are traditionally conserved, the commercial importance of the bark for dye has resulted in killing of the trees, which are now scarce.

Urban fuelwood and charcoal use

Most urban areas in southern Africa are surrounded by cleared land, the result of intensive woodcutting to supply urban demand for fuelwood. In areas where there are sufficient trees, woodcutters choose certain types which burn better and command a higher price. As the area is stripped of the preferred species, any trees remaining are often cut or burnt for later removal.[8]

Wood-use in southern Africa — Table 7.1

(000 cubic metres)

	Fuelwood and charcoal	Roundwood	Sawnwood and sleepers	Panels	Pulp	Paper
Angola	5,539	6,448	5,000	11,000	15,000	-
Botswana	1,303	1,389	-	-	-	-
Lesotho	613	613	-	-	-	-
Malawi	7,814	8,215	48,000	14,000	-	-
Mozambique	15,022	16,036	35,000	5,000	-	2,000
Namibia	1,790	-	21	-	-	-
South Africa	7,078	12,168	1,827,000	398,000	1,614,000	-
Swaziland	560	2,223	103,000	8,000	133,000	-
Tanzania	32,240	34,276	156,000	15,000	54,000	25,000
Zambia	11,565	12,221	76,000	8,000	-	4,000
Zimbabwe	6,269	7,893	190,000	26,000	42,000	86,000

Fuelwood and charcoal includes all rough wood used for cooking and heating.
Roundwood includes all wood harvested, round, split or roughly squared.
Sawnwood includes wood shaped into products such as planks, beams and railway ties.
Panels includes veneer sheets, plywood and particle-board.
Paper products includes newsprint, writing paper and paper-board.

SOURCES: Mwaura, Peter and F.M. Kamau, "An Overview of Forest Industry in Eastern and Southern Africa", *Unasylva*, Vol 42, 1991, p. 37
Government of Namibia, *National Forest Policy for Namibia*, Ministry of Agriculture, Water and Rural Development, Windhoek, Mar 1992
World Resources Institute, *World Resources 1992-93*, Oxford University Press, New York, 1993

Much of the fuelwood cut in Angola, Mozambique, Tanzania and Zambia is converted to charcoal for urban households. A little more than half of Zambia's fuelwood is converted to charcoal and every year the equivalent of some 430 sq km of woodland is cleared to produce more than 100,000 tonnes of charcoal.[9]

Photo 7.1 IRIS-C Thege

Charcoal produces almost twice as much heat per unit weight as dry wood.

Four tonnes of wood produce about one tonne of charcoal. This seemingly ridiculous waste of scarce resources has led to demands that charcoal-making be banned. But the energy equation is not what it seems. Charcoal has almost twice the heat content per unit weight of dry wood, and burns well, which makes it cheaper and easier to use.[10] There has been some research into increasing the efficiency of charcoal production to reduce wastage.

The situation for charcoal differs in South Africa where, instead of using indigenous trees, most charcoal is produced from plantations of wattle. Industries use more than a third of the charcoal, much of it at one silicon smelter at Pietersburg. Another third is exported, and the remainder is used in the luxury market.

Prices for fuelwood have increased as sources diminish. Except in extreme cases, however, wood continues to be the cheapest fuel available compared to electricity, paraffin (kerosene), solar energy and biogas. The necessary equipment for use of alternative fuel, such as stoves or batteries, is too expensive for most people in southern Africa.[11] New technology may also be unacceptable for social, cultural or practical reasons. Solar cookers, for example, have not been popular because women do not want to leave food cooking outside and unattended for long periods.

Fuelwood for rural industries

Rural industries use substantial amounts of indigenous fuelwood to burn bricks, smoke fish, cure tobacco, brew beer and dry salt.

Tobacco curing is particularly significant on both commercial and subsistence farms in Malawi, Mozambique, Tanzania and Zimbabwe. The equivalent of one hectare of woodland (50-60 cubic metres of solid wood) is cut to cure each hectare of tobacco — enough to supply the yearly domestic needs of up to 200 people. Tobacco estates in Malawi clear about 100 sq km of woodland annually and now occupy almost 3,000 sq km. Large amounts of fuelwood are required for curing, most of it (two million cubic metres) taken from indigenous woodlands, though there have been some advances in using charcoal from tree-plantation wastes.

Tobacco estates consume a quarter of all woodfuel used in Malawi. [12] In Zimbabwe, some 700 sq km of woodland are cleared each year to grow tobacco. Zimbabwe has been more successful in substituting coal for fuelwood in curing barns, but curing still demands some two million cu m of fuelwood annually — the equivalent of cutting trees from at least 400 sq km. In the region overall, more than 1,400 sq km of indigenous woodland is cleared annually to supply fuelwood for tobacco curing.

Brick-burning also consumes large amounts of fuelwood. In Tanzania, six percent of the total fuelwood is used to burn bricks. Constructing a village of 350 brick homes, takes 1,050 cu m of fuelwood, or more than 20 ha of clear-felled woodland.[13]

While most rural households cannot afford to pay the US$500 for a biogas unit or $250 for a solar water-heating system, in some of the rural-based industries and in institutional settings such as schools, there is potential for fuel-saving with biogas and solar energy systems.

Fuelwood-use in rural industries* Box 7.2

One cubic metre of wood:
- provides heating and cooking for one person for a year
- brews 400 litres of beer
- smokes one tonne of fish
- dries 150 kg of tea
- produces 3kg of salt (the amount produced by Tanzanian salt-makers in half a day)
- burns 3,000 bricks (one-third of the bricks needed to build a standard rural house)

*These are rough estimates that vary from place to place, given as indicators rather than absolute figures.
SOURCES: Granger, Alan, *The Threatening Desert: Controlling Desertification*, IIED, London, 1990

Afforestation

Southern Africa contains Africa's largest tree plantations. Swaziland's Usutu pine plantation is the largest single plantation in Africa at more than 700 sq km. Tanzania's Mufundi plantation is the second largest, more than 400 sq km. Through much of the region, indigenous forest and woodland has been cut and planted with commercial woodlots of exotic trees (trees brought in from outside the region such as eucalyptus and pine). Some exotics do so well that they push out native trees and spread into nearby indigenous forests. Pine trees planted in the Tsitsikamma mountains in South Africa, for example, have spread into indigenous mountain fynbos and are threatening to overgrow natural water-courses. Black wattle is a notorious coloniser.

Afforestation can constitute an environmental problem because indigenous plants and animals cannot survive in exotic woodlots. Single-species plantations of exotic trees are nothing like the complex ecosystems found in natural forests. Blue swallows disappeared from Zimbabwe's Eastern Highlands in the 1970s, for example, because of loss of habitat due to exotic-tree planting.[14] In South Africa, about 30 percent of the Transvaal's rare and endangered plants are in areas targeted for tree plantations.[15] In Tanzania, pine plantations occupy land previously covered with indigenous woodland,[16] and most of Malawi's tree plantations replace afromontane forest.

The influence of large plantations of exotics on water supplies has long been a cause for concern.[17] Exotics grow faster than most indigenous trees, using large amounts of water[18] and causing streams to dry up. This has been a particular problem in South Africa, which has most of the region's plantations. On Cathedral Peak in South Africa, streamflows were reduced by almost half within two decades of widespread planting of pines in grasslands. Overall in South Africa, tree plantations have reduced river runoff by 2.4 percent, or 1,284 million cubic metres, a substantial amount in such a dry area.[19]

Afforestation can be a useful conservation tool in certain situations, such as peri-urban fuelwood plantations. Recently, Tanzania has begun to protect the edges of East Usambara forests by planting a strip of exotics, 10-20 m wide, around forest reserves. The exotics supply poles and fuel to local people, and make a definite boundary to show where the forest reserve begins.[20]

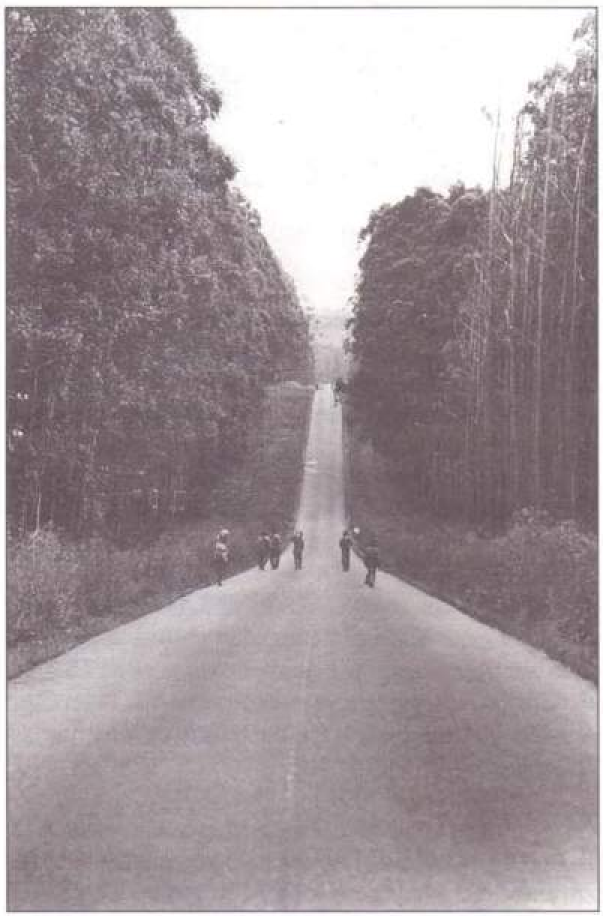

Photo 7.2 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO-L Aersoe

Plantation of blue gums (eucalyptus) in Manica province of Mozambique. Indigenous plants and animals often cannot survive in exotic woodlands.

Fire

Fire now contributes to the region's deforestation problems, in spite of the fact that it is a natural part of southern African woodland ecosystems. Fire has a major role in determining the balance between grass and trees — frequent fire favours grass and less-frequent fire favours trees.

The problem comes with too-frequent fires. Savanna woodland may be able to withstand a fire every six years (or every 25) but not every year — and half or more of the region's woodland is burnt every year.[21] Some of the burning is caused by traditional hunters relying on fire to drive wildlife into the open, but most woodland fires are deliberately set and intended to improve grazing by encouraging grass growth.

Too-frequent fires are extremely damaging, killing tree seedlings and saplings, depleting soil nitrogen and organic matter, decreasing rainwater infiltration,[22] and eventually transforming woodland to shrubs. Areas that do manage to regenerate have about half the amount of wood found in unburnt areas.[23] There is no simple way to predict fire survival for particular types of trees, though the size of the tree, the thickness of its bark, and the intensity of the fire all play a role.

Subsistence use

Rural subsistence use of forests and woodlands is a different matter from collection of fuelwood for urban customers and rural-based industries. Scattered branches are used selectively instead of whole trees being cut. Nearly all fuelwood used in rural households comes from indigenous trees, but household fuelwood collection did not, in past, contribute significantly to woodland clearance.

It is often wrongly assumed that fuelwood collection is extensive and unselective. The common phrase "indiscriminate cutting of trees" is ample testimony to this misconception. In fact, rural people are highly selective about the fuelwood they collect. Certain types of trees and shrubs are trimmed or cut for fuel, particularly hardwoods which give a hot fire, make long-lasting coals and produce little smoke. Dry, deadwood is preferred as it is more lightweight and easy to carry and,

Woodland and forest resources in southern Africa Table 7.2

(land areas sq km)

	Total land	Natural forest and woodland*	Existing plantations	Annual reforestation	% annual deforestation
Angola	1,246,700	1,170,651	1,800	30	0.2
Botswana	566,730	525,600	7	-	0.1
Lesotho	30,355	160	70	9	-
Malawi	94,080	46,510	1,440	40	3.5
Mozambique	784,090	581,350	400	40	0.8
Namibia	823,290	560,650	<2	-	-
South Africa	1,221,037	45,150	16,400	630	-
Swaziland	17,200	5,996	1,040	50	-
Tanzania	886,040	599,400	980	90	0.3
Zambia	743,390	676,067	629	20	0.2
Zimbabwe	390,580	233,900	1,500	40	0.4
TOTALS	6,803,492	4,445,434	22,959	949	-

*Woodland includes both moist and dry savannas.

SOURCES:IUCN and others, *Angola: Environmental Status Quo Assessment Report*, IUCN, Harare, Oct 1992
Kingdom of Lesotho, *National Paper on Environment and Development in Lesotho*, Maseru, 1992
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Republic of Mozambique, *Country Report for UNCED 1992*, Maputo, Aug 1991
World Resources Institute, *World Resources 1992-93*, Oxford University Press, New York, 1993

Photo 7.3 IRIS-C Thege
Improved stoves, or jikos, in use in Tanzania.

depending on the type, burns better than green wood.[24]

Almost all of the region's rural residents rely on fuelwood as their primary source of energy. More than 80 million cubic metres of wood are burnt as household fuel every year, two-thirds of it for cooking. This works out to an average of one cubic metre of wood annually per person, though there is a large range between countries with more woodland cover such as Mozambique and Tanzania, and countries where fuelwood is scarce such as Botswana. One cubic metre is about the same as the average amount of wood each person in North America uses each year in the form of paper.

Fuelwood scarcity is more a consequence of deforestation than a cause, and this is a widespread problem. Wood must be collected more intensively from nearby areas, and people are forced to choose less-preferred types and live tree-branches. More time is spent travelling greater distances to collect wood. To meet their fuelwood needs, for example, QwaQwa women in South Africa walk several times a week to Lesotho — over eight hours per trip.[25] Most women prefer to spend more time collecting fuelwood, and conserve fuel by protecting the fire from wind and extinguishing the flame directly after cooking, rather than cut back on cooking, heating water or brewing beer. On the whole, rural populations have effectively weathered the effects of woodland clearance by protecting and managing certain key types of trees, and by reducing their wood consumption to cope with shortages.

Rural people depend on a multitude of products from woodlands and forests which are fundamental to their survival and can represent as much as half the annual household income of small-scale farmers.[26] One of the first signs of deforestation is scarcity of poles and timber for construction. Small trees and bushes can be used as fuel, but building materials cannot be substituted easily. In some areas, shortages of construction poles and fuelwood have resulted in illegal cutting of trees in protected areas. Today, because of shortage of suitable poles, people are substituting palm-leaf stems and millet stalks for some or all of the wooden poles.[27]

The cutting of trees for agricultural tools (such as yokes, hoes and tool-handles, animal pens, granaries, ox-carts), and furniture and craft carving also contributes to deforestation. In Swaziland, more wood is cut for crafts than for poles, as the trees are too twisted to be useful for construction.

Attempts to reduce deforestation with fuel-saving stoves have met with little success in southern Africa, primarily because the major cause of deforestation is not fuelwood use. Also, the stoves have not been appropriately designed or promoted. Generally, the potential impact of fuel-saving stoves on deforestation has been overblown. Often stoves that rank as extremely efficient in test situations do not actually reduce fuelwood consumption by much in rural settings. They reduce cooking time but cannot be used for household space-heating, lighting, or brewing beer.

Part of the reason for the reported low levels of improvement is that stove programmes are usually promoted in areas where there is already a fuelwood "crisis", and where people are already using fuelwood as conservatively as they possibly can. Special stoves cannot make much difference under these circumstances.

Promotion of "fuel-saving" stoves Box 7.3

Stoves often fail to meet the needs of the users because of a mismatch between how the stove is designed to be operated and how it is actually used in the home. A stove project in South Africa, for example, distributing single-pot stoves found they were not popular because only one pot could be used at a time so previously cooked food could not be kept warm. Fuelwood consumption did not decrease because people did not use them, or used them in addition to open fires. The subsequent introduction of a two-pot stove produced a fuel saving of 14 percent compared to open fires, but the cost — more than R200 ($US 67) — was too expensive for most rural residents.

Locally produced stoves are cheaper and do not require a large change in behaviour to use them. The drawback is that success depends on extremely well-trained extension workers and well-organised institutional backing, relying on financial resources and trained stove-builders. Locally produced stoves do not significantly save fuel. In Malawi, "improved" mud stoves were 50 percent more efficient than open fires when used outdoors and exposed to the wind, but when used indoors, where village women normally cook, the stoves saved only five percent more wood.

Technical studies comparing the energy efficiency of open fires (with metal grate) to stoves actually suggest that open fires are two times more efficient. The Beijer Institute in Zimbabwe noted that open fires provide a better degree of heat transfer, and offer several other basic advantages. They cost nothing, and long pieces of wood can be used (an advantage when hardly anyone has a saw or even a sharp axe), pushing them further into the fire when more heat is required or pulling them out to extinguish the fire. The principal advantage of improved stoves is their time efficiency (food can be cooked faster), not their fuel efficiency. Since there is no way to guarantee that stove-users will use less fuel, their wood consumption can be higher than people using open fires.

It is still worthwhile promoting household stoves, particularly in areas where large amounts of wood are used, provided the needs of the people involved are taken into account sufficiently. Urban fuelwood and charcoal users are another group that who have been successfully targeted for fuelwood-saving stoves. They have to pay for their fuel and are motivated to use less if they can. Urban dwellers also tend to be more open to adopting new ideas and using new technology.

An "improve your kitchen" theme to promote stove-use is more appealing than "save trees", and may be accurate since a major benefit of stoves is faster cooking and reduced smoke in the kitchen. The main lesson from efforts to promote fuel-efficient stoves are that they have to be designed to meet the needs, priorities and financial capabilities of the people for whom they are intended, and that in areas where people are using little fuelwood already, stoves cannot make much of an improvement.

SOURCES: Chege, Nancy, "Cooking up a More Efficient Stove", *World Watch*, Dec 1993, Vol 6, no 6, p. 34-36
Chitenje, H.W., *Information on Fuelwood Shortage in Nsanje*, unpublished, Lilongwe, 7 Oct 1992
Dickson, B.J. and S.A. Baldwin, *The Development of Low Cost Fuel-Efficient Wood Burning Stoves Appropriate for Underdeveloped Areas of South Africa*, Energy Research Institute, University of Cape Town, Feb 1989
Workshop Proceedings on Energy Saving Stoves in SADCC Region, Lusaka, Aug 1991

STATE OF SOUTHERN AFRICA'S FORESTS AND WOODLANDS

Lowland Tropical Forest

Forests differ from woodland in having a completely closed canopy of trees which prevents sunlight penetration to the ground and discourages ground cover-growth. Forests contain a great variety of plants and animals, but not many commercial timber species. Forests in coastal areas have the important role of stabilising beach edges, and providing habitat for migrating birds.

The main centres of lowland tropical forest in the region are northern Angola and along the Indian Ocean coast, though it also penetrates along river systems as far as southern Malawi and eastern Zimbabwe. The northern Angola portion of the zone has low rates of deforestation, except for a strip of land parallel to the coast, which has been cleared for cultivation. Forests in the remainder of the zone are small and fragmented. South Africa's coastal tropical forests have almost disappeared and are confined to remnant patches near the coast north of Algoa bay.[28] A small remnant tropical forest area of about 10 sq km remains halfway up Tanzania's coast at Pugu Hills. It is being cut and planted with exotics, though it contains 12 plant species unique to the area and several other rare species.

In Mozambique, destruction of tropical forest is mainly a problem near urban areas, though many of the forests have been reduced through clearing, cultivation and fire. They are now interspersed with thickets on dry sites and grasslands on waterlogged sites. The biggest losses have been in the Rusitu valley near the border with Zimbabwe, and north of Beira. Zimbabwe's only tropical forests (too small to appear on the map) may disappear soon unless stronger measures are taken to preserve them. They are located south of the Chimanimani mountains bordering Mozambique.

Uncontrolled tree cutting, encroachment by local people and an influx of Mozambican refugees have reduced the forest in the Haroni Botanical Reserve from 20 hectares to two hectares. Rusitu reserve was originally 150 hectares but only 30 hectares remain. Zimbabwe's Department of National Parks is working closely with a non-governmental organisation, the Chipinge Wildlife Society, to survey the remaining tropical forests, mark and protect them.[29] Once tropical forest has been cleared, little can be done to restore it, and even if indigenous species were routinely regenerated they would take up to a century to grow.

Afromontane and Temperate Forest

Afromontane and temperate forests contain several commercially harvestable trees but are generally poor in fruit-bearing types. Frequently the wildlife includes rare, unique or endangered plants and animals. About three-quarters of the plants are endemic (found nowhere else). Forest and grassland coexist in many places at higher altitudes along the eastern escarpment from South Africa through to Tanzania. These forests have been extensively cleared for cultivation, and it is largely forest reserves and areas with steep terrain that remain.

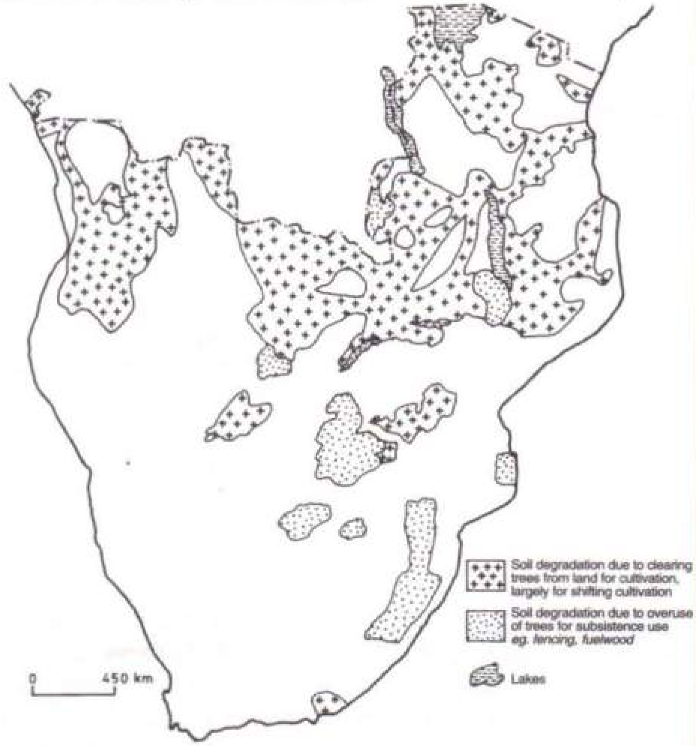
About two-thirds of Malawi's afromontane forests are in reserves and are protected from general access. The formerly extensive forests on Mbozi plateau and Bulambya mountains, to the north of Malawi, are now limited to forest reserves and hills where the terrain is too rugged to be cultivated. Mount Mulanje in the southern corner of Malawi has some 66 sq km of forests containing about 30 unique plant species, more than 100 types of ferns and three endemic butterflies. This forest is threatened by expanding cultivation. Mozambican refugees and Malawian tea-plantation workers, initially confined to lower slopes, have moved onto the steep upper slopes as well, removing the forest that protects the source of the area's streams. Southern slopes of Mulanje are almost completely deforested. Rehabilitation is in progress but it will be many years before the area is covered with trees again.

Photo 7.4 SAMSO-T Davies

Tree ferns in Chimanimani mountains of Zimbabwe.

The steep slopes of Tanzania's Uluguru mountain have kept some 120 sq km of forest almost intact. Lower slopes are being cleared because of high population densities. Above the cultivation line, most of the mountains are covered with afromontane forests which protect the source of water for dry-season, small-scale irrigation lower down. In areas where cultivation reached the top of the mountains before the

Areas affected by deforestation Map 7.1



SOURCES: Oldeman, L.R. and others, *World Map of the Status of Human-induced Soil Degradation: A Brief Explanatory Note*, ISRIC/UNEP, Nairobi, Apr 1991
Middleton, Nicholas J. and David S.G. Thomas, *World Atlas of Desertification*, Edward Arnold, London, 1992

forests were protected, the streams have dried up and the soil is very poor. The Uluguru area has many endemic birds, plants and animals.

Tanzania's major afromontane forests are in the East Usambara mountains which cover more than 455 sq km. They contain about 300 different types of trees, about half of them endemic,[30] and several types of endemic or rare birds, reptiles and insects. Half of the forests have been cleared to make way for teak and eucalyptus plantations, and commercial agriculture, including tea, rubber, cocoa, sisal and cardamom. At least 50,000 people depend on the mountain for fuelwood, poles, wild foods and land for subsistence production of maize, coconut, cassava and banana. Most of the remaining natural forests are in forest reserves. Until 1986, one aid-agency was subsidising local sawmills to cut timber in eastern Usambara forests, but this has now been stopped. Since then, timber is removed selectively by pit-sawing, which is less destructive than large-scale clear-cutting.[31]

Angola's afromontane forests were never extensive and only scattered patches remain, adding up to about two square kilometres. In the central-western part of Angola, north of Huambo, the Amboim forests were cleared extensively for coffee production but have reverted to secondary growth of dense bush and thicket, unlike the original tall, open forests. Northeast of Luanda, the Bailundu highlands have tiny patches of remaining forests, which are under threat from continuing timber and fuelwood extraction. The remaining pockets of pristine forest contain several unique and threatened birds and plants.[32]

In Zimbabwe, afromontane forest is still relatively extensive on eastern and southern slopes of the Nyanga and Vumba mountains,[33] and patches remain on Chimanimani and Himalaya (Cashel/Banti) mountains. Total forest area is around 70 sq km, of which 14 sq km are protected in the Nyanga and Vumba highlands. These forests contain several rare birds. The main threat is clearance for agriculture, while frequent fires inhibit expansion back into previously forested areas.

In South Africa, natural afromontane forests remain on the eastern Transvaal escarpment. Huge areas of about 14,000 sq km[34] have been planted to eucalyptus and pine. More than half of the plantations are in Transvaal and a quarter in Natal. Generally, the southern Cape's afromontane forests are managed well and are not threatened.

In Swaziland, as much as a quarter of the country was original afromontane forest. Now 364 sq km remain, protected in Swazi National Forests, and recently inventoried to allow for sustainable management. Lesotho's remaining forest is even more confined, scattered in small remnant pockets along the escarpment area adding up to 60 sq km.

Grassland

Grassland is mainly grass and some areas have trees, but it differs from savanna woodland by being generally cooler and drier. Historically, Lesotho's lowlands and foothills had sparse woodland cover, with patches of trees growing in sheltered ravines. Some of these remain as small pockets of indigenous thicket growing on northern slopes and deep narrow valleys. The climate in Lesotho is harsh, and once the indigenous trees were removed from the grassland by increasing populations, browsing and fires, few could grow back. Today in Lesotho, some fuelwood is collected from trees planted on homesteads, but most is from encroaching bushes, dung and crop residues. The Lesotho Woodlot Project, started in the early 1970s, has planted more than 70 sq km of village lands spread among 350 locations. A third of Lesotho's villages now have a woodlot, mainly eucalyptus and pine.[35]

Savanna Woodland

About half of southern Africa is covered by some form of savanna woodland vegetation. The term "savanna" refers to areas where trees and grass grow together, though the proportions of each vary with rainfall, soil type and other physical factors. Seasonal rainfall is the key factor.

Moist Savanna Woodland

The main vegetation type is *miombo*, which typically consists of a partly closed canopy of trees up to 20 m high, a few shrubs beneath and an often sparse, but continuous, layer of grasses and other ground cover. Historically, *miombo* and other moist savanna areas have been relatively underpopulated. The soils are not suited to cultivation, being low in nutrients but high in iron and aluminium which "bind" chemical fertilisers, making them unavailable to plants.

In the last few decades, increasing pressure for land has forced people to move into moist savanna areas. There are some isolated pockets of old-growth (undisturbed) moist-savanna woodland, but most have been disturbed by expanding cultivation and commercial logging, overgrazing and too-frequent fires. Communal lands in the north-west of Zimbabwe were sparsely populated, for example, but eradication of tsetse-fly means that people are settling and clearing croplands. War has created artificial population pressures in parts of the zone as well. Concentrated refugee populations have cleared land for cultivation, leading to localised fuelwood shortages along the central and northern coast of Angola, coastal portions of Mozambique, and central and southern parts of Malawi.

Malawi's moist savannas have the highest rate of deforestation in the region, and the second highest in Africa,[36] related mainly to expansion of agriculture. Part of the Rift valley escarpment remains well-wooded, but most of the country's woodland has been removed, replaced by dry, bush thickets. The only large indigenous trees are found in forest reserves, and in graveyards, as custom dictates that the natural vegetation be left intact. Fuelwood supplies are low, and half of rural-household energy comes from crop residues rather than fuelwood. Because of the land shortage, people are clearing land in forest reserves for subsistence cultivation.

One of the main agricultural techniques affecting moist savanna woodlands is shifting cultivation. In Tanzania, most of the shifting cultivation is for subsistence farming but about a quarter of it is for tobacco, grown by 260,000 people, some of them refugees from Burundi and Mozambique.[37] Cropping areas are abandoned after only two years because of pests which build up in the soil. There are acute fuelwood shortages along the border with Zambia, and some areas can no longer produce tobacco due to the lack of fuelwood.[38]

Urban use of fuelwood and charcoal is also important in this zone. In southern parts of Mozambique, trees equivalent to those found in an area covering 150-200 sq km are cut every year to supply fuelwood to Maputo.[39]

The region's most valuable indigenous teak and *mopane* woodland is the Zambezi valley catchment area including south-central Angola, the Angolan border area with Zambia and Namibia, including the Caprivi strip, northern Botswana, as

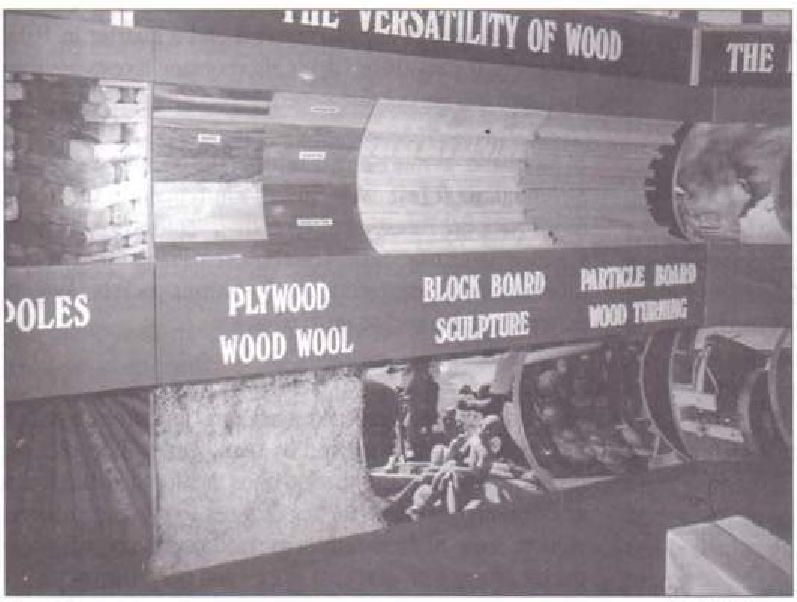


Photo 7.5 SAMSO-T Davies

There are many commercial uses of wood products today.

well as northwestern Zimbabwe and central Mozambique. This huge woodland area covers hundreds of thousands of square kilometres and sustains the headwaters of a number of rivers, including the Zambezi. Use of the area by commercial woodcutters — particularly for selective logging of Zambezi teak and *mukwa* (Transvaal teak)[40]— is largely uncontrolled due to its remoteness and the difficulty of management during war. Most of the large trees have been cut and sold for use as railway sleepers, furniture and parquet flooring. In Zambia's Copperbelt, widespread cutting of timber trees for the mining industry destroys 40,000 trees each month and has markedly increased runoff into the Kafue river. In northern Botswana, there has been extensive logging of the dense woodland in Chobe and Ngamiland which hold more than 40 percent of the country's marketable trees.

Dry Savanna Woodland

Untouched dry savanna consists of widely spaced trees, sometimes with touching crowns, but a light canopy that allows grass to grow beneath. Examples include the short-grass plains of the Serengeti in Tanzania, the *acacia-commiphora* wooded grasslands of eastern Africa and Namibia, and the *acacia* woodlands of the lower-altitude regions of South Africa, Zambia and Zimbabwe.

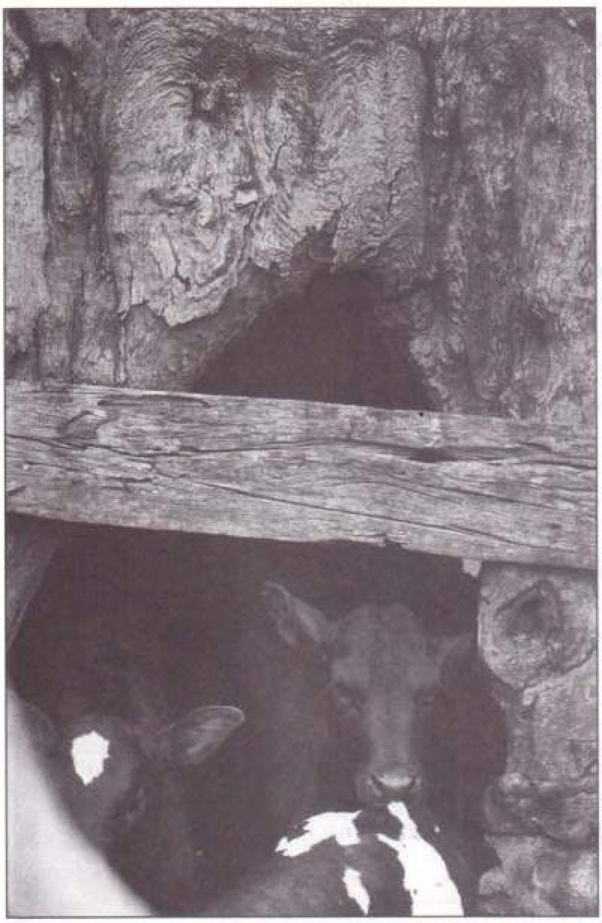


Photo 7.6 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO-R Rangel

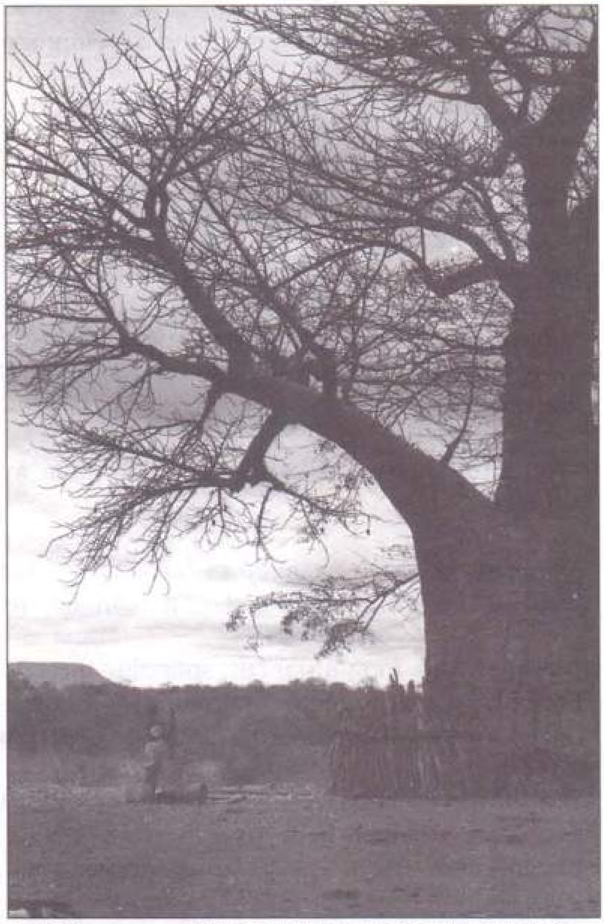


Photo 7.7 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO-R Rangel

Trees provide shelter for people, plants and animals. These cattle are confined in the hollow of a giant Baobab in Tete province of Mozambique.

Though huge, much of the zone has been cleared for cultivation. Urban areas tend to be surrounded by extensive cleared areas due to commercial fuelwood collection. Overgrazing and frequent burning has degraded much of the remaining woodland to shrubs rather than trees and grass. The shrubs are useful for fuelwood, but the trend represents a significant loss of other woodland products such as poles and food sources.

The most serious deforestation and fuelwood problems in the dry savanna are in densely populated areas. In south-central Zimbabwe and along the Botswana-Zimbabwe border, over-

Women combine environment and development Story

Iringa, Tanzania (SARDC) - Janet Mwakasonda sits on a tree trunk, tired after a long journey to and from the forest to collect firewood.

It is just a brief rest. She has 10 kilometres to trudge home with her load — a bundle of firewood on her head and her two-year-old baby on her back. Fatigue is apparent on her face as she sits looking around the landscape, which is part of the Usangu plains in southern Tanzania.

"I have been walking for four hours and the remaining distance to my place seems a decade away," she says, with resignation in her voice. "I go to the forest three times a week to collect firewood.

"You see, this has made me look older than my real age," she says, without, however, stating her age.

Mwakasonda is an example of hundreds of women in Mbeya rural district who are forced to walk 100 km a week in search of a dwindling resource — firewood.

"Women walk long distances, spending three to seven hours a day collecting firewood. This is not only a great waste of time but also increases their workload," says Mary Msemwa, project officer for the Mbeya-based Women Irrigation Agriculture (WIA).

She, however, believes there is hope through the Irrigation Agriculture project, started about five years ago with help from the Netherlands and the United Nations Food and Agriculture Organisation (FAO).

She says the project aims to rehabilitate six irrigation schemes — Majengo, Mswiswi, Ipatagwa, Matombaya, Meta and Lumwa — covering 3,300 hectares. Twenty-three villages of 14,000 families are serviced by the schemes.

WIA is already active in eight villages — Chamoto, Igurusi, Majene, Uhambule, Kongolo-Mswiswi, Mahango, Azimio and Nsonyanga — with a total population of about 19,000 people. The regional forestry department has provided seeds and technical staff to help set up the nurseries and woodlots, and WIA members have learned how to manage them.

Joseph Haule, an extension officer with the project, says trees planted are fast-growing, suitable for the climate in the Usangu plains and popular with the local people. The trees, which include eucalyptus, pawpaws and avocado, have a 70 percent survival rate. Losses are due to theft, drought, wild animals and pests. Out of the 33,530 trees planted this year, 15,620 are for fuelwood and the remainder are fruit trees.

"Long-term objectives are the improvement of the living conditions of the people, particularly women, and identification of the main obstacles to their full participation in development," says Msemwa, adding that the intention is to find ways to solve those problems.

— **Francis Nyange,** Journalists Environmental Association of Tanzania (JET), Dar es Salaam, for SARDC, 1993 grazing by livestock, and collection of fuelwood and poles, inhibits regrowth of trees. Many people rely on crop residues for at least some of their energy needs. Tanzania's border area with Kenya and the area south of lake Victoria and near Arusha are also severely affected. In the Shinyanga and Singida districts, deforestation and soil degradation has led to water shortages and the drying of streams.

Toward the western end of the zone, the war in Angola has concentrated people along the Namibian border, contributing to localised fuelwood shortages and repeated cutting and burning of land for agriculture. Woodland along the Angola-Namibia border has been burnt frequently to clear cover for soldiers.

In northern Namibia, where there is little additional land suitable for cultivation, the major threat to woodland is collection of wood for fuel, household and fence construction, crafts and fodder.[41] Namibia's slow-growing riverine forests are endangered by people moving into floodplain areas and removing trees faster than they can grow. Traditional ways of life collapse as people are forced to use less preferred alternatives such as cow dung for fuel and palm leaves for fencing.

Fynbos

Most of the fynbos does not have large trees, but features shrubs and shrubby woodland to three metres high, with patches of hardwood forest. This may be because of fire. Some types of fynbos plants require fire in order to release seeds, but others are killed by fire. Natural fires were infrequent in the area, but there have been frequent fires for at least the last 300 years.

RELIEVING DEFORESTATION PRESSURES

The decline of natural forests and woodlands, increasing populations, and the lack of alternatives to wood make the planting of trees and better management of existing natural woodland necessary to prevent complete deforestation, and to meet the need for fuelwood and other woodland products. Clearing of land for agriculture and use of wood for building, as well as fires and overgrazing all play a role in deforestation, so management interventions must be multi-faceted and not concentrated solely on large-scale exotic tree-planting.

In general, large plantation woodlots are managed by governments or companies for commercial production of timber, pulp and tanning extracts. Smaller community-level woodlots provide building poles and fuelwood and are operated by forestry departments or municipal and village organisations. In South Africa, local authorities have some responsibility to

Tree-planting and land-tenure Box 7.4

Under conditions of increasing land scarcity in some parts of the region, tree-planting is becoming an important means to secure land. It is often argued that if people do not have secure land tenure, and cannot be sure that they will derive the benefits from trees they plant, it is pointless for them to invest effort and resources in tree planting. However, most rural people do traditionally recognise rights to crops, and planted trees, generally, are viewed as crops. When farmers cultivate trees, therefore they actually strengthen their rights to the land. This is happening in KwaZulu, where field boundary trees, particularly, have become so valuable in some areas that they are well cared-for and have high survival rates.

Building on the traditional views of rights to planted trees, with legal instruments protecting tree ownership, can result in far-reaching changes in attitudes and land-use practices.

Mamire village, in Tanzania, passed a law stating that a person who deliberately destroys another person's tree will be fined 1,000 shillings (US$2) and has to buy, care for, and plant 20 new seedlings wherever the injured party wishes. On the strength of this law, virtually every small-holder in Mamire planted trees along field boundaries in 1989, because of escalating local conflicts over land access.

The nearby village of Sigino copied the bylaw but raised the fine to 10,000 shillings (US$20). In another village, the council decided that one small tree destroyed should be compensated by the full value of the timber boards which the mature tree would eventually have yielded — an estimated 27,000 shillings (US$54). The conflict was eventually settled out of court.

SOURCE: Johansson, Lars. *Successful Tree Growers: Why People Grow Trees in Babati District, Tanzania*, SUAS Working Paper 155, IRDC, Uppsala, 1991

Photo 7.8 RED CROSS-D Sanger

School children planting trees at Popanyane (above) and Nkoeng primary schools in Lesotho.

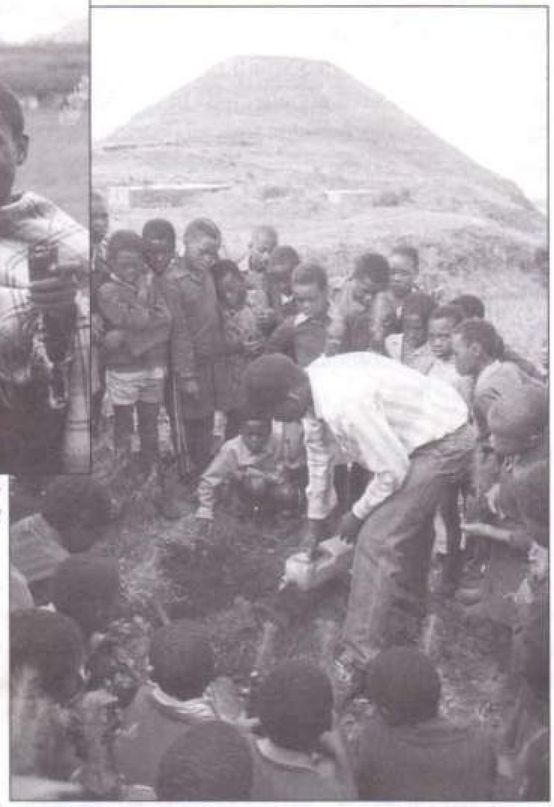


Photo 7.9 RED CROSS- D Sanger

establish and maintain woodlots, but most of these are neglected. Individuals also plant trees for their own use, usually on their own land.

Tree-planting and village woodlots

Most countries in the region have attempted to improve fuelwood resources in rural areas by promoting the planting of eucalyptus village-woodlots. This has not been popular with rural people, for several reasons. Eucalyptus trees provide good poles, but have poor burning qualities compared to indigenous trees, and cannot substitute for the multitude of other resources that natural woodlands provide.

People also resent the loss of grazing land, especially when it is without compensation. "Food for Work" programmes often support the initial site-preparation and tree-planting, but the site is then closed to all uses for eight years or longer. This can build resentment between the community and the agencies that enforce the change in land use. Lesotho's Farm Improvement with Soil Conservation (FISC) programme involved restricting people's access to certain lands, for example, and woodlots planted in 1989 suffered inexplicable fires due, it is thought, to deliberate burning.

The lack of clarity over who is permitted to use the woodlot often builds resentment and leads to inadequate maintenance. Poor seedling survival and growth rates of exotics under communal land conditions are common, with half or less of the trees surviving the first few years because of browsing by livestock, fires, termites and drought. Lack of clarity over management can even result in the woodlot never being used. Many of the region's woodlots that have survived have not been harvested and now consist of over-mature trees too large to be used as fuelwood or poles.

Effects of *acacia albida* on millet yields* Table 7.3

	Near tree trunk	Edge of tree canopy	Outside tree
Yield of millet (kg/ha)	180.0	84.0	52.0
Number of ears/plant	5.4	4.2	2.9
Weight of grain/ear (g)	29.8	23.3	22.6

*Assumes 40 *Acacia albida* trees per hectare.
SOURCE: Skoupy, J., "The Role of Trees in Agroforestry", *Desertification Control Bulletin*, 1991, no 19, p. 44

Village woodlots have had different impacts in different areas. Most programmes failed because they were not taken as part of an overall rural development programme.[42] However, village woodlots should not be dismissed. Community support is the key requirement. In Swaziland, one village given a plantation by the government managed to sell the timber for E100,000 (US$35,000). Now this village is very interested in tree planting, has reinvested in the woodlot and takes advice from forestry officers.

In some areas, incorporating local priorities and traditional approaches to tree and woodland management has made a difference. The Zimbabwean Institute of Religious Research and Ecological Conservation (ZIRRCON) successfully promoted the replanting of traditional holy-sites by enlisting the support and involvement of chiefs and spirit mediums who still wield considerable influence. More than 750,000 indigenous trees were planted in the Masvingo area, with a better than 60 percent survival-rate.[43]

Individual plantings

Planted trees provide a means of savings and security and can be cut and sold if necessary — much as livestock are — with the additional benefit that they are easier to acquire and less often begged by relatives. Throughout southern Africa, half to three-quarters of rural residents plant trees, mostly for fruit but also for poles, shade, fodder, and live fencing to keep cattle out of the crop and homestead areas.

Since fuelwood is generally available free, there is not much incentive to plant trees for energy purposes alone. As crops give a higher return than trees, people are unwilling to use their scarce agricultural land for fuelwood planting. There are some exceptions to the general resistance to fuelwood plantations, however. In the most densely populated area in Swaziland, about a quarter of the households have planted woodlots of wattle, averaging three-quarters of a hectare, using local seed. A third of the households in the Bhekinkhosi and Sigombeni areas supply all their own fuelwood from wattle plantations.[44]

Generally, people are more interested in planting trees in areas where it is difficult to find poles and fuelwood. Three-quarters of rural women in Botswana, for example, are prepared to offer their labour for free in order to improve fuelwood supply.[45] Income is another factor. Tree-planting tends to be done by the better-off rural residents who have leisure time, not by the poorest. Wealthier Maasai villagers in Enguike, Tanzania, for example, were able to plant trees for shade and for windbreaks because they had time to tend the seedlings.

People who do not plant trees usually say it is too difficult, requiring special knowledge, seedlings, fencing to protect young trees from livestock and fetching of water. Residents of Babati, Tanzania reported to an interviewer that they would probably not have started planting trees if they had to raise the seedlings themselves, and that the first tree they planted was given to them by a friend, neighbour, school or nursery. Then, the experience of observing how quickly casually planted trees grew moved them to plant more. Eventually, some learned to grow their own seedlings collected from the wild or started from seed.[46]

Agroforestry

Agroforestry (agriculture using trees) is another system for increasing woody production in rural areas, while producing many other benefits.[47] It involves raising crops or grazing animals among trees especially planted or encouraged, as a way to conserve soil and improve crop-yields. The system makes use of different heights of plants and different rooting depths. A crop preferring shade can be grown under a tall, sun-loving crop. Shallow-rooted and deep-rooted crops grow side-by-side as they don't compete for water. The trees improve soil organic matter and nitrogen content by 50 - 100 percent, and the improved soil holds more water and resists erosion.

At the heart of any agroforestry scheme are multi-purpose trees which provide fruit, fodder, wood, other products and shade, and which grow quickly on poor soils. Agroforestry doesn't require large cash investments, and offers a way to raise farm production while reducing use of pesticides and fertilisers, restoring tree cover and reversing soil degradation.[48] More people can be supported by a given area because multiple cropping (growing a variety of plant and trees throughout the year) increases the overall production and provides a more continuous supply of food[49] and other products. When trees have palatable foliage, for example, about 10 percent of the foliage may be used by livestock without affecting fuelwood yields.[50]

Variations of agroforestry have been practised successfully on many small and medium-sized farms in the region for decades. Rural residents often have an in-depth knowledge of the uses and management of different types of trees. In parts of Malawi, people grow banana, guava and mango trees in vegetable gardens, and field crops under *acacia albida* trees. People in Lesotho plant vegetables together with fruit trees. On about 1,200 sq km of Mount Kilimanjaro's slopes in Tanzania, the WaChagga grow taro, coffee and banana under fodder and shade trees which are also used for poles, timber and fuelwood.[51]

There is some potential to using agroforestry to make shifting cultivation more sustainable.[52] In Zambia, the International Centre for Research in Agroforestry (ICRAF) is working with the government to try to improve methods of shifting cultivation by growing leguminous trees in rotation with food crops. ICRAF predicts that "acceptance rates for improved fallows are likely to be high among farmers".[53]
However, agroforestry is not a universal solution. Local environmental conditions must be considered. Planning for agroforestry and tree-planting must consider the area's natural type of vegetation. Trees planted in marginal land already degraded by overgrazing or overcultivation often do not do well.[54] Agroforestry may not suit local people either. Reasons given by farmers for not liking agroforestry include shading of crops, birds attracted that damage crops, tree-roots stealing water from crops, priority use of land for crops, trees taking too long to grow, and attraction of lightning. The time for planting trees corresponds with the time for planting crops in many cases.

For agroforestry to succeed, the integration of trees must arise from the objective of improving farming systems and the residents' welfare, rather than the objective of growing trees.[55] When compared to conventional systems, agroforestry must provide a higher output at the same cost, or equal output using less land, to be attractive to subsistence farmers. It is most suited to areas where farmers have long been consciously engaged in the struggle against soil degradation, and where they are already applying similar techniques such as tree-planting on their own.[56]

Conservation woodlots and management of natural areas

Tree-planting can be beneficial, but is not effective on its own without a change in land-use and protection from grazing and fires. The ecological benefits relate to soil-type, tree-type and how many are planted, the slope, and particularly to management factors related to harvesting and grazing. The ground cover such as grass must be protected from grazing, and leaf litter is crucial to erosion control.

Some countries, particularly Tanzania and Zimbabwe, have found that it can be more effective to improve management of natural areas rather than concentrate solely on tree planting. Some areas are simply fenced to prevent grazing and allow natural regeneration. This strategy has a number of benefits. Indigenous trees are adapted to local conditions, pests and rainfall levels, so improved woodland management is particularly appropriate for drier countries such as Botswana and Namibia where exotics do not produce well.[57] Countries with relatively high amounts of natural woodland remaining — such as Angola, Mozambique, Tanzania and Zambia — also benefit because woodland management is more economical than large-scale planting.

Indigenous woodlands provide a reliable supply of wood, with yields often equivalent or comparable to exotic plantations. Recent studies suggest that wood-yields from natural woodland have been underestimated in the past, and those from plantations overestimated. Techniques to improve wood production of indigenous woodland have been known for some time and now are being applied more intensively. Coppicing of trees (cutting them off near the base so that new poles can shoot up) produces dense regrowth containing up to three times more wood than uncoppiced trees. Pollarding trees (similar to coppicing but the cut is made at head height) produces even more wood, equivalent to increasing the woodland area 10 times.

Better management of natural woodlands and forest areas can also be done by individuals. In parts of Namibia and Zimbabwe there is widespread "annexing" of as much as two hectares of common woodland into private homesteads, by extending fences. Villagers with such private woodlands usually manage them efficiently and are self-sufficient in poles and fuelwood. Communal farmers in Zimbabwe commonly leave certain indigenous trees around their homes, on field contours and boundaries and along waterways. Often this is because of traditional laws prohibiting the cutting of certain trees. Trees are also protected if they provide valuable fruits or fodder, improve soil fertility, or provide shelter and shade for people working in the fields. In a survey carried out in Mutanda Resettlement Area in Zimbabwe, for example, 94 percent of households have left selected trees in their fields.[58]

While better management of existing natural woodland shows a lot of potential for increasing fuelwood supplies while maintaining woodland areas, planting large areas with indigenous tree seedlings is difficult. Indigenous trees are more difficult to start from seed than exotics, and most grow more slowly. Many cannot tolerate full sun and must be planted in shade, though sometimes the necessary shade can be provided by planting the indigenous seedlings under exotics. In some cases, individual seedlings can be collected in natural woodland and transplanted to nearby sites. The technique is best applied to limited areas, such as strips of indigenous seedlings planted along the edges of indigenous forests to protect them from developments and from overuse.

Plant seeds of the future

Story

Lilongwe (SARDC) — Along the lakeshore of Malawi, beautiful indigenous trees grow, right at the entrance of the Mangocha Hotel reception. These have been carefully protected from exploitation.

A few hundred kilometres away, in Lilongwe, Susan Minae, a scientist who works to encourage the planting of indigenous trees in agroforestry, says: "We are trying to integrate fruits in farmers' fields." She works with women, men and children in rural areas.

Susan believes women have a crucial role to play in agroforestry: "I get annoyed with survey takers who return and say the farmer wasn't home — only his wife."

Across southern Africa, the role of women in this and in development in general is assuming importance by the day. Meanwhile, the beauty and benefits of indigenous trees are gaining recognition among decision-makers in the region.

Southern Africa is endowed not only with beautiful trees — it has 80 indigenous varieties of fruit trees. These include the baobab, the marula and wild loquat trees. The plants are rich in vitamins, protein and calcium. Other plants such as the pepper-bark tree are good as medicine. Growing such trees on a large-scale has the potential to benefit society tremendously.

In view of the important role indigenous trees can play, especially in rural areas, the Southern African Development Community (SADC) has embarked on a tree-seed development programme funded by the Canadian International Development Agency (CIDA).

The SADC Forestry Sector in Malawi, through the SADC Tree Seed Centre Network, seeks to: "achieve a sufficient and sustainable supply of high-quality tree-seeds of a diversity of species ... through the strengthening of national tree-seed centres and the formation of a network."

The project is implemented in conjunction with the SADC Plant Genetic Centre in Zambia and national plant genetic committees in SADC countries.

The project has sponsored seed specialists to attend courses in the region — at the Sokoine University in Tanzania, the Forestry College in Zimbabwe and through visits to established plant genetic centres in the region. Others have been sent abroad to Canada, UK and US for short courses.

Jean Brouard, the manager of the Seed Centre, acknowledges that interest in indigenous trees is not a new idea in southern Africa. Some foresters in the region have been studying the growth potential of indigenous species.

In Zimbabwe, the weeping wattle, waterberry, and winter acacia are among those already on the market. South Africa and Zimbabwe have healer associations that grow medicinally important trees.

The project is outstanding in its involvement of women in the region. "Women have a lot to offer at all levels. And I have a strong feeling that they have to be involved. I am happy SADC countries have been promoting the role of women in forestry, which is traditionally dominated by men," says Brouard.

"The seed project's policy is to have 50 percent ratio of men to women at all levels of the organisation," he added.

—**Mutizwa Mukute,** Southern African Research and Documentation Centre (SARDC), May 1994

Photo 7.10 PHOTOGRAPHIC TRAINING CENTRE. MAPUTO-R Rangel

Photo 7.11 PHOTOGRAPHIC TRAINING CENTRE. MAPUTO-R Rangel

Cutting trees with chainsaw, saw and axe.

Photo 7.12 PHOTOGRAPHIC TRAINING CENTRE. MAPUTO-R Rangel

Linkages to other chapters Box 7.5

1 PEOPLE
Human activities impact on forest resources through cultivation, fuelwood collection, and commercial and industrial uses. Tree-planting and afforestation can help to balance these impacts if local conditions are considered in planning.

2 HISTORY
Traditional methods of using forests were more balanced than today, and there were fewer people. Forests were used for food and medicine as well as shelter, fuel and agricultural pursuits (wood ash).

3 POLICY
The tendency to oversimplify the causes and effects of deforestation on the environment, and on rural livelihoods, has led to the propagation of a number of unsuitable policies and programmes.

4 ECOZONES
Ecozones align closely with woodland and forest zones, and ecological factors determine the distribution of plants and trees.

5 CLIMATE
Drought can kill trees, temporarily increasing wood supplies but reducing future resources. People cut more wood to sell as fuelwood or crafts when their crops fail.

6 SOILS
Soil degradation inevitably follows when woodland soils not suitable for cultivation are ploughed. Overgrazing and burning of woodland prevents regeneration of trees, and ultimately results in declining productivity and soil erosion.

8 FRESH WATER
Woodland and forest areas play a key role in maintaining freshwater resources, absorbing rainwater and releasing it through the year. Deforestation has caused a decline in freshwater fisheries productivity by increasing erosion and siltation, while large-scale replacement of indigenous woodland with water-hungry exotics causes the drying of streams.

9 WILDLIFE
National parks and protected areas play a key role in preserving the biological diversity of woodland and forest areas. Deforestation results in loss of biodiversity.

10 MARINE
Ocean-edge mangrove forests, which shelter marine life such as young prawns, are an important component of coastal ecosystems. Mangroves are cut for fuelwood and threatened by sedimentation caused by deforestation and erosion.

11 POLLUTION
Fuelwood burning causes indoor air pollution in rural households leading to respiratory problems which affect children in particular. Following deforestation, water is polluted with eroded silt which smothers fish and their eggs, and results in localised extinctions of certain fish.

12 ARMED CONFLICT
Population movements caused by armed conflict can be harmful to forests and woodlands which are cleared for survival, with little regard for environmental considerations.

13 GLOBAL
Deforestation increases the threat of global warming, by removing carbon sinks. Biomass burning contributes to global warming by adding carbon dioxide to the atmosphere.

14 TRENDS
Information on the condition of the region's remaining forests is often outdated, incomplete, fragmented or misleading, so precise details of speed and extent of deforestation are not available. However, deforestation is having a serious impact on rural-dwellers and their environment.

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8

WILDLIFE
and Protected Areas

"Wildlife" embraces all living organisms occurring naturally in wild habitats — plants, mammals, birds, reptiles, amphibians, fish and invertebrates. Southern Africa harbours a vast range of these plant and animal species, and remains among the few regions in the world where abundant quantities and varieties of wild animals roam the wild.

Straddling summer and winter rainfall-belts, southern Africa enjoys the best of both worlds — from desert to rainforest, grassland to woodland. Within ecozones, 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 favours a diversity of plant and animal species — from the deep, species-rich Lake Tanganyika up to the nearly 6,000-metre high, snow-covered Kilimanjaro mountain, the highest in Africa, right down to the fynbos zone in the Cape, the southern tip of the continent.

The biological wealth is obvious when the plant and animal life in Lesotho, South Africa and Swaziland is compared with areas elsewhere 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.[1] While the world average for the number of plant species per 1,000 square kilometres (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.[2] Some of the region's protected areas have been classified as world heritage sites in recognition of their international ecological significance.

Wildlife is, however, under increasing pressure. Tough decisions will have to be made to keep southern Africa at the forefront of wildlife conservation. These include how to:

- safeguard the region as a repository of biological diversity;
- sustain the extensive network of protected areas;
- foster other conservation measures outside protected areas for maintaining species diversity;
- deal with increasing threats to biodiversity; and
- ensure that southern African countries can afford to maintain wildlife through income generated from wildlife resources.

DEVELOPMENT OF PROTECTED AREAS
Ecology

The protection of large mammals has been a key factor in the establishment and location of protected areas in this region. It is, therefore, important to look at the natural factors that affect distribution. Ecological factors determine, for example, that elephants are found almost everywhere in the region while black lechwe are restricted to particular areas. There is also an array of human factors that determines the location of wild animals in the region today.

Over 40 different large-mammal species inhabit southern Africa. Of these, five species are carnivores (animals that feed on meat) and the rest are herbivores (plant-eaters). The "large mammal" classification includes species in which each adult weighs at least five kilogrammes. Animals, like people, require food and water to survive, and the availability of both determines their distribution.[3] They also have habitat preferences, which vary from one species to another depending on how they have adapted to a particular environment. Research on southern African herbivores shows that in areas where soils are fertile, and rainfall generally higher, there is a greater concentration of animals.[4]

Mammals which inhabit dry savanna include white rhino, nyala, oryx, springbok, Thompson's gazelle and the lesser kudu. Mammals largely restricted to the moist savanna are kob, waterbuck, sable, roan and bushbuck. The largest mammals — including elephant, buffalo and hippopotamus — 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 therefore leaching of nutrients, is high. The same is true of the tropical forests zone, where rainfall is abundant and animal numbers low. The large mammals include primates such as chimpanzees and gorillas.

Where the vegetation is scrubby, sparse and dominated by succulents, as it is in the nama-karoo, succulent karoo and fynbos ecozones, large mammals are scarce because there is little browse and graze for them. On the other hand, grasslands, which occur in moderate rainfall areas and are highly productive, support large numbers of animals.

Another factor determining the distribution of large mammals is their feeding habits — whether they are grazers, browsers or mixed feeders. Browsers, such as giraffe and kudu, are found in woodlands; grazers, such as zebra and wildebeest, in grasslands; and impala and eland, mixed feeders, are in both habitats. Patches of different vegetation within an ecozone attract a rich diversity of animal species to the area.

Large herbivores also move within and between ecosystems. Just as people drift toward greener pastures, animals tend to follow the distribution of near-the-surface soil moisture where

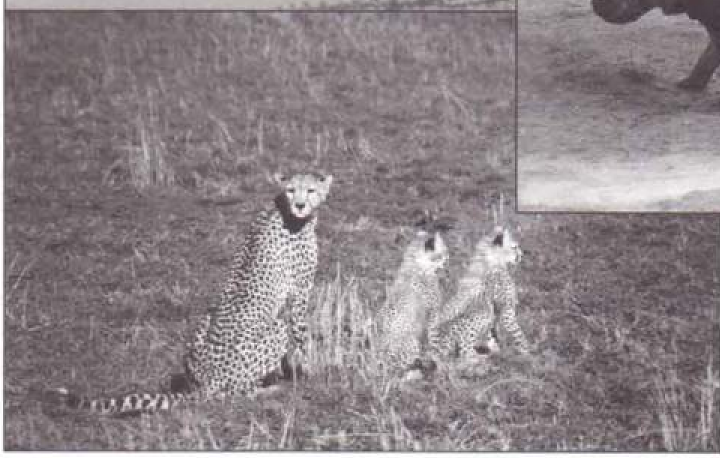


Photo 8.1/8.2/8.3 SARDC-P Johnson

Ecological factors determine the distribution of "wildlife", which encompasses plants, birds, mammals, reptiles, amphibians, fish and invertebrates. The large mammals inhabit both dry and moist savanna, and include herbivores (such as hippos, above) and carnivores (such as the cheetah mother and cubs, left).

green grass grows. This is particularly true of grazers. Wildebeest, buffalo and zebra on the Serengeti plains in Tanzania migrate long distances, following soil moisture, while lechwe in the Kafue flats of Zambia follow the rise and retreat of floods. In Tanzania's Ngorongoro crater, wildebeest move between communities.

Animal migrations are prompted by rainfall patterns. Thus the wildebeest, zebra and hartebeest of the Kgalagadi migrate seasonally to the wet north of Botswana during the dry season and return south in the wet season.[5]

Photo 8.4 SARDC-P Johnson

Wildebeest migrate long distances, in search of greener pastures, in the Serengeti (Tanzania) and the Kgalagadi (Botswana), and move between communities in the Ngorongoro crater (Tanzania).

History

Conservation of plants and animals in this region began well before colonisation, through a variety of traditional means of protection, including royal game reserves, as shown in Chapter 2. Hunting with simple weapons, such as bows and arrows, snares, spears and pits had little impact on wild animal populations, but the turning point came when settlers with more lethal weapons gunned down animals in larger numbers. Clearing land for agriculture gradually converted vast areas into farms, depriving wildlife of their habitat.

Excessive game-hunting and loss of habitat to grazing and cultivation, which almost wiped out wildlife in Europe, was creeping into southern Africa in the late 19th century. Fortunately, the desire to conserve wildlife began to gain ground among colonial governments at the same time. In southern Africa, the first protected areas of the colonial era were set aside in the 19th century to preserve game.

Initially, game reserves were established where high concentrations of large mammals were found. Later, game reserves were set up in tsetse-infested areas which had fewer people or were of poor agricultural potential. Wankie (now Hwange) of Zimbabwe, Sabie (now Kruger) of South Africa, and Luangwa of Zambia are among the game reserves established at that time. In Tanzania, part of the Selous game reserve was established in 1922, and the world-famous Serengeti became a regulated hunting area seven years later.[6]

Beyond big game

People realised later that it was futile to conserve wild animals without consideration for the plants, rivers, soils and other components of the environment on which they depend. Consequently, the practice of establishing protected areas only where there were high populations of large mammals began to fall away, although this remained the focus of legislation.

This new approach was shaped by the 1933 London Convention to which the colonial governments of southern Africa were signatories. This convention resulted in the establishment of many of the region's national parks for the purpose of protecting and preserving wild animals, plants and features that were geologically, culturally, and scientifically important. The convention also provided for controlled hunting areas and recreational parks.

Protected areas were established primarily for large mammals but also to cover representative samples of ecosystems and habitats, as well as the vast range of species of plants, mammals, reptiles, birds, amphibians and invertebrates (such as insects and butterflies). Ideally, under the convention, all the different types of plants and animals, including the different varieties of species, should be protected. For example, there are four varieties of black rhino and protection of any one of them suffices at species level — but genetic conservation requires protecting all four.

The state still owned all wild animals even though hunting was allowed outside national parks, controlled hunting or safari areas. In Tanzania, for example, permission to hunt in such areas was granted in 1947. This marked the beginning of an approach to conservation that had elements of utilisation.

The laws regulating the establishment of protected areas, as well as control of wildlife, remained without redefinition for many years. Protected areas failed to benefit local people despite losses of property from raids by wild animals. Another weakness of the protected areas approach was that the enduring reasons for establishing them (catchment area, genetic conservation and recreation) meant very little to people who lived nearby and were preoccupied with day-to-day survival.

While protected areas provided long-term conservation benefits, they were not designed to help local people meet their needs. This created hostility toward such areas. Consequently, game was slaughtered in communal lands as well as on private farms, especially near protected areas where wild animals frequently ravaged crops and killed livestock.[7]

The protected areas network

Relative to its size, the protected areas network of southern Africa is quite extensive, perhaps unequalled in the world. Over 90 percent of mammal, amphibian and reptile species are represented in protected areas, making southern Africa a popular tourist destination. Of the region's total land area of almost seven million square kilometres, over one million square kilometres are designated as protected areas. This amounts to 15.66 percent of the total land area, well above the minimum of 10 percent recommended by the United Nations Environment Programme (UNEP) and the World Conservation Union (IUCN).

Tanzania has the largest area under protection (237,005 sq km) comprising 25 percent of its total land area, while Botswana devotes the highest proportion of its land — 39 percent. Some of the world's largest protected areas are found in southern Africa, notably the Central Kgalagadi Game Reserve (52,800 sq km) in Botswana, Selous Game Reserve (51,200 sq km) in Tanzania, Namib-Naukluft National Park (49,768 sq km) in Namibia and Kafue National Park (22,400 sq km) in Zambia.[8]

IUCN suggests that some areas need extra protection, including those that:

- are important for the maintenance of essential life-supporting processes such as catchment areas, migratory routes and wetlands;
- support endemic plant or animal species; and
- are representative areas of each ecosystem type.

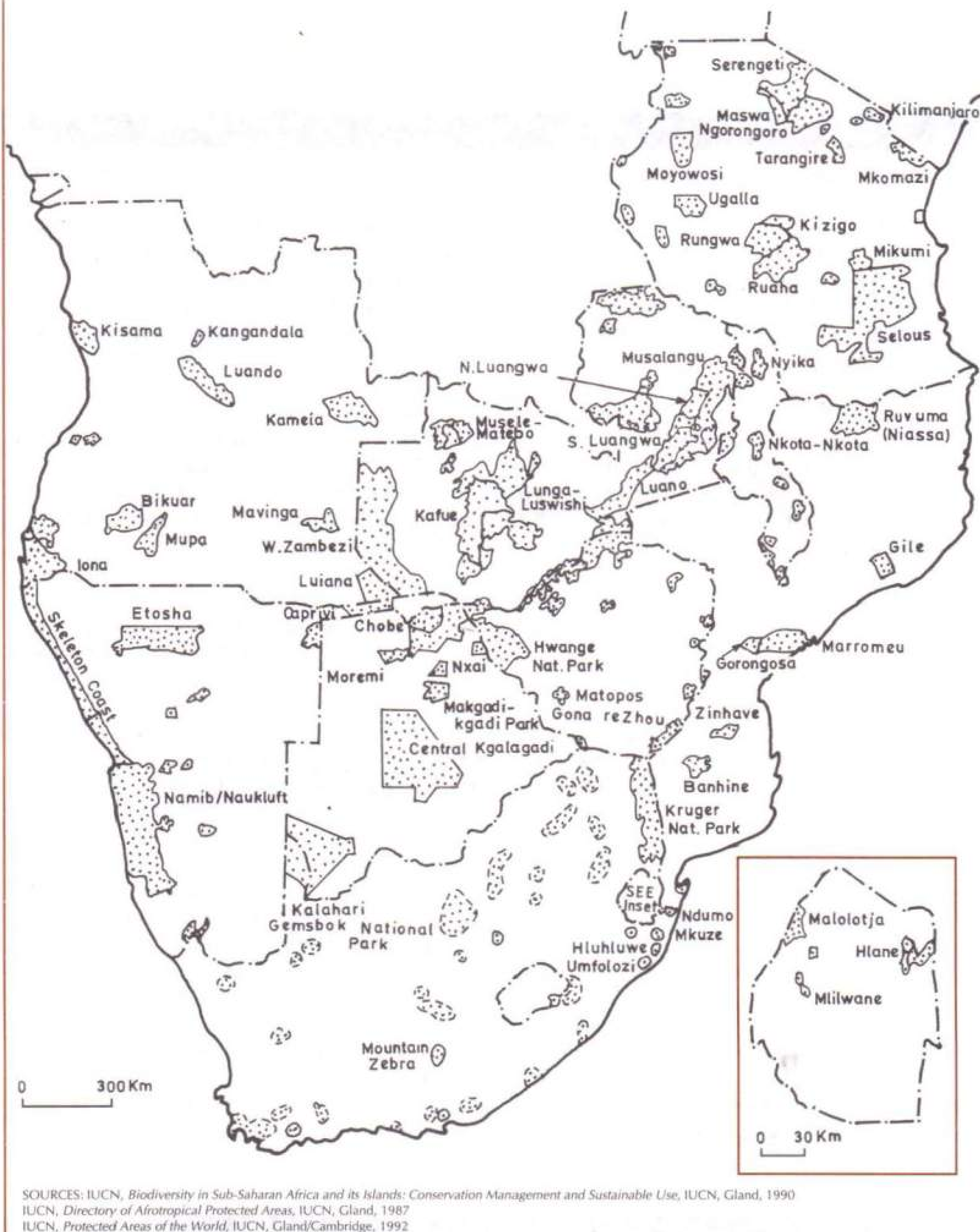
Protected areas in southern Africa as proportion of national land area Table 8.1

Country	Country size (sq km)	Proportion of protected areas (%)	Size of protected areas (sq km)
Angola	1,246,700	6.4	80,000
Botswana	581,730	39.0	226,875
Lesotho	30,350	0.2	68
Malawi	118,480	8.9	10,545
Mozambique	799,380	8.7	69,790
Namibia	824,290	13.5	111,414
South Africa	1,221,040	5.9	72,000
Tanzania	945,090	25.1	237,005
Zambia	752,610	29.8	224,078
Zimbabwe	390,580	12.9	50,385
Total	6,910,250	15.66	1,082,160

SOURCE: IUCN, *Protected Areas of the World. A Review of National Systems Volume 3: Afrotropical*, IUCN Publications Service Unit, Gland and Cambridge, 1992

The protected areas network of southern Africa

Map 8.1



SOURCES: IUCN, *Biodiversity in Sub-Saharan Africa and its Islands: Conservation Management and Sustainable Use*, IUCN, Gland, 1990
IUCN, *Directory of Afrotropical Protected Areas*, IUCN, Gland, 1987
IUCN, *Protected Areas of the World*, IUCN, Gland/Cambridge, 1992

Protected areas enable survival of a large variety of species, and safeguard rare and endangered species, thus meeting the current generation's moral obligation to future generations. Protected areas serve as natural laboratories for scientists and others studying biodiversity and biological sciences. Some varieties of wild plants are used in research that leads to an increase in productivity of domestic crops through hybridisation, (cross-breeding), and others are used to develop disease-resistant crops.

Protected areas also serve an important economic function, in generating income from both consumptive and non-con-

The modified system of protected areas categories Box 8.1

1. *Strict Nature Reserve/Wilderness Areas.* Areas of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring; or large areas of unmodified or slightly modified land, and/or sea, retaining their natural character and influence, without permanent or significant habitation, which are protected and managed so as to preserve their natural condition.

2. *National Park: Protected areas managed mainly for ecosystem conservation and recreation.* Natural areas of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for this and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.

3. *Natural Monument: Protected areas managed mainly for conservation of specific features.* Areas containing one or more specific natural or natural/cultural feature which is of outstanding or unique value because of its inherent rarity, representative or aesthetic qualities or cultural significance.

4. *Habitat/Species Management Area: Protected areas managed mainly for conservation through management intervention.* Areas of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.

5. *Protected Landscape/Seascape:Protected areas managed mainly for landscape/seascape conservation and recreation.* Areas of land, with coast and sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character, with significant aesthetic, cultural, and/or ecological value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such an area.

6. *Managed Resource Protected Area: Protected areas managed mainly for the sustainable use of natural ecosystems.* Areas containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs.

SOURCES: Makombe, K. (ed.), *Sharing the Land: Wildlife, People and Development in Africa*, IUCN-ROSA, Harare, 1993, p.10
IUCN 4th World Congress on National Parks and Protected Areas, Caracas, 1993

sumptive tourism. Tourism is the second fastest growing industry in the world after the petroleum industry.[9] In southern Africa, tourism is largely wildlife-based and most of the wildlife is in protected areas. A labour-intensive industry, tourism provides many jobs, and makes a significant contribution to the economies of southern African countries.

EXTENT OF ECOZONE PROTECTION

Lowland Tropical Forests

The lowland rainforests, most of which are in Angola, are underprotected. There is one park in this ecozone but it could be extended to Cuando, Luxico, Chipaca and other Zaire river catchment areas.

Threats in this zone include armed conflict, which has disrupted the management of existing national parks and the establishment of new ones. The war has also led to overexploitation of wildlife for food and cash.

Much of the coastal zone has been disturbed, leaving little pristine forest to protect. Though inadequately represented in terms of protected areas, pockets of coastal forests are conserved in places such as Maputo National Park in Mozambique and St Lucia Wetland Park in South Africa. To increase the level of representation of coastal forests in protected areas, the Zambezi delta of Mozambique and samples of the forests in Tanzania could be added. The Dukuduku and Ngoye forest reserves of South Africa need a higher degree of protection.

Coastal forests are threatened by shifting cultivation in Mozambique. The rapid population growth in the ecozone, resulting from settlements of displaced people, has increased the threat of deforestation and soil degradation. In South Africa, industrialisation and sand-dune mining remain the major threats.

Afromontane and Temperate Forest

Coverage of protected areas, though not yet adequate, is significant. Protected areas in this zone include Nyanga and Chimanimani National Parks in Zimbabwe, Nyika National Parks in Zambia and Malawi, Sehlalabathebe National Park of Lesotho and Royal Natal National Park in South Africa, as well as Kilimanjaro, Udzungwa, Gombe and Mahale National Parks of Tanzania.[10]

The mountain forests of Angola are not included in the protected areas network of the region, and forest reserves in other countries receive a lower level of protection and have been unsustainably exploited. The reserves, which include Uluguru and Usambara of Tanzania and Mulanje of Malawi, should be upgraded and afforded greater protection.

Threats to the ecozone are deforestation and afforestation. Pine and eucalyptus plantations in the mountain grasslands of the Drakensberg in South Africa have displaced indigenous plants and animals. There are, however, attempts to prohibit afforestation in more sensitive catchment areas.

Grassland

Only two percent of this ecozone is placed in protected areas,[11] largely as a result of suitability for human settlement and agricultural production. Maize-fields and urban areas swallow up much of the grassland. However, 80 percent of plant species and 100 percent of mammal species occur within protected areas. Protected areas in grassland include the Golden Gates Highlands National Park, the Giant's Castle and Royal National Park in South Africa.

Industrialisation and urbanisation are threats to this area as it encompasses the highest concentration of urban centres in the region — the industrial heartland of South Africa. Some plants have been removed and many mammals and birds that heavily depended on the grassland have disappeared. Overstocking and overgrazing are threats. In addition, exotic tree plantations reduce rainwater flows by using much more water than the indigenous vegetation, so wetland-dependent species such as the crowned crane are disadvantaged and threatened.

Savanna

Moist Savanna

This large ecozone has good representation in protected areas. Examples include Kameia National Park in Angola, Kafue National Parks of Zambia and Kasungu National Park in Malawi. The protected areas in this zone cover large tracts of land and most are 1,000 sq km or more. This is suitable for large animals which have an extensive home range.

Some areas identified for protection include more of the Great Dyke of Zimbabwe, which is partially protected, and the area around Lake Rukwa in southern Tanzania. Tsetse-infested areas in the ecozone are covered by protected areas as they are not fit for human settlement. The tsetse fly transmits nagana to livestock and sleeping sickness to people.

Large concentrations of wild animals, especially elephants, in protected areas sometimes cause woodland damage.[12] To keep the population down to manageable numbers, elephants have been culled by national parks personnel.

Excessive elephant populations in some areas notwithstanding, poaching in Zambia has lowered overall elephant populations in the ecozone.

Dry Savanna

This is one of the most extensively protected areas in the region, largely for historical reasons, because game reserves were located in areas with abundant game, of poor agricultural potential or inhabited by tsetse fly. This ecozone contains national parks with the highest raptor (birds of prey) concentration in the world (Zimbabwe's Matobo National Park)[13] and with the highest predator concentration (Serengeti National Park in Tanzania).[14] The Serengeti in northern Tanzania and the adjacent Masai Mara ecosystem in southwestern Kenya are in one of the most important wildlife regions in the world. It is the scene of a massive annual migration of animals, including wildebeest and zebra, which number 1.7 million and 250,000 respectively. Other well-known protected areas in this ecozone are South Africa's Kruger National Park and Chobe in Botswana. Many of the protected areas are large, covering over 20,000 sq km each. Some additional areas identified for protection are the Notwane-Limpopo area and the Tamafuri-Jari pan of Botswana, and the Gaap Plateau and Witsands of South Africa. Namibia plans to unify Mahango and West Caprivi, and establish Etosha-Skeleton Coast migratory corridor as a park.

The ecozone's frequent droughts force animals to migrate to wet areas such as pans and floodplains. But human settlement and cordon fences have blocked some of the major migratory routes, causing massive deaths of migratory species. Protected areas have also experienced tree-loss where wild animals, particularly elephants, exceeded their carrying capacity. This has been a problem in the Zambezi valley, and in Serengeti, where overcrowded elephants killed five percent of the trees annually from the 1960s to the early 1980s (when the study was undertaken).[15]

Elephants roam NED villages Story

Masunga (BOPA) — Residents of Masunga, Kalakamati, Sekakangwe and Gambule villages in the North East District have been advised to stop moving around at night to avoid being attacked by elephants which are reported to be roaming those areas.

The advice was made by the Masunga Police Station Commander, Superintendent Samuel Ntwa, in an interview.

He noted that elephants are very dangerous and warned people who are living in the area not to chase them away either by shouting or beating drums, because doing so could make the elephants angry and attack them.

He said they should instead report them either to the nearest police station or Department of Wildlife and National Parks in Francistown.

Ntwa said elephants were seen by some people passing near Kalakamati and later near Vukwi ward in Masunga.

He suspected that they came from Zimbabwe.

— **Robert Ditshwang**, *Botswana Daily News*, Gaborone, 30 Sep 1993

Nama-Karoo

Just one percent of the nama-karoo within South Africa is protected, and some of the sub-categories of the ecozone are not represented. Currently, the best covered sub-class is the great karoo, which has almost35 percent of plants and 95 percent of invertebrates found in protected areas.

Areas identified as a priority are Norsveld, Bushmanland, Gordonia, Central and Upper Karoo as well as the Karas, in South Africa. Agriculture, especially sheep-farming, threatens 95 species of indigenous plants and animals. Habitat loss also arises from mining and industrialisation. Another threat is excessive picking of wild-flower for sale.

Succulent Karoo

The succulent karoo is inadequately represented in the protected area network of the region, with only 1.2 percent of it protected.[16] The protected areas do, however, carry 90 percent of the bird, mammal and reptile species. Protected areas include Richtersveld National Park in South Africa. Protected diamond-mining also incidentally protects some parts of the zone.

The areas already identified for protection include: Vanrhynsdorp, Roggeveld, Kamiesberg and parts of the Western Mountain Karoo, Namaqualand and West Coast Strandveld.

Photo 8.5 SAMSO-T Davis

Elephants can severely damage their habitat when carrying capacity is exceeded.

The importance of wild resources to local economies Box 8.2

South Africa: For over 200 years, aloe "tapping" has been a small but important industry in South Africa's eastern and southern Cape Province. In 1992 alone, almost 300 tonnes of aloe bitters, the crystal remaining when the juice extracted from the aloe leaves is dehydrated, and 45,000 dried aloe species were exported. The vast majority of these exports, worth close to US$1 million, involved a single species, *Aloe ferox* or Bitter Aloe. Aloe and aloe derivatives are commercially used worldwide in products as diverse as nail-biting remedies, soft drinks and creams to treat skin damaged by sunburn, X-rays and radioactivity. The trade makes a significant contribution to local economies in the Cape. In the Herbertsdale region alone, over 200 people are employed as aloe tappers.

SOURCE: Makombe, K. (ed.), *Sharing the Land: Wildlife, People and Development in Africa*, IUCN-ROSA, Harare, 1993, p.16
Newton, D., "Is the export industry endangering the Bitter Aloe?", *Our Living World*, Sep 1993, p. 10

The ecozone is threatened by overgrazing, cultivation, exotic plantations, open-cast mining and urbanisation. For example, alluvial gold-mining on the west coast of South Africa and Namibia is destroying the only habitat of a rare adder. Habitat loss, wild-flower picking and poaching of lizards of commercial value threaten 600 species, most of them plants.

Desert

The desert ecozone is well represented in the protected areas, especially by the extensive Skeleton Coast Park of Namibia, and Iona National Park of Angola, where all desert plant species are found. The proposed Etosha-Skeleton Coast park would extend the protected areas network in this zone.

Major threats are open-cast mining, armed conflict, poaching, fencing (fragmentation) and drought. Overhunting has depleted animal populations in Angola during the past two decades of war.

Fynbos

Though 14 percent of the fynbos is in protected areas,[17] the lowland portion of the zone is poorly represented, heavily settled and cultivated. About 80 percent of it is taken up by sheep, grape, and wheat farming. Under one percent of the fynbos lowland is protected. The highlands are well represented due to difficult access and the need to protect them as catchment areas. Protected areas include the Cape of Good Hope Nature Reserve, De Hoop Nature Reserve and botanical gardens such as Kirstenbosch.

The lowlands of the fynbos deserve priority attention in the extension of the protected area network in the ecozone. At least five plant species are extinct, with a further 169 threatened by urbanisation and industrialisation. Some plants are threatened because of their beauty, which attracts wild-flower-collectors and ultimately leads to overutilisation. Fire is also a threat to some plant species.

THREATS TO BIODIVERSITY

Contemporary conservationists recognise that biodiversity can be protected only if rural poverty is alleviated. There are examples of land-hungry people encroaching on wildlife conservation in many parts of the region. Half of Tanzania's protected areas have been affected. For example, the size of

Maswa Game Reserve was reduced three times in 25 years, and Mkomazi Game Reserve was reduced twice, because of people moving into the area.[18] There have been instances of encroachment in Malawi in Kasungu National Park but more recent information suggests that the resettlement of people has helped to resolve the problem. In Mozambique, even prior to the war, Gorongosa national park had a permanent population of settlers. As the war progressed, more people moved into the park.

Habitat change is perhaps the single major threat to biodiversity. Grazing, agriculture, mining and human settlement change ecosystems in various ways. When habitats change, wildlife can have problems adjusting and sometimes fails to do so. Large tracts of land have been converted into farms for production of food for the growing human population, taking away wildlife habitat.

Grazing not only displaces wild animals but also disrupts the plant-species composition. By selecting the more palatable grasses, livestock cause non-palatable grasses to increase. This is a widespread problem in the region's grasslands, savanna and nama-karoo ecozones. Dams have altered fish and animal habitats downriver by submerging some plant species, and have modified flood and nutrient regimes, negatively impacting the species downstream. Kariba and Cahora Bassa dams changed the flow of the Zambezi river and transformed the Marromeu floodplain from a seasonally wet, grassy plain to a dry, bushy area prone to fire. Buffalo, which fed on the grassy plains in high numbers, lost an important food source.

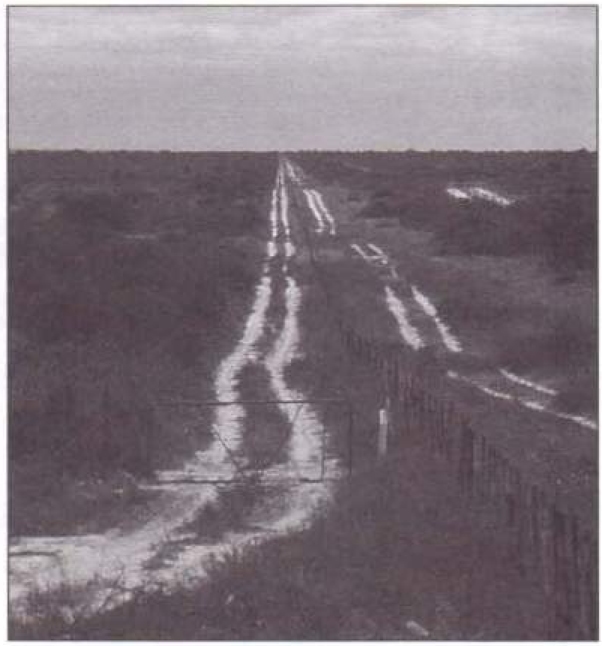


Photo 8.6 IUCN-D Reed

Much of Botswana is criss-crossed by cordon fences (above) which have tended to channel wildlife movements into overgrazed areas near open surface water. Water canals in Namibia (below) have proved hazardous to domestic and wild animals but plans are being made to cover them.

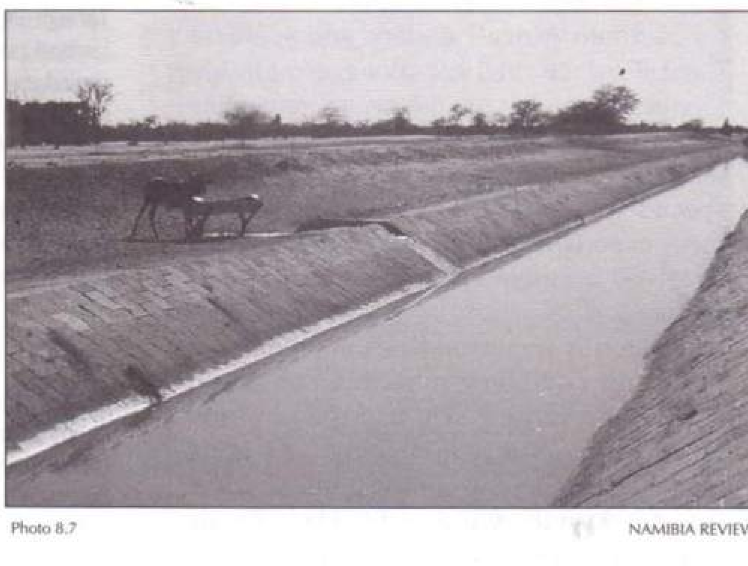


Photo 8.7 NAMIBIA REVIEW

In Zambia, the lechwe (an antelope that lives in swampy areas) lost part of its habitat when the Kafue dam changed the flood regime in grazing areas downstream.[19] The Eastern National Water Carrier (ENWC) of Namibia, which is an open, 3.7-metre-wide canal, has also caused the death of thousands of wild animals, especially reptiles and amphibians. Between June 1985 and August 1986, about 7,000 animals were removed from the 302-km-long Grootfontein-Omatako section of the ENWC, many of them dead.

Urbanisation and industrialisation have had some negative impacts on wildlife through pollution, wholesale removal of vegetation and displacement of animals. Mining has damaged wildlife habitat, threatening animal resources above ground.

While all forms of land-use have contributed to wildlife habitat loss, cultivation has had the most significant impact because it takes up a lot of land and completely alters the landscape.

Fragmentation

The division of land for various uses (for residential and industrial areas, mines, farms, roads and other projects) curtails the ability of wildlife to migrate when necessary. Scientists argue that some species will disappear if their habitats are reduced — the smaller the area, the higher the number of species to be lost. This is because the large animals require a big area in which to feed, grow and reproduce. Some parks are too small to accommodate even the minimum number of animals required in an area to sustain a given species, without causing inbreeding.

In some areas, fences have been erected to keep wild animals and domestic livestock apart with harsh impacts on wild animals. The most devastating effects of fencing has occurred along Botswana's Kuke fence.[20] About 80,000 wildebeest died in 1964 and 50,000 in 1983 because they could not reach food or water in the Okavango delta and Bobeti river. The most conspicuous victims of fragmentation are migratory species such as zebra, wildebeest and buffalo. Some of the largest national parks, including Zimbabwe's Hwange National Park, have been separated from other habitats or ecosystems. The migratory routes to and from these areas have been cut off or blocked by human settlements and other human activities. However, some protected areas such as Serengeti National Park have kept migratory routes open by merging protected areas, even across borders.

In South Africa, most of the parks are very small and fenced — only five out of 582 reserves exceed 1,000 sq km. Most of the parks are so far apart that wild animals are forced to inbreed.[21] Wildlife on private land suffers from this "island effect" even more since the farms are generally smaller than protected areas. However, the development of nature conservancies, which allow wild animals in a number of adjoining farms to mix, will help to reduce this problem. Nature conservancies have already been established in South Africa and Zimbabwe.

Exotic species

Some exotic species (also called invasive alien species) such as trout, Nile perch and bass have had devastating impacts on species diversity in some southern African lakes and rivers in which they have been introduced. They feed on other fish, but do not have natural predators to control their numbers. For example, Nile perch has driven some 200 local fish species to extinction since its introduction into Lake Victoria.

The water hyacinth has altered river and dam environments to the detriment of some species. It is highly adaptive and grows fast, at the expense of local plants and to the disadvantage of local animals that depend on those indigenous water-plants. It displaces local plants, reducing the supply of fish-food. When the plant rots it uses oxygen needed by fish and other aquatic flora and fauna. The weed thrives in many countries of the region, especially Mozambique, South Africa, Tanzania, Zambia and Zimbabwe.

Hunting and poaching

Legal hunting of wildlife and illegal hunting (poaching) have caused a severe drop in wild-animal numbers in some parts of the region. Big-game hunting during early colonial days was responsible for slaughters that eventually drove both the quagga and the blue antelope to extinction.

Poaching is a more recent problem. Animals noted for their decline because of poaching include rhinos and elephants. The poaching of elephants has been driven by the demand for ivory abroad, particularly in Asia. The population of elephants

Photo 8.8 SARDC-P Johnson

The rhinocerous is poached for its horn, which is made into dagger handles in the Middle East and Asia, and is ground into powder in the belief it is an aphrodisiac.

has severely declined in the region — except for Botswana, Namibia, South Africa, and Zimbabwe. Overall, the African elephant population declined from 1.3 million in 1979 to only 609,000 in 1989. Zambia's elephant population dropped from 250,000 in 1960 to about 40,000 in 1990. East Africa was losing elephants at a rate of just over 100 a day between 1981 and 1989.[22]

The rhino is the animal most affected. Its numbers are down from 65,000 in 1970 to about 15,000 in 1980 and to about 3,000 in 1990.[23] According to government figures, in 1992, Zimbabwe may have lost as much as 80 percent of its remaining rhinos, from 2,000 in January to 400 in December,[24] though the January estimates are now believed to have been optimistic.

Ill. 8.1 IUCN-C Bass

Other animals whose numbers have shrunk due to overexploitation are the giant sable, pangolin (illustration) and turtles. Birds have been subjected to overutilisation through smuggling. According to the World Wildlife Fund, the international trade in birds is worth about US$40 million a year. Illegal market prices for some protected species provide great incentives for the illegal capture of wild birds. Sophisticated smuggling operations for live birds and eggs have been uncovered in many countries. In 1984, Zimbabwe exposed an eagle-egg stealing racket. A black-eagle egg can fetch US$600. Another bird with a good market in Europe is the threatened shoe-billed stork which is also being pursued and smuggled. Today, it is endangered.[25] Other birds spirited out of Africa are parrots, raptors and songbirds from various southern African countries. Many of the smuggled birds die before reaching their final destinations.

Poaching and smuggling of rare plant species such as cycads and orchids has also been a problem in the region.

Conservation funds

Human life or wildlife? That's one of the questions that southern African countries often grapple with as they try to satisfy the needs of the region's growing numbers of people. At the same time, wildlife conservation requires money. It becomes difficult to meet the needs of the human population and the wildlife without making sacrifices in one or both areas.

For southern Africa's cash-strapped governments, food, health, education and jobs are pressing socio-economic issues. Most countries in the region do not have adequate funds, personnel and equipment to implement all the necessary wildlife-conservation measures.

Many conservationists that US$200 per year is the minimum amount required to manage one square kilometre of a protected area: and this region has over one million square kilometres of protected areas. Thus the minimum amount required per year is $200 million. The Ivory Trade Review Group, which is affiliated to the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), says southern Africa needs US$1,000 million to protect its elephant population, yet total donations and money generated from wildlife falls far short of this figure.

While some international donors have supplied southern Africa with funds, equipment and personnel for wildlife conservation programmes, others have failed to honour their commitments. This exerts more financial pressure on governments in the region, while making planning and management difficult. Even South Africa and Namibia, which have fairly large budgets for their wildlife conservation projects, find this sector underfunded. Consequently, the number of staff managing protected areas in the region is inadequate and poaching abatement remains patchy.

Laws and enforcement

In addition to resource shortages, some laws are outdated and too weak to boost wildlife conservation efforts. For example, in Lesotho, a poacher of a protected species can be convicted only if it is proved beyond doubt that the poacher knew beforehand that the animal was specially protected. Fines against poaching are generally light, lacking sufficient deterrence. In Malawi, elephant dealers and poachers were fined MK100 (US$44) in 1987 for killing an elephant and MK200 (US$88) for unlawful possession of ivory — whereas the ivory could fetch US$500 per kg on the international illegal market.

Some progress, though slow, is being made to put teeth into conservation laws. The penalty for shooting rhino was stiffened recently with some countries in the region allowing game wardens to shoot poachers on sight. Captured offenders are liable to imprisonment of up to 25 years and there is usually no option for a fine.

Armed conflict

Wars wreak havoc on the environment both directly and indirectly. They interrupt management activities, destroy infrastructure, lead to uncontrolled utilisation of resources and proliferation of firearms that can be used for poaching.

After 1983, Mozambique's conservation activities collapsed because of the civil war and IUCN has declared Angola's protected areas threatened for the same reason.

Diseases

While many of the threats to wildlife result from human activities, there are a few natural factors which have caused the depletion of wildlife. Some conservationists do not consider these as threats but as natural forms of wildlife population control. Diseases such as anthrax, foot-and-mouth, rinderpest and, to an extent, rabies periodically kill wild animals. Anthrax is a problem in the nama-karoo, moist and dry savanna ecozones. Currently, countries affected by anthrax are Namibia, South Africa, Tanzania and Zambia. Rinderpest continues to be a killer of animals in the region.

Drought

The dry savanna and some parts of the moist savanna have had high numbers of wild-animal deaths due to drought. 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 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 because people harness the little water there is for domestic use and sometimes to supply their livestock. Ultimately, there is little left over for wildlife.

All the massive wildlife deaths in the Kgalagadi have been associated with drought and were magnified by cordon fences. In Gona reZhou National Park in southeastern Zimbabwe, wildlife died in large numbers due to the 1991-92 drought despite an innovative translocation exercise. The 1962 drought in Botswana nearly wiped out zebra, and hundreds of thousands of wildebeest died, as well as some sable, tsessebe, roan and rhino. Central Kgalagadi, lost 99 percent of wildebeest and 95 percent of hartebeest in the 1980s due to drought.[26]

THREATENED SPECIES

As a result of the threats discussed, some species of plants and animals have become extinct and others face varying degrees of threats. IUCN, which extensively collects and disseminates data on threatened species, has the following categories:

- Extinct — species wiped out of existence;
- Endangered — species facing extinction;
- Vulnerable — species that will become endangered if current threats are not checked;
- Rare — species restricted in distribution or thinly spread over an extensive area and at risk of declining;
- Out of danger — species that were once endangered or vulnerable but have since recovered; and
- Indeterminate — species about which too little is known.

Mammals

Two mammal species are extinct in southern Africa — the quagga and the blue antelope. They were both hunted to extinction in the 19th century. The major threats to mammal populations have been overhunting and poaching (for meat, skin, and horn in the case of the rhino and tusk in the case of the elephant). As more land is taken up by agriculture and animal husbandry, loss of habitat will increasingly become a limiting factor.

Mammals are threatened by:

- poaching and overhunting (black rhino, Cape mountain zebra, giant sable, black-faced impala, lechwe and riverine rabbit);
- loss of habitat (the riverine rabbit, lechwe, Cape mountain zebra);
- elimination by farmers as pests (wild dog, cheetah, leopard, hyena); and
- pet trade (chimpanzee).

The African elephant has been depleted in some parts of the region, resulting in CITES declaring it endangered globally even though there are large numbers in other parts of southern Africa.

Plants

There are a number of threatened plant species in the region but not much work has been done to establish their status outside Lesotho, South Africa and Swaziland. In the fynbos, 1,326 plant species are threatened; in succulent karoo, 558; and in the nama-karoo, 67. Of these, 123 species are endangered — 108 in the fynbos, and 15 in the succulent karoo. In these ecozones, 34 plant species have become extinct, most of them (27) in the fynbos.

Plants are threatened by:

- habitat loss (chondropetalum and protea);
- overgrazing (the carallum species);
- overexploitation of fruit (a palm species);
- fire (erica species);
- quarrying (moraea species);
- flower-picking (erica species);
- invasive alien species, particularly exotic acacia and pine trees (restio, erica and protea species); and
- deforestation (gigasiphon species).

Birds

No birds are known to be extinct in the region although the Egyptian vulture and the African skimmer are considered endangered by conservationists in South Africa. Many of the threatened bird species are in the rare category and include Cape vulture, Jackass penguin, Damara tern, wattled crane, black-cheeked lovebird, Swynnerton's forest robin, East coast alakat, spotted ground thrush, papyrus yellow warbler and shoe-billed stork.

Southern African birds have declined largely due to:

- egg-collection (Jackass penguins);
- lack of food (Jackass penguins due to overfishing of pilchard, their main source of food; and the Cape vulture due to farmer's use of pesticides and loss of food as more and more carcasses find their way to the markets);
- pesticides such as DDT cause birds to lay eggs with shells that are too thin to hatch properly;
- illegal trade (shoe-billed stork)
- lead poisoning; and
- habitat change, loss and contamination by toxic chemicals (Jackass penguin due to guano collection which made it hard for them to nest in the ground and encouraged seals to establish colonies on areas devoid of guano; the East Coast alakat which has lost habitat to sugar-cane plantations, shifting cultivation and land clearance in general; and the Damara tern, due to gravel-mining in its breeding area and excessive pressure from tourists).

Reptiles and amphibians

The endangered reptiles are Green, Hawksbill, Olive and Leatherback turtles. The Geometric tortoise and the Nile crocodile are vulnerable. Some reptiles such as the Pancake tortoise, the African slender-snouted crocodile and the African dwarf crocodile are in the indeterminate category.

Threats to reptiles are:

- overexploitation of eggs and adults for meat, shells for ornaments, and skins for leather;
- accidental killing (all endangered turtles);
- pets (Geometric tortoise);
- loss of habitat (Geometric tortoise has lost its habitat to cultivation and urbanisation); and
- fire (Geometric tortoise is slow and lives in a fire-prone fynbos vegetation).

Invertebrates

In terms of biological research, invertebrates (animals with no spine, such as insects, spiders and snails) are not well-researched the world over and southern Africa is no exception. There is, therefore, little data and the current assessment is inadequate. However, two types of butterflies are presumed extinct, two endangered, and six vulnerable among the 141 species and sub-species of butterflies listed in the South African Red Data books, which are miniatures of the IUCN Red Data books.

The extinct butterflies are the Bashee River Buff and Morant's Blue, both of which used to exist on the east coast of South Africa. The endangered butterflies are the Cottrell's Blur and Dickson's Monkey Blue both residents of the Cape province.

Some of the threatened invertebrates of the region are:

- some types of earthworms;
- Plant's Gulella snail;
- coconut crab; and
- many types of clams including the Small Giant and the Giant.

Main threats are:

- habitat change (earthworms, butterflies that in losing habitat also lose food, and snails);
- overexploitation for food and for use as an aphrodisiac (coconut crab);
- introduction of alien species such as pigs, rats, monitor lizards (coconut crab); and
- indiscriminate use of pesticides to kill insects and grasshoppers (molluscs).

WILDLIFE MANAGEMENT STRATEGIES

After realising the weaknesses of the protected-areas approach, and with a view to addressing threats to biological diversity within protected areas and outside, the region has come up with many innovative programmes. Inherent in the new approaches is the idea of sustainable utilisation of resources. The programmes also seek the support and participation of people in communal areas and on private land. Some management approaches are aimed at rebuilding depleted stocks, others at keeping wild animal populations within the carrying capacities of the land.

Game-ranching

The approach of protectionism, where governments owned all wildlife and prohibited gainful utilisation of game on private land, was not favourable to wildlife or farmers. Farmers killed wild animals as pests. The interest in game-ranching began in the 1950s as farmers and governments began to realise its potential.

Among the perceived benefits of wild animals were:

- better resistance to disease than livestock;
- more adapted to arid conditions;
- more efficient use of plants;
- higher reproductive rates and meat-production potential;
- cheaper to keep; and
- higher growth rates.

Former wildlife legislation vested ownership and control of wildlife in the state. However, recent changes in legislation have facilitated the development of ranching of game, often kept together with domestic livestock. In Namibia and South Africa, ranchers own game on their land while in Zimbabwe they are proprietors. In South Africa, game-ranching is recognised as a legitimate form of land-use and enjoys the same incentives and subsidies from government as livestock.[27]

Keeping wild animals on private land contributes significantly to the conservation of the region's biodiversity. It has halted and even reversed the decline in wildlife abundance and distribution, notably in South Africa. In Namibia, about 80 percent of wild animals are found on private land.[28] South Africa practises game-ranching on about 10,000 ranches covering 16 million hectares.

In Zimbabwe, about 10 percent of commercial farmers keep wild animals. Botswana has eight percent of the land under private ownership, much of it is used for hunting and wildlife-based tourism. Swaziland is setting up game-ranches. In other countries in the region, game-ranching is just beginning or yet to start.

Game from private land has been used for restocking areas where wildlife populations have been depleted. Game-ranching has contributed to the conservation of rare and endangered animal species such as cheetah, roan, tsessebe, sable, bontebok and white rhino. Multispecies game-ranching causes less damage to the environment than to livestock alone as long as stocking densities and mixes are appropriate.

Wild animals yield economic benefits through consumptive and non-consumptive use, especially tourism. Animals are killed for trophy and meat or may be photographed by visitors who often pay in foreign currency. The sale of live animals also yields income, as does food, accommodation and curios that tourists buy. Under current economic conditions, cash generated from wildlife and related activities exceeds that from livestock production. However, studies on ranches in the semi-arid areas of Botswana and South Africa show that multi-species game production is economically inferior to cattle-ranching because of the high capital expenditure on purchasing game, fences and luxury accommodation.

Some conservationists criticise game-ranching because it restricts the movement of wild animals and mixing of populations. Although there is no evidence of adverse effects on such populations following inbreeding, there are bound to be differences between inbred and free-ranging populations. The removal of natural predators also interferes with the natural selection process.

Today, in South Africa, many game-fences are being pulled down and movement of game is "freer", with emphasis on ecotourism.[29] If this trend continues, the problem of restricted movement and inbreeding will decline.

Culling: another management strategy Box 8.3

Culling is the selective killing of wild animals in excess of the carrying capacity of their habitat, as a deliberate strategy to ensure that they do not die from overcrowding and lack of food and water. Ecologists determine the carrying capacity of a given area, do a population count of various species of animals, and recommend the removal of a certain number of animals. This is done to protect the animal species itself, as well as other species living in that area, and to protect the habitat in question.

This approach to wildlife management has been used in many countries in southern Africa. Toward the end of the 1960s, South Africa, Zambia and Zimbabwe were already culling elephants in the Luangwa valley, Kruger National Park and Hwange National Park respectively.

Since then, culling has been done many times in several areas of the region. In Kruger National Park, about 1,000 elephants are culled every year. Though elephants have been the main target, impala, nyala, buffalo and warthog, among others, have been culled in some parts of the region. Malawi culled 3,000 nyala in Lengwe between 1981 and 1988.

SOURCES: Munthali, S.M. and H.M. Banda, "Public Attitudes Towards the Culling of Nyala (Tragelaphus angasi) and Warthog (Phacochoerus aethiopicus) in Lengwe National Park", *Nyala*, 1985, Vol 11, no 2, p. 73-82
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Community-based wildlife management

The protectionist approach to conservation, where the state owns and controls all wildlife, has proved inadequate to save wild animals from poaching and other threats in rural areas. The vast majority of people who occupy marginal land near the protected areas, and have been neglected in wildlife conservation, are now seen as vital in wildlife management.

Before colonisation, wildlife was an important food source and played an important cultural role as well. This was possible because people had almost unlimited access to wildlife.

Colonial governments forced people out to make way for game reserves and parks. Thus the inhabitants lost both the land and the right to hunt wild animals. The same wild animals they were not allowed to kill, devoured their livestock, destroyed their crops, and even injured people or trampled them to death. Consequently, conflicts arose between rural people and wildlife officers.

To resolve the conflict, policy-makers added a new dimension to conservation — community-based wildlife management. Under this system, wildlife in and around rural areas is managed and utilised for the benefit of the residents.

Community-based wildlife conservation seeks to enhance conservation of biological diversity outside protected areas and private lands while at the same time affording rural people benefits from the wildlife resources in their areas. This is intended to create a positive attitude toward wildlife so that people are less inclined to poach.[30]

The main targets for community-based, wildlife-conservation programmes are areas with abundant and useful natural resources, including caterpillars, honey and thatching grass.[31] Some of the programmes in this region are:

- Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) in Zimbabwe;
- Administrative Management Design for Game Management Areas (ADMADE) in Zambia;
- Selous Conservation Programme in Tanzania;
- Wereldsend Community in Namibia;
- Wetlands Programme in the Kafue and Bengweulu flats of Zambia;
- Luangwa Integrated Resource Development Programme (LIRDP) in Zambia;
- Serengeti Ecosystem Conservation in Tanzania; and
- Lebatlane Community Game Management Programme in Pilanesburg, South Africa.

These programmes have created jobs and generated income for some communities. The main form of wildlife utilisation that brings money is hunting. The cash is distributed to people or put toward community projects. In addition, since the 1980s, Botswana, Tanzania and Zambia have set aside game-management areas, game-controlled areas and wildlife-conservation areas respectively, where local people can hunt and have to pay only 14 percent of the market value of the wild animal. In Malawi, people living near national parks can collect caterpillars, honey and grass for thatch under the supervision of national parks personnel, while in South Africa some communities living near national parks get a certain percentage of the revenue from wildlife-based tourism. In Tanzania, people living near hunting areas receive 25 percent of the trophy fee.[52]

The main weakness of community-based wildlife utilisation has been inadequate control of wildlife by the local communities because they do not own the land. Unlike private land-owners, these people do not often have title to the land they occupy and cannot effectively own and control the wildlife. This legal weakness stems from the colonial land-tenure system where communal people lived on state-owned land.

If the communities do not benefit meaningfully from the programmes, they are unlikely to continue to cooperate. Conversely, the more control and benefit people get from wildlife, the greater the incentive they will have to conserve it.[53] The approach of combining wildlife conservation with sustainable utilisation offers a promising and practical solution.

Tanzania: The Selous Conservation Programme (SCP) Box 8.4

SCP was created in 1988 and was at that time the first practical conservation programme specifically aimed at involving the local communities surrounding the Selous Game Reserve.

The Community Wildlife Management part of the programme is directed toward the villages in the buffer zone surrounding the Reserve.

The main components implemented in cooperation with the villages are:

- to establish land-use plans demarcating village borders, the borders of the Selous Game Reserve and the new village wildlife management areas which will function as a buffer zone between the reserve and the cultivated and inhabited village land. Villagers will be given title deeds to the land demarcated, thus securing their land rights for the future;
- to elect a Village Wildlife Committee and appoint Village Scouts. Village Scouts protect village wildlife from poachers and protect crops from wildlife;
- to allocate wildlife quotas to the villages for consumption and sale. This quota normally consists of three buffaloes and six wildebeests per year;
- to develop other uses for village wildlife which bring cash to the village, such as safari-hunting tourism.

Today, 31 villages in the district are participating and the programme is under expansion. The Wildlife Division is currently shooting the quota animals as the legal preconditions to hand over wildlife management fully to the villages have not yet been created. A related problem is that there are no provisions for villagers to get a share from hunting royalties and fees. However, a legal framework allowing villagers to take full responsibility for managing wild resources in their areas has been prepared and is awaiting implementation.

SOURCE: Makombe, K. (ed.), *Sharing the Land: Wildlife, People and Development in Africa*, IUCN-ROSA, Harare, 1993, p.24
Selous Conservation Programme, 1993

Management of endangered species

The region's commitment to conserve wildlife has also been shown in the development of management strategies to replenish the populations of endangered species. This dates back to the 1920s when the white rhino almost followed the quagga into extinction. Some 70 years ago, southern Africa had an estimated 20-30 white rhino after numbers dropped due to overhunting. Today they number about 4,000.[34] The deliberate and careful protection of the white rhino, and the restocking of other areas from the few that remained in South Africa, saw their numbers gradually increase. They were also imported into Zimbabwe where, until recently, they existed in viable numbers.

The Nile crocodile was once severely overexploited for its skin. It became endangered and was put on CITES's Appendix 1 which prohibited trade in its products. Today, the reptile has become so plentiful that CITES has removed it from the endangered list and most countries in the region, including Botswana, Malawi and Tanzania, now export its products. The solution came from farmers who intensively raised these crocodiles by collecting eggs from the wild and artificially hatching them, returning a certain percentage into rivers — usually more than the two percent which naturally survive. Another example is the ostrich which, though still endangered in Mozambique, has recovered from overexploitation elsewhere. The region is now a major exporter of ostriches and ostrich products.

Southern Africa is now making attempts to rebuild its depleted rhino populations. The management approach involves intensive breeding in captivity, translocation of rhinos from poacher-infested areas to inland locations of relative safety where patrols are carried out. Zimbabwe engages in *ex-situ* (outside place of origin) breeding whereby some rhino have been translocated overseas to countries such as the United States, Australia and Korea. In addition, some countries, notably Namibia and Zimbabwe, have dehorned rhinos to discourage commercial poachers from killing them. Southern African countries work closely with other parts of the world to monitor trafficking. While the methods have not yielded success yet, they indicate the region's willingness go to protect its wildlife.

INTERNATIONAL COOPERATION

Southern African countries are signatories to a number of global conventions aimed at addressing environmental matters, including the Montreal Protocol, CITES, and the Convention on Climate Change.

Commercial utilisation — crocodile and ostrich farming Box 8.6

Crocodile Ranching: Somewhat strangely named, crocodile ranches are actually intensive farms which collect eggs from the wild to obtain their stock. This scheme was pioneered in Zimbabwe, but has since spread throughout much of east and southern Africa. The crocodile eggs are brought to the farm where they are incubated and hatched, the young crocodiles raised for their skins. In 1991, over 58,000 eggs were collected in Zimbabwe, most from Lake Kariba, and the industry earned US$2 million in hide sales. This alone is an incentive for conservation, but equally as important, a portion of the eggs are bought from rural communities which manage their wildlife under the CAMPFIRE programme. Thus, at all levels there is a conspicuous economic incentive to conserve crocodiles, something which would otherwise be unpopular given their heavy toll on both people and domestic livestock every year.

Ostrich Farming: South Africa is the world's principal producer of ostrich meat and leather, although several other countries are fast catching-up. Only in a few cases has the wild population integrated directly into ostrich farming schemes. Instead, ostriches are fast being domesticated. Indeed, in South Africa, it would be hard to argue that the ostrich is not already a domesticated animal. Ostriches produce a high quality, low-fat and low-cholesterol red meat, but most income is derived from their hide which is used to make luxury fashion leather-goods. Already a well-established agricultural enterprise, the challenge with ostriches is to find ways of farming which give direct benefits to wild birds. In Zimbabwe, birds that have pure wild blood are being restocked in areas where they once occurred.

Makombe, K. (ed.), *Sharing the Land: Wildlife, People and Development in Africa*, IUCN-ROSA, Harare, 1993, p.25
SOURCES: Hutton, John, pers. comm., 1993

Maasai warriors stand sentry over wildlife

Story

Loibosiret, (SARDC) — The hunting truck had hardly stopped when four *morans* (Maasai warriors) surrounded it. "*Oloju*, we have seen two today," said one of them. "They were definitely poachers," the second warrior said, holding his spear in a manner suggesting he would use it on the poachers if given a chance.

This is Loibosiret, a small trading hamlet in the heart of the vast Maasailand plains of Arusha region in northern Tanzania. The four warriors could have passed for any Maasai youth out for a stroll in the cool evening after a day in the bush with cattle, but tonight they were on patrol to guard wildlife against poachers.

"We could not arrest them because they were in the company of gemstone panners," said the first *moran*, the oldest of the four and leader of the group. It later transpired that poachers often come to Loibosiret under the pretext of prospecting for *green garnets*, semi-precious gemstones mined nearby.

As the leader gave further details of the suspected poachers, a third warrior pitched his spear on the ground below the passenger's seat, and suspiciously peered inside to make out my identity. George Alexiou, driver and proprietor of Bundu Safaris hunting company, came to my rescue.

"This is my friend from Arusha. He is a journalist, not a prospector," Alexiou said. We all laughed at the qualification. A quick mental calculation by the first warrior classified me as an elder — and greeted me accordingly: "*Sobay, Orobaiyan*!" We all laughed again.

The warm reception of the first night in the open hunting grounds of Loibosiret led to a long working relationship with the warriors — and to more insights about the Maasai, a proud people with perhaps the closest affinity to nature in Tanzania.

The Maasai know the terrain well, and can tell you where a pride of lions is likely to have an afternoon nap. They can be extremely good animal-trackers and can tell where poachers are likely to strike — an attribute often disregarded when government-trained rangers attempt the task without much success.

Bundu Safaris, then facing difficulties containing illegal hunting in their block from rival companies and poachers, agreed to pay 10 percent of their earnings from every trophy gunned by professional hunters in exchange for village patrols by warriors. According to village accounts, poaching was rampant then, and the Maasai could not tell the difference between licensed hunters and poachers. Open hunting areas are not protected by government rangers like national parks and other protected reserves.

In 1993 alone, the village collected US$10,000, a good sum by village standards anywhere. To keep a record of such earnings, the elders have appointed warriors to join hunting expeditions — to work as trackers and keep a list of every trophy killed and the fees paid by hunters. When Loibosiret faced acute food shortages during the 1992 drought, they used proceeds from their commissions to buy enough stocks for themselves, and sold the surplus to outlying villages.

Decisions on how to spend the money are taken collectively at the village council, but elders hold extensive consultations to determine priorities. At one such meeting in August 1993, water was high on the agenda, because even at the *No-omuny* — the Pond of the Rhino — which seldom dried, the water was perilously low at a time when the rains were still months away.

—**James Mpinga,** Environment Press Foundation, Arusha, for SARDC, 1993

Like the rest of the world, southern African countries seek further cooperation in the conservation of natural resources and sustainable utilisation. In keeping with this view, the countries in the region prepared reports for the 1992 Earth Summit, at national, regional and continental levels, spelling out their positions and concerns. In principle, the countries have accepted most of the provisions of the conventions that were drawn up at the Earth Summit, such as the Biodiversity Convention.

International cooperation has benefited southern Africa. Through organisations such as IUCN and World Wildlife Fund for Nature and Natural Resources (WWF), the region has received technical, monetary and material support. The strict monitoring of products from endangered species by CITES has helped the crocodile and ostrich industries to prosper.

International cooperation can benefit biodiversity protection. Debt-for-Nature Exchange involves the purchase of foreign debts by international environmental organisations in return for setting aside land for conservation where no development should take place. So far, in southern Africa, only Zambia has such a deal. The Zambian government agreed to allow WWF to manage the Kafue and Bengweulu flats in return for US$2.27 million debt. The lack of use of the facility by other countries may arise from the suspicion that debt-for-nature swaps can hamper the right of national governments to develop their land.[35]

There are still fundamental problems between the viewpoints of the North and the South, most of which were discussed at the Earth Summit, with little success in resolving them. Southern Africa and the rest of the developing world argue that their biodiversity should not be freely accessible to industrialised countries and patented, as is the current position. They object to the idea of an industrialised country developing drugs or seeds or any other product from their biological resources without benefit to them. The problem is that once a drug is developed and patented, no one can develop a similar drug, not even the country in whose area lies the resources. Dissatisfaction also arises from the high prices at which drugs and other products from the biodiversity of the South are sold back to the South. Vandana Shiva, an Indian scientist, argues that Madagascar's periwinkle does not benefit the country as it should.[36] The periwinkle is a source of at least 60 alkaloids (organic substances mostly made into drugs) worth US$160 million in sales.

Information on the usefulness of raw genetic material gathered from countries such as those in southern Africa is neither patented nor paid for. Another area of discontent, albeit less widespread, has been the ban on trade in ivory since 1992 by the CITES — even for those countries where elephant populations are too large. This has been viewed by the affected countries as counterproductive since it tends to punish the states that have been able to manage their elephants well.

Ill 8.2 ACTION MAGAZINE

Linkages to other chapters Box 8.7

1 PEOPLE

Human activities impact on, and are affected by, the availability of a range of wild resources. Population pressures are causing competition for land between people and plants and animals.

2 HISTORY

Low human populations, use of basic weapons and appropriate conservation measures enabled wildlife to thrive for centuries.

3 POLICY

Post-colonial environmental policy frameworks in the region have been moving away from protectionism toward wise utilisation, and national governments also continue to play a role in development of international policy.

4 ECOZONES

Wildlife distribution and abundance aligns closely with ecozones. Physical factors determine the distribution of plants and other wildlife in the region.

5 CLIMATE

Droughts are a natural occurrence in southern African ecosystems. However, animals adapt by migrating and plants by using less water.

6 SOILS

Expanding cultivation and soil degradation are primary threats to the biodiversity of wildlife, fragmenting remaining habitats and migratory routes, and reducing the ability of species to reproduce and survive.

7 WOODLANDS

Deforestation in southern Africa due to expanding cultivation and cutting of trees for timber and other uses has harmed some plant species and deprived wild animals of habitat.

9 FRESH WATER

Expanding cultivation, deforestation and plantation forestry, and dams and irrigation schemes, have combined to cause a decline in water supplies and wetland habitat.

10 MARINE

Mangrove forests and coral reefs shelter marine life and are an important component of coastal habitats, adding to the biological diversity of the region.

11 POLLUTION

Pesticides, oil-spills and sedimentation are detrimental to wildlife and they kill, smother and reduce the ability of wildlife to reproduce.

12 ARMED CONFLICT

War in Angola and Mozambique has made consistent wildlife management impossible, and widespread poaching has reduced animal numbers. Largescale population movements caused by war have caused localised environmental damage. However, the natural areas from which people flee often recover.

13 GLOBAL

Distribution of various habitats could be altered by predicted long-term changes in weather and rainfall patterns. Increased temperatures resulting from global warming could inhibit regeneration of indigenous plants in their present locations. Increases in ultra-violet radiation could damage plant and animal life.

14 TRENDS

Toward more sustainable utilisation of resources. New methods of sharing the land and sustaining the environment have to be found, and progress is being made with innovative programmes on sustainable use of wildlife.

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9 FRESHWATER Resources

A bird's-eye view of most of southern Africa in January looks down on broad expanses of vegetation in varying shades of green, from lush grasslands to leafy woodlands. A similar view in September reveals a yellow-brown, parched landscape, with occasional strands of green. Dryness is a fact of life, and no one takes it for granted.

Although parts of the region are well-watered, the demand is increasing rapidly and it is not surprising that anxieties have begun to develop over access to water. Three of the region's 11 countries face inadequate freshwater supplies within 30 years — Botswana, Namibia and South Africa.[1] All have seen the dark shadow of extreme water scarcity within the last decade. Water demand is projected to rise at almost three percent annually until at least the year 2020. Governments in the region are responding by looking for ways to manage water fairly and cooperatively.

In most of southern Africa, inadequate water is the main limitation on all living things. Plants must have water in the soil to grow, and animals cannot survive more than a few days without it. But fresh water is not just a vital resource on which ecozones, and their constituent parts, depend; many plants and animals can live only in water or close to a permanent source of water.

FRESHWATER ECOSYSTEMS

Almost 13 percent of the Southern African Development Community (SADC) region, excluding South Africa, is made up of freshwater ecosystems, known as wetlands;[2] and much of the rural settlement (which comprises about 60 percent of the population) is concentrated there.[3]

Wetlands are usually quite different from the surrounding ecozone due to the increased water availability, and it is more useful to think of them as a separate type of system than to treat to them as one of the defined ecozones. Freshwater wetlands can be divided into four main types:

- lakes, deep or shallow;
- rivers, including floodplains;
- dams, which convert stretches of a river into artificial lakes; and
- palustrine areas (swamps, marshes, fens, bogs and *dambos*).

These categories overlap to some degree, but provide a guideline when looking at the main processes which produce different kinds of wetlands. Many species are adapted to living in or near water for all or part of their lives. Freshwater fish are part of wetlands ecosystems and are an important source of protein throughout most of southern Africa. Fish catches vary from place to place, with the largest yields associated with major lakes and dams.

In a recent joint study, SADC and the World Conservation Union (IUCN) concluded that wetlands throughout the region are threatened by a variety of human activities. The study recommended a plan of action within a regional framework, based on national initiatives.[4]

Lakes

There are few large, deep, natural lakes in this region. The largest are the Rift-valley lakes — 9-4Victoria, 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.

Deep lakes

While the water in shallow lakes mixes thoroughly every day, the very deep lakes develop two distinct layers which rarely, if ever, mix. The surface heats up under the sun's rays and becomes less dense, "floating" on the cold lower layer,[5] like oil on water. Only the upper, warmer layer circulates, leaving the deep layer of cold, nutrient-rich, oxygen-poor water immobile below. Plants, and animals to a lesser extent, live largely in the upper layer where the sunlight penetrates. When the plants die, they sink to the bottom. Until the water mixes, the nutrients from the rotting plants are not available to the living organisms above. The lack of oxygen in the lower layer releases phosphorous, an essential ingredient for plant growth. Poisonous substances also form at the bottom of these deep lakes when bottom-dwelling bacteria extract oxygen from sulphates.

Although it is difficult for the layers in the deep lakes to mix, an external force such as a strong wind can initiate mixing, or "overturn". This usually happens in June, July or August, when the two layers are closest in temperature due to the cold weather and windy conditions. Wind triggers a sudden increase in plant productivity by releasing nutrients which had been trapped in the deep layer. The increase in availability of plants, as food, increases the amount of fish. Such activity may kill fish, however, when toxic substances are released from the bottom. Several times over the last decade, de-oxygenated and poison-laden water from the bottom of Lake Victoria was pushed up by the force of wind.

Several of the lakes are unique and it is difficult to generalise about them. The Rift-valley lakes have large numbers of unique species of fish and plants because they are isolated from other freshwater systems. The deepest, 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 to the lake.[6] Lake Malawi has 250 species of fish, the highest number in the world, and 90 percent of these are endemic. Among them the three lakes have the world's richest diversity of lake-fish species.

Shallow lakes

Shallow lakes are quite different from deep lakes in that the water circulates most of the time, resulting in fairly uniform conditions of temperature, nutrients, oxygen and other chemicals. Shallow lakes are generally no more than 10 m deep and often have large surface areas. These lakes can lose a large proportion of their water due to evaporation, or the water level can rise quickly during a heavy rain. These changes in water levels also produce rapid changes in temperature, acidity and oxygen. Some shallow lakes in southern Africa can disappear seasonally. Levels of deep lakes also rise and fall, some quite dramatically, from wet to dry season and back again. 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.

Soda lakes and pans

There are also the "soda lakes", such as Lake Manyara in Tanzania, which have high salt levels (largely *sodium bicarbonate*, baking soda) and relatively alkaline water, with accompanying unique species which have adapted to those conditions. Most of these lakes are found in the Rift-valley area in the northeast, in moist and dry savanna. They tend to be small and shallow and do not have many different types of species, but are very productive with a lot of algae. These lakes go through abrupt changes in species composition, although the reasons are not well understood.[7]

Pans are very shallow, often seasonal, bodies of water found in arid zones such as the nama-karoo and southern dry savanna, and are usually salty. Soda lakes and pans furnish a unique habitat, and their unusual collections of species, such as huge flocks of flamingos, are often conserved for tourism. The Makgadikgadi pan in Botswana and Etosha pan in Namibia are examples. Pans are particularly important as habitat for migratory birds. They are sometimes mined for salt or soda ash, as in Botswana's Sua pan.

Fisheries

The large lakes are quite productive in fish and provide almost all of the inland commercial and subsistence catches in the region, almost 500,000 tonnes per year (t/yr). Many people depend on fishing in the lakes for their livelihood, and fish are often a large part of the diet of people living near lakes. Some lakes are showing signs of overfishing, including Victoria and Malawi, two of the region's largest producers of fish. At present, southern Africa's lake-fish do not face many serious environmental problems. The main problem relates to transplanting of species from one lake to another.

In some cases, fish species have been introduced to lakes, and especially dams, where it was thought they could produce larger fish catches. The "Lake Tanganyika sardine" (also

Villagers save rare fish Story

Mangochi (AIA) — Villagers near the southern tip of Lake Malawi have helped to save a rare species of fish from extinction by changing their traditional way of life.

The people of Chembe, Malawi's largest fishing village, which is situated at Cape Maclear, have in the past cut down trees along the shores of the lake.

Unknown to them, the clearing of forest along the shore posed a threat to one species of fish. This type of fish, which is known locally as *mbuna*, is rare and among the world's most highly prized.

The colourful *mbuna* is of the family of fish biologically called *cichlidae*. Lake Malawi is unique for harbouring more than 500 species of fish (far more than any other lake anywhere in the world) and holds the largest collection of *cichlidae*.

Fish researcher Mike Tweddle explains: "The fish feeds on algae which grows on rocks and free-living organisms associated with the algae.

"What happens when deforestation occurs is that a lot of soil erosion takes place, silt accumulates on the rocks in the lake around where the *mbuna* live and this in turn depresses the algae and the *mbuna* starve."

Recognising the importance of this species of fish and the need to save it from extinction, the government declared the area around Cape Maclear and Chembe village a national park in 1980.

The park, which includes 87 sq km of land and water extending 100 m from the shore, was also declared a World Heritage Site by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) in 1984 because of its biological importance.

Before the establishment of the national park, scientists and environmentalists were concerned that villagers were catching the fish in large numbers.

Later it was discovered that deforestation along the shore also threatened the existence of *mbuna*, as the villagers were cutting down a lot of trees for fuelwood.

"Instead of forcing people out, we try to make them understand the importance of the environment to their well-being," says George Banda, a senior officer in the Department of Parks and Wildlife Management.

Villagers are charged a small fee for collecting dry wood within the park. They are also encouraged to use less firewood.

"We do understand what the government is trying to do," says fisherman Guza Nkhoma. "It wants us to manage the park as part of our property. After all it's us who will benefit from it."

Parks officials measure the size and density of trees regularly. They also monitor soil erosion to ensure that conditions in the water remain favourable for the *mbuna*.

Scientists say they find the *cichlidae* interesting because there are so many different species in the park and each is closely associated with the rocks upon which it feeds.

Cichlidae rarely grow larger than 15 cm. Each variety has completely different tooth and jaw arrangements which are uniquely adapted to feeding on different parts of the same algae.

Cichlidae are extremely popular among fish lovers worldwide. They are exported live to various parts of the world where they become part of the international trade in ornamental fish.

In 1988, aquarium fish exports netted MK890,000 (US$231,000) in foreign exchange. The fish are exported to North America, Germany, France, Belgium and other European countries.

— **Felix Mponda,** *AIA/Development Dialogue*, Jul/Aug 1993, p. 35

Major lakes and fish production Table 9.1

Lake/Dam	Volume (cu km)	Fish production (tonnes)	Country
Victoria	?	400,000	Kenya, Tanzania, Uganda
Tanganyika	18,940	85,000	Burundi, Tanzania, Zambia, Zaire
Malawi/Nyasa	8,400	85,000	Malawi, Mozambique, Tanzania
Kariba	156	40,000	Zambia, Zimbabwe
Chiuta/Chilwa	?	14,000	Malawi, Mozambique
Cahora Bassa	56	10,000	Mozambique
Bangweulu	10	8,000 - 12,000	Zambia
Mweru	38	7,000 - 10,000	Zambia, Zaire
Malombe	?	4,000 - 10,000	Malawi
Rukwa	?	6,000	Tanzania

SOURCE: FAO, *Source Book for the Inland Fishery Resource of Africa*, Vol 1, FAO, Rome, 1990

known as *kapenta*) was brought into Lake Kariba and now provides the majority of the fish catch, about 21,000 t/yr, although some experts question whether this is sustainable. In other cases these introductions have caused problems. Nile perch, for example, was introduced into Lake Victoria in the mid-1970s because of the strong market value of the fish. It has thrived and become economically important, increasing from a catch of 42 tonnes in 1978 to 148,500 tonnes in 1988 — about 70 percent of the lake's total catch. But Nile perch is a voracious predator that has driven an estimated 200 species to extinction and many others to dangerously low levels. Once prey species are depleted the number of Nile Perch is expected to drop.[8]

The introduction of sardines into Lake Malawi has been discouraged because scientists think that this could lead to the extinction of other fish species[9] This recommendation is based on the experiences with the Nile perch in Lake Victoria.

Sedimentation is having a negative effect on the fisheries of the Rift-valley lakes. In Lake Malawi, increased sedimentation at the mouths of inflowing rivers has reduced fisheries due to disturbance of spawning areas or high levels of sediment in the water. Changes in flow speed due to sedimentation have also affected some species.

The invasion of some southern African lakes by water hyacinth has resulted in major changes in fish habitat. The hyacinth outgrows the local water-plants and takes over. When the massive quantities of hyacinth die, they sink to the bottom and use up oxygen as they rot. The thick mat also blocks out light and alters the water temperature. Malawi, South Africa, Tanzania, Zambia and Zimbabwe all have problems with the weed.

Rivers

River species (from plants to fish and insects) are especially adapted to live in or near flowing water. Moist river-bank habitats are home to many wildlife species that would not otherwise be found, especially in arid areas. Rivers can be divided into three basic ecological zones, each supporting different life-forms. These zones — upper, middle and lower — result from changes in speed of river flow, which in turn result from topography.[10]

There are many rivers in southern Africa, large and small. The largest is the Zambezi river, fed by tributaries in eight countries, which drains about one-fifth of the region. Many of the rivers are shared, running through several countries or acting as borders between them — including the Cunene, Limpopo, Orange, Rovuma, Zaire and Zambezi. In addition to the permanent rivers, there are many seasonal rivers which flow for part of the year, for a short time after the rains. 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.[11] In the nama-karoo, succulent karoo and desert ecozones, there are few permanent rivers and there are none between the Cunene and Orange rivers, which mark the northern and southern borders of Namibia.

The large variations in flow levels make the conditions beside rivers very dynamic. The difference between the high and low water-mark may cover a large area with almost constant flow variation, which means plants living there must be adapted to a wide range of conditions.

Floodplains

The rainy season brings river-flooding, covering huge floodplains with thin layers of water, 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. Fish also follow the water and nutrients, breeding and feeding in the floodplain. Fish spawn and the fingerlings grow before they return to the rivers. Insects found in the floodplains provide food for the small fish.

Floodplains are very productive fish environments. Several thousand tonnes of fish are harvested annually from these floodplains, including Barotse (part of the Zambezi) and Kafue of 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-river headwaters of the central plateau. The Okavango river and flood-

Characteristics of river ecological zones Table 9.2

Zone	Physical	Vegetation	Fish	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 dead leaves	- low
Middle	- shallower slope - slower, wider - warmer - less oxygen - less rocky - more nutrients - more light	- much more vegetation - some reeds	- larger fish - molluscs - insects - fish eat insects and water plants	- 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	- large and small fish - more fish species - many bottom feeders	- 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

Freshwater fish production by country Table 9.3

Country	Range of actual production (tonnes)	Range of potential production (tonnes)
Angola	6,000 - 8,000	50,000 - 113,000
Botswana	1,200 - 1,750	8,000 - 15,000
Lesotho	12 - 32	620 - 870
Malawi	31,000 - 113,500	114,200 - 151,600
Mozambique	246 - 5,000	55,000
Namibia	150	350+
South Africa	5,000 - 6,000	6,000+
Swaziland	63 - 150	200 - 280
Tanzania	211,975 - 221,975	226,500 - 358,500
Zambia	66,500	117,300
Zimbabwe	13,613 - 16,007	19,400 - 26,000

SOURCE: FAO, *Source Book for the Inland Fishery Resource of Africa, Vol 1*, FAO, Rome, 1990

plains are the only significant areas for freshwater fish in Botswana and Namibia.

In recent years, the large dams, such as Kariba and Cahora Bassa on the Zambezi and Kafue 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, which reduces the area available for spawning in the plains below the dam. Dams also interrupt fish migrations, which can disrupt or prevent spawning. Low rainfall and increasing water demand are causing the shrinking of some floodplains once useful for fish production.

Fisheries

Significant fishing takes place in the Shire river of Malawi and the Kafue of Zambia. The lower Shire produced 10,000 tonnes of fish in 1986, and has potential to produce more but has been hit hard by a water-hyacinth infestation.[12] Fish are caught throughout the Zambezi system — on floodplains, in reservoirs and on the river and its tributaries. The Limpopo is another large river, but it contains few fish. The Cunene and Orange rivers do not account for much of the annual catches either, although the Cunene has the potential to produce 5,000 tonnes annually.

Introduced species have caused problems in many rivers. Trout introduced in the rivers of Natal in South Africa fed on a rare fish of the *cyprinid* species, which is now found only in three small streams in Lesotho. Trout have been introduced in many rivers, always with a serious impact on indigenous fish.

Dams

Dams essentially change parts of rivers into lakes, but are different from both ecologically. Their water-levels fluctuate faster and more extensively than a natural lake, affecting the vegetation in the area between high and low water. Water tends to flow through dams more quickly than lakes, but slower than natural rivers.

Photo 9.1 SAMSO-J Spencer

Kapenta fishing co-operatives at Lake Kariba — 50,000 people in Zambia and Zimbabwe depend on the lake for income and food.

Since they are artificially located in a river, dams also change the ecology of the area where they are built, decreasing or eliminating downstream flooding, damaging shoreline vegetation and changing the characteristics of the river-flow below the dam — including temperature, nutrient and silt levels, and oxygen content. Reduced flooding dries up floodplains, generally leading to a loss of riverbank vegetation and wildlife. The Kariba dam reduced the flooding of the Zambezi river by 25 percent, affecting important floodplain areas such as Mana Pools in Zimbabwe[13] and Marromeu plains in Mozambique, as did the Cahora Bassa dam.

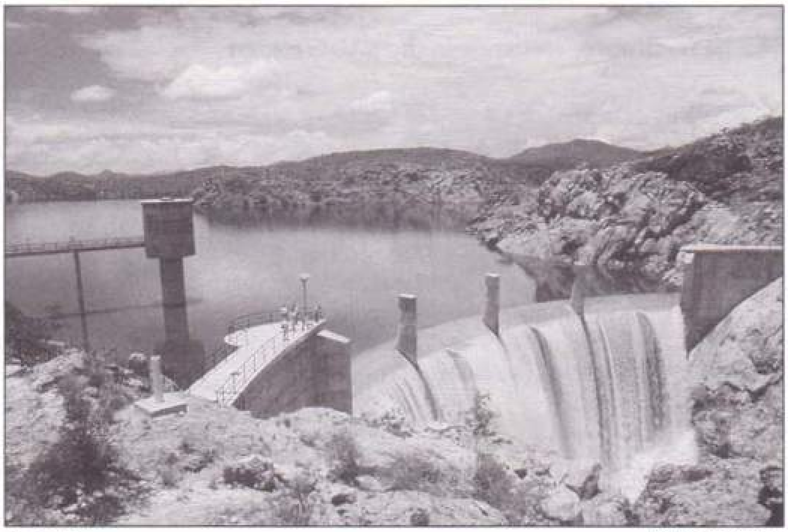


Photo 9.2 NAMIBIA REVIEW

Dams provide electricity and irrigation, and can increase fish-yields. But dams also change the ecology in an area, trap silt and nutrients and the filling period can cause major disruptions. Shown here is Oshivelo dam in Namibia.

Dams also trap silt and nutrients, decreasing or eliminating their availability downstream and lowering production of vegetation and fish, as well as blocking fish-migration. By restricting the flow of water, dams also change the mix of fresh and salt water at river-mouths. Fish and other marine creatures have difficulty adjusting to these changes, so populations decrease and some species may be replaced by others.

In addition to benefits from electricity and/or irrigation, a dam normally increases fish-yields over those from the previously free-running river, though species diversity usually decreases.

The filling period for a dam can cause major disruptions. Water flow can be cut off completely or nearly so, causing massive fish-kills 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 quantity 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. In 1962, shortly after filling up, almost a quarter of Lake Kariba was covered by Kariba weed. This has declined as the initial flush of nutrients from drowned vegetation slowed.[14]

As the reservoir fills, water quality tends to be good and can even improve as silt settles in the slower water. But the increased access to light in the wide area covered by the reservoir later overstimulates growth of aquatic plants. This can lead to the depletion of oxygen caused by rotting plants, a decline in water quality and a dramatic reduction in the number of species.[15] River-adapted species are replaced by lake-adapted species. There may be a rapid increase in the plant population, but some river-adapted species may become locally extinct. This increase in vegetation provides more food for fish, so is followed by an increase in numbers.

Shallow and deep dams display similar circulation characteristics to shallow and deep lakes, with complete circulation in shallow dams while deep ones develop warm and cold layers. If the gates of a dam are at the top, such as for hydroelectric generation, the water discharge will be warm, with low levels of silt and a tendency to cause downstream erosion ("silt-hungry"). Most of the reservoir's life is found in the upper layer, so water released from there provides excess nutrients downstream, in the form of vegetation, compared to the original river system.[16] Water released from the bottom (as in dams used for irrigation or water supply) is cold, silt-laden, nutrient-rich and oxygen-poor. The heavy silt load from the lower layer can smother downstream life forms. As with lakes, poisonous gases can form at the bottom. All of these factors affect downstream ecosystems, because they are different from the natural river regime.

A large amount of dam-water evaporates. More than a quarter of the average inflow to Maputo's main reservoir, Pequenos Libombos, evaporates.[17] Annual evaporation from Lake Kariba is about eight cubic kilometres per year.[18]

Cahora Bassa and Kariba are the only major dams that are important to the fisheries of southern Africa, with Kariba providing about 90 percent of Zimbabwe's fish-yield.[19] Most of the fish are of a few types, however, and dams tend to support a low diversity of fish species.

Large freshwater wetlands in the SADC region Table 9.4

System	Name	Locality	Wetland type	Approximate area (sq km)	Status	Special features
Eastern system	Chilwa	Malawi, Mozambique	sl, sw	6,500	un	fsh
	Chiuta	Malawi, Mozambique	sl, sw	115	un	fsh, res
	Amaramba	Mozambique	sl, sw	2,500	un	fsh, res
	Usangu	Tanzania	fp, sw	520	pp	wld, grz, agr
	Kilombero	Tanzania	fp, sw	6,650	pp	fsh, wld, agr
	Rufiji	Tanzania	fp	1,450	pp	wld, res
Zambezi	Barotse/Zambezi plain	Zambia	fp	9,000	pp	grz, fsh, agr
	Liuwa plain	Zambia	fp, sw	3,500	pr	wld, grz
	Luenya	Zambia	fp, sw	1,100	un	fsh, grz, agr
	Lukanga	Zambia	sw	2,500	un	fsh, grz, agr
	Kafue flats	Zambia	fp, sw	6,500	pp	fsh, grz, agr
	Chobe-Linyati	Botswana, Namibia	sw	200	pp	wld, fsh, grz
	Cuando	Angola	fp, sw	-	pp	wld, fsh
	Liambezi	Namibia, Botswana	sl?	150	un	fsh, grz, agr
	Cameia	Angola	fp	-	pr	wld, grz
	Malombe	Malawi	sl, sw	390	pp	fsh, wld, agr, grz
	Elephant marsh	Malawi, Mozambique	sw, fp	520	un	fsh, grz, agr
	Vwaza marsh	Malawi	sw	-	pr	wld
	Marromeu	Mozambique	fp	-	un	wld, fsh
South-eastern	Pongolo river	Mozambique, S. Africa	fp	100	pp	fsh, grz, wld
	Pungue river	Mozambique	fp	-	pp	wld
	Incomati river	Mozambique	fp, sw	-	un	rds
	Limpopo river	Mozambique	fp, sw	-	pp	wld
Okavango	Okavango river	Angola, Namibia	fp	-	un	grz, agr
	Okavango delta	Botswana	sw	16,000	pp	wld, grz
	Ngami	Botswana	sl	790	un	fsh
	Dow	Botswana	sl	100	un	-
Nile system	Upper Kagera	Burundi, Rwanda, Tanzania	sl, fp	350	pp	lks
	Lake Victoria	Uganda, Kenya, Tanzania	sw	-	pr	fsh, agr, wld
Western	Cunene river	Angola, Namibia	-	-	-	-
	Cuanza	Angola	fp, sw.	-	pp	oil
Zaire/ Congo	Kifukulu depression	Zaire, Zambia	sw, fp	1,500	un	fsh
	Mweru	Zambia, Zaire	sl	4,850	up	fsh
	Bangweulu	Zambia	sl, sw, fp	11,000	pp	wld, fsh
	Mweru wantipa	Zambia	sl, sw	1,300	pr	wld, fsh
	Rukwa	Tanzania	sl	2,300	pp	wld, grz, fsh
	Malagarasi	Tanzania	fp, sw	7,360	pp	wld, grz, fsh
Congo	Wembere	Tanzania	fp, sw	2,500	un	wld, fsh, grz
	Moyowosi	Tanzania	sw	-	un	wld

KEY: sl - shallow lake; sw - swamp; fp - floodplain; un - unprotected; pr - entirely/largely protected; pp - partially protected; fsh - fishery; grz - grazing; lks - lakes; wld - wildlife; agr - agriculture; res - reservoir; rds - harvesting of reeds

SOURCE: Chabwela, H., *Wetlands: A Conservation Programme for Southern Africa*, IUCN and SADCC, Nov 1991

Other wetlands

There are a number of internationally known marshes in southern Africa, such as the Okavango delta and Kafue flats. There are also many smaller marshes that serve a diverse range of ecological and human uses.

Marshy areas are home to many kinds of plants and animals, including fish, which are often present in high numbers. The Elephant marshes of Malawi are especially important for fish-spawning. Marshes also serve as stopping points for migratory species, especially birds. These areas play an important role in trapping sediment and stopping siltation downstream.

One of the most common types of marshy area in the region is the *dambo* — a meadow grazing land, or more precisely, a seasonally waterlogged grass-covered depression. The savanna ecozone contains many *dambos*, (also known as *mbuga, molapo, naka* or *vlei*), taking up as much as 10 percent of central southern Africa, including parts of Angola, Malawi, Mozambique, South Africa, Zambia and Zimbabwe. They are found in river headwaters and along streambanks, but can also occur independent of a drainage system.

Dambos were once thought to be like sponges, absorbing water, then releasing it slowly, in the classic "swamp" form found in temperate countries. But studies show they are actually groundwater discharge zones.[20] *Dambos* represent extensive wet-zones during the dry season. They are a good source of grazing and allow the cultivation of maize, rice or vegetables.

Dambo soils are generally more productive than surrounding upland soils because they have a more reliable water-supply, and because they receive eroded soils and nutrients. *Dambos* can be degraded through draining, cultivation of too large an area (studies show about 30 percent is safe) and especially overgrazing.[21]

SOURCES OF FRESH WATER

Since rainfall is often limited, so are water sources. The crucial factor to determine is how much water enters the supply each year, since taking more than that amount will be unsustainable over the longer term. The rainfall fluctuations and cycles must also be considered.

Water sources vary in type, quantity and quality across the region. Water management also differs considerably, from highly managed in Botswana, Namibia and South Africa (each has a National Water Master Plan) to largely unmanaged in areas of armed conflict such as Angola. Some countries, such as Tanzania, have outdated National Water Master Plans.[22]

Rainfall

The primary source of fresh water is rainfall. Virtually all of this comes from seawater which evaporates to form clouds, with a small proportion coming from evaporation of water from land or through transpiration of water in plants. This water vapour is then evaporated from the leaves by the sun, a process called evapotranspiration.

Rainfall affects peoples' ability to live and prosper. Generally areas receiving less than 600 mm of rain annually cannot produce crops unless there is some supplementary water. About 500 mm is considered the minimum, although certain crops can flourish below this. The variability of rainfall is an added factor. If the rain comes too late, or ends too early, crops will be damaged or destroyed.

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 and/or dry winds. The water that remains amounts to about 600 cu km/yr[23] (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.

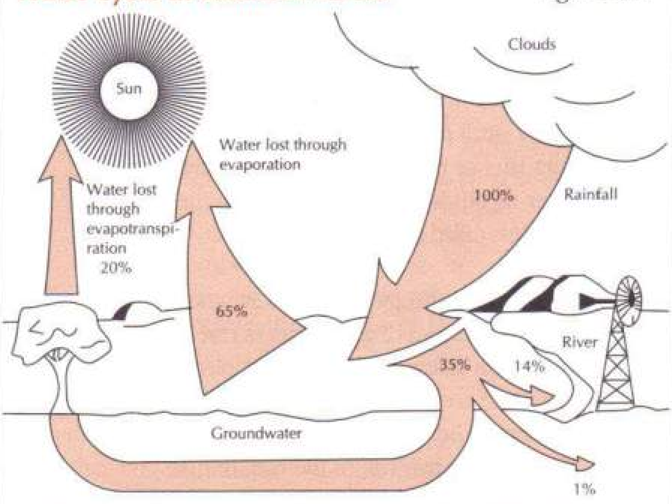
Evaporation

A major factor in water availability is evaporation. 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 run off.

The nama-karoo, succulent karoo and desert have very high rates of evaporation with potential evaporation higher than average rainfall. Evaporation does not normally exceed rainfall in the savanna zone.

In the Kgalagadi, when the weather is hot and dry, the first 5 mm of rain evaporates before it penetrates the surface of the sand. During a long, dry period, the sun dries out the soil through evaporation at the same time as plants suck up every available drop they can get. This leaves the soil short

Water cycle in southern Africa Figure 9.1



SOURCE: Heyns, P., "Water Demand and Supply Management", for SARDC, 1993

of moisture and considerable rain must fall before sufficient water is available for plants.

In addition to direct evaporation, a large amount of water is lost through evaporation from plants (evapotranspiration). The Okavango delta is a good example. About 150 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.[24] 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 evapotranspiration and may have contributed to reactivation of some *dambo* systems.[25]

Burning of vegetation can increase the minimum flow of streams in mountain catchments by reducing evapotranspiration. Intensive grazing to keep grass short may increase this baseflow for the same reason, while trampling and ground compaction from high cattle numbers can decrease baseflow. 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 and wells which used to dry up began yielding water year-round.[26]

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.

Some water plants also have very high evapotranspiration rates. More water is lost from a water body with water hyacinth growing on it, for example, than from one exposed directly to the sun.

Human activity

Clearing of vegetation may modify rainfall, leading to a drier climate in certain ecozones. Removing vegetation decreases evapotranspiration, thus decreasing moisture available for rain formation. As an area is cleared of forest or vegetation, a locally drier climate may result. However, this is less likely to be true in arid zones of southern Africa, where most rain comes from the regional weather systems and little, if any, rain is generated locally.

Clearing for agriculture increases runoff and decreases infiltration rates, lowering the water table, as does compaction of soil caused by heavy machinery or large numbers of livestock. Vegetation slows the rain before it hits the ground and slows the speed of runoff, giving water a better chance of sinking 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 other vegetation cover.[27]

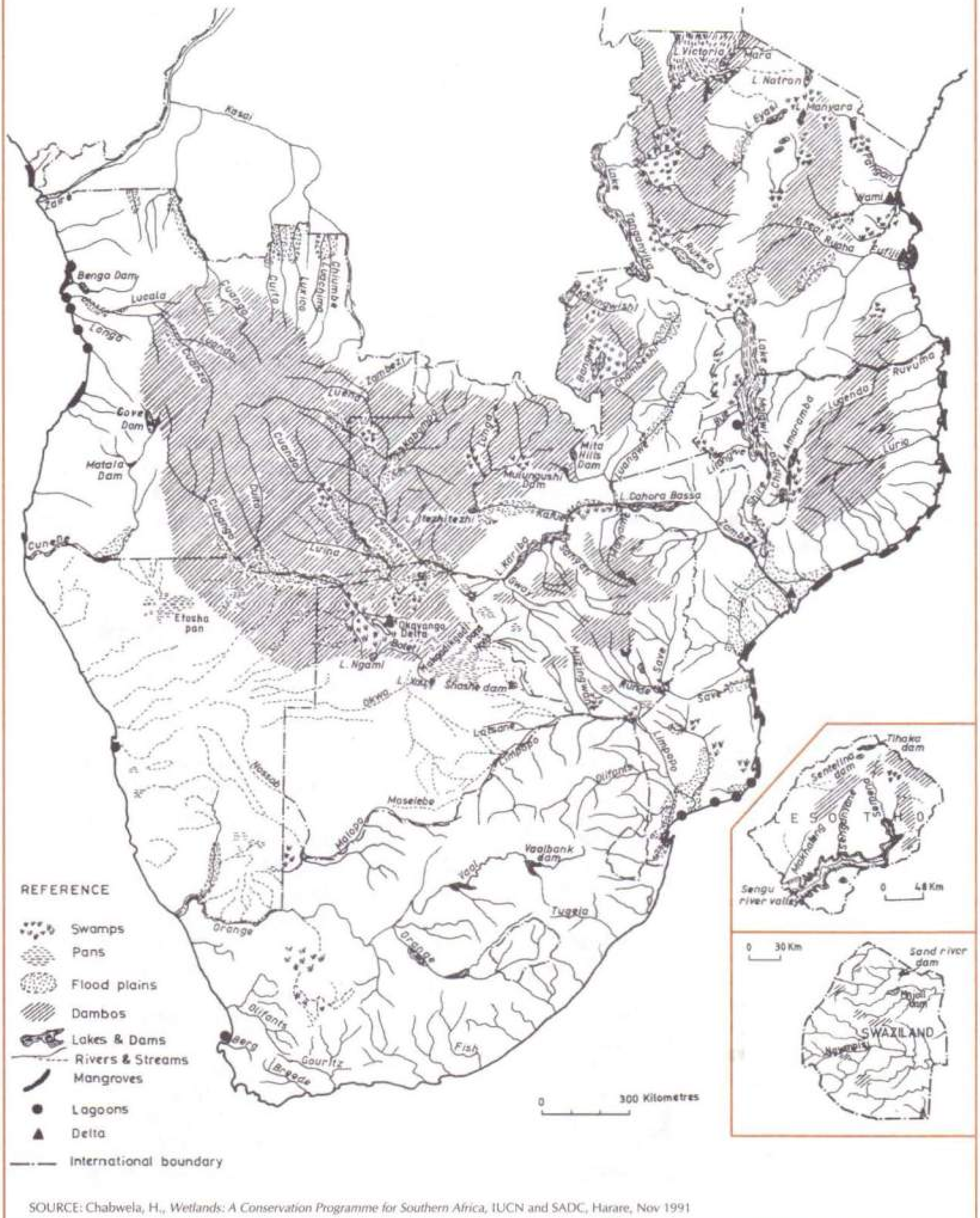
An area that loses one-third of its rain to runoff may receive 600 mm/yr, but will retain only 400 mm/yr in the ground where it is available for plants. The less water that penetrates the soil, the lower the groundwater recharge. For people, plants and wild animals in an ecozone, more runoff means less water unless it can be stored by some means such as in a dam. Reduction in the soil's ability to absorb water is invariably caused by human activity, usually related to agriculture. Loss of soil moisture makes it more difficult to grow crops, and magnifies the effect of a low rainfall or drought year.

Surface water

Surface waters provide a large proportion of freshwater sup-

Wetlands areas—river systems

Map 9.1



SOURCE: Chabwela, H., *Wetlands: A Conservation Programme for Southern Africa*, IUCN and SADC, Harare, Nov 1991 ply in southern Africa. These surface waters are the same wetlands that provide habitat for aquatic plants and animals, and the potential for competition between these different roles is quite high.

Surface sources provide water directly, through reservoirs, and as part of the water-supply infrastructure. Rivers and lakes furnish direct water supply only locally — in spite of the vast quantities of water they hold. Indirectly, they supply large and small reservoirs, which are strategically located near areas of high demand. The long dry-seasons throughout most of southern Africa require that water be collected and stored during the rains, for later use.

River flow

Southern Africa's annual wet and dry cycles have a dramatic effect on river flow over a year. The average annual flow of the Zambezi river at Katima Mulilo, Namibia, is 41 cu km/yr, but this figure hides the real situation — average November flow is about 300 cubic metres per second (cu m/s), increasing to 3,800 cu m/s in April.[28] If each of these momentary flows continued for a year they would result in an annual flow of 9 cu km/yr and 114 cu km/yr respectively. Many rivers in the drier zones of the region are actually seasonal, only flowing when sufficient rainfall occurs and ceasing to flow for part of the year. Some may flow only after an abnormally heavy rain, once in several years. The Zambezi river appears to have a long-term high- and low-flow cycle, and is currently in a low-flow period, which scientists say will likely continue for several more years.[29]

Many of the rivers in southern Africa carry high loads of sediment, due mainly to poor land-management practices. About 120 million tonnes of silt go into South African rivers each year.[30] Siltation makes a river more shallow, forcing water to spread over a wider area outside the channel, increasing evaporation. In Malawi, increasing silt loads have caused rivers to meander more than usual and to flood their banks more often, washing away river-bank crops. Excess silt also clogs river bottoms, smothering insects and other small creatures living there, and ruining fish spawning areas.

As water supply becomes an issue, the management of international rivers will increase in importance. Virtually all of the major rivers in Mozambique and Swaziland rise in other countries. Upstream actions on any river can have tremendous downstream impacts such as decreased water flows, increased siltation and pollution, or blocking of fish migration. This can be a potential source of conflict,[31] and has stimulated the establishment of a number of international water commissions, such as those between Namibia and South Africa, Lesotho and South Africa, and Angola and Namibia.

Importance of dams

There are a few, very large dams in southern Africa primarily intended for hydropower generation —Kariba, Cahora Bassa and Kafue Gorge. But there are more than 300 medium-sized dams and thousands of small ones used for urban and rural water-supply, livestock watering and irrigation. South Africa has over 500,000 dams,[32] while Zimbabwe has about 8,000.[33] Botswana has about 300, largely for livestock, although additional storage has been added to allow for irrigation.[34] Namibia has 13 major state-dams and another 500 small farm-dams.[35]

Major river basins and flows — Table 9.5

River	Flow (cu km)	Countries
Zaire	1.174	Angola, Zaire, Zambia
Zambezi	212	Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, Zimbabwe
Lilongwe	29	Malawi
Cuanza	26	Angola
Rufiji	26	Tanzania
Kilombero	14	Tanzania
Orange	12	Lesotho, Namibia, South Africa
Shire	11	Malawi, Mozambique
Kafue	10	Zambia
Luangwa	8	Mozambique, Zambia
Okavango	8	Angola, Botswana, Namibia
Lurio	7	Mozambique
Cunene	7	Angola, Namibia
Limpopo	5	Botswana, Mozambique, South Africa, Zimbabwe
Save	5	Mozambique, Zimbabwe

SOURCE: FAO, *Source Book for the Inland Fishery Resources of Africa*, FAO, Rome, 1990

Water-supply dams store water against shortages and as security against low rainfall. They collect water from both permanent and seasonal rivers during the wet season for use in the dry season or drought periods. In Swaziland, where there are no supply dams, water rationing is becoming common during the dry months.[36]

Dams collect a huge amount of runoff. In South Africa, farm dams have reduced runoff by up to 40 percent in the Orange and Upper Breede rivers.[37] Large hydroelectric dams, which release water only through the top, hold vast amounts of water (known as "dead storage") which cannot be used directly though it does serve as habitat to fish. Lake Kariba has 114 cu km of dead storage, equivalent to almost 20 percent of the entire region's annual runoff.[38] This unusable water is worth US$130,000 million in terms of Botswana's water costs.

Conflict can occur over hydroelectric supply and other uses of water. In Tanzania, the national electricity authority, TANESCO, has accused upstream irrigation schemes of depriving its hydro dams of water and has demanded closure of the irrigation schemes.[39]

Silting 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. Dams are a major investment and anything which shortens their life represents a large cost to the investors. High silt-loads also wear away power-generating equipment, further eroding investments. A survey of 120 dams in Zimbabwe's Masvingo province showed almost two-thirds were over half full of silt and others up to 100 percent silted.[40]

Siltation in South Africa is better monitored than in most other countries in the region, and some idea of the regional extent of sedimentation can be interpreted from that country's figures. In high-erosion areas, dams lose capacity at the rate of 10 percent each decade. Following the construction of two large dams in the Orange river catchment, for example, the amount of sediment carried to sea dropped from 35 million tonnes in 1935 to less than 20 million tonnes due to sediment being trapped in the dams. The cost of constructing new dams to replace storage capacity lost to siltation in South Africa is estimated at between R100 million and R200 million per year (US$36 million and US$72 million).[41]

Lakes and marshes

While rivers can be used to feed reservoirs, lakes are useful water sources only to those nearby. This is especially true of the Rift-valley lakes, which are at a much lower altitude than the surrounding area. Although Lake Malawi takes up 20.4 percent of the country, most Malawians rely on other sources of water.[42] The large lakes and dams in southern Africa are largely a future resource, requiring vast funds to develop as water sources to meet long-term needs.

The marshy areas of southern Africa are not major water sources either, but many people and animals rely on them as water sources for at least part of the year. Marshes also provide an important water-purification function, absorbing wastes from contaminated water. Several schemes are in place or being developed to use marshy areas as natural sewage-treatment plants.

Groundwater

Surface water and rain often sink into the ground. The water that is not taken up by plant roots or evaporation eventually filters down until it reaches some barrier where it sits, in the spaces in soil or in porous and fractured rock as groundwater. This barrier is usually the base-rock, though it can also be a layer of clay or other material that water cannot penetrate. Water will collect there, and the top of this layer of water is known as the water-table.

Storage

Accumulations of groundwater in certain types of geological formations are called aquifers. These aquifers can be in cracks in rock or in huge caves or channels which form in certain kinds of rock. Groundwater flows from high to low areas, or from 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.

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 towards the Kgalagadi. Some boreholes are as deep as 600 m. Water quality varies greatly — especially the level of dissolved solids that make water salty. Groundwater is protected from evaporation, so much less water is lost than from dams, and it is more reliable.

Groundwater is taken 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 faster than it is replaced there is a danger it will run out, leaving no source of water. In some dry areas, groundwater has been used so heavily that wells have dried up. Once an aquifer has been depleted the spaces where groundwater once was can easily collapse, permanently decreasing the capacity to store water again.

In parts of the dry nama-karoo, succulent karoo and dry savanna ecozones, groundwater is being abused. Urban use, mining and other water-using industries tend to be the main culprits, although irrigation is by far the greatest drain. Irrigation accounts for over three-quarters of groundwater used in South Africa, and most farms currently using groundwater for irrigation are running short.[54]

Photo 9.4 IUCN-D Reed

A fossilised insect from the sediments resting on the Orapa diamond pipe in Botswana suggests a wetter climate 90 million years ago.

Pollution

Another important consideration is the purity of groundwater. In addition to high salt-content in very old groundwater, other substances can contaminate it. Human sewage disposed of in pit latrines can make groundwater unfit for human use. Substances used to disinfect or deodorise latrines, such as paraffin, can also pollute groundwater. Two metres of sandy soil is required between the bottom of the pit and the water-table to prevent such contamination.[55]

Once groundwater is polluted by sewage, it can remain polluted a long time — depending on the type of soil, the rate of ground-water recharge and the amount of sewage being added. Groundwater pollution in Botswana is caused by sewage and bacteria, usually via leakage from pit-latrines and cattle concentrations near boreholes, or from poorly sited or badly built wells.

Borehole pumping can also contaminate groundwater by sucking salty water into the borehole, rendering it useless. This is a serious problem in coastal areas where seawater can be drawn in. Scientists warn that moderate pumping of coastal aquifers in Tanzania could pull seawater into the freshwater aquifers, so development should be done cautiously.[56] In arid areas where deep groundwater is usually salty, the same problem can occur if not managed properly.

Open-pit mining disrupts groundwater flows by diverting flow into the mine where it can also be polluted. Surface heaps of mine-waste also contaminate water. The Zambian copper-mines pump groundwater out of the mines and discharge it into the Kafue river. The river discharge above the mines is 0.84 cu m/s and below the mines is 3.74 cu m/s,[57] an increase of more than four times. Groundwater pumping of this enormity depletes supplies, while people downstream have come to depend on this increase in year-round flow and will have problems adjusting when the mines close.

Demand for groundwater in southern Africa is increasing and will continue to increase, as will demand for water from all sources. 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 inadequate. Supplies and their quality are not really known except in specific cases, levels of usage are only estimates, recharge rates are partially known and processes are debated. Effects of various industries on water quality and quantity remains largely speculative. Even the number of boreholes and wells are largely estimates.

DEMAND FOR FRESH WATER

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 per year (mcm/yr) in

The environment uses water too Box 9.1

The water needs of the natural environment have not been included in national water-demand planning 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. Environmental demand is the water needed for lakes, floodplains, estuaries, rivers, marshy areas, parks and vegetation growth, and it is by far the highest of any sector.

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.

SOURCE: Heyns, P., "Water Demand and Supply Management", for SARDC, 1993, p. 10

1970 to 95 mcm/yr in 1993, an average of 4.2 percent per year and well above the population growth rate of three percent.[58]

Irrigation

The main use of water by far is irrigated agriculture, and changes in irrigation demand will have the greatest effect on overall water demand.

Irrigation is a particular concern in the region's future. With growing populations come growing demands for food. Irrigation is often proposed 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.[59]

While there are examples of good irrigation management, they are fewer than the bad ones. Irrigation accounts for almost three-quarters of all water used.[60] Of this about 60 percent of the water is wasted, not only throwing away a valuable resource, but causing serious environmental problems. These include soil poisoning through salinisation and waterlogging of land, which can harm or kill crops and other plants and ultimately remove land from production.

When irrigation programmes do not include a health component, bilharzia and malaria can become common problems.

Appropriate irrigation Box 9.2

Irrigation is not new to southern Africa — a number of traditional irrigation methods have been used for centuries. Valley-bottom soils in Angola have been exploited in an ecologically sound manner, using ditches 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.

One potential area for expansion of a traditional form of irrigation is *dambo* agriculture. While *dambos* (meadow grazing lands or seasonally waterlogged grass-covered depressions) can be overexploited, research has shown that up to 30 percent of one can be cultivated without any significant environmental impact. *Dambo* cultivation does not require specialised equipment nor does it involve loss or wastage of water associated with mechanical irrigation. Currently, legislation prohibits *dambo* cultivation in countries such as Zimbabwe, but with careful monitoring to prevent degradation, these resources might provide extensive irrigation potential while building on local knowledge — without requiring expensive and often inappropriate technology.

SOURCES: Lambert, Robert A. and others, "The Use of Wetlands (Dambos) For Micro Irrigation in Zimbabwe", *Irrigation and Drainage Systems*, 1990, Vol 4, p. 17-28
Whitlow, Richard J., "A Review of Dambo Gullying in South-Central Africa", *Zambezia*, 1989, Vol 16, no 2, p. 123-150

Current and projected water demand (cu km/yr) Table 9.6

Country	Demand 1993	Irrigation 1993	Demand 2020	Irrigation 2020	Total Available
Angola	1.335	0.350	2.757	0.750	78.000
Botswana	0.129	0.020	0.336	0.047	0.230
Lesotho	0.118	0.070	0.268	0.160	2.490
Malawi	1.135	0.795	2.578	1.820	4.240
Mozambique	1.967	1.308	3.210	3.000	132.000
Namibia	0.265	0.108	0.538	0.248	0.740
South Africa	19.295	9.615	30.168	12.674	28.470
Swaziland	0.454	0.310	0.511	0.331	1.160
Tanzania	5.374	4.560	12.220	10.450	44.000
Zambia	0.994	0.690	2.192	1.580	60.000
Zimbabwe	2.524	2.175	5.737	4.980	7.860
TOTAL	33.590	19.981	60.515	36.130	359.190

Total Available has been calculated as 60 percent of the Absolute Total, the amount hydrologists assume as available for human use.
SOURCE: Heyns, P., "Water Demand and Supply Management", for SARDC, 1993

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.[61] Of the 11 countries, eight use more water for irrigation than all other uses combined. Most irrigation is taking place in the savanna or grassland ecozones. Arid and semi-arid areas such as the nama-karoo, succulent karoo and large areas of dry savanna simply cannot afford to use precious water in such a wasteful way, although some irrigation is taking place there. South Africa estimates that irrigated agriculture should be able to achieve the same levels of production with 25 percent less water.[62] Other studies show much greater levels of efficiency are possible.

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.[63] This is an uneconomic use of water, normally requiring some form of agricultural subsidy.

National agricultural policies often promote irrigation to grow more food from the same amount of land, as in the case of South Africa, Tanzania and Zimbabwe. Water for irrigation is commonly supplied at lower than cost of supply to encourage agricultural development. This can lead to very high demand, which may not be economic. Demand from existing irrigation schemes in Zimbabwe is greater than supply.

While irrigation is touted as the cure to domestic food shortages and a potential means of boosting production of cash crops for export, it also creates a huge drain on limited water supplies. This leads some water economists to question why irrigation, which creates a strain on water-supply infrastructures, is subsidised to grow low-value crops.

Botswana has recognised its predicament as a country in the dry savanna ecozone and in 1991 decided it could afford to irrigate only where there is no other possible use for the water. This has meant giving up the goal of food self-sufficiency in favour of food security.[64]

Population

Water planners think of water in "flow units" each of which equals 1 mcm/yr. The relationship between the population and the amount of water, measured in flow units, is a good indicator of water stress:

- generally, where population numbers per available flow unit are low there is no problem meeting water demand;
- where the ratio of population to flow units exceeds 600, stress begins to appear;
- above 1,000 there is invariably chronic water shortage; and
- above 2,000 there is extreme water scarcity.

Southern Africa, which has a population of 136 million, has about 360,000 flow units available. The overall ratio of population to flow units in southern Africa is about 360, not a problem, but, with the population doubling in just under 24 years, the ratio will be 720 by 2016 and over 1,000 by 2030. In other words, at current population growth rates, this region will experience chronic water-shortage by 2030. And these calculations do not consider that some parts of the region have much lower access to water than others.

The current demand is to some degree an estimation, since many water-uses cannot be monitored cost effectively, especially in rural areas. Projected demand is also educated guesswork since it must consider the rate of growth of a number of different sectors, but provides a general idea of where things appear to be heading.

Water transfers

The increasing pressure on water resources in the region has forced planners and politicians to look far afield for long-term water sources. Many see the problem as simply one of water distribution — there is plenty of water for everyone, it simply is not in the right place. This approach treats water-demand largely as a technical engineering problem of taking water from underutilised areas and moving it to areas of high demand, with the only obstacle being the political problem of developing management agreements to share water resources. Environmental assessments of such projects are seen by the engineers and planners as costly and time-consuming, something to be avoided. In the case of the region's first international water transfer, the Lesotho Highlands Water Project (LHWP), construction began before the potential impacts were published.[65]

There are a number of large water-transfer projects in southern Africa, although so far only the LHWP is international.

Photo 9.5/9.6 PHOTOGRAPHIC TRAINING CENTRE,MAPUTO-R Rangel

Clean water is often taken for granted in urban areas, but is still a "luxury" in many parts of the region. Both views are from Mozambique — an urban water reservoir in a Maputo suburb, and a women pumping water in a village.

Where drinking water is a "luxury" Story

Mabile, Mozambique (IPS) — In a remote village in southern Mozambique, villagers with buckets and clay pots stand in queue hundreds of metres long, awaiting their turn at a little manual pump for the area's most precious liquid, water.

Some of the water carriers, mainly women, are carried away by impatience and start quarrelling, while others leave their buckets in line and go home to attend to other matters.

The pump can bring out some five litres of water per minute, but the water runs out every 10 minutes and it takes more than an hour to fill up again.

Mozambique remains one of the world's poorest countries in drinking water supply for the rural and peri-urban population.

But for the people of Mabile in the south of Inhambane Province, a comparison is made only with the recent past. Most say what they have today is a "luxury" — at least the water is within a maximum distance of four kilometres.

"Now it's much better. Before we travelled 30 km from here (for water). We fetched water by hand from small open wells and we couldn't manage to get more than 20 litres a day," said Carolina Bambo, one of the community leaders in the area.

A water systems engineer posted to the area by the United Nations Children's Fund (UNICEF), T. Pillai of India, said if "Rural Water" were a person's name, the person would be the most beloved by Mozambique's rural population.

"Rural Water" is the name given to a national programme of water and sanitation supply to rural areas, which the government introduced in 1985, with financial support from UNICEF.

An evaluation by government and international financiers shows the programme has managed to raise the percentage of the rural and peri-urban population with access to drinking water from six to 25 percent between 1980 and 1990.

—adapted from **Gil Lauriciano**, *Inter-Press Service/Development Dialogue*, Dec 1991/Jan 1992, p. 11

This project will send about one cubic kilometre (946 mcm) annually from Lesotho to the Vaal dam in the Pretoria-Witwatersrand-Vereeniging (PWV) area of South Africa by 1996, rising to 2.2 cu km/yr by 2004.[66] It was proposed in 1979, with a formal treaty signed in October 1986. LHWP involves the Katse dam and two tunnels of 46 km and 37 km feeding the Ash river, a Vaal river tributary.

South Africa already has a number of internal water-transfer projects, most focusing on getting water to PWV.[67] Namibia has a major internal scheme composed of several phases, known as the Eastern National Water Carrier (ENWC). The plan is pegged to projected demand, with each stage completed to meet growing demand, and includes three major dams, pumping groundwater from the aquifer, 550 km of pipelines and a 200 km canal. The final stage will be a second 250 km pipeline to the Okavango river, expected to divert about 60 mcm/yr,[68] to bridge temporary shortfalls in the interior of Namibia.

The Zambezi river is seen as an attractive source of water by many of the drier areas in the region. Currently only a small amount of water is taken directly from the Zambezi. Zambia takes about 180 mcm/yr from the Zambezi for irrigation and domestic water while Zimbabwe takes about 55 mcm/yr for domestic supply. There are Zambian government proposals

Proposed major water-transfers in southern Africa Table 9.7

Project	Amount (mcm/yr)	Source	Beneficiaries
Lesotho Highlands Water Project	964 by 1996 2,200 by 2004	Orange river (Lesotho)	South Africa: PWV area
Eastern National Water Carrier	60 by 2006	Okavango river	Namibia: Windhoek
North-South Carrier	40 by 2013	Motloutse river (Limpopo)	Botswana: Gaborone
Matebeleland Zambezi Water Project	120 by ? 3,000 by ?	Zambezi river	Zimbabwe: Bulawayo
North-South Carrier Extension	3,000 by ?	Zambezi river	Botswana, South Africa, Zimbabwe
Zimbabwe Water Supply	? by 2008	Zambezi river Lake Kariba	Zimbabwe's major cities

SOURCE: IUCN and SADC, *Zambezi River Water Basin Conference: Proceedings of a Workshop at Kasane, Botswana*, IUCN and SADC, Harare, 1994

for an additional 190 mcm/yr and 250 mcm/yr for a Namibian sugar-plantation in the Caprivi Strip. There are also dams on tributary rivers, which take water that would have ultimately fed the main river. Zimbabwe, for example, takes 1,300 mcm/yr for irrigation, domestic and industrial use, about one-ninth of what the country's runoff would naturally contribute to the Zambezi.[69]

There are plans for Zambezi water, such as the proposed Matabeleland Zambezi Water Project (MZWP) to pipe water from the Zambezi to Bulawayo in Zimbabwe, with potential to continue on to South Africa. MZWP supporters propose to take up to 3,000 mcm/yr, depending on whether it is also used to irrigate large tracts of land along the route. Botswana's planned North-South Carrier will transfer 40 mcm/yr to the capital, Gaborone, from the Motloutse river, a tributary of the Limpopo. It could be expanded to include a connection to the Zambezi river at Katima Mulilo in Namibia's Caprivi Strip, an extension to PWV in South Africa and a possible branch connection to Bulawayo.[70] This proposal would tentatively divert about 3,000 mcm/yr. Lake Kariba is seen by Zimbabwe as the final

Photo 9.7 SOUTHLIGHT-D Marie

Lesotho Highlands Water Project is region's first international water transfer.

backup water-source coming on stream for Bulawayo by 2008, Harare in 2015 and the rest of the country around 2026.[71]

The obvious impact of such projects is that the "donor" basin stands to lose water to the "recipient" basin which can have substantial downstream impacts as well as affect on the water-table. The actual transfer of water can also introduce alien species of fish, plants, insects and other life-forms to the recipient basin. Current and proposed abstractions from the Zambezi total 7.6 percent of annual flow at Victoria Falls.[72] This would have enormous impacts on downstream ecology and fisheries production, and cause potentially very serious problems for the huge power-generating stations at Kariba and Cahora Bassa.

Major water-transfers require a significant amount of international negotiation and agreement. So far these have been restricted to bilateral arrangements such as the LHWP.

Conservation and water management

The demand for water is still largely related to irrigation, which makes up almost two-thirds of current demand and nearly half of demand projected for the year 2020. This irrigation water is not only used wastefully, but is often used to produce low-value crops, which would not be economically viable to irrigate without subsidy. In some cases, poorly designed irrigation schemes have resulted in soil degradation and reduced crop production. Some have made the land unusable for agriculture. Substantial water savings would accrue through improved irrigation techniques and removal of subsidies on uneconomic crops.

Water conservation is not a systematic practise anywhere in the region, except for occasional campaigns during droughts. Botswana's Morupule power station is dry-cooled to save water. Industries in South Africa have begun to implement water conservation, with notable success by the state electrical utility ESKOM, which has built two air-cooled generating plants, saving up to 30 mcm/yr.[73]

Sewage recycling

Box 9.3

Sewage recycling is a concept that until recently had not received much attention from water planners. Today such planners realise that there is one potential source of water that increases as water-use increases. That is waste water, or "return flow", as planners call it.

Some cities have already recognised the value of recycling return flow. In Namibia, Windhoek recycles about 13 percent of its waste water for domestic consumption. Harare, Zimbabwe, recycles about 10 percent (18 mcm/yr) and has plans to increase this to 20 percent, at least partly due to government policy on funding major water-supply projects. The policy requires that 20 percent of a city's waste water be recycled before funding for new projects is made available. South Africa recycles return flow for industrial and irrigation use, but not for domestic consumption.

Consultants estimate that 90 percent of water used in Gaborone, Botswana, is returned to the sewers. If this approximate figure holds for other major centres then there is a substantial value of water literally going down the drain throughout the region. Gaborone plans to re-use 38 mcm/yr of treated sewage by 2020, equivalent to 60 percent of return flow. Using a figure of 7,201 mcm/yr of domestic and industrial water-use throughout the region, a recycling rate of 20 percent would save 1,440 mcm/yr. Long-term studies in Namibia indicate no increase in water-borne diseases resulting from incorporation of recycled water in water-supplies.

SOURCES: Durham, D.S. and H.B. Williams, "Summary of Zimbabwe Presentation", Workshop on Water Resources Management in Victoria Falls, 5-9 July 1993, p. 7
Botswana Ministry of Agriculture, "Agricultural Aspects of Water Use", Workshop on Water Resources Management in Victoria Falls, 5-9 July 1993, p. 6
Isaacson, Margaretha and others, *Studies on Health Aspects of Water Reclamation during 1974 to 1983 in Windhoek, Namibia*, Report to the Water Research Commission by the South African Institute for Medical Research, Johannesburg, 1987

With fresh water being such a crucial constraint to ecosystems and human development all over southern Africa, 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.

The action plan recommended by SADC and IUCN in their 1991 "Wetlands Conservation Programme for Southern Africa" says its goal is the attainment of an acceptable standard of living, achievable only if certain objectives are fulfilled:

- to ensure sustainable use of wetland natural resources (fisheries, wildlife, forage, water, forests, agricultural land, etc.);
- to maintain wetlands biodiversity (ecosystem diversities);
- to maintain essential ecological and hydrological processes of wetlands.

The action plan is based on the assumption that it falls within the framework of the SADC natural resources policy and development, and that it is seen as a "helping force in enhancing current national initiatives." [74]

Water harvesting Box 9.4

For small-scale farmers in southern Africa, irrigation dams are out of the question. Such infrastructure requires too much work and too much money for an individual small-holder to afford. Cooperative or state-run collective schemes, however, can give such farmers improved access to water. Small-holders can also turn to other appropriate ways of increasing soil water, or simply augmenting supplies. One of these methods is water "harvesting" — a technique practised around the world since ancient times to trap stormwaters.

Water-harvesting has been studied in Botswana in an experiment that diverted water from a tiny stream basin to a field, using earth-ridges up to half-a-metre high. In this system, the area used for harvesting water was up to 50 times the size of the growing area. The result was improved yields in low rainfall years and in seasons when rainfall came at the wrong time. The system shows great promise in countries with low and variable rainfall, such as Botswana, though the downstream environmental impacts of removing the water from the stream have not been studied.

Water-harvesting can also use a system of small channels flowing into half-metre-deep pits and channels to catch runoff and let it sink into the soil rather than leaving the area. This system is practised by proponents of natural farming, or permaculture.

Rooftops also provide excellent water-harvesting opportunities, providing water for household supply, gardening, increasing soil moisture or even filling a swimming pool. This technique has been used in arid urban areas. It is currently practised in Botswana's smaller urban centres, and was effective in Bulawayo, Zimbabwe, in helping to stretch limited water-supplies during the disastrous 1991-92 drought.

Water-harvesting is practised by a very small percentage of those who could take advantage of it. The World Resources Institute says water-harvesting could increase agricultural production in semi-arid and sub-humid Africa on 10 million hectares of land in the short-term and 50 million hectares over the long-term.

SOURCES: Carter, D.C. and S.T. Miller, "Three Year's Experience With An On-Farm Macro-Catchment Water Harvesting System in Botswana", *Agricultural Water Management*, 1991, Vol 19, p. 192
World Resources Institute, *World Resources 1992-93*, Oxford University Press, New York, 1992, p. 163

Linkages to other chapters Box 9.5

1 PEOPLE

People depend on water for survival, but the demands of increasing populations and industrial expansion are putting serious pressures on water supply and quality in the region.

2 HISTORY

Water shortages have been a regular feature in southern Africa for hundreds of years, and management methods have existed for as long as people have lived here. Some traditional means of coping with drought are being studied and modified.

3 POLICY

Water supply and quality is becoming a major policy issue throughout the region. Reservations are developing about how water is used,and southern African states are discussing decision-making processes and water allocations.

4 ECOZONES

Water availability is the main factor determining plant distribution and ecological functions. Wetlands are a modifying feature found in most of the region's ecozones.

5 CLIMATE

Water supply and distribution depends on weather variability, the "climate factor", particularly cycles of drought.

6 SOILS

Water is integral to the process of soil development and degradation. Soil degradation impairs water infiltration into the soil, reducing groundwater recharge, while eroded sediments cause siltation in rivers. Water is the main agent of soil erosion.

7 WOODLANDS

Water supplies are affected by vegetation cover, and therefore by the extent of deforestation in the region. Large-scale afforestation can impact negatively on groundwater.

8 WILDLIFE

Fresh water affects wildlife habitat, and the distribution and variety of wildlife. Wild animals migrate according to the seasonal variation in soil moisture and surface water sources.

10 MARINE

Fresh water is an important input to coastal ecosystems, especially river-mouth estuaries where fresh and salt water mix, producing some of the most productive ecozone types in the world.

11 POLLUTION

Pollution is a key aspect of water supply, as pollution limits the productive use of water and effectively reduces supplies. Once water pollutants are in the environment, they continue to have an impact.

12 ARMED CONFLICT

Large concentrations of displaced people can put pressure on water supply in a certain area. Weapons production and testing also creates water pollutants.

13 GLOBAL

Climatic changes and ozone depletion could affect rainfall patterns and water availability in southern Africa. This could have serious impacts on the region's ecozones, agricultural productivity and biodiversity.

14 TRENDS

Clean, fresh water is much in demand in southern Africa, and supplies are diminishing in some parts of the region, as elsewhere in the world. New ways are being explored to conserve and share this essential resource before its too late.

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10

MARINE Ecosystems

From Tanzania on the east coast, around Cape Agulhas (off South Africa) to Angola on the west coast, southern Africa commands a 9,600 kilometre marine highway, which has facilitated and enhanced global trade for centuries. Five of the 11 countries in the region are part of this transportation link of the high seas that has helped to bridge the gap between North and South, and East and West.

The region's marine areas are home to a wide variety of natural resources, including plants, animals and fish. The habitats of most living resources lie within a few kilometres of the coast. Under the Law of the Sea Convention, all coastal states have economic rights over natural resources within an Exclusive Economic Zone (EEZ), stretching 200 nautical miles off their coast.

Regardless of their apparent vastness, marine resources are finite and they have been overexploited. The history of the utilisation of marine resources such as guano, whales and shoaling fish bears evidence to this in southern Africa and beyond.

MARINE ECOZONES OF SOUTHERN AFRICA

Southern Africa 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;
- the temperate Agulhas bank;
- the cooler Benguela system; and
- the warm Angolan coast[1].

Ocean currents, especially the Agulhas, are important in the dispersal of marine plants and animals, even between different ecological areas. The Agulhas current, for example, carries fry, juvenile turtles and other marine plankton from the Natal coast to the adjoining Agulhas bank. But ocean currents are not the only means by which marine organisms move and disperse offspring. In winter, sardines from the Benguela system are trapped in a cell of cold water which slowly mixes with surrounding water, transporting the sardines and their predators along the Natal coast of South Africa in what is known as the "Natal sardine run".[2] Humpback whales instinctively swim from the Southern Sea to the Indian Ocean off Mozambique in July to calve. There is, therefore, considerable interdependence between these neighbouring marine systems.

Warm East Coast

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.

This zone is rich in species diversity but is generally poor in nutrients, resulting in low rates of plant and animal production. A general rule for marine biological diversity is that where the temperature is higher, an area is more infertile but higher in diversity. This happens because where plentiful food abounds, some species outcompete others.

The nutrients in the surface water come from inland rivers and are dispersed by waves and currents. Unlike on land where leaves die and become nutrients which other plants re-use, when plants and animals in this marine zone die, they drop down to the dark seabed where they become inaccessible. Nevertheless, the coast has habitats that are rich in nutrients, plants and animals. These are estuaries, mangroves and coral reefs.

The fauna off the coasts of Tanzania, Mozambique and eastern South Africa is typical of that of warm water. Coral reefs extend along the Tanzanian and Mozambican coasts to northern Natal. Mangrove swamps occur as fardown as the south coast of south Africa.

The main fish species are sardinella, predatory mackerel and tuna. Recreational fishing is popular for billfish, sailfish and black marlin. Dominant seabirds that inhabit and breed in this zone include the masked booby, sooty tern, swift tern and brown noddy.[3] Sea mammals such as whales and dugongs inhabit the coastal waters. Some fish, such as bronze bream and square-tailed kob, are restricted to the warm east coast but there are others, such as elf and garrick, that are also able to live in cooler waters in the nearby Agulhas bank. Various species of turtles breed along the coast and at islands in the Mozambique channel.

Some of the resources in this ecological zone are overexploited. Prawn stocks off Mozambique are heavily exploited locally, and prawn-poaching by foreigners reduces numbers further. Off Mozambique, for one kilogramme of prawns caught, an equal weight of by-catch is landed.[4] To a lesser extent, endangered mammals, such as sharks and dugongs, are netted and often dumped dead into the ocean. Since many sharks mature late and produce relatively few young their population increases are naturally slow, and by-catches further endanger them.

Some rock-reef fish species that are found only in southern Africa (bronze bream, Natal stumpnose and seventy-four)

Exclusive Economic Zones (EEZ) Box 10.1

All countries with direct access to the sea have exclusive use of marine resources found along their coastline up to 200 nautical miles out to sea. These resources are the waters, seabed, subsoil, living and non-living things. The United Nations Law of the Sea Convention, to which the coastal countries of the region are signatories, empowers coastal states to control activities in this Exclusive Economic Zone (EEZ). Beyond that limit, the resources fall under the world's "common heritage" and can be utilised by other states without permission, except where there are specific international laws demanding otherwise (such as the ban on hunting whale for consumption).

There are obligations too. The Law of the Sea requires coastal states to "prevent, reduce and control pollution of the marine environment from dumping." Coastal states may adopt laws and regulations for their EEZs compatible with international rules and standards to combat pollution.

The Law also requires approval by coastal states before dumping can take place in their territorial waters, in the EEZs, and onto the continental shelf. Coastal states have a duty under the same law to make sure that activities in their EEZ do not hurt the marine environment of other states.

The Law, which by 1987 had been signed by 159 countries (including some from southern Africa), reconciled widely divergent interests of states, establishing the basis for equity in the use of the oceans and their resources.

"The Convention removed 35 percent of the oceans as a source of growing conflict between states. It stipulates that coastal states must ensure that the living resources of the EEZs are not endangered by overexploitation."

SOURCE: World Commission on Environment and Development, *Our Common Future*, Oxford University Press, New York, 1987 have been severely reduced by angling. Endemic species contributed half of Natal's deep-sea gamefish catch in the 1920s, but less than five percent in the 1980s.[5] Shark-nets erected off Natal to prevent sharks from attacking people on beaches have trapped and killed guitarfish and turtles. The dead animals are used for research.[6] The removal of large sharks by the nets has led to an increase in their prey, such as young dusky sharks, which feed on fish. Consequently, the structure of the inshore ecosystem may have been changed, influencing the composition of the fishermen's catches. Turtles have been overexploited off both Mozambique and Tanzania for their eggs, shells and meat.

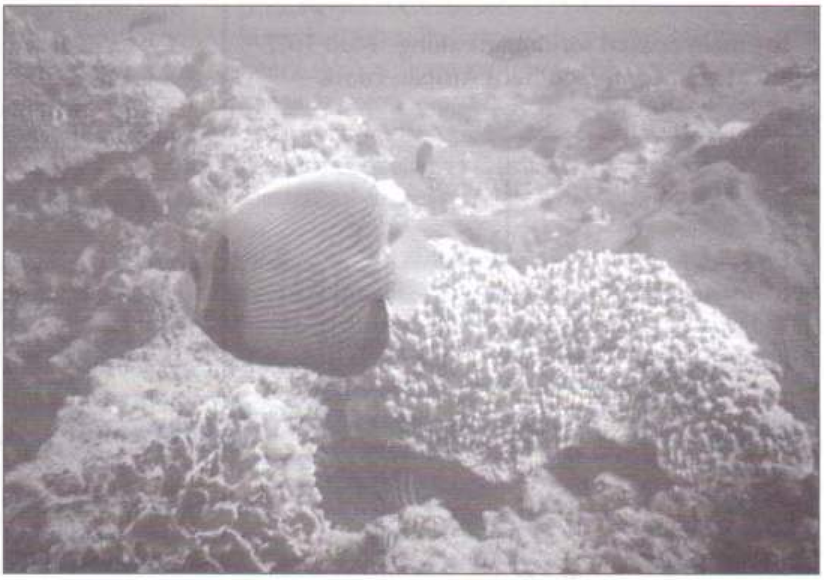


Photo 10.1 J Rosado

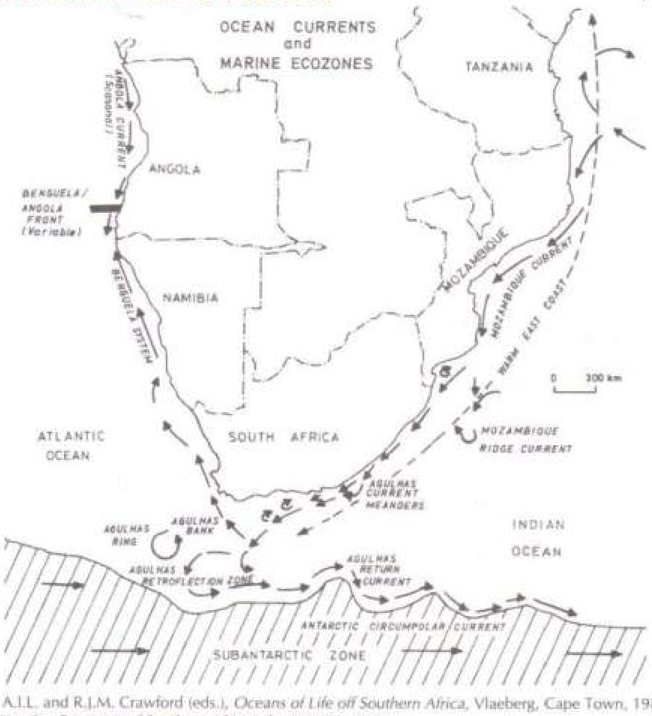
Dynamite fishing, particularly off the coast of Tanzania, threatens the rich coral-reef habitats.

Dynamite fishing off Tanzania has destroyed many coral reefs, which are an essential habitat for marine animals. Of the eight coral reefs identified for conservation in 1968, only two remained in 1983; the rest had been destroyed by dynamite.[7] The estuaries of Mozambique and Tanzania are also threatened by excessive silt from inland soil erosion.

Agulhas Bank

The Agulhas bank is a broad, relatively shallow part of southern Africa's continental shelf, at its widest extending more than 200 km offshore. Much of the bank is covered by sandy sediments but mud occurs in the western part, providing

Ocean currents and marine ecozones Map 10.1



SOURCES: Payne A.I.L. and R.J.M. Crawford (eds.), *Oceans of Life off Southern Africa*, Vlaeberg, Cape Town, 1989
Crawford, R.J.M., "Marine Ecozones of Southern Africa", for SARDC, 1993

province have been adversely altered by pollution, industrial development and poor agricultural practices upstream, which release too much silt into rivers that then carry it to estuaries. When habitats change, fish and other marine organisms have to adjust, often to the detriment of their survival and growth potential.

Benguela System

The cold, nutrient-rich Benguela system lies off the western coast of South Africa, Namibia and southern Angola. It is bound by the warm Agulhas current to the south and the warm Angola current to the north. The surface water temperature varies between 10-18°C. The Benguela current originates in the bottom layers of deep water which are cold, hence the low temperatures of the surface water. The Benguela current flows upward because winds that blow away from the land push surface waters away from the coastal area, creating a vacuum. The cold, nutrient-laden bottom water then rises to fill it.[10]

Due to plentiful nutrients, microscopic and large plants that occur in the surface waters flourish. The large sea-plants include red seaweed such, as Gigartina species and green seaweed such as kelp. The abundance of sea-plants makes

Interdependence of marine plants and animals Box 10.2

As on land, there is a complex relationship among sea fauna, through preying on others, and competing for food and space. Some interactions benefit the species, others disadvantage them. For example, when plant quantities fall significantly, plant-eaters such as some fish, turtles and dugongs starve, and may even die. This also affects carnivores, when prey populations shrink. Conversely, when plants or prey populations flourish, so do the animals that depend on them for food. When sardines were overfished in the waters of Namibia and South Africa, some of the seabirds that depend on them for food died of starvation, particularly the chicks of Cape gannets.

On the other hand, a decline in the number of predators leads to an increase in the prey populations, if other factors are constant. This seldom happens under natural conditions, but the interference of people using mechanised fishing methods has engendered such situations in the region. The increase of anchovy stocks off South Africa in the 1970s has been partially attributed to the decline of many of its predators such as snoek, chub mackerel and seabirds due to overfishing.

Fish and other marine species also compete for food and space. Generally, if one population which has a similar set of requirements to another decreases, it leaves more space and food available for the other. When the sardine stock declined in the late 1960s, anchovy, whose population was believed to be low in the early 1960s, began to build up. Other fish species that increased to take its place are horse mackerel, bearded goby and jellyfish. Wherever sardine, horse mackerel and anchovy occur together, when catches of one species are on the increase, those of the other two fall because their requirements are similar and they compete for food and space.

If the right kind of food for both seabirds and seals is available on islands, competition for space ensues. Seals have pushed out seabirds on Hollams Bird, Mercury and Sinclair islands as well as on at least six other islands off the coast of Namibia and South Africa. Beneficial interaction also exists where underwater fish-eaters such as dolphins and seals chase their prey to the water surface; seabirds that depend on fish in surface waters benefit.

SOURCES: Crawford, R.J.M. and others, "Competition for Space: Recolonising Seals Displace Endangered, Endemic Seabirds off Namibia", *Biological Conservation* Vol 48, p. 59-72
Payne A.I.L. and R.J.M. Crawford (eds.), *Oceans of Life off Southern Africa*, Vlaeberg, Cape Town, 1989

for high populations of plant-eating fish and ultimately, flesh-eating fish, birds and mammals. Fish sizes are also influenced by the Angola system to the north which flows southwards. When this system considerably intrudes the Benguela system, it displaces many fish southwards and disrupts production in northern Namibia. This extreme intrusion has been called the Benguela *Nino* because it resembles the *El Nino* of western Central America. The Benguela *Nino* is associated with global weather changes, triggered by unusual pressure changes in the southern hemisphere that lead to high rainfall in the adjacent Namib desert.[11]

The major fish species are similar to those of the Agulhas bank. The inshore kelp beds provide habitat for abalones and spiny lobster. Thirteen species of seabirds breed in the system, of which seven are endemic to South Africa and Namibia. These include African penguins, Cape gannets, Damara terns and Hartlaub's gull. Large numbers of guano-producing cormorants, boobies and gannets make this one of only two regions in the world where seabird guano is harvested commercially on an annual basis. The other is the Humboldt system in the South Pacific. There are estimates of some two million South African fur seals in the Benguela system. Only one mammal, the Heaviside's dolphin, is found exclusively in the Benguela system.

Threats to marine resources in this ecozone include overexploitation, inappropriate fishing practices and, to a lesser extent, diseases. The mining of diamonds in the Benguela system off Namibia also threatens seabed plants and animals. Foreign trawlers overfished the Benguela system prior to the UN declaration of the exclusive economic zones, resulting in the decline of hake landings by a significant amount. From 1968 -1990, hake landings declined from 700,000 tonnes to about 200,000 tonnes. Local overfishing resulted in the drop of catches of sardine from 1.4 million tonnes in 1968 to 10,000 tonnes in 1980.[12] Overexploitation has reduced the populations of seven of the 14 seabird species that breed in the Benguela system and Agulhas bank — especially through excessive collection of their eggs and lack of food due to overfishing of species on which they feed.

Another threat, though not of the same magnitude, is the use of small-mesh nets to catch small fish species such as anchovy, as it occasionally removes juveniles of larger species (such as adult horse-mackerel), and occasionally the endangered turtles. In addition, the removal of guano (large deposits of bird droppings) to make fertiliser has deprived the birds of ideal nesting areas. Added to competition with seals for food and space, this has conspired to further decrease the seabird populations. In the 1930s, for example, South Africa's Dassen island had well over one million African penguins, but in 1993 the total at all breeding sites was down to 120,000.[13] Today, African penguins are extinct in 11 of 38 colonies. Diseases, albeit on a smaller scale, have also played havoc with the birds. Recently, avian cholera killed tens of thousands of Cape cormorants and the Newcastle Disease virus (NDV) reduced the African penguin population at Boulders beach by over 10 percent.

Habitat change by offshore dredging for diamonds in the Benguela system is likely to disrupt the seabed, but its impact on marine plants and animals is yet to be ascertained.

Angolan Coast

The Angolan coast is dominated by the warm Angola current (which originates north of Angola), making the system as warm as the east coast. The southern boundary of the south-flowing Angola current is variable at about Mocamedes in southern Angola. The marine forms of life in this system are different from those in the nearby Benguela, largely because of the temperature differences.

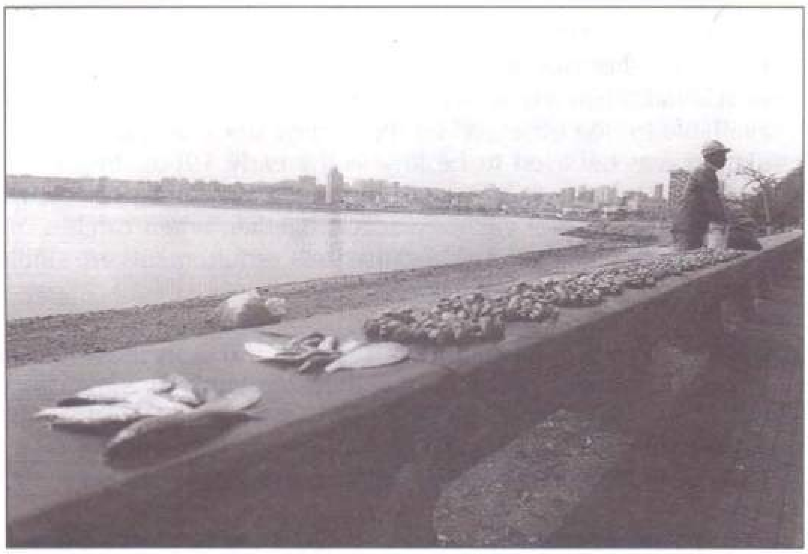


Photo 10.2 SOUTHLIGHT-P Weinberg

Selling fish provides a livelihood for thousands of families in the informal sector in coastal cities such as Luanda, Angola.

Who eats more fish? Box 10.3

Angolans generally eat more fish than nationals of any other country in the region. The average annual fish consumption in Angola is almost 23 kg/year. In coastal areas within Angola, consumption can be as high as 45 kg/person/year.

The average fish consumption per person in southern Africa in a single year is almost 10 kg while the world average is about 12 kg.

South Africa and Namibia land the highest quantity of fish from marine areas in the region because they have access to one of the richest fishing-grounds in the world — the Benguela system. Angola also catches many of its fish in this system and lands more fish than either Tanzania or Mozambique, which fall under the nutrient-poor Mozambique current. The latter system has poor plant production, limiting fish quantities. Tanzania catches annually over 80 percent of its fish in Lake Victoria and other inland water bodies.

SOURCES: Gopa Consultants, *Regional Fisheries Survey: Country Situation Reports*, Gopa, Hamburg, July 1989
Food and Agriculture Organisation, *Yearbook of Fishery Statistics*, FAO, Rome, 1990

The Angolan coast is poor in nutrients because, as with the warm east coast, there are no mechanisms to bring nutrients from the bottom of the sea to the surface where most plant growth takes place. This limits growth of seaweed and other plants on which marine animals and various species of fish depend for food, directly or indirectly. The coast has productive habitats such as mangrove swamps and estuaries which are enriched by nutrients through land erosion and runoff. In fact, Angola has about 20 large estuaries formed by perennial rivers pouring into the sea.[14]

The Angolan shelf supports several prawns of commercial importance. The dominant fish are sardinella, Cunene horse-mackerel and predatory tropical tuna, all different from those in the nearby Benguela system. However, some predatory fish, such as snoek, move between the two systems. Some birds from the Benguela system migrate, via the Angolan coast, to the Gulf of Guinea. Prior to their overexploitation, the Humpback whales used to migrate to the warm Angolan coast to calve.

Threats to the Angolan coast include overexploitation and habitat change. Present-day marine fish catches by Angola are substantially lower than the several hundred thousand tonnes per annum recorded between the late 1950s and early 1970s. Excessive exploitation by foreigners may occur, but prawn stocks are believed to be subject to lighter fishing off Angola than off Mozambique.

In the three coastal cities of Lobito, Benguela and Baia Farta in Angola, the human population increased threefold from 1970 -1990. In the city of Namibe the population more than doubled between 1984 -1990,[15] increasing fish consumption and localised human waste problems in habitats near the towns. Off the Cabinda enclave, oil pollution has had negative impacts on the living marine resources, although the severity of the problem is not yet known.

OPEN SEA HABITATS

The open sea, lying beyond the coastal area, can be divided into habitat areas called the epi-pelagic (near the surface), mesopelagic (in the middle) and benthic (at the bottom).[16] Generally, the resources of the open sea are utilised by commercial fishermen because they have the necessary capital and equipment, which artisanal and subsistence fishermen do not.

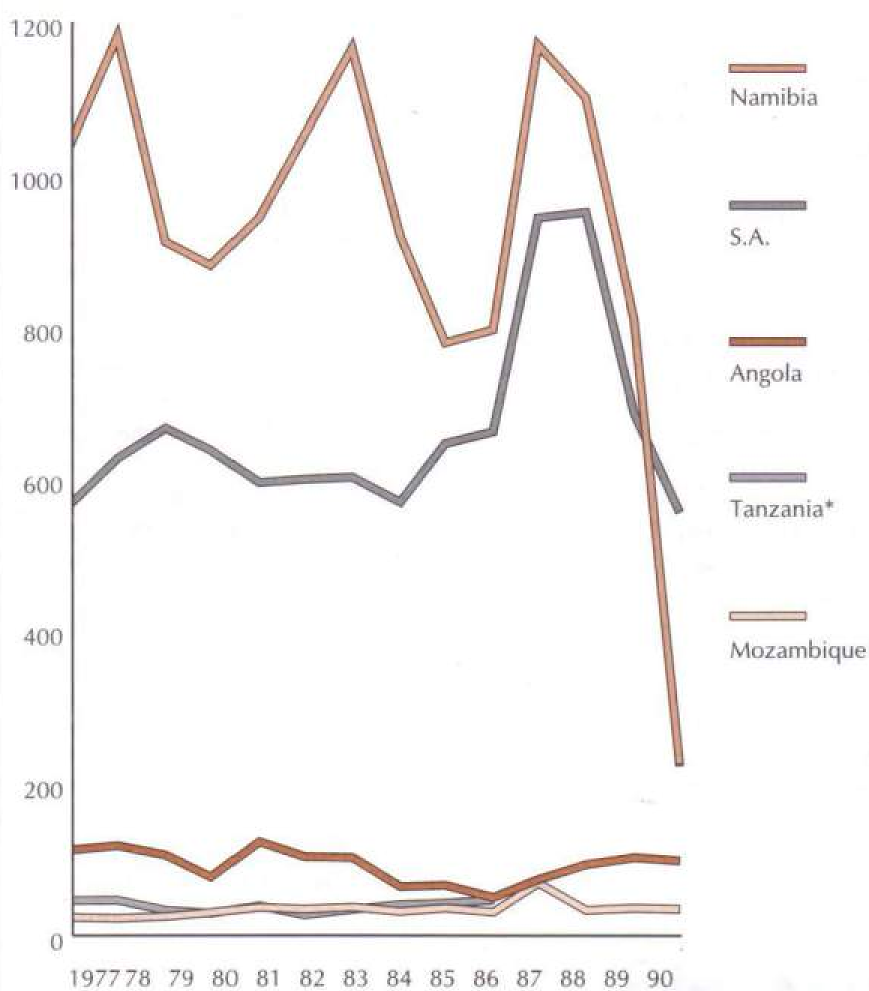
Epi-pelagic

The epi-pelagic habitat lies near the water surface to a depth of about 50 metres. It contains a good supply of dissolved oxygen and light which are vital for many life-forms. Most plant-food production in the sea takes place near the surface. Plants take in carbon dioxide, transform the carbon and water into plant material, and release oxygen. This process of *photosynthesis* requires sunlight, which generally penetrates water to about 50 m.

Fish found in this habitat include snoek, sardines and anchovies, which feed on small plants and animals, and occur in large groups called "schools". Many of the fish are fast-growing and are eaten by bigger fish such as tuna and snoek, birds such as penguins and gannets, and sea mammals such as seals. Because sardines and anchovies occur in large shoals, they enable high catches which can support profitable fisheries.

Marine fish landings (000 tonnes)

Figure 10.1



*No data available for Tanzania 1987-90.
SOURCES: Gopa Consultants, *Regional Fisheries Survey: Country Situation Reports, Gopa*, Hamburg, July 1989
Boyer, David, "Total Fish Landings in Namibia", for SARDC, 1994
Food and Agriculture Organisation, *Yearbook of Fishery Statistics*, FAO, Rome, 1990
Fisheries *Annual Reports*, Fisheries Division, Dar es Salaam, 1987

Namibia and South Africa have taken measures to restore their fish stocks. For example, Namibia introduced an annual quota system to give the depleted stocks a chance to recover. The system is supported by strict enforcement, which has been successful in curtailing illegal, foreign fishing. The control measures have been so effective that Namibian sardine stocks doubled between 1990 - 1992, although they have since contracted again, probably due to environmental factors.[18]

Meso-pelagic

The meso-pelagic habitat lies immediately below the epi-pelagic waters and runs down to just above the seabed. It receives diminished light and air, resulting in reduced concentration of oxygen.

Many fish in this zone are predators feeding on zooplankton and fish. Some rise to the upper layers of water to feed. Others are scavengers (some small sharks and kingklip) that feed off dead organic matter falling from the upper layers of the water.

Fish landings for Angola, Namibia and South Africa include plenty of epi-pelagic fish, generating considerable income. However, not many people can afford the fishing vessels, the gear and the costs of fish processing.

Following many years of overuse, stocks of fish occurring near the water surface have fallen well below historical levels, particularly off Namibia where they collapsed in the 1960s and 1970s. In the 1980s, fish stocks dropped below previous levels by up to 20 times. Many gannets died because of the fall in sardine stocks, and penguin populations were decimated.[17]

In Angola, Namibia and South Africa, the main fish of economic importance are hake and horse mackerel. Many people in those countries are employed in the fisheries industry. Namibia alone employs about 10,000 people in this sector. But costs make it prohibitive for subsistence fishermen to exploit the resource. For Mozambique and Tanzania, there is little exploitation of resources in this zone because of lack of proper fishing equipment and capital, as well as the low fish populations.[19]

Some mid-water stocks have fallen well below previous levels. For instance, in Namibia, the hake stocks (which also inhabit the bottom part of the sea) had by 1990 dropped to about 20 percent of the 1969 levels but effective control measures have seen the hake stock increase since 1990.[20]

Benthic

The benthic habitat lies at the bottom of the sea — the seabed. It traps dead organic matter falling from the upper layers of the ocean. The falling matter becomes food for the scavengers. Some fish in this zone rise to upper layers to feed. Others, for example sole, prey on organisms in the seabed such as worms.

The living resources include prawns, rock lobsters, crabs, hake and sole. Non-living resources (such as oil, gas and diamonds) are also found here and their exploitation threatens the marine environment. Angola, Mozambique, Namibia, South Africa and Tanzania each have at least one of these non-renewable resources. Although the economic importance of the resources in this zone is high, small-scale fishermen find it difficult to access them. However, sea-bottom fishing provides considerable employment and relatively cheap protein in the form of hake. Petroleum and diamond-mining generate employment and make handsome contributions to the economies of Angola and Namibia.

Prawns have been severely depleted by foreign poachers off Angola and Mozambique due to war, which has inhibited fishing control. In addition, prospecting and mining have increased the potential for habitat degradation.

COASTAL HABITATS

Coastal areas have many different habitats — estuaries, mangroves, coral reefs, seagrass meadows, beaches, rocky shores and islands. The coast is accessible to all groups of fishermen — subsistence, artisanal, sport and commercial.

Estuaries

Estuaries are coastal areas where freshwater and seawater meet in river mouths. They trap sand, silt and dead organic matter from both the land and the sea. Many of the animals found in estuaries feed on suspended organic matter and green plants. 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.

Estuaries have varying salinity levels from the lower to the upper reaches. Their depth is important in relation to temperature changes and the mixing of water. Shallow estuaries tend to be more prone to temperature and salinity fluctuations which, when extreme, can be hard on the species found in the estuary. When the water temperature becomes too warm, burrowers such as sand-prawns evade excess heat by digging into the ground where the temperature is lower and tolerable. Biological diversity, mainly of fish species, in estuaries tends to be reduced upstream from the sea toward the river because very few freshwater species occur in estuaries.

Photo 10.3 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO-Xerinda

Subsistence fishing supports many families in the region.

Estuaries are among the most productive habitats of the sea. Some turtles and birds depend on estuaries, while fish use them as nursery grounds. Studies in South Africa show that the majority of fish species there depend on estuaries for at least part of their life.[21]

Commercial, artisanal and subsistence fishing all benefit from estuaries due to proximity to land and accessibility.

Improper land husbandry and subsequent soil erosion are degrading many estuaries in the region by causing excessive deposition of silt. The silt entering estuaries can smother plants and reduce their accessibility to fish and other marine animals. Poor land-management upstream has resulted in the degradation of 72 percent of Natal's estuaries[22] and the situation is similar in coastal areas elsewhere.

Damming of the Zambezi river at Kariba in Zimbabwe and Cahora Bassa in Mozambique changed the water flow and the flooding times to which the estuary organisms were adapted.

Damming also traps sediment that would otherwise reach the sea and provide the necessary nutrients for plant growth. This harms the organisms that depend on freshwater and nutrients from rivers.

Oil pollution is a major threat in the Zaire river estuary in Angola because of mining in the vicinity. Sewage and industrial-waste dumping have also played a role in degrading some estuaries, especially Msimbazi creek in Tanzania and Maputo estuary in Mozambique. The False Bay of South Africa is heavily polluted with industrial waste.[23]

Although generally under threat from habitat alteration, some estuaries are protected in southern Africa. Mozambique protects quite a number, including 15,000 hectares of the Zambezi river delta, 20,000 ha in the Pomene reserve and 70,000 ha of the Maputo estuary.[24] South Africa protects several estuaries including Great Fish River Mouth Sanctuary. Namibia, whose estuaries are largely formed by seasonal rivers, protects five estuaries in the Skeleton Coast Park alone. Currently there are efforts to protect some of the estuaries in Tanzania, including the Rufiji delta.

Photo 10.4 J Hatton

Channel showing growth of creek mangroves in Mossuril district of northern Mozambique. Mangroves and the rich biodiversity they support are a special area of study for Mozambican biologists.

Photo 10.5 J Hatton

Mangroves

Mangroves are flowering plants that can grow in estuaries. They are adapted to an environment which is flooded by seawater at high tide, high salinity during low tides and freshwater during river floods. Mangroves are abundant in:

- the deltas of the Rufiji, Wami, Pangani and other rivers in Tanzania;[25]
- the Zambezi-river delta in and Inhaca island in Mozambique;
- Kosi Bay, St Lucia and Richards Bay in South Africa; and
- on Angola's coast, in Cabinda and Cuanza floodplains, Mussolo Restinga (sheltered bay or lagoon), Lucula, Lucunga and M'bridge river-mouths.[26]

Mangrove plants remove excess salt through openings on roots and leaves. Some of the mangrove species have aerial roots which enable them to breath as the submerged saline environment in which they live is oxygen-deficient. Mangroves are home to many sea animals, including amphibious fish, crabs and molluscs, and are a nursery ground for some species of crabs, oysters, prawns and cockles. Additionally, mangroves serve as a base upon which some species of algae grow, and support seabirds that feed on the fish and crustaceans.

Mangroves are vital to the prawn industry. Studies in Mozambique show that prawn catches rise or fall after the expansion or contraction of mangroves.[27]

Mangroves shed leaves which provide organic matter as well as nutrients, adding 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.[28] The roots of the trees protect coral reefs from river sediments by trapping silt.

A properly managed mangrove habitat can give an annual yield of 380 kg of fish and other marine animals from a single hectare, and simultaneously support 475 kg of fish and prawns that will mature elsewhere.[29] Mangroves have a high social and economic value. The trees are felled for use as construction poles, for export and fuelwood. Mangrove plants are also used for medicine and as food. Today, mangroves cover 850 sq km of Mozambique, 820 sq km of Tanzania,[30] and between 700-1,250 sq km of Angola.[31]

In all of these countries, mangrove swamps have been shrinking over the years due to overexploitation for timber and fuelwood. In 1990, the United Nations Environment Programme (UNEP) estimated that Mozambique and Tanzania had lost 60 percent of their mangroves. More recent estimates say the rate of loss has been even higher in Mozambique during the last 20 years.

Some mangrove plants have been killed by oilspills, notably in the Msimbazi Creek near Dar es Salaam and along the southern coast of Mozambique. A dozen years have passed since the spill in Tanzania yet the mangrove forest has not recovered. The spill of more than 16,000 tonnes of heavy fuel-oil from the *Katina P* in 1992, off the Mozambican coast, killed mangroves. At the mouth of the Zaire river, and in the Cuanza floodplains of Angola, the mangroves are intact. Unfortunately, they are not protected. But the new State Secretariat for Environment is investigating environmental policy which could lead to mangrove protection.

All mangroves in Tanzania are forest reserves and hence protected. Recently, Tanzania established a mangrove protection programme which affords different levels of protecting mangroves, ranging from preservation proper to controlled felling. Meanwhile, Mozambique has embarked on a coastal-zone management programme, which will develop and introduce better strategies for mangrove-management. Similarly, South Africa plans to protect the mangroves in Maputaland.

Coral reefs

Coral reefs are a unique marine habitat which hosts 3,000 species, including almost one-third of all marine fish in the world, making them comparable to equatorial rainforests in terms of biodiversity.[32] This is so because they occur in nutrient-deficient tropical waters where biological diversity is already generally high. They take advantage of the clear waters through which sunlight penetrates far down. Coral reefs are highly productive because they retain and reuse nutrients. In addition, two separate communities of fish can use the coral reef — one during the day, the other at night as the first group forages.

Coral reefs are built by polyps (small animals that grow in clear, warm, sea water with an optimum temperature of 26-27°C). The algae which live on the coral reefs provide food for both the polyps and the fish. As the algae require sunlight for photosynthesis, growth usually takes place no more than 20 m below the surface. The coral reefs in the Indian ocean, where there is relatively low production, have been likened to an oasis in a desert.

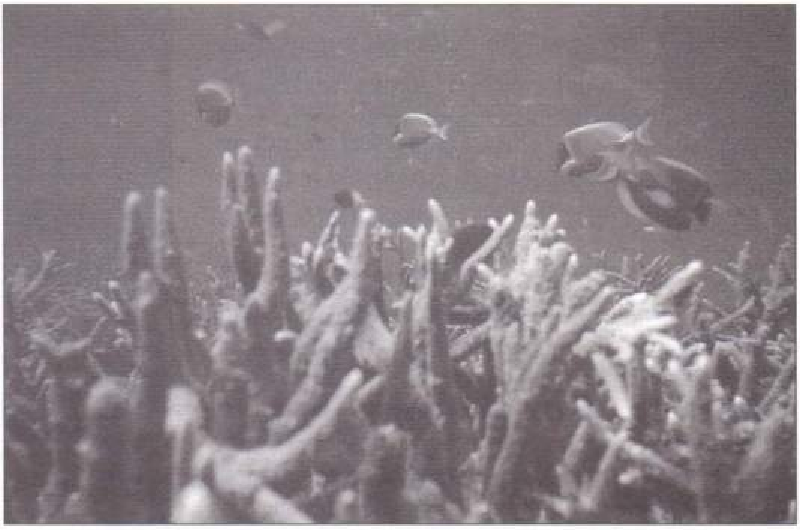


Photo 10.6 J Rosado

Coral reefs are the marine equivalent of equatorial rainforests in terms of biodiversity.

The warm waters of Angola, Mozambique and Tanzania are dotted with coral reefs. Tanzania has them throughout the coastal areas while Mozambique's main coral islands are Bazaruto, Nacala and Pemba. A few lie between the Mias coral islands and Nacala, and others are still located along the southern coast.

Coral reefs are ecologically, socially and economically important. They provide suitable shelter for the growth of seaweeds, fish and other marine animals on which people depend. They also serve as wave-breakers, thus protecting seashores from excessive erosion. In addition, dead coral reef is mined for lime and cement-manufacture. Pieces of coral are also sold to tourists for their aesthetic value.

But this highly productive and species-rich habitat is threatened by dynamite-fishing which has led to the destruction of many coral reefs along the coast of Tanzania. Six of the eight coral reefs identified for conservation in 1968 were destroyed within 15 years — by dynamite.[33] The problem is particularly acute around Dar es Salaam, off the coast between Africana and Kunduchi beaches.[34]

Mozambique protects some coral reefs, especially in the southern region. However, in the north, where the majority occur, they are inadequately protected.

Seagrass beds

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. Surfaces of seagrass stems and leaves also serve as a base for the growth of many species of algae. Seagrasses provide important habitat for fish to spawn and grow. They also act as breeding grounds for dugong (a sea mammal now endangered) and as feeding grounds for turtles and some fish.

Though not deliberately protected, seagrass meadows are in good shape in some localities where the dugong, a major seagrass-eater, has been overexploited.[35] However, in some areas seagrasses have been devastated by explosives and trawling. There is also lack of knowledge on the biology and ecology of seagrass beds. Seagrass exploitation is not significant in the region, hence the low social and economic value. In some countries, such as Kenya, it is used for making baskets and other products.

Beaches

Beaches are stretches of sand running between the sea and the land, bathed by waters from the sea. They are found throughout the coastal areas of southern Africa. The productivity of beaches depends on nutrients brought in by water, generally those brought in by the nutrient-rich Benguela system support more plants and fish than those on the east coast where water is generally nutrient-poor. However, even along the Benguela coastline, strong, destructive waves prevent the build-up of nutrients. Organisms found on beaches include sand mussels, prawns, fish and birds, as well as microscopic organisms in sediments. Many fish use beaches as a nursery ground and turtles lay eggs in the sand.

Beaches are important both socially and economically as they attract tourists and help create employment through tourism. Sand from beaches is used for construction at both subsistence and commercial levels. Some valuable minerals such as titanium are mined from coastal sand dunes.

Tourism and mining both disturb the habitat of some coastal animals and plants. The conservation and management of beaches is generally inadequate. However, there are still protected coastal areas, such as the Iona National Park of Angola and Skeleton Coast Park of Namibia.

Photo 10.7 N Ussene

Low tides enable people to collect sand mussels.

Rocky shores

Rocky shores are stony outcrops that lie between the land and the sea. These are inhabited by organisms such as algae, barnacles, mussels, starfish, octopus, rock-lobster and birds. The inhabitants of the upper parts are subjected to various stresses associated with periodic submergence under water due to tidal rise and fall. The various intertidal animals and plants have evolved adaptive features for tolerating the stresses, which include exposure to direct sunlight during low tides, fluctuation in salinity and temperature, as well as prolonged loss of moisture. Below the low-water mark, rocky surfaces provide habitat for lobsters which are important to the fisheries of South Africa. In some localities of the region, rocky shores support abundant populations of seaweeds, some of which are harvested for export. Some of the more accessible areas are popular tourist attractions. The rocky shores are, therefore, socially and economically important.

Photo 10.8 PHOTOGRAPHIC TRAINING CENTRE,MAPUTO-R Rangel

Water erosion and pollution can disturb the ecological balance of an island, such as Inhaca in Mozambique.

In South Africa, the Cape province's extensive rocky shores fall within protected areas, nearing 20 percent of the total.[36] Most of the protected area lies in Tsitsikamma National Park.[37] But on the Natal coast, rocky-shore protection is inadequate. South African conservationists recommend increasing protection by extending private coastal reserves, forest reserves and military conservation areas to include intertidal areas. Generally, where rocky shores are protected it is incidental to the protection of other marine habitats.

Islands

Most of the species found on islands interact with those in water, or use both island and water habitats. The large islands, such as Pemba, Mafia and Zanzibar (all in Tanzania) are found on the east coast, but smaller ones are found throughout the coastal area.

Some islands off Mozambique, Namibia and South Africa are conserved. But others have been disturbed by oil and diamond-mining, guano-harvesting, sealing and bird-egg collection. In addition, exotic plants and animals have been introduced on some islands. These include feral cats and house rats.[38] On Dassen island, off the west coast of South Africa, feral cats have preyed extensively on seabirds. Diseases can also decimate some island resources. In the 1990s, unprecedented levels of adult birds (tens of thousands of Cape cormorants) were killed by cholera.[39]

Considerable economic value is attached to some islands which bear deposits of oil, gas, diamonds or guano. Lagoons are usually found near islands and support sea plant and animal life of high social and economic value. Being close to land, lagoons are accessible to both subsistence and artisanal fishermen.

THREATS TO MARINE RESOURCES

Some areas of the region have seen their resources shrink to a point where certain species are endangered. The greatest threat seems to be overutilisation, but factors such as habitat deterioration and improper fishing practices also play a role.

Overutilisation

Many human activities are harmful to the marine environment and resources. These include unsustainable harvesting of some of the resources such as whales, fish, prawns and turtles. Extreme overutilisation lowers the capacity of a species to reproduce.

Due to excessive harvesting, reptiles are among the most threatened marine species. Already pronounced endangered are the Green, Hawksbill, Leatherback and Olive Ridley turtles. They have been overexploited for their popular shells and meat. In addition, turtles are occasionally caught in nets during trawling. Along the coast of Angola, turtles are still hunted for meat and their eggs are collected for food.

Whale populations have been decimated to very low levels over the last century due to hunting for their meat and oil, and the use of gill or drift nets to harvest pelagic fish.

Sex adaptation Box 10.4

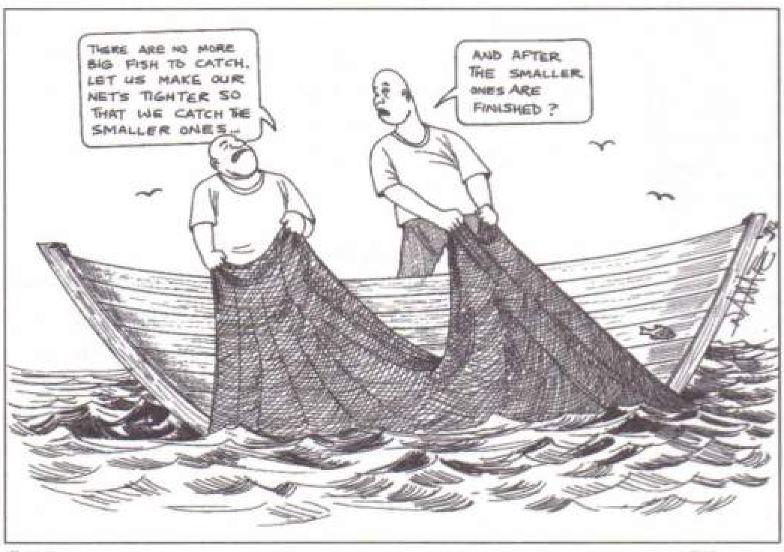
Overfishing has altered the male to female ratio in some sea-bream species. The sea bream change from females to males as they grow older. The bigger males are caught by anglers, leaving too few males to fertilise the eggs. When the females adjust to this alteration in population structure by changing to males at an earlier age, they leave young, smaller females to produce eggs. These are fewer per fish and in total, and curtail the ability of the population to grow.

SOURCE: Crawford, R.J.M, "Marine Ecozones of Southern Africa", for SARDC, 1993

Threatened invertebrates include the coconut crab which has been sought for both meat and alleged aphrodisiac properties. Other overexploited species are green snail, pearl oyster, spiny lobsters and whip coral.[40] Some South African linefish have been severely overfished, including red steenbras, seventy-four, garrick, stone bream, catface rock-cod and red stumpnose.

Habitat damage

Sudden changes in the temperature or other alterations in the habitat threaten the survival of marine organisms. In addition, human activities on land and at sea have adversely affected seas.



Ill 10.1 T Namate

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. Civil wars in Angola and Mozambique forced people out of the interior into coastal towns where excess deforestation and cultivation increased the siltation of rivers and coastal areas.

In the Zambezi delta, loads of soil brought down by the river have "downpressed" the delta because of their sheer weight.[41] This has allowed seawater to advance upstream, altering the salinity of the water to the disadvantage of plant and animal species which are used to a lower level of salt concentrations.

Sand-dune mining can harm coastal habitats by making then less suitable for the survival of some species. Mining for heavy minerals along the coast of Natal has led to the shrinking of nesting habitat for a threatened bird species — the African skimmer. Similarly, tourism and related infrastructure developments alter marine and coastal environments.

Fishing practices

Some fishermen use dynamite to stun and kill fish. This practice not only kills eggs, larvae and fry but also destroys other species — both plants and animals — and upsets the feeding relationships between organisms. Dynamite destroys coral reefs which protect shores against erosion from ocean currents and waves.

Fishing using nets with small mesh occasionally removes non-target marine fish and other organisms, altering their population structure negatively.

Trawling can lead to the destruction of seagrass beds upon which some marine animals depend. Use of nets results in the capture of non-targeted species of fish and turtles, sharks and dugongs.

Pollution

By global standards, the southern African coastal and marine areas are relatively clean but there are a few "hot spots" usually near coastal cities, which are victims of industrial activity, and improperly disposed sewage. The toxic pollutants kill organisms, cause diseases among fish and reduce the productivity of fish.

Pollution of marine environments is also caused by excess nutrients in water due to discharge of agricultural fertilisers, waste from food-making industries and sewage into the sea, with human waste problems being exacerbated by an influx of people into coastal areas, particularly in Angola and Mozambique. Nutrients, especially nitrogen compounds, cause a bloom of algae which can release poisons and reduce light penetration into the water.

Oilspills around Dyer and St Croix islands, which are home to over 50 percent of the world population of African penguin, have killed many of the birds and have the potential to further reduce vulnerable populations.

Entire penguin colony polluted Story

Cape Town (SAPA) - The worst scenario has occurred and the entire colony of 20,000 endangered Jackass [African] penguins on Dassen Island off the Cape west coast have been polluted by oil which washed up on the island on Thursday.

"We are going to try and rescue as many of the birds as possible and transport them to the mainland where they will be cleaned, weighed and fed at the SA National Foundation for the Conservation of Coastal Birds (SANCCOB) centre," Cape Nature Conservation (CNC) spokesman Dieter Odendaal said. "We cannot rescue all but will save as many as possible."

He said there were chicks in nests on the island and if the adults were removed the chicks would still have to be fed. If it became too cold for the chicks they would be put in sheds and buildings on the island.

A new development in the rescue is that the navy has come into the picture. It is sending a minesweeper to the island to help bring crates of penguins to Yaterfontein, from where they will be transported to the centre. The Department of Correctional Services has also offered to send staff to the island to help with the rounding up of penguins.

"We are desperately in need of crates, boxes and cartons in which penguins can be transported and any donations will be welcome," Odendaal added, describing the incident as a "disaster affecting the whole marine ecological system."

He said SANCCOB was able to accommodate about 5,000 birds and the CNC was trying to find other suitable premises near harbours.

Democratic Party environment affairs spokesman Senator Errol Moorcroft has called for a commission of enquiry to establish the exact source of the oil. "The Government should then move to recover the expenses of the rescue and the clean-up operation from those responsible," he said.

Anton Molden, chief pollution officer for the Department of Sea Fisheries, said his department had asked for samples of oil from two ships to compare them with oil from the slick.

—South African Press Association (SAPA)/Weekend Star, Johannesburg, 25-26 June 1994

Global changes

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 lowlying areas, islands and estuaries, negatively affecting the plant and animal species adapted to those environments. Much of the coastal area of Mozambique, which is lowlying, could be submerged by a minor increase in sea level as might estuaries and beaches all along the coast. This would reduce the amount of land available for human settlement, forests and agriculture.

It is also possible that increased temperatures will upset the sex ratio of turtles as their sex at hatching is determined by temperature. Surface-nesting birds, such as African penguins, are likely to desert their nests to evade excessive heat.[42] This could lead to a continued decline in their numbers. As sea water warms and cool waters are heated by higher temperatures, habitat for warm-water species is likely to expand at the expense of that of the cold-water species.

The effect of global changes on wind and ocean currents is yet to be understood. Namibia fears that the Benguela current's behaviour might change due to the effects of global warming raising the sea level.[43] Global warming could result in changed wind pattern in a way that would decrease nutrient supply and, ultimately, fish production in the fertile fishing grounds off its coast.

Ultra-violet light coming from the sun through holes in the ozone layer reduces the ability of plants to make their own food. This could be disastrous for fish and other organisms whose survival depends on plants either directly or indirectly. The light may change genetic make-up of some plants and animals, and cause a rise in the incidence of cancer in people.

Conserving marine resources Box 10.5

The World Conservation Union (IUCN) defines conservation as "the management of human use of the biosphere so that it may yield the greatest sustainable benefit to the present generation while maintaining its potential to meet the needs and aspirations of future generations." Conservation is, therefore, the wise use of natural resources with an eye to the future.

IUCN gives three main reasons for conservation:

- to maintain essential ecological processes and life support systems;
- to preserve genetic diversity; and
- to ensure that ecosystems and species are sustainably utilised.

While southern Africa has a proud record of conservation on land, it has not yet done justice to its marine environments. This is partly because there is little information available on the ecology and dynamics of marine ecosystems in the region, making it difficult to establish appropriate and viable conservation priorities. The problem is compounded by a lack of adequately trained staff to define the areas for conservation and manage them scientifically.

Other limiting factors are shortages of equipment and finance to control the marine waters, which result in the proliferation of illegal foreign fishing. In addition, wars in Angola and Mozambique have made control and conservation of the seas difficult to manage and monitor.

The conservation of marine resources has been effected in part through quota systems, prohibition of fishing in some areas and during certain times of the year, and bans on the use of destructive fishing methods. This has worked very well in Namibia, where the capacity exists to enforce these regulations.

In general, marine conservation is inadequate. However, coastal southern African countries are trying to extend the size of marine and coastal protected areas. The habitats for expansion have already been identified and they range from seagrass meadows to mangroves, estuaries to coral reefs, beaches and coastal areas.

Tanzania proposes to establish a few more coastal protected areas:
- ❖ Tanga coral gardens, for the protection of coral reefs;
- ❖ Dar es Salaam coral gardens, for the protection of coral reefs, coconut crab, and limestone islands;
- ❖ Latham island, for the protection of sea birds and green turtles' nesting grounds;
- ❖ Mafia island-Rufiji delta, for the protection of corals, mangroves, dugongs, turtles, and the estuary; and
- ❖ Kilwa, for the preservation of turtles and dugongs.

In Mozambique, the proposed marine conservation areas are:
- ❖ Quirima islands, to protect coral reefs;
- ❖ Primeira and Segundo islands, to protect corals, cays for nesting green turtles, seagrass beds, dugongs, dune forests and mangroves; and
- ❖ Nacala-Mossuril islands, for coral reefs and rookery, and the extension of the Bazaruto National Park to protect seagrass, birds, turtles and dugongs.

South Africa plans to protect:

off the Natal coast
- ❖ Maputaland, the area north of the Umfolozi estuary in Zululand to the border with Mozambique, for the high species diversity, swamp and palm forest, mangroves and rich fish diversity.

on the southern Cape
- ❖ De Hoop reserve extension to cover sandy beaches and the Agulhas bank, which is of scientific importance; and
- ❖ coastal lakes, estuaries, plants and animals between George and Tsitsikamma National Parks.

Off Namibia and South Africa, the Benguela areas earmarked for protection are:
- ❖ Cunene river mouth (Namibia), breeding ground for the endangered green turtle;
- ❖ Langebaan coast (SA), including Dassen island for the rich benthic animals and seabirds; and
- ❖ Namaqualand, proclamation of a coastal reserve which will add 21 km of beach area and 32.8 km of rocky shore to protected areas.

On the coast of Angola, conservation areas will cover:
- ❖ mangroves, some of them almost pristine;
- ❖ estuaries; and
- ❖ beaches where endangered turtles nest.

SOURCES: Hatton, J.C. and others, *Wetlands, Coastal Zone Systems and Marine Fisheries: Angola's Environmental Status Quo Assessment*, IUCN, Harare, Aug 1992
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Linkages to other chapters Box 10.6

1 PEOPLE

The oceans are a global resource and need international, as well as local, protection from pollution, overexploitation and other abuses by people in and outside the region.

2 HISTORY

There was very little effect on marine ecosystems prior to colonisation and industrialisation in Africa.

3 POLICY

More attention is being given to the management of marine ecosystems. Policies are putting emphasis on sustainable utilisation and the creation of marine conservation areas.

4 ECOZONES

Marine ecosystems affect ecozones on land, particularly the cold Benguela system which deprives the adjacent area of rainfall, leading to the extremely dry conditions in the Namib desert.

5 CLIMATE

Events such as *El Nino* affect the ocean currents and ultimately the productivity of marine waters. Extreme fluctuations in climate, such as droughts and floods, affect marine areasv negatively by changing freshwater discharges and nutrients reaching estuaries.

6 SOILS

Soil degradation results in siltation of marine habitats. Rivers carry waste matter and sediments from eroded and deforested lands to the sea.

7 WOODLANDS

Deforestation leads to soil erosion and siltation of estuaries. Silt smothers plants in estuaries and reduces food available to marine animals there.

8 WILDLIFE

Protected marine areas have the same purpose as those on land — to sustain the diversity of plant and animal life.

9 FRESH WATER

Freshwater supplies into estuaries are important for breeding and growth of certain marine fish.

11 POLLUTION

Pollution affects marine and coastal areas. Human, domestic and industrial waste, oil spills and other pollutants alter habitats of marine organisms, and may even kill them.

12 ARMED CONFLICT

Armed conflict has indirectly impacted on the fisheries of Angola and Mozambique in that it inhibits control of marine-resource management and conservation. Armed conflict has increased the number of people dependent on marine resources.

13 GLOBAL

Climatic change alters the flow of currents, changing the habitat of fish and other marine animals and plants. Global warming leads to a rise in sea level.

14 TRENDS

All countries in the region with coastal areas are planning to extend protection of marine areas and resources.

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11

POLLUTION

Pollution is the poisoning of the environment with anything that reduces its ability to support life. Population growth, urbanisation and industrialisation all contribute to the increase in waste and pollution in southern Africa. Most pollutants cannot be seen, smelt or tasted. While it is easy to believe they are not there, they produce a measurable change in the region's environment and affect human health, as well as plants and animals.

Southern Africa is dealing with greater volumes of waste — and more dangerous waste materials. The problem of pollution is intensified by the fact that a mix of pollutants is more hazardous than individual ones because of the way they work together in the environment. One type of pollutant may weaken fish, for example, making them more vulnerable to other pollutants and diseases.

The main sources of pollution are found in urban areas and major developments, such as mines and irrigated agricultural estates. Household burning of fuelwood and coal creates a localised health hazard in the region, and grass and forest fires contribute to air pollution. People who are poor are at higher risk because they are more likely to live or work in polluted environments, and are more likely to suffer from inadequate nutrition, which exacerbates the toxic effects of pollution. Industrial workers and those in the mining industry are exposed to noxious gases and poisonous chemicals. Workers on commercial farms handle poisonous chemicals. Low-income housing is typically located near rubbish dumps, electric-power plants, mines and factories spewing smoke.

Less than half the population of southern Africa has "safe" drinking water, according to the United Nations and the World Bank. Water contaminated with poisons from agricultural estates, mines and industries passes through some areas where it is used for drinking, washing, and watering livestock and gardens. Diarrhoeal diseases, such as cholera, and other water-borne diseases, such as bilharzia, are found in water contaminated with untreated human waste and sewage.

The overall impact of pollution on environmental and human health in southern Africa is difficult to judge, because there is no *baseline* information. No long-term study of pollutants has been undertaken at regional level, and appropriate control mechanisms are not in place or are poorly enforced. In some cases, pollution is not monitored. However, a review of the individual sources of pollution and their known impacts is being done and provides a starting point for assessment.

INDUSTRIAL PRODUCTION

Manufacturing and service industries are the primary sources of pollution in southern Africa, producing millions of tonnes of effluents (poisoned waste-water), tens of millions of tonnes of solid waste (rubbish stored on land) and hundreds of millions of tonnes of emissions (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.

Industrial water pollution

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 dangerous. There are four main categories of water pollutants:

- organic materials from sewage and animal-products industries;
- nutrients from soaps, fertilisers and eroded sediments;
- poisons, such as agricultural chemicals, and industrial and mining wastes; and
- fouling substances such as oil.

In coastal areas, most industries dispose of 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 Natal and Cape Town in South Africa, Walvis bay in Namibia to Baia do Cacuaco, 15 kilometres north of Luanda in Angola.

Photo 11.1 SOUTHLIGHT-P Weinberg

Fish are vulnerable to toxic effluent discharged in water bodies.

Industries located away from the coast usually provide some kind of treatment for their liquid wastes before discharging them, though the process may not be effective and poisoning of fish is common in the region. The Peleng river in Botswana, for example, has been polluted with liquid industrial waste to the point where fish and reeds disappeared and boreholes, which provided drinking water for Peleng Village, had to be closed.[1]

Industrial wastes may also be dumped on factory properties, where they can wash into surface water supplies or into groundwater. Because of this kind of surface runoff from factories and laundries in Lesotho, Maseru's main water-supply is contaminated with lead six times above World Health Organisation (WHO) standards.[2] The Mukuvisi river in Zimbabwe, which runs into Harare's drinking water supply, contains high amounts of nutrients, such as phosphorus and nitrogen, sulphate, calcium, magnesium and fluoride, aluminium and iron, largely from industrial dumps along the river banks.[3]

Pulp-and-paper mills are among the worst industrial polluters. Production of pulp and paper requires large quantities of water. Each tonne of paper requires 100 cubic metres (cu m) of water on average, 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. Cancer-causing organochlorine compounds are formed in the process, and treatment of the effluent does not remove all the contaminants. Dioxins and other organochlorines end up in rivers, where they impair the reproduction of fish, retard their growth or kill them. In laboratory tests, trout are killed by dioxin concentrations as low as 40 parts per quadrillion, an amount equal to a thimbleful of dioxin in 50,000 Olympic-sized swimming pools.

Treatment of waste waters at the Swazi Paper Mills (SPM) on the Great Usuthu river, for example, is well below standard, according to the Swazi government.[4] The downstream town of Malkerns relies on the river for its drinking water. Phenols, which are by-products of pulp production, have increased steadily since 1988 and now average about four times above standards. Phenols accumulate rapidly in fish, giving them a strong odour and taste. At high concentrations the fish are unsafe for eating — and many die.

A portion of the mill's effluent is sprayed onto open land but this has not significantly improved the quality of the effluent. Paper fibres are discharged into the 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.[5] Even such a simple matter as blockage of water passages in the bottom gravel by decaying debris can reduce the survival of young fish and fish eggs.[6] Chances of reversing the environmental degradation in the stretch of the Ushushwana river between SPM and the Great Usuthu river are reported to be slim.[7]

The textile factories are also major polluters. 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 (acid-alkaline balance) as well. The Cone Textiles mill in Chitungwiza near Harare, for example, discharges effluent containing lead at six times the standard. Swaziland's textile mill (NATEX) discharges cancer-causing phenols into the Ushushwana river, the water supply for Dwaleni, at seven times the permitted standard.[8] Most of Tanzania's textile mills release dyes, bleaching agents, alkalis and starch directly into Msimbazi creek in Dar es Salaam.[9] Along the west coast, Angola's largest textile factory at Lobito-Benguela discharges its effluent straight into the Cavaco river.

Industrial air pollution

Air pollution is particularly insidious because it spreads easily from the source, so it is difficult for individuals to protect themselves against it. The major air pollutant is sulphur dioxide. Virtually any industry with a smokestack is releasing sulphur dioxide, which reaches the ground in the form of dry *oxide* particles and *acid rain*. Both acid rain and dry deposition create environmental problems, though acid rain may be carried hundreds of kilometres away while dry deposition tends to happen close to the source.

Electric-power plants are notorious air polluters, especially those running on coal. Coal contains sulphur. When it is burnt as fuel, some of the sulphur ends up in the ash, but most of it becomes sulphur dioxide gas.

South Africa's Eastern Transvaal Highveld (ETH) has the worst industrial air pollution in the region and is among the worst in the world, because it has one of the highest concentrations of coal-burning industries found anywhere. Coal-burning power plants are the main source of sulphur dioxide emissions in the ETH, though brickworks, steelworks, smelters, Sasol plants (which convert coal into oil), chemicals manufacturing plants, sawmills, and pulp-and-paper-mills contribute.

Photo 11.2 SOUTHLIGHT-D.Goldblatt

Air pollution spreads easily from the source. Johannesburg area has the most serious air pollution problems in the region.

Wastes produced by coal and nuclear plants Table 11.1

	Nuclear process (tonnes)	Coal process (tonnes)
Fuel	30 (uranium)	3 million (coal)
Radioactive elements	30	4
Air pollutants		60,000 (sulphurous gases) 30,000 (nitrogenous gases) 8 million (carbon dioxide)
Trace metals including lead, cadmium, arsenic		150

SOURCE: Huntley, Brian J. and others, *South African environments into the 21st century*, Tafelberg, Cape Town, 1990

Acid deposition

The effects of acid pollution on environmental and human health have not been well-studied in southern Africa, but in Canada some 14,000 lakes are considered "dead" and another 150,000 are suffering from acid damage. Forests have been severely affected as well, with up to 10 percent of the trees already dead in some areas.

Acid deposition damages plants directly. The sulphur oxides interact with moisture on leaves, and the build-up of acid burns holes in leaves, particularly those lacking protective layers on their leaf surfaces, such as ferns and mosses. Trees which grow quickly, such as pine and eucalyptus, are generally more sensitive to sulphur dioxide than slower-growing indigenous trees. Crops also have varying vulnerabilities, with maize more tolerant than sunflowers, for example.

Different ecosystems vary in their sensitivity to acid deposition. Soils containing clay and organic matter are better at resisting acid deposition than the sandy, thin, naturally acid soils found in certain parts of Swaziland and the eastern Transvaal in South Africa, and under tree plantations in KwaZulu. While commercial cultivated areas are routinely limed to protect the soil from acidity, the impact of acid rain on subsistence farmers (who cannot afford lime), natural grazing lands and forest plantations could be substantial.

Acid deposition changes soil chemistry. Initially, alkaline elements, such as magnesium and calcium, are released by the acid. These dissolve and help buffer some of the effects. With more acid deposition, the magnesium and calcium are used up, the soil becomes more acidic, and poisonous metals such as aluminium and cadmium dissolve into the water in the soil. High concentrations of aluminium can prevent plants from taking in and using nutrients. Over the long term, acid deposition reduces soil fertility by dissolving nutrients so they can be washed away.

Deposition of acid particles may have its largest impact on wetlands. Most aquatic plants and animals tolerate only a certain range of acidity. During the dry season, acidic particles collect on soil. With the onset of the rains, the accumulated particles washing into surface water cause a sudden increase in pH and a change in the water chemistry, nutrient balance and trace metals. This impairs plant growth. Invertebrates (the water-beetles and shrimps that fish feed on) disappear because of an inability to reproduce. Fish may be stressed, affecting their ability to reproduce, and may be killed by the abrupt change.[10]

Wetlands and pans in the ETH are among the endangered natural habitats in South Africa. As many of these habitats have naturally acidic soil, they are vulnerable to additional acidification. A study of 25 streams along the Drakensberg escarpment near Newcastle in South Africa, downwind of major pollution sources in the eastern Transvaal area, revealed changes in water chemistry and destruction of aquatic life, typical of the kind of damage caused by acid pollution.

There are no guidelines for deposition levels that may endanger ecosystems, though 20 kilogrammes per hectare per year (kg/ha/yr) has been proposed as the maximum that aquatic ecosystems can tolerate. There is no accurate way to measure dry deposition, though the amount has been estimated for the eastern Transvaal as being more than 11 kg of sulphur per hectare each year. This is in addition to the 3-6 kg of wet deposition per hectare estimated by ESKOM, South Africa's electrical utility. Sulphate deposition levels at Topfontein (Vaal area) and Sabie (eastern Transvaal) have exceeded 20 kg/ha/yr, which indicates a possible ecological threat.

MINING AND MINERAL PROCESSING

Mineral extraction has four main processes, all of which can be extremely damaging to the environment. These are mining, mineral processing, pyrometallurgy and hydrometallurgy. The first two processes produce mined waste. This is essentially earthy in nature, and is hazardous if the mineral being extracted is dangerous (such as radioactive rock or asbestos), or if it has been washed with toxic or harsh substances (such as cyanide, mercury and sulphuric acid) to separate the valuable materials from waste products. 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.

The remaining processes (smelting, roasting and other methods for refining ore) produce waste materials in solid, liquid and gaseous form. Mineral processing in the countries of the Southern African Development Community (SADC), excluding South Africa, contributes an estimated one million tonnes of sulphates to the environment annually.

Disposal of solid mine-waste

Coal dumps

Coal-mines often cause serious air pollution because the overburden and the coal wastes contain significant amounts of combustible materials which can actually burst into flame on their own, spewing poisonous particles and noxious gases. Coal-fields in Botswana, Malawi, South Africa, Tanzania, Zambia and Zimbabwe are located under highly reactive sandstones and mudstones which ignite spontaneously. Discarded coal dumps can burn for many years without much chance of being extinguished. This has been a problem at Grootpan in South Africa, and the Maamba colliery in Zambia.

Photo 11.3 IUCN-D REED

Mining, a major industry in southern Africa, can seriously damage human health and the environment.

Asbestos dumps

Asbestos-mine dumps are a particular hazard in South Africa, Swaziland and Zimbabwe. Asbestos is made up of tiny fibres which cause scarring of the lung tissue, leading to asbestosis (lung disease) and bronchial carcinoma, and mesothelioma (cancer of the chest or abdominal lining). South Africa has the highest rate of mesothelioma in the world.[11] Some experts believe that crysotile (white) asbestos is not as dangerous as other types, but most evidence points to a severe health hazard for all types.

Asbestos mines claim to follow a self-imposed standard of two fibres per millimetre of air. Even at this concentration, workers risk of death from lung cancer five times higher than other people. People using asbestos products, and people in the transport industry (such as railway and dock workers) are also exposed to asbestos fibres, as are people living near asbestos mine dumps.

Mafefe, South Africa Box 11.1

A survey in 1987 in Mafefe, a South African town located at an asbestos mine, found that more than one-third of the homes were plastered with asbestos or built with bricks made of asbestos. Half the public buildings were constructed with asbestos bricks. Since then, local people have been informed about the dangers and seldom use asbestos waste for new construction. Since asbestos-related diseases take as long as 20 years to appear, they will continue to claim lives in Mafefe for a long time to come.

SOURCE: Cock, Jacklyn and Eddie Koch, *Going Green: People, Politics and the Environment in South Africa*, Oxford University Press, Cape Town, 1991

Radioactive dumps

When uranium is milled for use in power plants, only about 15 percent of the radioactivity is removed. The rest is discarded as "tailings". At the Rossing Uranium Mine, outside Swakopmund in Namibia, radioactive dust from tailings is controlled by applying large amounts of water, about 2,500 cubic metres per day (cu m/day), and by spreading natural non-radioactive material on top. The covering will eventually reach a depth of 30 cm, which is expected to reduce the radiation emitted by about one-third.[12]

All life is normally exposed to very low levels of natural *background* radiation from the sun, soil and rocks, and the sea, but the large doses of radiation from artificial sources (such as uranium-mine sites) are extremely hazardous to the environment and human health.

Waste water

After the extraction of minerals, toxic substances remain in the waste-rock powder which is deposited in the tailings at the mine-site. These toxic materials can contaminate rainwater or other water passing through the tailings. The main environmental concern at Namibia's Rossing Mine, for example, is seepage and spills from the watered wastes causing radioactive contamination of groundwater under the Khan river. Rossing's containment pond leaked radioactive tailings into the river system in the 1980s, exceeding by eight times the biggest spill until that time.[13]

Nuclear power Box 11.2

Proponents of nuclear power argue that it is a clean alternative to coal, producing less pollution and less risk to the environment and human health. Opponents argue that each of the stages of nuclear power production — including mining, milling, enriching uranium, manufacturing it into nuclear fuel, reprocessing of spent fuel and disposing of nuclear waste — present serious risks.

Very low doses of radiation cause cancer, and mining of uranium, power production and disposal of wastes exposes people and the environment to radiation. A 1991 study of nuclear workers and their families in Oak Ridge, Tennessee, found that leukemia (cancer of the blood) rates were 63 percent higher than for non-nuclear families. Similarly, a 1990 study in Sellafield, England, found that children of nuclear workers were 7-8 times more likely to develop leukemia if their fathers had received *legal* low-level doses of radiation.

The only African country using nuclear power is South Africa. Less than six percent of the country's electricity is provided from one site — Koeberg, about 30 km north of Cape Town, and the future of the nuclear industry in a democratic South Africa is now a subject of debate.

The nuclear industry in South Africa was criticised for its involvement in manufacture of nuclear weapons between 1980 -1989, and the country will have to decide what to do with its stockpile of highly enriched uranium, formerly used in nuclear weapons. The end of the weapons programme may spell the end of South Africa's nuclear programme. The huge costs of the enrichment plants, widely suspected to have been constructed mainly for military purposes, will not be borne easily by a democratic government with substantial social priorities.

The industry itself has admitted that these plants are losing money and will be closed down by 1996. The nuclear fuel produced at Pelindaba in South Africa is up to 20 times the price of fuel available on the world market. ESKOM, the utility that operates Koeberg, is trying to avoid entering into further contracts to purchase local fuel.

Disposal of wastes from nuclear-power plants remains the key problem. Radioactivity takes tens of thousands of years or more to decay to acceptable low levels. Medium and low-level wastes (such as discarded equipment and disposable overalls worn by workers) are trucked from Koeberg to one of the few nuclear-waste disposal sites in the world, opened in 1987 in the desert at Vaalputs in the northern Cape.

High-level waste makes up just one percent of the waste but contains nearly all the radioactivity. It is stored, for now, in cooling ponds at Koeberg. Earthlife Africa estimates that Koeberg now has more than 1,000 kg of plutonium, a substance so toxic that only 5 kg is enough to kill every person on the planet. After a 10-year cooling period, the contaminated fuel rods will be transported to the nuclear-waste disposal facility at Vaalputs. After further storage in silos, it will be sent to France for reprocessing — the separation of spent fuel into plutonium, uranium and other radioactive products. No system has been developed, anywhere in the world, for the permanent disposal of high-level nuclear wastes.

SOURCE: Fig, David, Research Director, Group for Environmental Monitoring, Johannesburg, for SARDC, Feb 1994

Tailings in much of the region are acidic because of the nature of the parent rock, especially at coal- and gold-mines. Bacteria accelerate the chemical reaction by 20-100 times, so the acidity can continue to increase for decades after mine tailings have been abandoned, a problem known as "acid generation". Acidic water from the tailings dissolves toxic metals (such as zinc and copper, aluminium, lead and manganese) from the tailings and carries them into rivers used for drinking and irrigation. Often, tailings are located near streams and community water sources and provide a continuing source of contamination.

Similarly, acidic drainage from arsenic tailings from gold-mines at Barberton, South Africa, near Swaziland, has polluted nearby surface waters. One stream about a kilometre from the tailings contains double the allowed amount of arsenic, which causes weakness, skin lesions and skin cancers in humans.

Salts in tailings are also a problem. In the Vaal area in South Africa, some 8,000 hectares of tailings contain salts. About 50,000 tonnes of salts seep out of the tailings into the Vaal barrage each year, creating problems for irrigation downstream. Irrigation from the Waterval river was found to add seven tonnes of salt per hectare.[14] "It's like watering your garden with sea-water," a farmer in the district told reporters. Because salty tailings are usually barren, particles of salts can be carried away by wind, contaminating farm lands.

Acid streams Box 11.3

The Klipspruit stream that flows through Soweto is extremely polluted by acid and toxic metals from old mine-dumps and tailings dams. Residents of the informal settlements known as Chicken Farm and Klipspruit rely on the stream for drinking and bathing. Water sampling has found sulphates more than 2,000 times over the World Health Organisation (WHO) standard. Cadmium and lead are at double the standard. Nickel levels are four times the standard, aluminium 20 times over, and mercury 60 times. Levels of dissolved uranium, cyanide and arsenic are also far above WHO standards, enough to make someone bathing regularly in the stream develop skin lesions and, possibly, skin cancers.

SOURCE: Coetzee, Henk, *A Study of Water Supply to Shack Settlements on the Witwatersrand*, A GEM Discussion Document, GEM, Johannesburg, Nov 1991

Groundwater pumping

Ore extraction disturbs land surfaces and groundwater flows. In large excavations, groundwater drains downwards into the mine where it dissolves chemicals used in the mine and trace metals naturally present in underground rock. The contaminated water is then pumped out into surface waters.

At the Maamba colliery in Zambia (an open-pit coal-mine) acid drainage produces waste water about 1,000 times more acidic than natural water. Lime can be added to neutralise it, but the mine has problems getting a reliable supply, and cannot afford better control equipment. Other mines with similar problems include Emaswati in Swaziland, Mundonguara and Moatize in Mozambique, and Botswana's Morupula mine.

Maamba colliery pumps the acidic water to ponds, and from there to the Izuma stream which discharges into Lake Kariba. During much of the dry season, Izuma stream is empty except for mine effluent. People digging for water in the dry stream-bed complain of the taste, and report that it has killed cattle. It is a measure of the scarcity of water in southern Africa that people have grown to depend on groundwater pumped out of mines as their primary source of water.

Acidity and trace metals are not the only problems associated with pumping groundwater out of mines. Groundwater in the region is often alkaline or saline (salty) and this can have a significant impact on nearby streams as well.

Mineral processing

Any form of heating (combustion, smelting or calcining of minerals) produces contaminated water, noxious gases and fine dust, and injects heavy metals into the atmosphere. The steel industry, for example, is responsible for high aerial concentrations of iron, manganese and zinc in parts of Pretoria. Gold ores in Botswana, South Africa and Zimbabwe contain arsenic which is released to the environment during roasting (heating), an extremely dirty process. Two gold-roasters in Zimbabwe, one near Kadoma and another in Kwekwe, emit an estimated 40 tonnes of arsenic daily, although ways are being sought to reduce this.[15]

Poisons often build up in the soil near smelters. Some of these toxins find their way into food crops. In Zambia, the

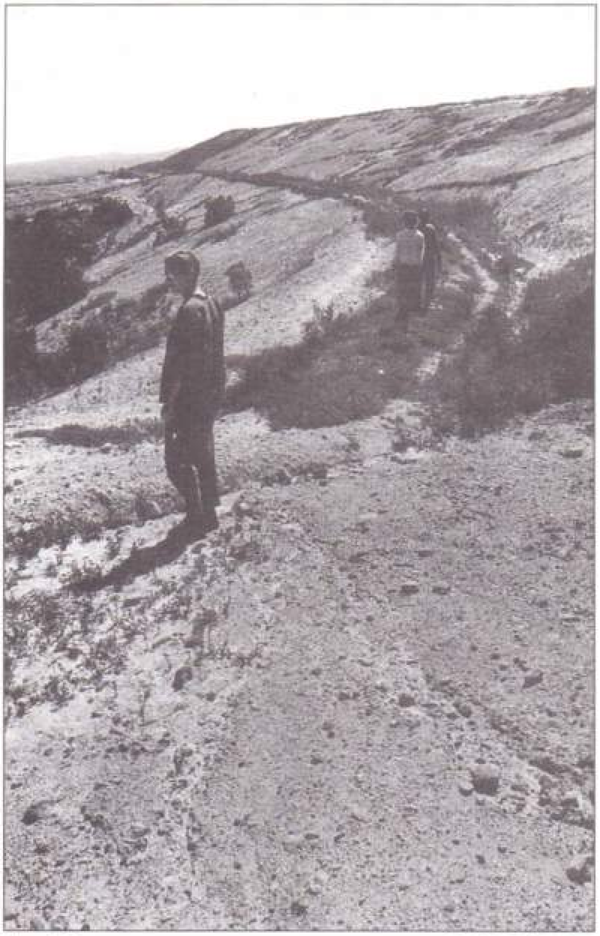


Photo 11.4 SAMSO-D Deudney

The environment can take long to recover even after a mine, such as Kaolin in the Eastern Cape, has been abandoned.

natural vegetation downwind of the Kabwe copper smelter shows definite damage from air pollution. Zambian copper smelters emit more than 200,000 tonnes of sulphur dioxide and hundreds of tonnes of dust containing trace metals such as lead, zinc and copper. Almost a quarter of Zambia's children have respiratory diseases, largely because of air pollution from copper smelters.[16]

Cement manufacture

The manufacture of cement involves crushing lime, silica and alumina, blending and heating them to a high temperature. This can be hazardous to workers and the surrounding area. The main sources of air pollution are the kiln and the cooler exhaust stacks. Two cement plants in Zambia are currently discharging dust and particles of unburnt material into the air, adversely affecting their surroundings. One of the country's agricultural research stations had to be moved because the fields were contaminated with dust.

The crushing and milling sites in cement plants are the main areas where people are exposed to dust. Cement workers can suffer from skin, eye, nose and respiratory diseases. Due to technical problems in 1991, including inadequate filtering and ventilation systems, a cement plant at Otjiwarongo in Namibia was temporarily emitting dust 12 times higher than the South African standards.[17] At an asbestos-cement factory in Dar es Salaam, workers and management report health problems, including persistent coughs, asthma and difficulties in breathing.

Contaminated effluent

Disposal of the contaminated effluent left by mineral processing creates a serious environmental problem. Cyanide, for example, is usually neutralised with other chemicals but any remaining cyanide may react with the environment to form hydrogen cyanide, which is extremely toxic and kills bacterial and aquatic life.[18] Cattle are attracted to the smell of cyanide (it has a salty odour), and poisonings have been recorded in the region.

The Nchanga division of Zambia Consolidated Copper Mines (ZCCM) in Chingola has a poor pollution record. At 18-month intervals, Nchanga spills effluent from the tailings leach-plant, according to a report commissioned by SADC.[19] The effluent, contaminated with high amounts of copper, runs into Chingola stream which feeds the Kafue river. The stream has no fish at all. Problems are blamed on lack of maintenance and shortage of spares. The African Development Bank (ADB) has now loaned ZCCM US$2.5 million to repair the plant and redirect the flow from the Chingola stream into an abandoned open pit.

Small-scale operators

Even small-scale, mineral-processing operations can be extremely damaging, depending on the chemicals used. Artisanal gold-miners often use mercury to separate gold from sand, especially in Tanzania and Zimbabwe. Mercury vapour is poisonous, and liquid mercury becomes more "bioavailable" (capable of being absorbed by the body) when it mixes with bacteria on river bottoms and is transformed into methyl mercury. Methyl mercury accumulates in animal tissues and destroys the central nervous system, causing loss of sensation, tunnel vision, birth defects, and delayed mental and physical development. One tablespoon of mercury in a body of water covering a football field to a depth of about five metres is enough to make fish in that water unsafe to eat. People eating meat from cattle drinking from streams polluted by small-scale gold-mining have come down with diarrhoea because of mercury contamination.

Hand-dug mines and gold-panning can be extremely disruptive. Siltation caused by small-scale diamond-mining in Angola has destroyed fishing, and hippos are reported to be locally extinct. Vegetation and soil has been stripped for up to a kilometre from the river bank.[20] In Zimbabwe, gold-panning is causing major river-siltation problems.

OIL DISCHARGES AND SPILLS

Oceanic tankers are the main source of oil 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 six major oilspills affecting South Africa since 1965. One of these was in 1983, when almost 200,000 tonnes of oil spilled about 100 km from Cape Town and blew toward Saldanha bay, an important nesting area for seabirds. The oil killed one-third of the 1,500 resident gannets, despite local attempts to clean the oil off the birds.[21] There have been two major spills off the coast of Tanzania, in 1981 and 1986. The 1981 accident destroyed fish and crabs, algae and seagrasses as well as mangroves, which began to die within three weeks. Seven years later, there was no sign of regrowth. Spills off the coast of Mozambique in 1979, 1982 and 1992 also killed mangroves.

The environmental and economic consequences of large oilspills can be devastating — smothering aquatic plants and fish eggs, reducing their resistance to infections and disease, destroying food sources for fish, and introducing cancer-causing poisons into the water. Beaches, mangroves and marshes, estuaries and coral reefs are most vulnerable. Waterfowl are typically the first and most visible casualties. The spill, or the subsequent clean-up, may place entire species of birds at risk if it occurs during moulting or interferes with migration patterns.

The most recent large oilspill in the region was in 1992, when the *Katina P* ran aground in the Mozambique channel, spilling more than 16,000 tonnes of heavy fuel-oil about 400 km northeast of Maputo. More than 100 km of coastline were affected. Much of the oil came ashore on Maputo's main beach, and at the island of Xefina and the Incomati river estuary. Mangroves died within a month. The 50,000 people who make their livelihood from fishing and collecting shellfish had to wait more than two weeks during the clean-up. Though it was predicted by outside experts that the 50,000 tonnes of oil that went down with the ship would solidify at the cold temperatures and not escape, overflights a month later showed a new slick drifting, fortunately, away from the coast.

Chronic pollution from frequent minor spills and routine disposal of oil-wastes can be just as hazardous to wildlife as infrequent large spills. More than 4,000 smaller vessels pass through southern African waters every year. During routine cleaning operations, emissions release some 33,000 tonnes of oil into the ocean each year. In 1988, a South African oil-spill patrol aircraft located 128 smaller oilspills, mostly from general cargo vessels. The number of unreported small spills for the entire region is obviously much higher.

Photo 11.5 TEMPO-N Ussene

Cleaning up the beaches near Maputo after the Katina P oilspill in 1992.

On the region's west coast, UNEP estimates that oil-drilling platforms spill about 5,000 tonnes of oil and grease into the sea annually.[22] Fishing near Luanda and Cabinda in Angola has been affected, although the impact on the sea-bed remains unknown. Luanda bay is also polluted with oily discharges from bilge-pumping and other routine discharges.

AGRICULTURE

Pest control

Conventional agriculture relies heavily on chemicals to kill unwanted diseases, insects, plants and animals. The degree of environmental concern posed by a particular pesticide depends on how long it lasts in the environment, and how much is used. Generally, wild animals near large commercial farms are more contaminated with pesticides than those in remote areas. The eggs of Cape vultures in South Africa's intensely farmed southern Cape contain more pesticide than those in Botswana, for example.[23] Dolphins offshore of Natal's commercial farming areas are the most contaminated in the region, with such high levels of the pesticide DDT that they have trouble producing offspring healthy enough to survive. Seals in South Africa are also reported to be having reproductive failures due to pesticides.[24]

Photo 11.6 IUCN-D Reed
Pesticide-spraying helps to kill pests but can be toxic to people, animals, plants and soils.

One of the main problems with widespread use of large amounts of pesticides is that the pests adapt and become immune. Efforts to control locusts in South Africa underscore this. Before 1907, locust outbreaks typically lasted about 13 years, with periods between outbreaks lasting about 11 years. Pesticide spraying was introduced in 1907, and outbreak periods soon shortened to about six years, with periods between breaks about seven years. Since the locusts have become more resistant, the pattern has adjusted to about two years of major outbreaks separated by two years of minor invasions.[25] Pesticides are indiscriminate killers, and can actually enable populations of pests to increase when their natural predators are killed instead.

Large commercial farms use huge amounts of pesticides. But, in recent years, subsistence farmers have been increasing their use of pesticides. As well as being major polluters of the farm and the natural environment, pesticides also pose risks to users. An estimated 11 million people are poisoned by pesticides every year in Africa.[26] In southern Africa, it is estimated that Tanzania has 368,000 cases of pesticide poisoning annually, Mozambique 240,000, Zimbabwe 160,000 and Malawi 128,000.[27]

Some of these poisonings are fatal. Exact numbers are not known, but WHO estimates 220,000 deaths worldwide every year. South Africa, Tanzania and Zimbabwe each report about 100-200 deaths annually. A majority of pesticide deaths are deliberate suicides, about 15 percent are accidental and only one percent are occupational.

Another common cause of exposure is the collection of food from fields too soon after pesticide application.

Insecticides

The major pesticides used to control insects are manufactured from hydrocarbons (petroleum) and chlorine or phosphorus. Hydrocarbon-based pesticides kill insects by interfering with the nervous system. Warm-blooded animals can usually neutralise most of the effects, though overexposure can cause severe headaches, trembling, blurred vision and difficulty in breathing. The best-known hydrocarbon-based pesticide is DDT but the group includes dieldrin, lindane, chlordane, toxaphene and endosulfan.

Initially, DDT was highly regarded as it killed many different kinds of insects, continued to work long after application, and appeared to have low toxicity to mammals including people. Workers in the DDT production industry were poisoned from time to time, but they appeared to recover completely afterwards.[28]

In the 1970s, the disastrous effect on raptors (birds of prey) was noticed. The shells of their eggs became so thin that they would break before the chicks hatched. Fish eat large numbers of invertebrates which contain minute quantities of

Safe use of pesticides Box 11.4

Many small-scale farmers do not use any protective gear or proper pesticide application equipment because it is not available or too expensive, or because spare parts are difficult to get. Some borrow or hire equipment, but this also tends to reduce safety because users are not individually responsible for the maintenance of the equipment.

Misuse of pesticides by small-scale farmers has been reported in some areas, with farmers using any pesticide against any pest. Sometimes this problem stems from poor labelling of pesticide containers. In Tanzania, a company sold pesticide for killing insects on maize in unlabelled containers without instructions. People using the chemical found it seriously damaged their maize. Upon testing it, the government chemist found that it was a weed-killer, not an insecticide.

Workers on large farms also run a high risk of pesticide poisoning, due to the high amounts of pesticides used, and the often poor working conditions. Aircraft spray noxious chemicals onto fields where workers without protective clothing have to breath in the fumes. In some cases, workers are exposed to pesticides which are banned or restricted in most other parts of the world. Many workers handling pesticides directly cannot read or understand the product labels, are unaware of the laws regarding pesticide handling and ignorant of their rights.

A health and pesticide specialist at the University of Cape Town, Dr. Leslie London, says Temik, one of the most poisonous farm chemicals, is "easily absorbed through the skin", and that "workers should have gloves, masks and protective overalls and should wash themselves and their clothes immediately after work so their homes do not become contaminated."

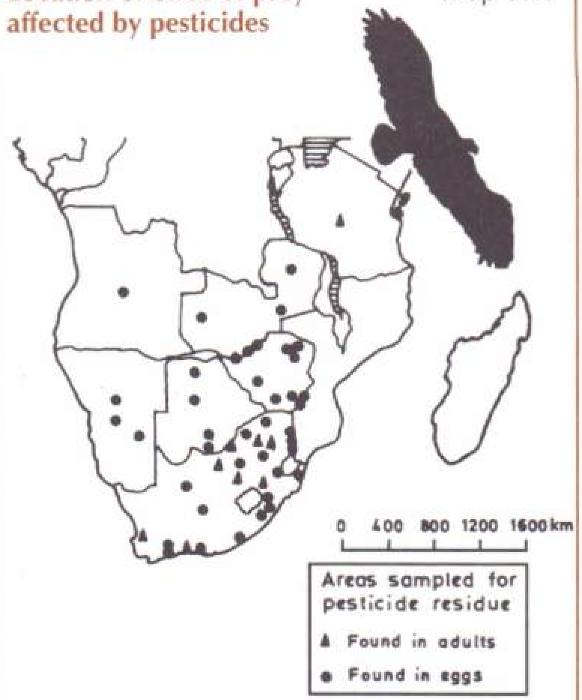
A survey was done in Zimbabwe during the 1985-86 pesticide spraying season to determine awareness of safety procedures. More than one-third of the workers believed that the discarded pesticide containers could be used for domestic purposes such as storing water, and for other purposes on the farm, such as mixing other chemicals. The same study showed that workers involved in mixing, loading or spraying pesticides had significant (though temporary) blood chemistry changes from pesticide exposure. Even farm workers not directly involved in handling pesticides showed blood changes, though not as marked.

The responsibility for safe handling rests with farm-owners and managers. Some farm-owners and managers take their responsibility seriously and ensure pesticides are handled safely. In Zimbabwe generally, three-quarters of state-farm workers wear protective equipment while less than one-third of the private-farm workers do. Blood tests of workers confirmed that those on private farms were more affected by exposure to pesticides.

The use of gumboots, a plastic apron or overcoat, and a face-shield are required by law under Zimbabwe's Hazardous Substances and Articles Act, when using pesticides displaying a red and purple triangle. However, most of the surveyed workers wore only one of the three required items.

SOURCES: Bwititi, T. and others, "Health Hazards in Organophosphate Use Among Farm Workers in the Large Scale Farming Sector", *Central African Journal of Medicine*, May 1987, Vol 33, no 5, p. 120-126
Nhachi, Charles F.B. and Ossy J. Kasilo, "Occupational Exposure to DDT Among Mosquito Control Sprayers", *Bulletin of Environmental Contamination and Toxicology*, Aug 1990, Vol 45, no 2, p. 189-192

Location of birds of prey affected by pesticides Map 11.1



SOURCE:Crick, Humphrey, "Poisoned Prey in the Heart of Africa", *New Scientist*, Nov 1990, Vol 24, p. 39-41

the pesticide and, in turn, are eaten by birds. This concentration of DDT through the food chain poisons the gland that determines eggshell thickness. In North America and Europe, some raptors became extinct in parts of their ranges and only returned some time after the chemical was banned.

There have been about 20 studies on effects of hydrocarbon-based, or organochlorine, pesticides in Africa. Bottom sediments along Kariba's southern shore contain high concentrations of DDT, as do the freshwater prawns, mussels, snails, fish, bats and birds, and crocodiles. A recent survey of DDT residues in eggs of Fish Eagles in Zimbabwe found that eggshells at the eastern end of Lake Kariba were 20 percent thinner than they were in the 1930s.[29] A 1992 study examining pesticide residues in cormorants (fish-eating birds) in South Africa and Zimbabwe found they had 30 times the levels of DDT found in fish, and concluded that this was enough to cause hatching failure.[30]

DDT for tsetse control and agriculture is being substituted with endosulphan, but recent studies of pesticide residues in birds and animals continue to find high levels of DDT and little endosulphan.

DDT and insect control Box 11.5

Pesticide-spraying to kill tsetse fly (which carries the parasite that causes sleeping sickness in people and *nagana* in cattle) began in the early 1940s — first with dieldrin, followed by DDT and then endosulphan. In the 1970s, about 1,000 tonnes of DDT were used annually for tsetse control in Zimbabwe, half of it near streams and rivers draining into the Zambezi river.

Use of DDT today is mainly restricted to control of malaria-carrying mosquitoes. Hundreds of tonnes of DDT are used every year to spray millions of homes. Though the long-term effects of low-level exposure are not known, high doses of DDT affect the nervous system. Hyporeflexia (reduced reflexes) in infants has been associated with DDE (metabolised DDT) levels as low as four milligrammes per kg of breast milk.

Banning or restricting the use of pesticides such as DDT is not the simple answer it seems. When the dangers of DDT to the environment became known, the search for replacements provided many pesticides which had less impact on the environment generally, but were more toxic to human beings. One example is parathion. Despite the fact that DDT persists and accumulates in the environment, safer substitutes such as malathion are not popular because they cost 3-8 times more. Mosquito-control operations contribute very little to DDT contamination of insect-eating wildlife compared to the widespread spraying formerly done for tsetse control and agriculture. The World Health Organisation (WHO) continues to recommend DDT as "an affordable, effective and relatively non-toxic pesticide" for malaria-control spraying programmes.

SOURCES: Bouwman and others, "Malaria Control and Levels of DDT in Serum of Two Populations in KwaZulu", *Journal of Toxicology and the Environmental Health*, 1991, Vol 33, No 2
Chikuni, O. and others, "Residues of organochlorine pesticides in human milk from mothers living in the greater Harare areas of Zimbabwe", *Central African Journal of Medicine*, May 1991, Vol 3, No 5

Endosulphan is a Category 1 (most toxic) pesticide, heavily restricted in developed countries, and poisonous to aquatic life, though its effects are temporary. A 1986 study in Zimbabwe found that some of the fish in shallower pools died within a day of spraying. Dragon-flies and water-beetles were severely affected and vanished almost completely for short periods.[31] Another study in northern Botswana, in the Ngamiland wetlands, found that endosulphan spraying killed one percent of the fish outright. Surviving fish had liver and brain damage for a month or more.[32] This caused hyperactive behaviour which attracted predators such as birds, and made it easy for the fish to be caught.

In areas where there is danger of poisoning water systems, pyrethroid is used instead of endosulphan because it is less toxic to aquatic life. Results are very encouraging, with adequate tsetse control and no fish kills.[33]

Cattle dips

Cattle dips create a localised environmental hazard. The chemicals are emptied into pits which slowly drain, contaminating groundwater. Oxpeckers (birds which eat ticks off livestock) have disappeared in some farming areas in Zambia because they eat ticks on cattle that have been dipped.[34] In Lesotho, dip-tanks located near rivers have killed fish downstream. Crocodile eggs in Zimbabwe have been found to contain toxaphene from cattle dips, but not at levels considered to be harmful. Some of Swaziland's rivers and streams have been polluted in the same way though the Veterinary Department has made strenuous efforts to substitute the toxic and persistent tick-killers containing arsenic with readily degradable amitraz (triatrix).

Herbicides

Herbicides (weed-killers) are another major group of pesticides. Sugar-cane estates and forestry plantations use large amounts of herbicides that are extremely toxic to most plants. The herbicide paraquat is extensively used in South Africa and Swaziland. Continued exposure is extremely dangerous to the lungs and can cause irreversible damage within months. It is also toxic to animals and is responsible worldwide for more poisonings than any other weed-killer.

Rain tested near sugar-cane estates outside Pietermaritzburg in South Africa was heavily contaminated with the herbicide 2,4-D (Dichlorophenoxy acetic acid). There was enough 2,4-D in the rain in 1987 to kill the nearby Tala Valley's crops a million times over. The rain also contained 10,000 times more of a related chemical, 2,4,5-T (Trichlorophenoxy acetic acid), than is allowed under American standards. Farmers in the *Natal Fresh Produce Growers Association* launched a lawsuit against 20 local and multinational chemical companies, seeking to halt the manufacture and sale of all such herbicides in the country, but the case was rejected on the grounds that it was the users' fault, not the manufacturers'.

Since then, the Department of Agriculture has agreed to ban the use of 2,4-D in the Tala Valley, pending investigation. In Natal province, people living downwind of sugar-cane estates frequently complain of asthma and chest ailments. Doctors routinely ascribe the symptoms to herbicide spraying.

Agent Orange, which was used during the Vietnam war to clear forests and plants, was made from dioxins containing 2,4-D and 2,4,5-T. It caused liver damage and severe birth defects in human infants.

In South Africa, the government states that the types of 2,4-D used today contain safe levels of dioxins. But birth defects have been linked to 2,4,5-T used to clean weeds out of forest plantations. More than 300 cases of deformities have been reported among children of people living or working in sprayed areas.[35] 2,4,5-T is no longer manufactured and its use will decline as stocks of the herbicide are used up, and possibly replaced by safer substitutes such as glyphosate.

Disposal of obsolete pesticide stocks

In much of the region, government facilities for pesticides are inadequate. There are reports of poorly fenced outdoor-storage areas and unventilated warehouses full of obsolete stocks and empty drums. Chemicals are often stored on the floor and not separated, creating a high likelihood of air and water pollution. In Mozambique, spilling and cross-mixing of pesticides stored together resulted in fires producing extremely toxic smoke.[36] Malawi has some 125 tonnes of obsolete DDT.[37] Zambia has also reported serious problems with storage and disposal of obsolete pesticides.

Fertilisers and manure

Use of too much nitrogen fertiliser pollutes soil, resulting in acidification which releases toxic substances into the soil, 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.

Excess nitrogen from fertilisers readily dissolves and moves down through the root zone into groundwater. High levels of nitrates in drinking water are a health hazard and are thought to cause miscarriages, and blood poisoning in young children, which can result in death.[38] Nitrate contamination of groundwater is also a problem where manure from cattle, pigs and chickens is allowed to pile up. In Botswana, cattle herds concentrating near water wells pose a serious threat to the limited groundwater resources.

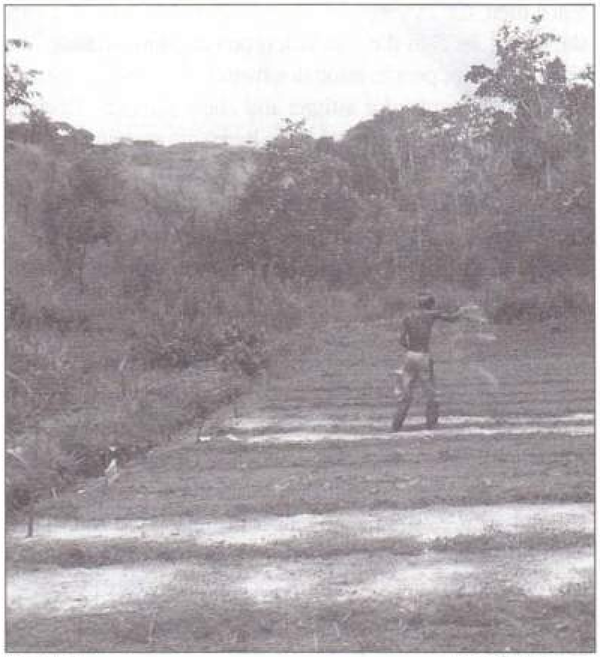


Photo 11.7 SPLASH-M Segerros

Excess use of fertilisers pollutes soil, resulting in acidification. Shown here, reclaimed wetlands in Angola.

When fertilisers are washed from crop lands together with eroded soil, nutrients are added to the water, increasing the overall impact of sedimentation. Growth of algae is stimulated by fertiliser nutrients such as nitrogen and phosphorus. When the excess algae dies, it rots and robs the water of oxygen, suffocating the fish and other aquatic life and producing putrid odours. Surviving species are restricted to the few that can tolerate nutrient-rich and oxygen-poor environments.

Irrigation

In dry areas, soil tends to become saltier with irrigation. This reduces its ability to hold the air, water and nutrients essential for plant growth, and makes it difficult for plants to take moisture in through their roots. After use, irrigation water runs into nearby surface waters, making them more salty. When the environment of fish and aquatic plants is polluted with salt, they become weaker and more vulnerable to other pollutants and disease.

Maputo's drinking water supply is contaminated by major sugar-cane estates upstream in Swaziland. Similarly, in parts of Zimbabwe's southeastern lowveld, water has become too salty to drink because of irrigation. The high amounts of fertilisers and pesticides used on irrigated estates also end up in the water.

Grass and forest fires

About half of southern African savanna woodlands are burnt every year, largely to stimulate new grass growth on grazing lands. This causes air pollution high above the earth, which builds up in the atmosphere for months or even years, and is detectable from space by satellite.[39]

Satellite images show a peak of burning in southern Africa in May, when fires are widespread — especially in Angola, Zambia and Zimbabwe. Through July to October, drier conditions extend eastward and fires increase in Tanzania and Mozambique.[40] Most of the fires are deliberately set to improve agricultural productivity and, once started, they are left to burn uncontrolled. Gases produced are found over the entire region, carried thousands of kilometres from their source by winds. At times, the cloud of pollution extends more than 3,000 km, stretching out over the South Atlantic.[41] The environmental impacts are not known, but are thought to cause local air pollution problems, influence weather patterns and contribute to global climatic change.

HAZARDOUS WASTES

There has been a great deal of interest in the issue of importation of hazardous substances to southern Africa. Manufacturers in industrialised countries are facing tougher and more expensive restrictions on local disposal of hazardous wastes. In the US, incineration costs as much as US$1,500 per tonne. In Europe, costs are even higher — more than US$2,000. In comparison, a World Bank survey found that the cost for toxic-waste storage facilities in West Africa is, at the most, US$50 per tonne. The issue is of grave concern, because southern African countries lack the facilities, regulations and safeguards necessary to handle such waste.[42]

South Africa's former homelands were a target for lucrative offers from foreign companies to accept shipments of toxic wastes, although most refused. Botswana, Mozambique and Zambia have each rejected overtures by Prodev, a South African waste-hauling company, to import and bury wastes. On offer are pesticides, industrial sludges (containing lead and heavy metals), asbestos and chlorine compounds. The Zimbabwe government has also spoken out against waste imports and rejected several offers.

Though there is not much evidence of widespread imports of hazardous wastes, hazardous substances are commonly imported into southern Africa for use in industry and agriculture. Lead nitrate, for example, is used in gold-mines with cyanide plants. About 60 tonnes a year is imported to Zimbabwe for this purpose. Botswana, Lesotho, Namibia and Swaziland obtain their pesticides mainly from South Africa, which has a functioning registration scheme for pesticides. This suggests a certain amount of protection against undesirable types of pesticides being imported. However, there have been allegations that leftover consignments of pesticides (almost expired, recently banned or restricted, etc.) have often found their way from South Africa to neighbouring countries.

The most notorious hazardous substance importer in the region is Thor Chemicals in South Africa, the world's largest mercury recycling plant. A US newspaper, the *St Louis Post-Dispatch,* investigating reports of pollution resulting from US waste shipments, found massive concentrations of mercury downstream of the plant in the Umgeweni river. Water samples contained more than 1,000 times the WHO standards for drinking water, among the highest levels of mercury pollution ever recorded. Subsequently, Greenpeace collected river sediment samples containing more than 8,000 times the amount necessary to classify it as a hazardous waste in the US.[43]

The stream is used locally for drinking and bathing, and further downstream joins to Umgeweni river which supplies drinking water to Durban and Pietermaritzburg. Mercury is extremely poisonous, attacking the central nervous system and the brain, causing seizures and eventually coma. Since the investigations, two former workers have died after long periods in a coma.

Four months after the newspaper's investigation, the Department of Water Affairs closed Thor Chemicals for four weeks due to "trouble controlling mercury in effluent" because of increased production and "recent heavy rains", causing the holding ponds of mercury-contaminated liquids to overflow. Subsequently, Thor was given a new license to continue its operations.

South Africa has now ratified the Basel Convention on hazardous waste which governs movements of dangerous waste products, requiring exporters to notify governments of any exporting or importing of the defined wastes. It has declared itself "off limits to waste imports".[44] However, South Africa's law does little to bar imports of the mercury waste recycled by Thor Chemicals because loopholes exist which allow the waste to be considered "raw materials" or materials to be recycled.

HOUSEHOLD POLLUTION SOURCES

Domestic wastes also pose major threats to human health. The fact that household pollution is produced by individuals may suggest that this should make it easier to control. In fact, the opposite is true, and many small sources of pollution are much more difficult to manage than a few single, large sources.

Many health problems in the region result from indoor pollution from cooking fires and coal stoves. Human waste can contain diseases such as hepatitis and cholera, micro-organisms and parasitic worms, organic matter and nutrients, and creates a major water pollution problem in southern Africa because most of it is untreated or inadequately treated. Poorly managed municipal rubbish dumps contaminate air and water, posing a health hazard to people living nearby. Vehicle exhaust can be a locally significant source of air pollution, especially in large cities with many poorly tuned vehicles. The problem of wastes produced by households is compounded by the addition of industrial wastes which often end up in the same poor management system.

Home heating and cooking

A majority of people in southern Africa use fuelwood, crop residues or manure, for home heating and cooking, and 20 million use coal. People who rely on these fuel sources and live in overcrowded conditions with poor ventilation have very high levels of poisonous and cancer-causing chemicals in their homes.[45] Long-term exposure to sulphur dioxide reduces the ability of the lungs to clean themselves and increases the incidence of coughs and colds, shortness of breath, and bronchitis and fatigue.

Levels of indoor pollution are of particular concern because that is where infants, the young and the elderly spend most of their time. Acute respiratory infections are a leading cause of death in South African children, killing 100 times more children than in western Europe.[46] One study, in the Vaal Triangle in South Africa, found that, on a typical winter weekend, residents of coal-burning areas were exposed to levels of pollution five times higher than the US standards. Carbon monoxide, which reduces the blood's ability to carry oxygen, in some cases is double the standard.[47]

Health problems are significantly worse among children exposed to wood smoke. In Zimbabwe, a study examining

Electrification Box 11.6

The high levels of inequality which characterise the South African political economy are reflected in its patterns of energy use. In spite of considerable overcapacity of electricity, two-thirds of South Africans do not have access to it. They rely instead on coal, wood and paraffin. Urban air quality is unhealthy as a result.

South Africa's electrical utility, ESKOM, says that 90 percent of low-income households must be electrified to achieve desirable standards of air quality. Increased electrification will require an increase in electricity generation, itself a polluting process, and ESKOM calculates there would be an overall decrease in sulphur dioxide, carbon dioxide and particulates, and a slight increase in nitrous oxides. The main benefit is the relocation of power generation from people's homes into centralised locations, where pollution can be more easily controlled.

Provision of electricity is not enough to reduce household coal-use on its own. Soweto's air pollution is more than twice as bad as any other place in South Africa even though three-quarters of the formal houses have been electrified since 1983. Use of coal and paraffin remains very high because most families are low-income and cannot afford electrical charges or appliances. Even those who own them tend to use them as a backup, for heating up the home quickly while the coal stove is started up.

SOURCES: Sithole, J.S. and others, *Soweto Air Monitoring: Project SAM*, NACA, Johannesburg, 1992
Van Horen, Clive and others, "Energy, Environment and Urban Poverty in South Africa", *Energy Policy*, May 1993, p. 623-639

the health of 244 young children with respiratory disease found very high smoke levels in their homes, from 13-50 times over the recommended limit, due to wood fires.[48]

Sewage

The high amounts of nutrients in human waste have serious environmental implications for the receiving water, and phosphate-containing detergents boost the nutrient content even more. The problem is similar to pollution of water with eroded soil and fertilisers, where much of the organic matter is consumed by bacteria. In this process, the oxygen in the water is exhausted. Anaerobic (non-oxygen-using) bacteria then take over and produce poisonous gases, such as methane and "rotten egg" hydrogen sulphide, completely upsetting the ecosystem.

Most coastal cities in the region discharge untreated sewage

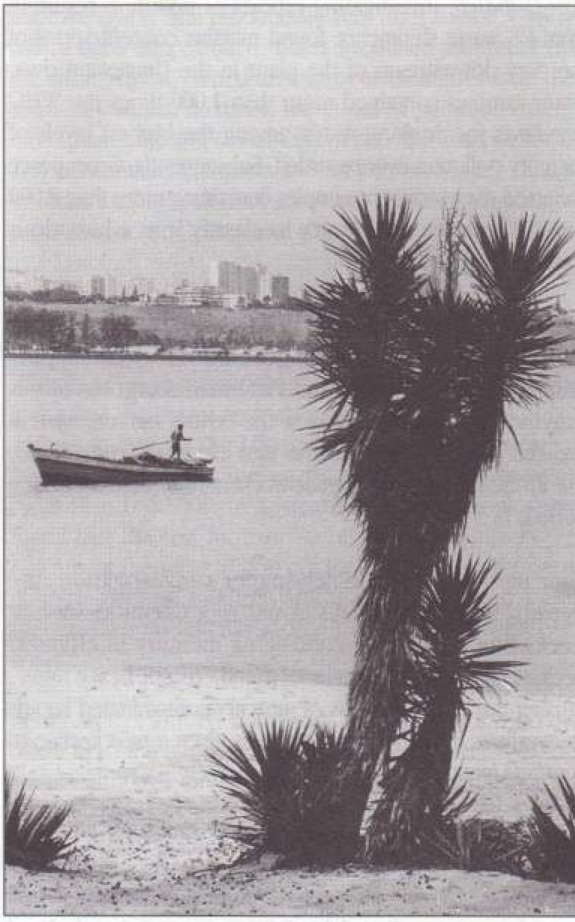


Photo 11.8 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO-R Rangel
Disposal of raw sewage into bays, such as Maputo, creates health hazards and damages marine habitats.

directly into the ocean. A cholera epidemic in Maputo in the mid-1980s, for example, was linked to the raw sewage disposal in Maputo bay where people fish and swim.[49] This discharge of sewage not only creates an environmental and health hazard, but represents an impoverishment of the region's natural-resource base as the nutrients nitrogen and phosphorous are removed from the land areas where they were produced and dumped permanently into the ocean.[50]

Major inland cities in the region do treat sewage before discharging it into the environment, usually with a series of "ponds" that allow solids to settle to the bottom. The solids are later landfilled, tens of millions of tonnes in the region every year. The effluent (water) is discharged into rivers or used to irrigate agricultural land. The effluent coming through this process is cleaner than raw sewage, but is still contaminated with nutrients and toxic substances. Some cities also provide secondary treatment so the water can be recycled and added to the drinking water supply. Bacteria are added to eat up the nutrients. Algae, chemical foams, filtering and chlorine improve the quality of the water even more.

In theory, this is adequate, but most of the region's sewage-treatment systems are overloaded. For example, Chitungwiza, a town 25 km east of Harare, has grown rapidly in the last decade and its sewage treatment system is under strain, handling about four times more sewage than it was originally designed for.

Sewage treatment works are also overburdened by toxic industrial effluents discharged into sewers. The sewage treatment process does not remove these types of poisons, which often interfere with the treatment process itself and kill the necessary bacteria. Tanneries, for example, use strong chemicals to treat hide and process it into leather. The Bata tannery in Zambia discharges effluents containing chromium in amounts slightly over a generous standard, chloride at 10

Making city water safe Box 11.7

Water containing industrial wastes, human wastes, chicken manure, rotting water hyacinth, among other things, is difficult and expensive to purify. Municipal waterworks have the job of making this "chemical soup" safe to drink.

Water-treatment plants are capable of producing very good water, but the quality of raw water is a critical factor. Some water-treatment plants add aluminium sulphate to the water to make it clear. When high pollution levels use up the water's oxygen, more alum must be added to get the same result. Some of the aluminium dissolves and remains in the drinking water, sometimes exceeding the recommended safe limits.

Chlorine is added to drinking water to disinfect it, but chlorine does not remove pesticides, or industrial poisons such as lead and cadmium.

The routine use of chlorine to purify water can be dangerous if the water supply is polluted. Adding chlorine to water containing a lot of organic matter produces cancer-causing substances (trihalomethanes and chlorobenzenes) some of which have been found in tap water in South Africa — at more than 700 times the guideline for drinking water in Europe. Many experts now believe there is no safe level for these chemicals.

Similarly, adding chlorine to water containing phenols, from pulp-and-paper mill waste, produces polychlorinated phenols which are cancer-causing, and kill plants and insects.

If discharge of industrial wastes into sewer systems continues unabated, water will become much more expensive to purify and, at the same time, unfit for use.

SOURCES: Bagg, W.K., "River Pollution in Harare", *Geographical Education Magazine*, Mar 1992, Vol 15, no 1, p. 7-15
Cock, Jacklyn and Eddie Koch, *Going Green: People, Politics and the Environment in South Africa*, Oxford University Press, Cape Town, 1991

times the allowed amount and almost four times the allowed sulphate.[51] Trace metals have destroyed the bacteria in Lusaka's sewerage works as well as in the receiving waters, with the result that there is no self-purification of the river.

Disposal of oils and fats into sewer systems can also be damaging. A film of oil on the water surface prevents the normal transfer of oxygen from air to water, which is necessary for effective sewage treatment. In Gaborone, Botswana, it was reported that the direct disposal of oil into the city sewerage caused problems at the water treatment plant resulting in offensive odours affecting nearby residential areas.

Where industrial effluents are treated in sewage treatment plants, the resulting effluent and sludge contain toxic substances. Some cities in the region use contaminated water from sewage treatment plants as a way to conserve water and dispose of the effluent. This can create more problems than it solves. Sodium derived from soaps and detergents has caused the salinisation of some agricultural soils. The discharge of sodium chloride (salt) from an abattoir near Masvingo in Zimbabwe came close to destroying a maize irrigation scheme in the early 1970s.[52] In South Africa, some 31,000 ha of land are irrigated with polluted water, and some 150,000-250,000 tonnes of contaminated sewage sludge are disposed of every year, much of it used on agricultural land, gardens and parks.[53]

Rubbish dumps

The standard of rubbish disposal throughout the region is poor, due to the high disposal costs.[54] Dumps are situated near residential areas and covered with soil infrequently, attracting vermin and leading to the spread of disease. Poisonous substances, such as pesticides, are often disposed of in municipal dumps without any special treatment, instead of being stored separately. Open burning of municipal and industrial wastes at dumps

Photo 11.9 SAMSO-E Alfonso

Many urban areas, particularly in Angola and Mozambique, have inadequate waste-disposal services.

Photo 11.10 SOUTHLIGHT-J Liebenberg

Poisonous substances are often disposed of at municipal rubbish dumps, such as this one at Windhoek. Burning dumps can produce dioxins and other contaminants.

Litter Box 11.8

Litter has not received much attention in the region, but it is a growing problem as economic development (and imports) increases the amount of packaging and plastics. Litter degrades slowly or not at all, and pieces of litter can entangle, or be swallowed by, birds, fish and other wildlife.

Throughout southern Africa there are reports of increased littering. An environmental profile of Namibia reported, "unsightly litter lying in the natural environment is an over-riding impression when travelling through Namibia." A review of waste-disposal problems in Botswana described the "indiscriminate littering" characterising Botswana's highways, streets and backyards — although soft-drink cans are often collected into neat piles along the main highway.

Lake Kariba, on the Zambia-Zimbabwe border, is also a victim of litter, mainly plastic bags and beer cans dropped by fishermen and visitors. In South Africa, there are more than 3,000 pieces of plastic in every square kilometre of coastal water, most of it dropped from fishing and pleasure boats, according to a 1991 report to the South African President's Council. This is almost twice as much litter as in 1984.

SOURCE: Jansson, Sven D.O., *Environmental Profile of Namibia: Report Prepared for the Swedish International Development Authority (SIDA)*, SIDA, Windhoek, Mar 1991

releases a complex mix of contaminants into the air together with the smoke and particulates. The health effects are unknown in southern Africa, but in other parts of the world burning dumps have been found to produce dioxins, one of the deadliest chemicals.

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, a special concern in this water-scarce region. A rubbish dump was purposely located in flooded sand pits in one country studied (although this has occurred in most countries in the region), with the intention of using the rubbish to fill up the pits. Officials are now becoming aware that such schemes are likely to pollute the area's drinking water.[55]

Another problem is that dangerous wastes are not always dumped in the "official" waste dump. 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.[56]

Vehicles

Fumes from trucks, buses and cars (petrol and diesel) contain particulates, nitrogen oxides, carbon monoxide and hydrocarbons. Diesel engines produce about 10 times more particulates than petrol engines. About half of total nitrogen oxide emissions are from motor vehicles. Carbon monoxide, a colourless, odourless gas produced mainly by vehicles, is one of the most widely distributed air pollutants. Hydrocarbons can damage plant growth and cause cancer.

Under the action of sunlight, these pollutants turn into ozone and smog (brownish haze). Ozone concentrations are frequently above South Africa's standards in Pretoria, Cape Town and Johannesburg (up to three times above the standard) and are clearly a hazard to health.[57] Ozone high in the atmosphere performs a protective role, filtering out harmful radiation from the sun, but at ground level ozone causes injury to plants. It also affects human health, causing headaches and nausea, eye, nose and throat irritation, and damage to lungs and other tissues.

There is still debate about the relationship between lead in petrol and lead poisoning in people. In some southern African countries, lead is added to petrol to increase mileage and prevent engine knock. About 70 percent of it is ejected from vehicles as tiny lead particles, which fall to the ground and contaminate soil within about 20 m of the road.

Studies in several parts of the region have reported high concentrations of lead in the air and soil beside busy roads. A South African study found that children attending school

Photo 11.11 SOUTHLIGHT-G Wolfson

Emissions from motor vehicles, seen here in Soweto, contribute to air pollution in cities and are detrimental to human health.

near industrial areas and busy roads had higher lead concentrations in their blood. Adults exposed to traffic exhaust, such as motor mechanics and particularly those who run regularly, had almost enough lead in their bodies to produce symptoms of lead poisoning. The effects of lead poisoning include anaemia, hyperactivity, miscarriages and stillbirths, and damage to nerves, brain and kidneys. Because of this, a Zimbabwean lead emissions study recommended that food should not be grown close to busy roads.[58] Low-income children who lack calcium and iron in their diets tend to be more affected by lead exposure than better-nourished children exposed to similar lead levels.[59]

Though it has not been conclusively proven that lead in fuel contributes substantially to lead levels in people, it is still a good idea to move toward eliminating lead from fuels so that vehicles can be fitted with catalytic converters, a small device which removes pollutants from exhausts very effectively.[60] Adding alcohol to petrol increases the potential for smog formation, but it can also replace lead as an octane booster (preventing engine knock). This is done in Zimbabwe and Malawi with ethanol produced as a by-product of sugar and molasses production.[61]

POLLUTION PATTERNS

Pollution levels in air and water fluctuate considerably through the day or over the course of a year, depending on emission rates and physical conditions. Dry and wet areas present different problems in terms of the types of pollution and the ways to manage it. Wet areas support more cultivation so have more pollution from agricultural chemicals. Dry areas have less water and have to safeguard their limited resources from pollution more carefully, but they also tend to have less industrial development and less cultivation — so there are fewer sources of pollution.

Water pollution

Southern Africa's rainfall is very seasonal. In the wet season, rivers can carry 50 times or more water than in the dry season. Because river flows change while most pollutants are produced in the same amounts year-round, the ability of rivers to dilute pollutants varies. This problem was noted in an environmental assessment of a pulp mill proposed for the Kigogo-Ruaha river in south-central Tanzania. The desired degree of effluent dilution could be achieved only during the wet season so the water would be safe to use for just a few months each year.[62] Similarly, the Black river flowing through Cape Town is 90 percent sewage during the winter.

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. For this reason, the Goreangab dam in Windhoek, Namibia, is so polluted that it cannot be used.[63] In a squatter settlement near Dar es Salaam, pit latrines pollute groundwater.[64] Septic tanks and pit latrines spilling polluted water into the streets and rivers are common sights in low-lying areas during the rainy season.

Coastal pollution

About three-quarters of the pollution in the sea emanates from land-based sources.[65] Coastal towns and cities in southern Africa discharge more than 850 million litres of industrial and human wastes into the sea every day through more than 80 pipelines, largely without any treatment. Generally, marine waste-disposal systems assume that pollutants will be carried far away, but in some cases this assumption is not true. Large discharges of wastes into the sea tend to be trapped near shore by waves and physical features such as sand spits or islands. In Mozambique, for example, discharges of wastes into the surf from Maputo have been seen spreading along the shoreline rather than dispersing.

"Stop polluting or get out of business" Story

Harare/Lusaka (SARDC) — Companies in urban centres still dump their wastes in prohibited areas, and often get away with it. Even when legislation is available, enforcement is lacking in most cases. The city of Bulawayo in Zimbabwe, for example, has only one trade-waste inspector and two assistants to cater for almost one million people.

Not surprisingly, a company whose pollution activities were noticed in 1987 was committed to trial six years later and fined a paltry Z$600 (then equivalent to US$100).

In some cases, however, courts in Zimbabwe have used their powers to control companies that continue to violate anti-pollution laws. One company cleaned up its act only after the High Court said "stop polluting or get out of business".

But heavy fines and adequate enforcement alone are not enough to discourage pollution. Zimbabwe's Minister of Environment and Tourism, Dr Herbert Murerwa, says companies need to be exposed to cleaner technologies, better waste-management and waste-disposal, through both market-based and legislative controls.

In Zambia, the 1992 Environmental Protection and Pollution Control Act now allows individuals interested in operating waste-disposal sites to apply for permits from local councils or the Ministry of Local Government and Housing.

Benson Chikalekale, a small-time transporter of waste in the Zambian Copperbelt city of Ndola, hopes to make even more money "now that I will have proper documents allowing me to engage in that business." Chikalekale is not alone. Another early application came from the Zambia Consolidated Copper Mines (ZCCM).

Unlike many environmental watchdogs, the National Environmental Management Council of Zambia (NEC) has real teeth, with powers to prosecute and jail senior managers and directors of companies for up to three years if they are found violating its regulations. NEC can also levy fines ranging from the equivalent of US$70 for careless disposal of radioactive pollutants up to US$285 for pesticide-waste dumping offences. In extreme cases, erring firms can be closed down.

The new law has put every chief executive on the alert. "I wouldn't like to go to jail on behalf of somebody ... this law makes everyone sit up," says Freddie Kambobe, Managing Director of Nitrogen Chemicals of Zambia, a fertiliser plant 50 km south of the capital, Lusaka.

Companies dealing in petroleum products, such as British Petroleum and others, will be allowed to operate their own dumpsites but NEC will collect samples for testing. Other operators are required to make reports every six months on the type of wastes they are handling and the volume handled.

The irony is that if the new law were to be implemented fully, 60 percent of industries would be closed down.

— **Emmanuel Koro and Katongo Chisupa,** Environment 2000/Environment Forum of Zambia, Harare/Lusaka, for SARDC, 1993

Air pollution

Southern African weather conditions often conspire to concentrate air pollutants in urban areas. In winter, Zimbabwe's capital, Harare, has air pollution levels exceeding WHO standards (up to 30 times higher than in farming areas 25 km away) because industrial air emissions cannot disperse.[66] Harare is not the only city with this problem. The central portion of southern Africa tends to have frequent temperature inversions (high layers of warm air trapping cooler air beneath) and stable, clear skies during the dry season. Pollutants build up over wide areas in Botswana, Lesotho, Namibia, South Africa and Zimbabwe because of poor air-circulation in winter.

Newer power-stations in South Africa have high smoke-stacks (almost one-third of a kilometre) designed to carry polluting gases above the inversion layer. Instead of being completely dispersed, the pollutants tend to accumulate in a high layer over a large area and travel as far as Mozambique, Swaziland and Lesotho.[67] The use of tall stacks has been quite successful in avoiding unacceptably high pollution-levels near the power plants. The result, however, is accumulations of pollution high up in the atmosphere, which may well transfer a local problem to one of regional consequence.[68]

A survey of trees in Swaziland, as well as Transvaal and Natal in South Africa, found many with yellowed and mottled needles. Researchers are investigating the possibility that these symptoms may result from air pollution.[69] Acid mists containing four times more acid than the local rainfall are common in the eastern Transvaal and nearby areas. Acid mist is potentially a serious problem for forests on mountains, where mist is more common than rain.[70]

Photo 11.12 SOUTHLIGHT-P Weinberg

Though taller smokestacks and higher plumes of smoke simply move the problem farther afield, they are often viewed as an alternative to reducing stack-emissions.

POLLUTION MANAGEMENT

While average pollution levels may not be alarming at national levels, there are localised pollution problems throughout the region. Most risk assessments ignore the fact that exposure to pollution is unequal.

Some intermediate steps may have the potential to protect the public and the environment. The first step 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.

The most desirable solution is preventing exposure in the first place. Farmers can be persuaded to reduce their use of pesticides, for example, with support to move toward integrated pest management which combines non-chemical methods of pest control, such as rotating crops, with selective use of chemicals. Implementing similar measures in industry is far more complicated, but many substitute chemicals and new processes are being introduced.[71]

In the past few years, in southern Africa as elsewhere, there has been more interest in pollution monitoring and in pollution as an issue. Governments are conducting surveys of industrial polluters to find out what toxins they are producing and how much. Pollution legislation is being enforced more, particularly in cases where public pressure has focused attention on the culprits. Not much can be done to eliminate the legacy of mining and hazardous dumps already peppering the region's rural areas and city margins. However, better controls being put in place now, together with a better-informed and more vocal public, should help mitigate the effects of future developments and improve the quality of sanitation systems and other infrastructure.

Linkages to other chapters Box 11.9

1 PEOPLE
People, their industries and their economic expansion are the main polluters, and people also bear the effects, along with plants, animals and other life-forms.

2 HISTORY
Industrial pollution, pesticides and acid rain are 20th century pollutants, without precedent in history.

3 POLICY
Pollution control has only recently become a policy priority for southern Africa and policy strategies are being revised to include information and technology, as well as penalties.

4 ECOZONES
The physical factors that determine the distribution of plants and wild animals — such as rainfall and soil types — also relate to the likely sources of pollution, and the path of pollutants once they enter the environment. However, pollution patterns are also determined by economic and other factors.

5 CLIMATE
Pollution levels in the region are related to weather patterns and extreme weather. Droughts and floods exacerbate the effects, making pollution more difficult to control.

6 SOILS
Pollution of soil and water results from over-use of fertilisers, causing acidification and chemical degradation of cultivated land. Irrigation can cause salinisation, a type of soil "pollution" affecting as much as half of irrigated lands in the region and reducing their productivity.

7 WOODLANDS
Forests and woodlands are affected by air and water quality. Acid rain, pesticides, defoliants and other chemicals have an adverse effect on plants.

8 WILDLIFE
Pollution is not a major problem affecting wildlife, though there are some localised problems in certain areas, and a few species (such as eagles and other birds of prey) have been affected over a widespread area.

9 FRESH WATER
Freshwater resources are threatened by pollution in some areas, as rivers and dams are used as dumps for sewage and wastes from industry and mines. Eroding soil is also a type of "pollutant" which changes wetland environments, choking fish and smothering aquatic plants, and reducing biodiversity by killing certain sensitive species. Pesticides and fertilisers carried into the water with eroded soil particles compound the damage.

10 MARINE
Marine areas are threatened in the same way as freshwater areas. Pollution from uncontrolled dumping of sewage and other wastes poisons marine environments and reduces species diversity.

12 ARMED CONFLICT
War in Angola and Mozambique has reduced agricultural and industrial production, and thus agricultural and industrial pollution. Pollution from human waste and rubbish has increased due to the concentration of people in areas with no sanitary facilities, and the breakdown in services such as water and sewage systems. In some cases, water supplies have been deliberately poisoned.

13 GLOBAL
Air pollution from burning of fossil fuels such as coal and petrol are the major contributors to global atmospheric changes, including global warming. Emissions from electric power stations, industries and mining consist largely of carbon dioxide, the main gas responsible.

14 TRENDS
Pollution awareness is increasing in most parts of the region, among all sectors of society, and controls and alternatives are being sought.

NOTES

CHAPTER 11

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12 ARMED CONFLICT and the Environment

When two elephants fight, the grass suffers, according to the old proverb. However, when people go to war, grass is not the only casualty. War destroys the environment directly and indirectly. The direct effects include fires, bombings, pollution from war chemicals, trenches, anti-personnel traps and the cutting down of trees to remove cover. Indirect effects include overexploitation of wildlife for food or cash, lack of management and law enforcement in protected and other areas, and refugees and displaced people who may cause localised environmental problems. More environmental damage has been caused by indirect effects of war than by direct destruction.

The main examples in southern Africa of the environmental effects of armed conflict result from the externally backed, post-independence civil wars in Angola and Mozambique. The conflicts in both countries have been long and intense. The environmental damage in those states, and in neighbouring countries such as Malawi, Zambia and Zimbabwe, has yet to be assessed fully. However, the economic and social damage has left people in Angola and Mozambique among the poorest in the world.

Some of the difficulties encountered in assessing the environmental impact of armed conflict are:

- a general lack of verified data on the impacts of war;
- the very limited data on the natural resource base prior to conflict or after war to provide a basis for comparison (particularly in Angola and Mozambique);
- the emotiveness of the subject, as well as political connotations, which hamper objective analysis; and
- the difficulties of distinguishing war-related environmental impacts from those that are economic, social or political.[1]

POLITICS AND ENVIRONMENT

All sides to a conflict contribute toward environmental damage during war. In some cases, they use environmental destruction as a propaganda tool to discredit each other. In southern Africa, however, most of the damage, particularly to large animal species, has been committed by post-independence rebel movements in Angola and Mozambique through poaching syndicates in South Africa, often involving the military.

Origins of armed conflict

The origins of conflicts in this region can be divided into four main categories:

- liberation wars in pursuit of independence from colonial powers or settler regimes. A number of countries in the region — Angola, Mozambique, Namibia, South Africa and Zimbabwe — experienced liberation wars during the last three decades;
- civil/regional conflicts inflamed by superpower rivalry, particularly in Angola and Mozambique. Both countries have known little peace since independence from Portugal in 1975;
- South African aggression and destabilisation strategy against virtually all independent states in the region — Angola, Botswana, Lesotho, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe; and
- internal dissent/social movements to promote free-mar-

ket economies and multi-party politics, or to protest against economic structural adjustment While this does not compare in extent and impact to the other three, it nevertheless contains the seeds of armed conflict.[2] Political instability due to economic and social tensions resulted in the state using armed force to control dissent — in a limited manner in Zambia (1991) and Malawi (1992-93), and a widespread military response in South Africa (1976-94).

Zimbabwe had limited or very localised impacts on the environment in those countries. During Zimbabwe's war of liberation, the guerrillas linked political and military strategies with spiritual and social components relating to the environment. It was taboo for the fighters to kill some types of wild animals because they were sacred and protected the freedom fighters from harm. The animals were believed to have a spiritual connection with the ancestors as guardians of the land and its resources. The combatants in Mozambique and Zimbabwe operated under codes of conduct that included penalties for mistreatment of the natural environment.

Photo 12.1 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO-R Rangel
Bridge in Mozambique destroyed by Rhodesian security forces during Zimbabwe liberation war.

Photo 12.2 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO-Luc
Bus destroyed by Renamo during post-independence conflict in Mozambique.

Colonialism and wars of liberation

The issue of land and its distribution was a major catalyst in the launching of liberation wars in southern Africa. South Africa's *apartheid* system, which marginalised the black majority in unproductive areas, provides an example of colonial or settler government policies that triggered a liberation war.

While the South African conflict had little direct impact on the environment, *apartheid* itself created severe imbalances in the distribution of natural resources among South Africans. Blacks, who make up 87 percent of the population, have been confined to a mere 13 percent of land, which constituted the homelands. This tightened the limited access to land, water, fisheries and wildlife by the majority, leading to human and livestock overpopulation. The consequent resource degradation, deforestation and soil erosion will remain, for generations, the worst environmental monuments of *apartheid*.

The liberation wars in Angola, Mozambique, Namibia and

During the liberation wars, combatants were fed by villagers or they slaughtered domestic animals, so there was little need to poach wild animals for the pot. Armaments and training were provided as an aspect of the "Cold War" between the United States, the Soviet Union and China, so there was little need to sell wildlife products to pay for weapons, as was the case later in Angola.

Some actions taken by the minority Rhodesian Front (RF) regime contributed to environmental damage in Zimbabwe. The then government created the so-called protected villages (PVs) or *keeps* in 1973 to stop rural people from interacting with the fighters.[3] Rural farmers were driven into 232 *keeps* scattered around the country; and each fenced area held up to 6,000 people. Each family was allocated a plot of 15 square metres (sq m) not only to live on but also to cut poles and grass to build huts.[4] The impact on the environment was localised but severe in some areas.

South African destabilisation

The perceived threat of a communist onslaught, after some neighbouring countries gained independence, led South Africa to start a military offensive of armed intervention and destabilisation in those countries. The aim was to destroy facilities of the anti-*apartheid* movements — the African National Congress (ANC) and the Pan Africanist Congress (PAC) — and to weaken the resolve of neighbouring states to support the anti-*apartheid* struggle by destroying their socio-economic infrastructure.

During the period of direct South African Defence Force (SADF) military activity in the region, 1976-89, over 1.5 million people died from war-related causes, according to a United Nations report. The report estimates that South Africa's destabilisation cost the countries of the region over US$60 billion,[5] through damage and lost Gross Domestic Product (GDP). A report presented to Commonwealth foreign ministers in 1989 calculated the direct cost alone at US$45 billion and said:

> "The full cost to the region may never be known. It is an accumulation over the past 13 years of war damage, extra defence expenditure, higher transport and energy costs, lost export revenue, greater import costs, lost production and reduced economic growth, the displacement of people, destruction of rural environment and infrastructure, even smuggling. The implications for the future, in terms of the health and educational impact on the youth and the cost of economic recovery, are unquantifiable."[6]

The countries of the region increased their defence budgets in this period. The slice of the national budgets allocated to defence far exceeded the internationally recommended five percent. Countries in the region spent between 4-46 percent of their annual national budgets on defence.[7] During the decade 1978-88, Angola spent an average of US$1.2 billion a year on arms. Its defence allocation ranged from 28.6-45.8 percent of its annual national budget in the 1980s.[8] In 1990 alone, countries in the region spent US$5.2 billion on defence.

Post-independence civil wars

In three countries of the region — Angola, Mozambique and Zimbabwe — the post-independence period witnessed the continuation of sporadic armed conflict due to ethnic, regional or ideological differences. While Zimbabwe managed to resolve its internal problems in the late 1980s, armed conflict in Angola and Mozambique escalated into full-scale civil wars. The war impoverished Mozambique, leaving it one of the poorest countries in the world. Conservation programmes suffered as only 200 staff were employed to manage 85,000 sq km of protected areas. In Angola, the government could allocate only US$20,000 a year for conservation programmes.

The Bicesse Accord brought peace to Angola for 16 months from June 1991 to October 1992, with nominal monitoring by the United Nations. The National Union for the Total Independence of Angola (Unita) returned to war after the government won parliamentary elections which were monitored by all political parties and the international community — and declared "free and fair". In Mozambique, a ceasefire was signed in October 1992 after more than two years of negotiations, and national elections set for October 1994.

Nature of armed conflict

The relationship between armed conflict and the environment, and the degree of impact, depends to a large extent upon the type and duration of the conflict. In southern Africa, the nature and duration of armed conflict varied widely. Even within a single country, the type of conflict can change, with two or more distinct periods of conflict. Generally, armed conflict in southern African has occurred at three levels:

- high intensity and long duration, greater environmental impact. Two countries — Angola and Mozambique — have experienced lengthy periods of conflict, first during the struggle for independence from Portuguese colonial rule and then the wars fanned by superpower rivalry and South African destabilisation.
- low intensity, less environmental impact. Namibia, South Africa and Zimbabwe have experienced low intensity armed conflict, which has generally been less wide spread in its impacts. For example, in Namibia, the armed conflict was largely restricted to the narrow northern belt or was fought in southern Angola.
- indirect impact of armed conflict with both long and short durations. Botswana, Lesotho, Malawi, Swaziland, Tanzania and Zambia were not involved in any significant armed conflict for independence. But they have all been affected by armed conflict in neighbouring countries, including the influx of refugees.[9]

DIRECT IMPACTS OF WAR

Manufacture of arms and equipment

Companies that manufacture military equipment pollute the environment through toxic and radioactive substances generated during the production of weapons. One example is the Kogelberg reserve in South Africa where the testing of missile fuel leaves residues that contaminate the water. The Atomic Energy Corporation of South Africa caused a huge spill of between 80,000-100,000 tonnes of caustic soda near Haartebeesport Dam in November 1991, killing fish and aquatic animals in the Moganwe Spruit.

Armscor, South Africa's major weapons manufacturer, first tested a 450-kg aerial cluster-bomb in 1985, releasing hundreds of small anti-personnel munitions to blanket an area of several hectares. Armscor has also been taken to court for noise pollution by Rooi Els residents.[10]

Installations and training

In some countries, the military consumes large tracts of valuable land, mostly for infrastructure and training. In South Africa, the military is the fourth largest land-controlling authority in the country and manages 60 facilities covering 600,000 hectares (ha). The land is for munitions depots, shooting and bombing ranges, and weapons testing.[11]

At least two nature reserves have been used by the SADF as missile-testing sites. Mock bombing raids kill plants and animals on and around the bombed areas. Military aircraft and other vehicles used during training consume a lot of oil and fuel, releasing pollutants into the air.

Even well-planned military training can go wrong, causing serious damage to the environment, as happened in South Africa in 1991. A rocket launched in Natal caused a huge fire that raged through St Lucia Wetlands Park, seriously damaging a wetland of international significance.[12] Also in 1991, the SADF handed back to the Natal Parks Board an environmentally damaged 72,000 ha piece of land at St Lucia which had been used as a weapons-testing ground since 1968. De Hoop Nature Reserve in the Western Cape was also used to test ballistic missiles with disastrous effects on plants and animals.

The 7,900 sq km Bikuar National Park in Angola's southern province of Huila has been used for military training, resulting in some habitat destruction.[13] Roads and buildings in the park have also been destroyed. The establishment of a military airbase in Kisama National Park drew thousands of people into the area, resulting in excessive hunting, tree-felling and damage to vegetation.

Weapons of destruction

Tanks and long-range artillery

During the mid-to-late 1980s, southern Angola became a theatre of destruction in which the superpowers tested their most sophisticated weaponry. South Africa began systematic use of armoured vehicles and the G-5/G-6 long-range artillery which could fire farther than any other gun in use. Unita began using US-supplied, shoulder-fired, surface-to-air Stinger missiles. The Soviet Union threw into combat surface-to-air and anti-tank missiles, and new helicopter gunships equipped with rockets and cannons.

The *Weekly Mail* newspaper in South Africa reported in 1990 that:

> "Just outside Mavinga in the south-east of Angola, the dry forest gives way to what appears, at first glance, to be a huge deserted building site. The few trees left standing have been reduced to burnt stumps and the sand below has been churned up into a maze of trenches and earthworks. In place of cranes and bulldozers, however, the landscape is littered with the wreckage from tanks, armoured cars and countless other pieces of military hardware."

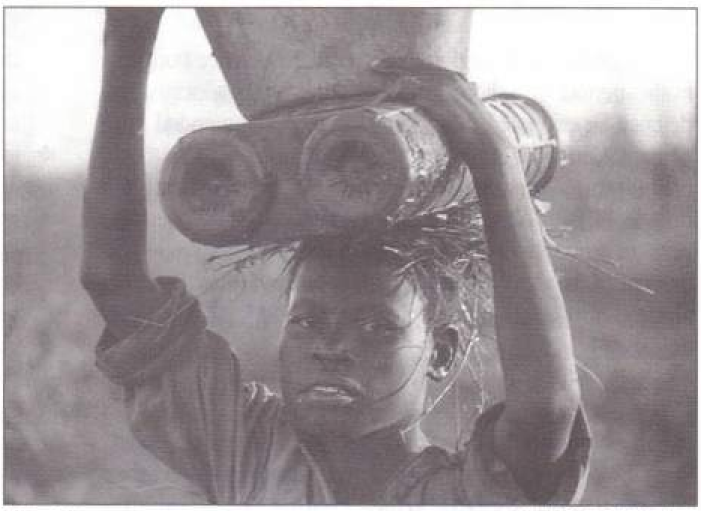

Photo 12.3 SOUTHLIGHT-J Liebenberg

Plastic mortar holder used by SADF, now a water container for a civilian in southeastern Angola.

Junk Box 12.1

Scrap metal is one of Angola's more important products. During the height of the war years, about 10,000 tonnes were added each year to the stock of scrap metal in the southwestern provinces alone. Overall, the country has generated about 50,000 tonnes of scrap metal a year — most of it in destroyed or abandoned vehicles. By 1990, as much as half-a-million tonnes of scrap metal may have accumulated, most of it in the vehicle graveyards of the two armed forces — government and Unita.

Angolan junk is described by UN experts as "rich in non-ferrous metals (aluminium, lead and copper), civil construction materials (tubes, different kinds of metal sheet, shaped metals), car engines, alloyed steel parts and other different equipment for second-hand utilisation."

At present Angola's sixth-ranking export is metallic junk. In 1990, it earned almost US$6 million — far more than coffee exports. Scrap processors supplied the national steelworks with almost all its raw material.

The Angolan defence ministry's scrap metal company, which possesses most of the nation's reserves of junk, announced in March 1992 that it was to form a joint venture with a South African firm to compress and ship to South Africa tonnes of scrap metal in the years ahead.

SOURCE: Sogge, D., *Sustainable Peace: Angola's Recovery*, SARDC, Harare, 1992

These high-technology, high-casualty battles marked a turning point in regional relations that eventually led to independence for Namibia in 1991 and democratic elections in South Africa in 1994.

Landmines

Anti-personnel landmines sown in the soil of rural Angola have made casualties of its people, domestic animals and wildlife. Landmines have given Angola the dubious title of having the highest per capita number of amputees in the world. Angola's estimated population of just over 10 million in 1990 included up to 70,000 amputees,[14] the majority of them landmine victims. According to the British military mission in Angola, 20 million landmines are scattered over one-third of the country. About 330,000 of them litter the municipality of Cuito Cuanavale in the southern province of Cuando Cubango, site of the fiercest and most prolonged confrontation with the SADF.

In Namibia, people and animals are still dying as a result of landmines planted by the SADF during the war of independence which ended in 1989. Wild animals have been blasted to pieces, as well as cattle, goats, donkeys and sheep, making people who are dependent on livestock poorer.[15] This is also the case in Mozambique, and to a lesser extent in Zimbabwe, due to landmines sown by the settler governments during the struggle for independence and by the post-independence Renamo war in Mozambique.

Other explosives

Explosives have been used for sabotage in many parts of the region, almost entirely for covert actions by the previous South African regime. The main target was communications infrastructure, which was extensively damaged in Angola and Mozambique.

In the mid-1980s, South African military frogmen sabotaged ships docked at the port of Namibe. The Angolan military detonated explosives underwater to deter the saboteurs.[16] The result was not only the complete disappearance of fish from the bay but also the destruction of the livelihood of many Angolan fishermen. The return of the fish, and the restoration of breeding areas in the bay, may take years.

Chemical warfare

Chemicals have been used in both Angola and Mozambique, but the impact on trees and other forms of life has not yet been assessed. A 1992 report by the World Conservation Union (IUCN) says the SADF used chemical defoliants in Angola, Mozambique and Namibia. These impacted on plant and animal life but the extent of the damage is largely unknown.

There are also reports of chemical weapons being used by the Mozambique National Resistance (Renamo), and sub-

Photo 12.4 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO
Train derailed by explosives in Niassa province in northern Mozambique, 1986.

stance samples were sent for analysis after one incident in a remote part of Gaza province near the South African border in which victims suffered severe burns.[17] In January 1992, two Mozambican soldiers said from their hospital beds in Maputo that they had been attacked with chemicals. They said a "projectile exploded in the air, releasing a dense cloud of black smoke which provoked severe pain and irritation." A subsequent report said at least 20 government soldiers were killed by the fumes and 10 seriously injured. The ecological consequences are yet to be assessed.

Paying for arms

The words inscribed on the souvenir in a little museum in George, in the Cape, appear harmless: "*From Unita to H.E. the Prime Minister of the Republic of South Africa P.W. Botha with respect*." But the carved ivory souvenir — an AK47 machine-gun — given to the then South African prime minister (later first president) is a perverse symbol of the relationship which existed between *apartheid* South Africa and Jonas Savimbi's Unita for the past two decades.

In 1980, Savimbi made a public declaration of wildlife conservation in areas under his control, prohibiting the killing of elephants. When asked about the source of ivory his men possessed at that time, Savimbi said it was from old stock that villagers had exchanged for food. Eight years later, however, he admitted in an interview with the French magazine *Paris Match* that South African military assistance had to be paid for with ivory and teak.[18]

A US Congressional sub-committee hearing was told in 1988 that tens of thousands of elephants were slaughtered by Unita forces in southern Angola to pay for military assistance provided by the SADF. In Mozambique, about 65,000 elephants roamed its forests and savannas at independence in 1975, according to the Environmental Investigation Agency (EIA). EIA estimates that more than 50,000 elephants have been slaughtered over the past two decades. However, other sources say the population was cut in half from 30,000 in 1979 to 13,350 in 1987. Evidence captured by the Mozambican army from Renamo indicates that the slaughter was perpetrated on a massive scale to help South Africa fund Renamo and Unita.[19]

According to a US Defence Department Intelligence Agency report, as recently as February 1991 South Africa was supplying arms and ammunition to Renamo in southern Mozambique, in exchange for ivory. The report quotes a Renamo defector as saying he "was often asked to go into a huge area with lots of elephants to kill the elephants for their tusks, (which were) brought to a camp near the border, where the tusks were given to a group of whites ...."[20] Former members of Renamo report that South African planes left rebel bases with "ivory, precious stones and timber."

Namibia also experienced poaching during its struggle against South Africa's illegal occupation. In 1970, Kaokaveld had about 1,000 elephants, 100 black rhino and up to 10,000 springbok. It was also home to lion, hyena and zebra. By 1983, only 360 elephants, 55 black rhino and 1,000 springbok remained, largely due to poaching by the SADF and, to an extent, by locals.[21] The population of other mammals also fell dramatically.

One of South Africa's most decorated officers, Col Jan Breytenbach (Rtd), said he discovered his country's complicity in the illegal ivory trade by accident. A keen environmentalist, he blew the whistle on his military intelligence bosses after he got evidence that they were involved in smuggling ivory from Angola and Mozambique. "My former bosses in military intelligence were deeply involved in large-scale

Protected areas left unprotected Box 12.2

Decades-long armed conflicts have left many of the region's wildlife protected areas unprotected and at the mercy of poachers, many of them with international connections.

The worst damage has been in Angola and Mozambique where wildlife populations in protected areas have been killed both for meat and to finance the war. In Angola, estimates indicate that declines of up to 90 percent occurred in the large mammal populations in protected areas between the mid-1970s and 1992. Organised wildlife harvesting and trading seem to have been a particular aspect of the late 1970s to early 1980s period of Unita's development, before it gained access to more lucrative sources of income, such as diamonds from northern Angola, and large-scale funding support from western powers.

Kisama National Park near the Angolan capital, Luanda, has been under particular pressure from armed forces based in the capital and in the park area as a centre for sport-hunting and a source of meat. The wildlife population is now dramatically reduced and no wildlife staff have been effectively deployed there for more than a decade. During the war, a large military airbase was established in the park, resulting in 10,000 people moving into the area. The infrastructure of the park has largely been destroyed and the park is in a critical state.

In Mozambique, government troops took over a large chunk of Zinave National Park (which borders the Save river along whose banks the majority of the wildlife was concentrated) and set up meat-processing centres. The infrastructure of the park headquarters was destroyed and the staff forced to evacuate during the 1980s. The results of intensive hunting (facilitated by the limited water points for wildlife) almost wiped out large animals in the park.

Another national park in Mozambique, Gorongosa, was taken over by Renamo before the rebels were routed by government troops in 1991. The Gorongosa area was selected as a base because of significant wildlife populations, a ready source of meat.

A South African newspaper, the *Weekly Mail*, reported that its staff had seen film footage showing Renamo rebels hawking ivory tusks across the electrified fence that separates southern Mozambique from South Africa — in full view of a SADF platoon. In South Africa itself, reports say game reserves have been used by the SADF for the secret training of special forces in terrorist tactics.

SOURCES: Dutton P., "Wildlife Victims of Mozambique's War", *African Wildlife*, Mar/Apr 1992, Vol 46, no 2, p. 65-69
Green, R., and others, *South African Destabilisation*, United Nations Inter-Agency Task Force and UNECA, New York, 1989

slaughter of elephants and the rhino. ... I started investigating these things, then I discovered this pipeline (through which ivory was smuggled to South Africa) which I did not know about. It was established through military intelligence.

"The trucks that went up with equipment usually came back with ivory, rhino horn and wood. We were not allowed to search them," says Breytenbach.[22]

He said the pipeline involved front companies set up by the SADF to hide its involvement in the shipping of weapons and ivory. "This InterFrama was actually the pipeline established with money from military intelligence. That I know, it's a fact."[23]

A secret 10-month investigation by the US attorney-general's office confirmed that members of SADF in Angola and

Namibia were "actively engaged in killing and smuggling of wildlife species — including rhinos and elephants — for personal gain and profit."[24] Two SADF members, Marius Meiring and Walter Schutte, were convicted in the US for attempting to bring in 100 rhino horns.[25]

The Endangered Wildlife Trust in Johannesburg revealed a South African network of illegal trade in ivory in 1988. Of the 50 tonnes of elephant tusks that originated in South Africa that year, official records accounted for less than 30 percent as legal exports (seven tonnes from elephants culled in Kruger National Park and seven tonnes of legal imports from other countries). It is reasonable to count the excess of 36 tonnes as smuggled from neighbouring countries.[26]

South Africa was also revealed as the major source of ivory sold in Taiwan. An official of the Trust, writing in the conservation magazine *Quagga*, said, "A number of discoveries have made it clear that South Africa is guilty of harbouring some big-time criminals who have been making a huge profit by dealing in rhino horn and ivory."

In southeast Angola, trees have been cut down to facilitate war. Many were burnt, others uprooted to construct roads for military vehicles, and others deliberately felled. Teak — a valuable hardwood which flourishes in the area — attracted suppliers of military equipment to accept it as barter, instead of cash, from Unita. According to the Commonwealth report on destabilisation, US satellite pictures in the 1980s showed the shrinking area of teak forests.

More recently, there has been uncontrolled exploitation and smuggling of diamonds from Unita-controlled areas to pay for weapons and fuel to sustain their post-elections conflict.

INDIRECT IMPACTS OF WAR

Most of the indirect impacts of armed conflict on the environment in southern Africa result from instability caused or aggravated by war. Many of these impacts are not unique to armed conflict but are a feature of instability — whether it is economic, social or armed conflict. The environmental degradation surrounding cities such as Dar es Salaam or Lusaka is not necessarily distinguishable from that of Luanda or Maputo. Both are a result of instability, but the former cases are economic while the latter are exacerbated by armed conflict.

Displaced people and refugees

The displacement and subsequent haphazard settlement of people is probably the major impact of war on the environment. By the end of the 1980s, southern Africa had more than 2.5 million refugees — mostly Angolans and Mozambicans. Another 4.5 million were displaced in their own countries.[27] The areas that hosted war refugees often had their carrying capacity exceeded, usually with negative effects on the environment. Some refugees made the situation worse by taking their livestock and overgrazing the areas in which they settled.

The type and extent of impact which displaced people can have on the environment depends on their number and duration of stay in a particular area. Generally, if large numbers settle in a small area, they cause more damage than fewer people spread over a large area. Some development officers say once the newcomers make up 10 percent or more of the host population, as happened in Malawi, they constitute too large a number. The longer they stay, the more they overuse the environment.

Paradoxically, a regeneration of natural vegetation occurs in areas depopulated as a result of armed conflict because there is very little or no agricultural activity. Reduced pressure on trees for fuelwood also favours the recovery of forests and woodlands. Wild animals in the deserted areas may also increase because there are no people to hunt them. In southern Angola, where cattle have been decimated by war, the problem of bush encroachment — common in neighbouring Namibia — does not occur.[28]

Photo 12.5 AGENCIA DE FOTOGRAFIA E AUDIO, LUANDA

Millions of Angolans and Mozambicans have been displaced within and outside their countries in the past decade.

Refugees in Malawi Box 12.3

The most obvious environmental effect of the hosting of over one million Mozambican refugees in Malawi is deforestation, especially in Dedza, Ntchetu, Mlanje and Nsanje districts in the southern part of the country. Expanding subsistence cultivation and collection of fuelwood has resulted in the clearance of about 2,500 hectares of Malawian forest annually.

Deforestation does more than just affect the availability of firewood. Once land is cleared, cultivation and overgrazing can lead to soil erosion which in turn reduces the ability of land to support plants. This makes people who are dependent on the land poorer as agricultural yields fall. The resultant poverty increases environmental degradation as people cut more trees both for their own use and for sale. An Oxford University study of Malawi says the effects of deforestation include, "... the loss of large varieties of woodland products including honey, wild fruits, construction timber, medicinal plants, fodder for livestock, and bark fibre."

Mozambican refugees in Malawi are so hard-pressed for fuelwood that they often collect maize stalks and other crop residues for fire, depriving the land of essential nutrients and organic matter and leaving it more prone to soil erosion. Agricultural yields fall and this may increase the need to put more land under cultivation, opening more land to degradation and removing habitat for plant and animal life.

Due to population pressure, made worse by refugees, Malawi is facing other problems with its environment. Wildlife is being overexploited in the southern districts, especially near refugee camps. Some camps such, as Nyamithuthu and Chifunga, do not have adequate water supplies, creating hygiene problems. The disposal of domestic and human wastes is difficult due to lack of transport and proper dumping sites. These conditions are conducive to cholera and diarrhoea outbreaks. Inadequate drainage also causes pollutants to accumulate, increasing the severity of pollution.

In another area, refugees established homes and gardens on seasonal swamps, exposing the sensitive wetlands to damage. The area dries up and is prone to erosion if more than a third of it is cultivated. This reduces water supplies for both people and animals. However, measures are being taken in Malawi to stop and correct negative environmental effects caused by refugees. Organisations have tried to protect the environment from unsustainable refugee activities by providing food (so less land is cleared for agriculture), latrines, environmental education, reclamation of degraded lands, and reforestation programmes.

International organisations such as the United Nations High Commission for Refugees (UNHCR), and the United Nations Development Programme (UNDP) have assisted by funding reforestation programmes. Some 10,000 ha have already been earmarked for tree planting. In addition, UNDP and the European Community are providing 34,000 stoves to refugees in Malawi to reduce the felling of trees.

SOURCE: Black, R., *Refugees and Environmental Change: Global Issues*, King's College, London, 1993
Schellenberg, W., "Impacts of Refugees in Malawi", for SARDC, 1993

The destruction of infrastructure in war zones and lack of means to market resources also help to scale down the exploitation of natural resources. This is just the opposite of areas in which displaced people resettle. When refugees are settled in areas of low population they tend to benefit the area by increasing agricultural productivity.

Types of settlements

There are different types of refugee settlements. Some refugees are placed in camps, others in planned settlements and yet others in "dispersed" settlements.[29]

Those in camps rely on external aid for survival and do not put much pressure on local resources, except for firewood and material for construction. But often this is not enough and refugees are forced to exploit the immediate environment. There is evidence of this in different countries in the region, which have hosted refugees over the past three decades.

Major refugee-settlement areas in 1993 — Table 12.1

Host country	Region	Country of origin	No. of refugees
Malawi	Southern province	Mozambique	1,070,000
Tanzania	Kigoma (NW)	Burundi	143,000
Tanzania	Ruvuma (S)	Mozambique	72,000
Zaire	Shaba	Angola	180,000
Zambia	NW Province	Angola	118,000
Zimbabwe	Manicaland (E)	Mozambique	264,000

SOURCE: USCR, 1993 in Black, R., *Refugees and Environmental Change: Global Issues*, King's College, London, 1993

The 264,000 Mozambican refugees who lived in Zimbabwe were placed in five camps,[30] which eventually became too small in terms of space and of local resources for thatching huts and fuelwood. The signature of refugee activities is today conspicuous around the camps, which are surrounded by land cleared of trees.

In planned settlements, there is a greater potential to degrade the environment, through cultivation. The dispersed refugees can cause even more damage as they are heavily dependent on the environment through cultivation, livestock-grazing and other activities. Resource use is more easily controlled in planned settlements, however, than in dispersed settlements.

Temporary tenants

Refugees' destinations are not always pre-determined, because their departure is forced and often abrupt. Sometimes they move into areas which are already overpopulated, making the problem worse.[31] In other instances, they settle in areas of low population but high ecosystem fragility, posing immediate environmental problems. The environmental degradation caused by refugees can be attributed to:

- an accelerated people-to-resources ratio;
- poverty, leading to severe resource exploitation; and
- lack of awareness of the local traditional practices which can make resource use sustainable.

Living under emergency conditions, refugees in neighbouring countries and people who are displaced within their own country have little time to adopt ecologically and socially sustainable methods. They are less inclined to utilise the environment with an eye to the future because their stay is usually temporary. They live for today and not for tomorrow. A study in one area revealed that people who previously lived in lowland areas caused severe environmental degradation when they sought refuge in mountains.[32]

In Mozambique, 3.5 million of the people who abandoned their homes because of the war remained displaced within their own country, most of them resettled in urban areas such as Maputo and Beira. Some went to live in the Beira Corridor (an area around the main road, railway and oil pipeline between the port city and Zimbabwe) because of the protection offered by soldiers who guarded it from rebel attacks. Other displaced people left for coastal areas and islands. At one stage, 75 percent of Mozambicans lived along the fragile coastal zone — which is 50 km wide. It had an average density of 120 people/sq km. This movement of people was not planned and often the settlers were not familiar with the environments in which they sought refuge. A whole village of people who moved 400 km in Mozambique's Zambezia province (from inland to a coastal area near the

Causes of degradation in refugee areas — Table12.2

Host region	Deforestation	Overgrazing	Agriculture
Tanzania (NW)	yes	some	yes
Zambia (NW)	yes	some	-
Zimbabwe (E)	some	some	some
Malawi	yes	-	yes

SOURCE: UNEP, 1992 in Black, R., *Refugees and Environmental Change: Global Issues*, King's College, London,

capital, Quelimane) found themselves in a wet, rice-growing zone. The newcomers were dryland maize-cultivators.

In Maputo, there were three times more people by 1992 than the city could support, resulting in sewage and pollution problems. In a 75 km radius, big trees have almost vanished around the city. They were cut down mostly to clear land for cultivation and to meet the swelling demand for fuelwood caused by the influx of people, the majority of whom could not afford electricity for heating and cooking. The city now empties tonnes of partially treated human waste into Maputo bay because the sewage facilities are literally bursting. This has resulted in localised but severe pollution.

Rural-urban migration in Angola has seen people fleeing strife-torn rural areas inland to coastal and urban areas, resulting in localised pollution and excessive deforestation in those areas. Marine pollution in and around major cities has, in some cases, reached toxic levels. For example, untreated industrial wastes are being pumped into the Bay of Luanda, resulting in bacterial contamination.[35] Over two million displaced people now live in coastal and urban areas. Less that six percent of Angolans lived in urban areas in 1950, yet today the majority of the 10 million people live in towns and cities. The National Institute of Statistics estimated in 1987 that the growth rate of Angola's urban population between 1990-2000 will be 5.5 percent per year compared to only one percent for rural areas.

Luanda, Angola's capital city, was built for 500,000 people, but the population has increased to about three million over the years and has the highest population density in Angola — 500 people/sq km. Population increase in Luanda is estimated at 174 percent in five years up to 1986. The port city's system of urban-waste and pollution management has virtually collapsed. Rapid and unplanned settlements have created a city with virtually no sanitation facilities, sewage system and refuse collection. Solid-waste collection is sporadic at best, and non-existent in many of the settlements. Only 13 percent of Luanda's urban population is estimated to have sewage connections and 16 percent has septic tanks.[34]

Services in another Angolan city, Huambo, are stretched due to overpopulation caused by war. Between 1970-1990, Huambo's population increased sixfold to 420,000, putting a strain on its infrastructure. The Namibe-Tambwa coastal zone along Angola's arid southern coast has also seen its population jump two-and-half times in seven years, damaging the erosion-prone area.

Effects of refugees on the environment — Table 12.3

Host	Soil degradation	Water erosion	Nutrient loss
Malawi	medium	medium	medium
Zambia	medium	medium	medium
Zimbabwe	medium	medium	-
Tanzania	low	low	medium

SOURCE: UNEP, 1992 in Black, R., *Refugees and Environmental Change: Global Issues*, King's College, London, 1993

Protected areas and natural resource management

Armed conflict in Angola and Mozambique has led to the fragmentation and often total collapse of the management of protected areas in both countries. Legal enforcement, administration and controls became impossible to undertake outside major urban areas. In Angola, two decades of war —

Where have all the trees gone? Story

Maputo (ew Ground) — Estuaries along the Mozambican coastline support five mangrove species that cover 1,700 square kilometres, one of the biggest mangrove forests in Africa. Half of Mozambique's land surface is covered by sprawling forests, containing lots of indigenous kiaat, jambire, Lebombo ironwood, canfuta and tangatanga trees.

The swampy mangroves are the breeding grounds for young prawns, a strategically vital resource which provides the country with 40 percent of its foreign exports. The coastal mangroves as well as the hinterland forests, which form the basis of a potentially lucrative lumber industry, are under severe threat from social dislocation caused by war.

"Mozambique's main environmental problems are concentrated in three areas: the coast, the cities and along the railway corridors that link the coast to the interior," says, Mozambican biologist and author, Mia Couto.

Seven out of 10 Mozambicans now live in towns and settlements along the relatively secure coastal strip or along the Beira corridor, which has been exempted from rebel attack in terms of an agreement reached by the government and Renamo during peace talks.

The bigger cities have grown at a phenomenal rate, with Maputo and Beira containing three times the number of people they were built for. "We are in danger of becoming a rural country without peasants," adds Couto. "And, as result, a real desert is forming around Maputo and the Beira corridor."

Eighty percent of energy used by households and industry in Mozambique is generated by burning fuelwood. Families who have resettled along the coast cut and burn the trees to make way for *machambas*, small fields in which they grow food.

Around the cities, people forage far and wide, risking death with each kilometre they travel, in search of wood for their own use and to sell. Officials in the wildlife and forest department have calculated that 15,000-20,000 hectares of woodland are stripped each year to satisfy the demand for fuelwood in the city of Maputo alone. War, and its social consequences, is the "driving force for the widening spread of deforestation around the urban areas of the country," one official said.

Sofala and Manica are provinces dissected by the heavily congested Beira corridor. "Some of our richest forests are located in these regions," says a senior Mozambican wildlife and forestry official. "There are some rivers in Manica that have dried up because of siltation that comes from all the trees at their source being destroyed."

Even more serious is that half of the coastal mangroves have been cut down in the last decade, leaving a potential crisis for the prawn industry, which has begun to experience severe drops in the size of its catches.

— adapted from article by **Gil Lauriciano** and **Eddie Koch,** in *New Ground*, Spring 1992 with troop movements through national parks, uncontrolled hunting and the paralysis of park administration — have left the protected areas in a shambles.

Today, the national parks system is threatened because management and infrastructure have been disrupted, and wild animals killed. Kisama and other Angolan national parks carry thousands of people. Wildlife species have been victims of indiscriminate hunting by some members of the armed forces and other groups that hunt in protected areas.[35] In Mozambique, the protected areas network has been dealt a similar blow. War also stopped research which is urgently needed for proper wildlife management once peace returns.

At community level, the local systems and capacity for managing natural resources declined as people left their areas and sought refuge elsewhere or settled in ecologically sensitive areas. Consistent forest management has been impossible. Trees planted in Angola and Mozambique before the 1970s are over-mature and too large to be used, while plans in Angola to plant some 250,000 trees in 1989 had to be abandoned because of war.[36]

Poaching for the pot

Fires, one of the main causes of deforestation in Angola, are frequently used for hunting and for the clearing of land for cultivation. Although the use of fire for hunting is traditional, there are indications that this has increased considerably in Angola in the last two decades due to the lack of control and the shortage of meat in both rural and urban areas. The use of fires as a hunting tool is responsible for the incineration of vast areas of Angolan woodlands and savannas, placing them under pressure. As the number of destitute people in the rural areas increase so will the incidence of grass fires and rate of deforestation.[37]

Wild animals have been hunted for food by civilians and soldiers on both sides of the conflict in Angola and Mozambique. With animals being killed for food, barter or cash, the war has destroyed many wild animals. As many as 21 species of mammals which occurred in fairly large numbers in Angola two decades ago are either endangered or extinct because of war. These include giraffe, hippo, rhino, lechwe, black-faced impala, chimpanzee and gorilla.

Photo 12.7 PHOTO OIKOUMENE-D Edkins,WCC

Over 300,000 refugees from Rwanda make temporary homes at Benaco refugee camp in Ngara district, Tanzania, in May 1994, with relief implemented by local and foreign NGOs and church organisations. "Thousands of refugees arrive daily. Water supply is insufficient, sanitation is non-existent and the threat of an epidemic is real," said the World Council of Churches (WCC). Conditions for the refugees in Tanzania facilitate safety and survival, however, unlike the camps across Rwanda's western border in Zaire.

Photo 12.6 PHOTO OIKOUMENE-D Edkins,WCC

In the Luando National Park, where lechwe roamed the floodplains before the post-independence war erupted in 1975, only three lechwe were observed in an aerial reconnaissance in May 1992. IUCN estimates that Angola may have lost as much as 90 percent of its wildlife in protected areas during almost 20 years of war. However, an IUCN study notes that animal populations surveys conducted in Angola, even prior to independence, appear inadequate[38] and the estimates upon which comparisons were based may be unreliable.

The wild animals in Mozambique's Zinave National Park, in northern Inhambane province, were overhunted to supply both urban and army centres. During the early and mid-1980s, the infrastructure of the park headquarters was destroyed and staff were forced to evacuate. The park was then systematically exploited for at least four years by Mozambique's provincial armed forces for meat production. The hunting was intense, causing the depletion of wild animals that once teemed the park. Today, the bones of wild animals are still found lying around meat-processing centres in the park.[39]

The Star, a South African daily newspaper, reported in August 1991 that large numbers of elephant, buffalo, hippo and antelope have been "mowed down from the air by hightech helicopter gunships either for 'sport' or to feed hungry soldiers or civilians." However, government helicopters were neither hightech nor operational by 1991.

Gorongosa National Park in central Mozambique has been subjected to heavy harvesting of wild animals. An environmental consultant in Mozambique said animal populations have been decimated. "The vast quantities of military weaponry brought into Mozambique by warring factions and bandits have now been turned against game populations, with catastrophic consequences for the once great herds."[40] The consultant reports that from a survey carried out in the Marromeu delta at the mouth of the Zambezi river, buffalo are down from 55,000 to 4,000, waterbuck 45,000 to 4,000, zebra 2,720 to 1,000 and hippo 1,700 to 260.[41] White rhino, reintroduced in Maputo National Park, have been slaughtered.

War in Angola and Mozambique has also increased the population's dependence on game. A 1992 IUCN report says local markets in Cabinda, in northern Angola, sell more game meat than domestic animals. According to Mozambique's report to the United Nations Conference on Environment and Development (UNCED), about five million people depend on meat, 70 percent of which comes from wild animals.

Non-renewable resources and war

The exploitation of non-renewable resources in Angola, including diamonds, has contributed to environmental degradation in some areas, such as Canpfunfo. The illicit diamond industry in Angola is worth up to US$500 million a year.[42] There has been uncontrollable exploitation of diamonds, particularly in Unita-controlled areas. Large areas have been degraded, forests destroyed and water sources polluted due to diamond-mining.

AFTERMATH OF WAR

In South Africa, the first democratic multi-party elections (in April 1994) have ushered in a new political era at home and in regional relations. The resolution of this conflict should have a profound effect on the region's environment.

Mozambican refugees in neighbouring states have started returning home, but most areas to which refugees have returned have war-damaged infrastructure. Assessments have been made of the areas to settle the returning refugees to determine the land's ability to support people so as to avoid environmental degradation through overpopulation.

"The resettlement process (of millions of people dislocated by the war) must emphasise the opportunity to set aside these areas so vital to the conservation of biological diversity, ensuring that rural people ... participate in the fruits of this resource base," says a 1992 Mozambican document on the environment.[43]

A Mozambican forestry and wildlife officer says successful replanting of trees in cleared areas will depend on the outcome of the peace process now in progress. "It would be much easier if people returned to their places of birth. A natural recovery would then take place in many areas," he says. "If natural recovery is not possible, we will have to resort to artificial planting programmes where there is a concentration of people so that we can supply wood for domestic consumption."[44]

The future of army bases in Mozambique's national parks is uncertain. But if the bases are moved just outside urban areas, wild animals will once again have a chance to multiply. For example, animals in Gorongosa National Park, which has a population of between 2,000-3,000 people, should not only recover from severe hunting but also have more space if people are moved or involved in sustainable management of the areas.

Photo 12.8 PHOTO OIKOUMENE-D Edkins,WCC

Often there is no infrastructure to return to, and resttlement is not well planned.

Conflict resolution can lead to changes in settlement patterns with relevant environmental impacts. Areas that will be repopulated when refugees and displaced people return after the war may become degraded if settlements are not well-planned. Areas which refugees and displaced people leave will regenerate with time.

The suspension of war in Angola during the implementation of peace accords reduced pressure on natural resources which had been used to pay for military equipment. Once peace is achieved in Angola, the government should be able to channel resources from defence toward conservation, and to control overexploitation on land and in marine areas.

The end of war may, however, place some hardship on people who have been dependent on poaching during nearly two decades of war. They may not have feasible alternatives to satisfy their meat requirements and are likely to continue uncontrolled wildlife harvesting.

Angolan and Mozambican governments could introduce community-based wildlife programmes similar to those in Tanzania, Zambia and Zimbabwe so that harvesting is both controlled and beneficial to the people. In Zimbabwe, some ex-combatants from the liberation war were incorporated into the national parks sector, and there are plans to introduce similar programmes in Angola and Mozambique. IUCN has already conducted research into the possibility of redeploying some ex-combatants in those countries as scouts and rangers.[45]

The SADF, which had a notorious record in conservation, has been improving its image by undertaking some projects designed to benefit the environment. — even before the political changes that have taken place in South Africa. In 1991, soldiers cleared cactus (an exotic plant growing at the expense of indigenous ones) on a 2,000 ha training base west of Kimberly. They also addressed problems of soil degradation, assisted with counting of wild animals and birds, and relocated penguins after an oilspill.

Such projects by the military often attract international support. The US Defence Department has earmarked US$15 million to assist African countries conserve their biodiversity. The department says, "The focus of the programme will be on maintaining wildlife habitats by military construction of park and reserve roads, bridges, dams etc.; assisting African anti-poaching efforts on land and in fishing areas; protecting marine life and environments."[46]

Linkages to other chapters Box 12.4

1 PEOPLE
: Armed conflict in some parts of southern Africa has hampered sustainable environmental management in the region, and caused economic and social instability which has impacted on the environment.

2 HISTORY
: Armed conflict is not new,but occurs on a larger scale, with more lethal weapons such as landmines, and mass movements of large numbers of people.

3 POLICY
: Conflict and instability inhibit the application of environmental policy and cause a policy vacuum that persists after the conflict has been resolved.

4 ECOZONES
: Armed conflict in some parts of southern Africa has caused wholesale movements of people, depopulating some ecozones and overpopulating others, often with disastrous consequences for the environmental balance.

5 CLIMATE
: The effects of drought are made worse by armed conflict, and can result in widespread famine and hunger if access is blocked to cultivation or emergency food aid.

6 SOILS
: Armed conflict can amplify soil degradation problems in areas of relative security by concentrating large numbers of people in limited areas in camps and coastal areas.

7 WOODLANDS
: While clearing land for agriculture is the major cause of deforestation in the region, armed conflict has contributed to some localised deforestation where large numbers of displaced people are concentrated, particularly around urban areas. However, in the depopulated areas, vegetation regrowth has prevailed.

8 WILDLIFE
: Armed conflict has led to the destruction of wildlife, especially in Angola, Mozambique and Namibia, as well as in the southeast corner of Zimbabwe. Some protected areas have been polluted by weapons testing and military training.

9 FRESH WATER
: Arms production pollutes freshwater sources, as do large concentrations of people living in unhygienic conditions.

10 MARINE
: In Angola and Mozambique, war drove people into the coastal areas, increasing erosion and siltation. It also reduced management effectiveness,leading to overfishing by foreign trawlers.

11 POLLUTION
: Armed conflict contributes to pollution problems, largely through the breakdown of infrastructure and management of wastes. Manufacture and testing of military equipment has led to the pollution of nearby water bodies, especially in South Africa.

13 GLOBAL
: This chapter does not examine impacts of armed conflict on global atmospheric change, which would be indirect.

14 TRENDS
: Although Angola plunged back into war after the 1992 elections, the peace process is holding in Mozambique, and with the end of apartheid in South Africa, regional prospects for conflict resolution are positive.

NOTES

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13

GLOBAL
Atmospheric Change

"If you can't get next Saturday's weather right, how can you predict global climate changes into the next century?"

That is the question often put to scientists peering into the future for signs of a warmer planet earth in the decades ahead. It is a sensible question. Meteorologists have difficulty predicting weather more than a few days ahead because the large-scale motion of the atmosphere is largely chaotic and not well-understood.[1]

Weather is the day-to-day changes in the atmosphere, while climate is the long-term, 30-year average of that weather. Climate is driven by the sun's energy and influenced by many factors including the oceans, glaciers, sea-ice and polar ice-caps, the earth's land-surface, and living organisms in the oceans and on land.

A few years of unusually wet or dry weather do not necessarily reflect trends in climatic change, but long-term weather records show a definite trend of global atmospheric changes. Generally, temperatures are higher now than they were 150 years ago. The increase has not been steady, and there have been cool periods as well as warm. For example, from the 1880s to 1940 global warming amounted to half a degree Celsius, and for a period after 1945 the atmosphere cooled, especially around 1960.[2] Most scientists currently believe that the short-term changes result from factors such as volcanic eruptions and changes in the sun's energy emissions, but the long-term trend reflects global warming.

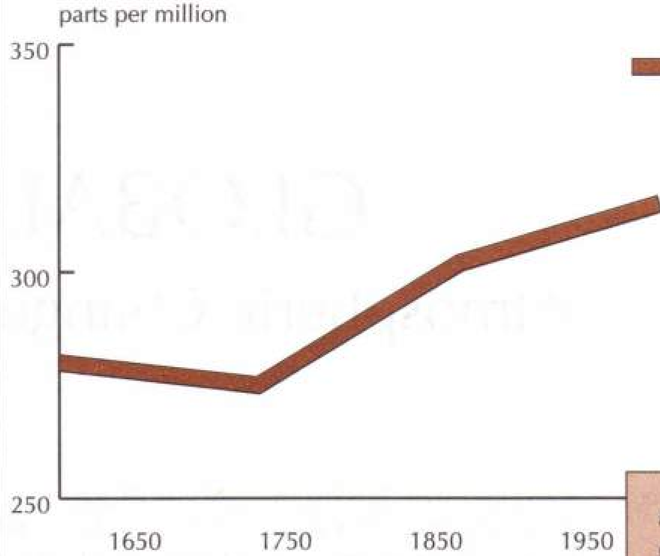
Five of the 10 years between 1980-1990 were the warmest on record. The year 1988 was the warmest, 1989 the second warmest. The years 1980, 1981 and 1986 were all warmer than any others in the last century.[3] In the next 30-60 years, scientists predict, the average temperature of the earth will continue to rise by between 1- 4°C.[4]

A temperature change of a few degrees may not seem like much, when day-to-day temperatures can vary by 20°C or more, but only rarely has the earth's average temperature varied by more than one degree over the past 10,000 years. Even during the last Ice Age, the average temperature of the earth's surface was only about 5°C lower than it is now.

Globally, a slightly higher temperature within a relatively short period would have wide-reaching impacts on atmospheric circulation, weather patterns and rainfall. In Africa, melting glaciers[5] and rising sea levels[6] are proof of the significant changes already taking place.

The warming is thought to result from human activities, primarily the burning of fossil fuels such as coal and petroleum, along with use of agricultural and industrial chemicals.[7] Thinning of the ozone layer (a form of oxygen which shields the earth from lethal ultraviolet rays that can cause skin cancer) is a related problem resulting from use of certain chemical products. There are conflicting views, however, on precisely how human activities affect the earth's atmosphere and climate, and what the effects will be.

Increase in atmospheric carbon dioxide since 1650 Figure 13.1



SOURCE: Cloete, D. (ed.), "The Greenhouse Effect", *New Ground*, no 9, Spring,1992

Main historical phases of carbon dioxide emissions Table 13.1

Period	Remarks
1850-1900	Deforestation, mainly in temperate regions, was the major source of human-caused carbon dioxide.
1900-1945	Fossil-fuel emissions from industrialisation increased and became the main source of carbon dioxide.
1945-1960	Rapid tropical deforestation started.
1960-1990	Massive cutting of tropical forests (increase from 11 million hectares cleared in 1980 to 22 million hectares in 1990), with deforestation adding more than 1,500 million tonnes of carbon dioxide annually. Fossil fuel contributions more than doubled from 2,500 million to 5,700 million tonnes annually.

SOURCE: Ominde, Simeon H. and Calestous Juma (eds.), *A Change in the Weather: African Perspectives on Climatic Change*, ACTS, Nairobi, 1991

Global Warming Box 13.1

For almost all of human history we have had no noticeable impact on the planet's atmosphere. Then in the 18th century the first steam engines and large factories appeared. Large amounts of coal were burned and large areas of forest cleared. European countries began to colonise the world, expanding their markets for manufactured goods and taking raw materials from the South. With the industrial revolution came the first global pollution problems. Since the mid-1700s, the carbon dioxide concentration of the atmosphere has increased to its highest level in the past 150,000 years. The last decade was the hottest in living memory.

SOURCE: Cloete, D. (ed.), "The Greenhouse Effect", *New Ground*, no 9, Spring 1992

CAUSES OF ATMOSPHERIC CHANGE

The carbon cycle

Carbon is a chemical element which forms the main building-block of all living matter. The atmosphere contains about 735,000 million tonnes of carbon as carbon dioxide. Because plants and oceans absorb large amounts of carbon, they are referred to as carbon "sinks". These sinks "mop up a significant proportion of the world's excess carbon dioxide".[8]

Carbon sources and sinks Table 13.2

	Emissions (billion tonnes carbon per annum)	Sinks
Fossil fuel	5	
Plant respiration/photosynthesis	50	100
Biomass decomposition	50	
Oceans	100	104
Deforestation	2	
TOTALS	207	204*

*Emissions are greater than sinks (carbon absorbers), resulting in excess atmospheric carbon dioxide and global warming.

SOURCE: *National Geographic*, Oct 1990, Vol 178

The natural exchange between carbon sources and sinks is known as the "carbon cycle". Plants grow by removing carbon from the atmosphere (some 100,000 million tonnes annually) as part of the process of photosynthesis. When plants burn or decompose, the carbon in their tissues is released back to the atmosphere as carbon dioxide. A similar amount of carbon dioxide is absorbed and released by oceans — half dissolves in the water, and the other half is absorbed by marine plants and by animals which store carbon in their shells.

Effect of human activities

Svante Arrhenius, a Swede, first described the relationship between the atmospheric concentration of carbon dioxide and surface air temperatures in 1890. He drew attention to the possible long-term impact that the coal-dependent Industrial Revolution would have on global climates.

A century later, his prediction seems about to be proved correct. Today's scientists are gathering evidence that the carbon cycle is being knocked out of balance. About 6,000 million tonnes of carbon dioxide are added to the atmosphere annually through burning of fossil fuels, and more than 1,000 million tonnes from deforestation. This is almost three times what the carbon sinks in the oceans and the biosphere can absorb.[9] It is this increased carbon dioxide in the atmosphere that is responsible for global warming.

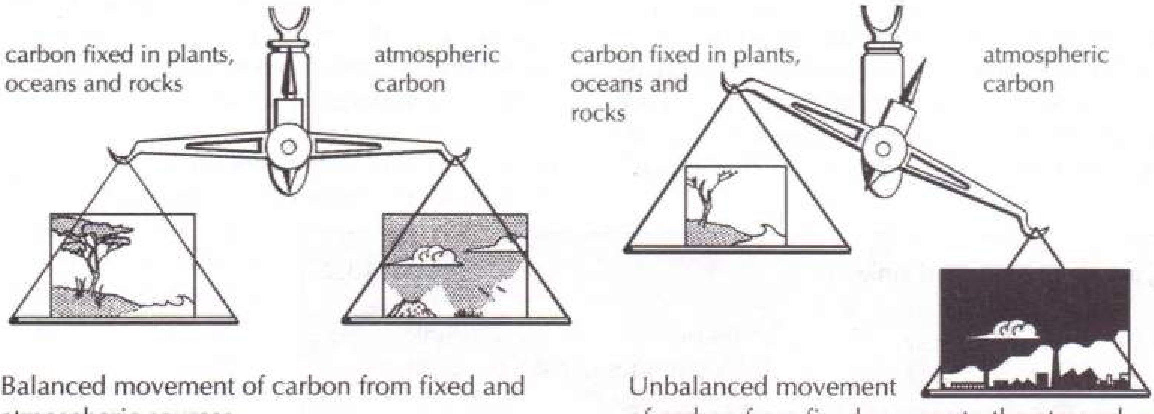
Current reserves of hydrocarbons (oil, coal and natural gas) are the fossilised remains of plants. Burning them releases carbon stores built up over millions of years. The United States — with just four percent of the world's population — produces a quarter of the world's carbon dioxide emissions from fossil fuels because of its level of industrialisation. Other industrialised countries, such as France, West Germany, Japan and United Kingdom, together account for most of the remainder.

Deforestation and clearing of land for agriculture removes carbon "sinks" and reduces the biosphere's ability to absorb carbon dioxide. Deforestation adds about 1,500 million tonnes of atmospheric carbon dioxide annually. One hectare of trees absorbs approximately 4-10 tonnes and if they are cut this amount of carbon dioxide is added to the atmosphere. Carbon uptake varies widely, depending on the type of trees, climate, soil, water and other factors. Younger, growing trees absorb more carbon dioxide than old trees.

Burning of tropical savanna woodlands also plays a significant role in the global carbon cycle. About half the world's tropical savanna woodlands are burnt each year (mostly for shifting cultivation) and then grow back, reabsorbing the released carbon. Savanna burning, together with the burning of biomass fuels, such as fuelwood and crop residues, makes up 15 percent of the total carbon emissions annually. It also reduces the stock of carbon sinks (forests and woodlands) though in theory the reduction is temporary as the biomass can grow back and reabsorb the released carbon.[10]

Fuelwood is the only carbon-based fuel with the potential to be used sustainably as it can be replaced by reforestation. While people in developing countries are often blamed for

Human impact tips natural carbon balance Figure 13.2



Balanced movement of carbon from fixed and atmospheric sources

veld fires & volcanic eruptions ⇨⇦ photosynthesis

decay and diffusion ⇨⇦ diffusion

The Natural Carbon Balance

Unbalanced movement of carbon from fixed sources to the atmosphere

reduced photosynthesis due to deforestation ⇨

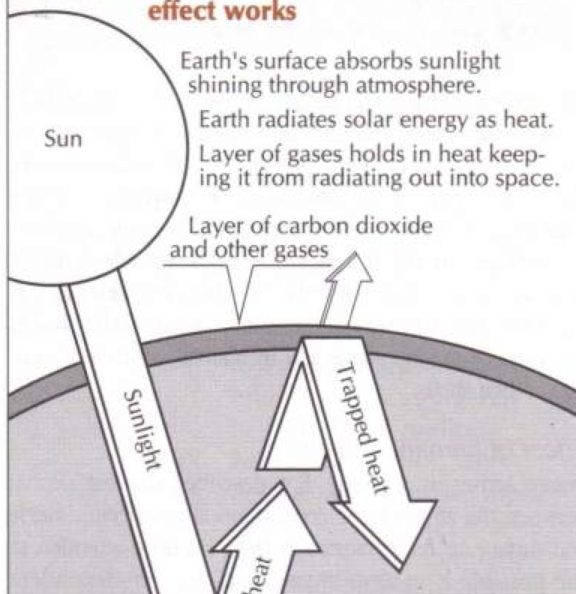
use of fossil fuels ⇨

Human Impact on Carbon Cycle

SOURCE: Cloete, D. (ed.), "The Greenhouse Effect", *New Ground*, no 9, Spring 1992

pollution caused by biomass burning, the burning of oil and coal in developed countries is a much more significant source of carbon emissions. Fuels pulled from deep in the ground make a permanent addition to atmospheric carbon because the biomass which produced those deposits is not going to grow back.

How the "greenhouse" effect works Figure 13.3



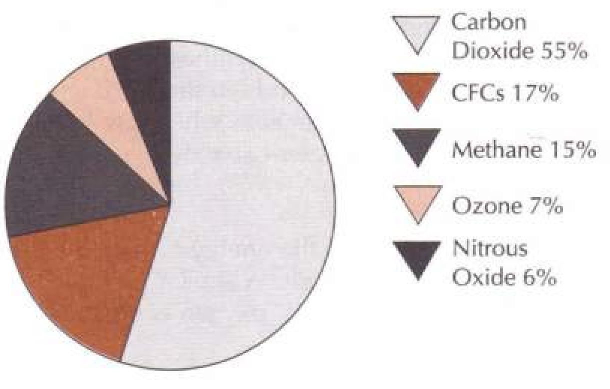
Certain gases in the earth's atmosphere are called *greenhouse gases* because they function in much the same way as horticultural greenhouses.[11] Sunshine entering the glass roof and walls of the greenhouse heats the interior. The glass prevents some of the heat from escaping, so the temperature inside the greenhouse becomes higher than that outside.

Similarly, naturally occurring trace-gases in the atmosphere trap some of the heat from the sun's radiation which would otherwise escape. As sunlight heats up the sea and land, the warmed surface of the earth radiates the heat back towards space. On its way, some of the heat is absorbed by the gases, raising air temperatures sufficiently to allow greater concentrations of atmospheric water vapour which is a very efficient absorber of heat.[12]

This captured heat is what makes the earth livable. Without it, the average temperature of the earth's surface would be well below freezing point, some 33°C lower than its present 15°C. The earth's nearest planetary neighbours, Mars and Venus, cannot support life. Mars, with almost no greenhouse gases, has a temperature of about minus 60°C. Venus has extremely high concentrations of greenhouse gases, and the temperature is about 480°C, hot enough to melt tin.[13]

Until recently, carbon dioxide was considered to be the main gas responsible for global warming. It is now becoming clear that other gases (particularly methane, nitrous oxide, ozone and CFCs) absorb a range of ultraviolet radiation where carbon dioxide and water vapour are ineffective. These additional gases will greatly speed the warming that has been projected from a doubling of atmospheric carbon dioxide alone. Their impact could exceed that of carbon dioxide over the next 50 years.[14]

Estimated contributions of different gases to the greenhouse effect Figure 13.4



SOURCE: Intergovernmental Panel on Climatic Changes (IPCC), established 1988

Ozone layer breakdown

The ozone layer comprises a naturally occurring form of oxygen which shields the earth from harmful ultraviolet rays from the sun. Located in the stratosphere, about 15-50 km above the surface of the earth, ozone is scattered so thinly that if it were all collected together near the earth's surface it would form a layer as thin and delicate as gauze — just three millimetres thick.[15]

Life on earth would be in jeopardy without the ozone layer, which has a key role in regulating global temperatures because it determines the amount of ultraviolet radiation reaching the earth's surface. The ultraviolet radiation it screens out is highly damaging to animal and plant life. In human beings it causes malignant melanoma, a serious skin cancer which begins as a mole but quickly spreads cancer cells throughout the body. Ultraviolet radiation also damages the eyes and can cause cataracts. A drop of total ozone concentration by 10 percent will increase ultraviolet radiation on the earth's surface by about 20 percent.

Chloroflourocarbons (CFCs) are the major threat to the ozone layer. These are manufactured gases first introduced in the US during the 1930s. Two of them are in common use, CFC-11 and CFC-12. However, they are both being phased out from use in most countries that have ratified the Montreal Protocol. One CFC molecule can destroy 100,000 molecules of ozone,[16] thinning the ozone layer that

Aircraft emissions and global warming Box 13.2

Some researchers believe that nitrous-oxide emissions from airplanes may be adding substantially to global warming. "There are new scientific data to suggest that air transport may be contributing between 5-40 percent additional global warming (which) previous scientific assessments may not have comprehensively taken into account," says Adam Markham, head of resource consumption and pollution policy at the World Wide Fund for Nature (WWF).

The effect of some pollutants is worse at high altitudes than at ground level. If increases in the aircraft numbers follow current trends, carbon dioxide emissions from aircraft will double and nitrous-oxide emissions will increase by 50 percent by the year 2020. The impact can only be reduced through improved technology and by decreasing the numbers of flights. There is also talk of replenishing ozone by attaching tanks of it to airlines for release at high cruising altitudes.

SOURCE: Cock, J. and E. Koch, *Going Green: People, Politics and the Environment in South Africa*, Oxford University Press, South Africa, 1991

Common greenhouse gases Box 13.3

The Intergovernmental Panel on Climatic Change (IPCC), asked to assess the science and impacts of climatic change, reports that carbon dioxide is responsible for 55 percent of the greenhouse effect, chlorofluorocarbons (CFCs) 17 percent, methane 15, nitrous oxide 6, ozone and others 7.

Carbon dioxide (55 percent)

Carbon dioxide makes up a tiny fraction of the total atmospheric gases (0.03 percent) but its role in stabilising atmospheric temperatures is critical. The concentration of carbon dioxide in the atmosphere is increasing at an annual rate of about 0.5 percent. Between 1958-1984, the concentration of carbon dioxide increased from 315 parts per million (ppm) to 345 ppm. At this rate of accumulation, in 50 years the concentration of carbon dioxide in the atmosphere will be 650 ppm, about double that of 1900.

In 1990, carbon dioxide contributed 98 percent of the total weight of the five major greenhouse gases. But its effect on global warming is much less (55 percent) because, gram for gram, carbon dioxide has the weakest effect of the five.

Carbon dioxide increases the amount of heat trapped near the earth surface, making the earth warmer. Ice and snow melt, and add more water to the sea, leading to a sea-rise, and as the sea water gets more heat, it expands, also causing a sea-rise. The melting of ice and snow, both good reflectors of heat, means that the earth would absorb even more heat near the poles. More carbon dioxide would speed up the growth of plants which use it for photosynthesis. While high carbon dioxide intake by plants would reduce the amount of carbon dioxide in the air, it will not be enough to remove excess gas. Scientists are concerned about warmer seas which are likely to store less carbon dioxide than they store presently. Cold water has greater capacity to absorb and store carbon dioxide than warm water.

When plants absorb carbon dioxide during the day, sunlight provides the energy to help them to break it down to form plant tissue in the process known as photosynthesis. A similar process goes on in the seas where carbon dioxide is absorbed by algae. In both cases, oxygen is emitted as a by-product.

Carbon dioxide is also released by people and animals when they breathe, plants when they respire (or when they die and rot), fuels when burnt and soils when tilled.

CFCs (17 percent)

Chlorofluorocarbons are artificial gases and powerful heat absorbers, which are increasing in the atmosphere at about four percent annually. The atmospheric concentration of CFC-11 (which is used as a propellant in spray cans among other things) is now estimated at 0.3 parts per billion — roughly a millionth the concentration of carbon dioxide. CFC-12, which is used in air-conditioning and in refrigeration, is under 0.5 ppb. These gases are highly persistent, remaining intact in the atmosphere for as long as 130 years. They may account for up to 20 percent of the total greenhouse effect over the next 40 years, though some scientists argue that their net effect is small since CFCs destroy ozone, itself a greenhouse gas.

Both gases are used fairly extensively in southern Africa. South Africa's gold-mines, for example, use the largest refrigerators in the world to cool the hot air in shafts deep below the surface. This refrigeration technology uses CFCs. The mines used to release tonnes of CFCs to the atmosphere whenever they overhauled their systems, but now they store the gases, waiting for the day when a technology will be developed to clean and reuse them.

Methane (15 percent)
The concentration of methane in the atmosphere is more than double what it was 300 years ago. It is increasing at an annual rate of almost one percent, adding an additional 400-600 million tonnes to the atmosphere each year. Methane has a more concentrated effect than carbon dioxide — a molecule of methane traps 20-30 times more heat than a molecule of carbon dioxide. It lasts up to 11 years before it breaks down, so small increases in atmospheric methane are significant.

Also called "rotten egg" gas, methane is produced naturally when organic material decays in swamps, by ruminants (animals which chew their cud, mainly cattle), termites (the digestive system of termites emits methane), and savanna and forest fires.

Human activity (mainly through expansion of rice paddies and cattle-grazing) has considerably increased the amount of methane released into the atmosphere. Studies show that rice paddies produce about one-quarter of all methane released to the atmosphere, and cattle a little more than that. Leaking gas-pipelines contribute about 20 percent. Substantial quantities are produced in rotting rubbish dumps (15 percent), where quantities are sometimes so great that it is profitable to collect it as fuel. Natural sources of methane include woodland burning, wetlands and termites, and together account for about a quarter of all methane releases. Still more methane remains locked up in the frozen tundra of the Arctic and muddy ocean floors which, if released, could raise global temperatures.

Nitrous oxide (6 percent)
Once used as a light anaesthetic, nitrous oxide causes people to laugh and so is known as "laughing gas". Its main source in the atmosphere (accounting for 90 percent of the total nitrous oxide) is tiny organisms called microbes which live in soil and water. Tropical forest soils produce almost half the annual nitrous oxides. Deforestation and cultivation increases nitrous oxide production because the soils are exposed to more sunlight and air. The major artificial source to the atmosphere seems to be overuse of nitrogen-based fertilisers, but nitrous oxides are also a by-product of fossil fuel burning, particularly from aeroplanes.

Currently, its concentration in the atmosphere is tiny. In 1986, it was about 310 ppb, and was increasing annually by 0.25 percent. This gas can last up to 150 years in the atmosphere, making even small emissions a long-term problem.

Ozone and others (7 percent)
Ozone is a form of oxygen which occurs naturally, and is also produced when vehicle emissions interact with sunlight. Though it shields the earth from damaging ultraviolet radiation when high in the atmosphere, it is a dangerous pollutant when in the lower atmosphere, damaging human lungs and plant growth, and contributes to the greenhouse effect.

IPCC was established by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) in 1988.

SOURCES: Bolin, B. and others (eds.), *The Greenhouse Effect, Climatic Change and Ecosystems*, SCOPE Paper no 29, Wiley, Chichester, 1986
OECD, *Greenhouse Gas Emissions: The Energy Dimension*, IEA, Paris, 1991
Pearce, Fred, "Methane: the Hidden Greenhouse Gas", *New Scientist*, 1989, no 1663

molecules of ozone,[16] thinning the ozone layer that absorbs lethal ultraviolet light.

Proof of damage to the ozone layer was discovered in the early 1980s by a British Antarctic survey team which first detected a decline of ozone in the stratosphere. By 1984, when there was a 30 percent loss, the team was convinced something was radically wrong. Measurements in the years that followed showed further evidence of depletion, which led to the discovery of the famous ozone "hole" over the South Pole. The most dramatic and recent decrease in ozone was reported by British scientists in October 1993, when they detected that the ozone layer over Antarctica had the deepest hole ever, with two-thirds of the protective shield destroyed.

The Antarctic ozone layer, which varies in size from season to season, usually reaches its thinnest level annually in the first half of October,[17] but in 1993 the lowest level was already surpassed by the end of September. Australia, close to the Antarctic, has the world's worst rates of skin cancer, but at Pretoria, South Africa, ultraviolet radiation has only increased by about one percent.

IMPACTS OF ATMOSPHERIC CHANGE

Scientists predict that if current trends continue, the combined effect of greenhouse gases will raise global mean temperature by between 1- 4°C.[18] This could trigger a "slow-moving global catastrophe that alters the very boundary of land and sea."[19]

Oceans

Studies suggest that global warming will cause sea-levels to rise by 20-140 cm by the year 2100, most of that due to thermal expansion of the ocean water as it warms up. The result would be inundated wetlands and lowlands, eroding shorelines and increased coastal flooding. The heights, frequencies and other characteristics of waves would change, so that tides would reach further into rivers and bays, changing the locations where rivers deposit sediments. Water quality would decline in coastal areas as salinity of estuaries and groundwater would increase.[20] After about 200 years, melting ice-caps and mountain glaciers would provide additional sources of water to the oceans, increasing sea levels even more.

The US Environmental Protection Agency (EPA) explains: "Concern about a possible acceleration in the rate of sea-level rise stems from measurements showing the increasing concentrations of the carbon dioxide, methane, chlorofluorocarbons, and other gases released by human activities. Because these gases absorb infra-red (heat), scientists generally expect the earth to warm substantially."[21]

Oceans are the generators of weather, heating and cooling the air that passes over them, and warmer oceans are expected to make weather more extreme all over the world. There could be more droughts, torrential rainstorms and hurricanes.[22] Shifts in atmospheric pressures and wind circulation patterns, together with changes in ocean currents, could markedly alter the distribution, abundance and availability of marine resources such as fish.

Warmer ocean water has also been linked with the "bleaching" of corals. Coral reefs are sensitive to any changes in their environment, expelling the algae (which give coral reefs their colour) and leaving the white carbonate skeleton behind. Higher temperatures eventually weaken the corals and they die. This problem has already been noted around the world. The consequences could be vast, as coral reefs shelter about 12 percent of global fisheries.[23]

The problem of coral bleaching has already been noted around the world, though scientists have been hard-pressed to prove whether it is increased warmth that is stressing the corals, let alone whether global warming is the cause of the

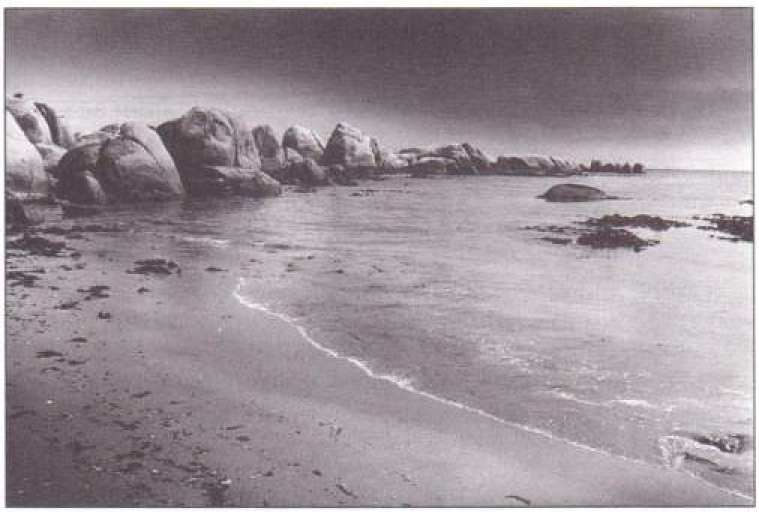


Photo 13.1 SOUTHLIGHT-S Greaves

Sea levels could rise due to global warming, affecting coastlines and coral reefs, and human habitats.

heating.[24] Scientists meeting at a workshop in 1991 concluded that current die-offs could result from pollution, and that regardless of global warming, coral reefs are already severely threatened by pollution and direct destruction.[25]

Agriculture

There are some tentative predictions of "positive" impacts of carbon dioxide increases. Increased concentrations of carbon dioxide are expected to boost the productivity of crops and rangelands. A doubling of carbon dioxide could increase productivity by 10-50 percent, depending on availability of water and nutrients (the plants must be fully fertilised or the increased growth rates will lead to rapid exploitation of the soil nutrients).[26] In addition, laboratory studies show that a doubling of atmospheric carbon dioxide would decrease the amount of water transpired by plants,[27] increasing their water efficiency by 10-40 percent. Crops would require less water, and more water would be left to supply river flows and groundwater.

On the other hand, more extreme and unpredictable weather patterns could result in more flooding, causing more soil erosion and loss of fertiliser. Increased carbon dioxide would favour weed growth (as well as crops), increasing the competition for existing soil nutrients and water,[28] and multiplication of pests and diseases. Laboratory experiments show that when plants take in more carbon they grow faster, though their nutrient levels decline, with leaves richer in carbohydrates and poorer in nitrogen. This is particularly true of such major mid-latitude staples as wheat, rice and soya beans. Pests would eat more of the crop to gain sufficient nutrients, and would flourish because of higher temperatures and atmospheric humidity. Some diseases affecting maize flourish in more humid conditions, for example. Generally, higher temperatures would accelerate the loss of organic matter from soil, with a corresponding decline in fertility and soil structure.[29]

Increased ultraviolet radiation damages plant growth and could reduce agricultural production, change the distribution of plants and affect their capacity to reproduce — possibly eroding genetic diversity as well.

The impact of increased ultraviolet radiation on non-agricultural plants is not known, but a reduction in ocean phytoplankton activity has been noted with concern. The "hole" in the ozone layer coincides with the longer days that trigger extensive phytoplankton blooms. University of California researchers found that the increased levels of ultraviolet light caused a 12 percent reduction in phytoplankton productivity in areas under the hole, thereby reducing the supply of food in the Antarctic food chain.[30]

Rainfall

Specific changes in rainfall patterns are difficult to predict. Global rainfall is expected to increase by as much as 12 percent, but most of this would likely fall in areas that are already wet. Forests will benefit from the rainfall increase, but improved weed-growth may reduce crop-yields. Leaching of nutrients will increase.

Dry areas could expect a decrease in rainfall of up to 10 percent while evaporation rates would increase because of the higher temperatures — resulting in drier soils and lower crop-yields.[31] The International Panel on Climatic Change (IPCC), established by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP), has identified changes in drought risks as "potentially the most serious impact of climate change on agriculture".

Ecozones

Changes of this magnitude will probably shift climatic zones, displacing indigenous plants and shifting the optimal areas for particular crops.[32] Organisms will also migrate so areas will be exposed to new plant, animal and human pests. More than 90 percent of the world's food comes from fewer than 20 types of plants. The genetic make-up of these plants (which enables them to adapt to changing conditions of temperature, moisture, nutrients and disease organisms) is limited, so the potential for breeding new strains and varieties capable of adapting to a changed global climate is also limited. Changing climatic patterns may also interfere with germination or with other key stages in the life cycle of plants. Generally, it is believed that global warming will disrupt the major vegetation zones, creating a game of "ecological chairs" in which species swap habitats as conditions change, with some dropping out altogether as suitable habitats disappear. Certain species and entire ecosystems may be lost.

Net losses in food production from the main grain-growers could have adverse effects not only on the producers but also on the economies of food-deficit areas.[33] Climate models suggest that today's leading grain-producing areas, particularly in the United States, may experience more frequent droughts and heat waves by the year 2030. Extended periods of extreme weather conditions would destroy certain crops, negating completely the potential for greater productivity through the projected carbon dioxide "fertilising" effect. An extended spell of drought in the US in 1988 cut maize-yields by 40 percent, and for the first time since 1930 the country had to import maize. Changed climate zones could effectively make the US grain-belt a permanent drought zone.

Emission scenarios and model predictions may overstate the risk. They are equally likely to understate it. The scientific community, however, agrees that the consequences for many of the world's societies and ecosystems may be serious if no action is taken now to reduce greenhouse gas emissions.

National carbon dioxide emissions in southern Africa Table 13.3

	Deforestation and land-use changes (million tonnes carbon dioxide)	Fossil-fuel combustion
Angola	55	13
Botswana	7	4
Malawi	157	2
Mozambique	70	3
South Africa	-	775
Swaziland	-	12
Tanzania	49	6
Zambia	42	8
Zimbabwe	42	44
Regional totals	422*	867
North America (for comparison)	250	12,435

*Total does not include figures for South Africa and Swaziland. No information is available for Lesotho and Namibia.

SOURCE:UNEP, *United Nations Environmental Programme Environmental Data Report, 3rd Edition*, Basil Blackwell, Oxford, 1991

SCENARIOS FOR SOUTHERN AFRICA

Most predictions point to slightly drier conditions for southern Africa, though some envision slightly wetter conditions in coastal areas. Models of the impact of global warming on Namibia, for example, suggest that there could be an increase in both summer and winter temperatures of up to 4°C. In arid and semi-arid areas, the magnitude of adjustments to new situations could be tremendous. There is already heavy pressure on water supplies, food production and energy resources, whose balance between supply and demand could be seriously affected by small changes in climate.

Sea-level rise

The consequences of sea-level rise could be profound for low-lying coastal parts of southern Africa. Large portions of the region's sandy beaches and estuaries would be lost. Agricultural lands near the coast would be submerged. The most dramatic effects from rising sea-levels would be felt in Mozambique. A UNEP report identifies Mozambique as one of the 10 most vulnerable countries which would be hit hardest by sea-level rise.[34] Almost half the country lies close to sea level. It has one of the world's shallowest coastlines. As a rough estimate, a rise of 10 cm means a loss of 10 m of beach.[35] Tanzania and other coastal countries would also be affected, though not to the same degree. Already some 60 percent of Mozambique's coast is vulnerable to environmental degradation. As well as swallowing land, increasing sea-levels would degrade the quality of the remaining land and cause other ecological impacts. Higher tides and an increase in the severity of storms due to changes in ocean temperatures would cause extensive damage to coastal areas, increased salinisation of ground water and soil, more flooding and loss of wetlands.

Socio-economic impacts of sea-level rise would include the uprooting of human settlements and loss of coastal fisheries and tourism. Resettlement problems could affect the entire country. Increased rates of deforestation in the wake of such resettlements would serve to further increase atmospheric carbon dioxide and global warming.

Marine resources

Apart from changes in sea levels, there could be impacts on marine resources. Current scenarios suggest that the region's most important fishery along the southwestern coast could virtually collapse if the offshore winds change direction. These winds produce the nutrient-rich Benguela current off Namibia and South Africa. Just as important, incursions of warm surface water along the west coast of southern Africa (a phenomenon known as the *Benguela El Nino*) could occur with greater frequency.[36] Along the eastern and southwestern coasts, coral reefs could be damaged or killed by the increase in sea temperatures.

Rainfall changes

If belts of warm weather move further south as predicted, the cold fronts which normally sweep up from the southern ocean bringing winter rain to the Cape area might increasingly miss the southern tip of Africa. The area could change from a winter to a summer rainfall pattern. This would mean that the agricultural crops grown there would have to change. The vineyards and winter wheat could be replaced by pineapples and maize. The implications of such changes for the local economy are enormous.

Photo 13.3 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO-R Rangel

Mozambique is one of the 10 countries most vulnerable to sea-level rise. Almost half the country lies close to sea level, and it has one of the shallowest coastlines in the world. Global warming would also affect the many islands along the coast of southern Africa.

Photo 13.2 PHOTOGRAPHIC TRAINING CENTRE, MAPUTO

Another predicted change resulting from a southward shift in climate belts is an increased frequency of lightning storms in the southwestern Cape. The summer rains which now bring lightning almost daily to the Transvaal highveld would centre instead on the Cape. There could be some serious environmental impacts on the Cape's unique, fire-sensitive fynbos vegetation. Some of the slow-maturing species of plants would be become rarer and possibly extinct. Areas burnt more frequently would suffer increased soil erosion and more rainfall runoff, with less recharging of underground water supplies.

If rainfall declines by the predicted 10 percent, and becomes more erratic, there would be a corresponding drop in wildlife densities, particularly of grazing animals. Some researchers believe that wildlife populations correspond to the lowest rainfall, not to average rainfall, so wildlife populations could be reduced by more than 10 percent.

Freshwater resources

It is possible that increased concentration of carbon dioxide could improve water resources by enabling plants to use water more efficiently. However, it is more likely that reduced rainfall would result in reduced water supplies. Impacts on water resources might include:

- altered regional precipitation and evaporation patterns, increasing in some areas and declining in others;
- shrinking freshwater storage reserves in areas of reduced precipitation, notably in the form of groundwater;
- worsening epidemics as a result of reduced freshwater supplies; and
- increased stress on already stretched budgets as more and more expensive facilities become necessary to store water during the rainy season to help alleviate shortages in the dry season.[37]

Critical to all these scenarios would be the need to conduct surveys of the vulnerability and resilience of water basins in order to support water-use planning in the event of predicted impacts taking hold. Equally significant is the spectre of political conflict as more and more neighbouring nations would source water from rivers that cross international borders.

Another area of concern would be declining water quality. Because of reduced river flows due to dam construction, salty ocean waters already travel some 80 km up the Zambezi river into the interior, ruining some irrigated lands and affecting fish and other wildlife. In a global-warming scenario, penetration of salt water inland could become a common problem on many of the region's rivers, as sea levels rise and river discharges decrease.

Impact on agriculture

There is consensus that climate change would strongly affect agriculture, but scientists still do not know exactly how. Crop production in southern Africa could benefit as a whole, some areas could benefit, or agriculture throughout the region may be jeopardised.[38] If agriculture in some or all areas fail, there would be increased competition for resources, and population shifts, with corresponding impacts on land and resources.

In humid areas where rainfall, temperature and carbon dioxide concentrations are expected to increase (the eastern and southeastern coast and north-central parts of the region), agricultural production could be enhanced dramatically because of improved crop and livestock yields, more seasons and more diversified cropping. Dryer parts of the region, however, could lose 10 percent or more of their rainfall, with impacts on dryland farming particularly. Crops such as maize, millet, sorghum and sugar cane benefit less from increased carbon dioxide "fertilisation" and may even be adversely affected.[39]

The impacts of climate change on agriculture are particularly serious when the predicted shifts in agricultural zones, due to temperature and rainfall changes, are taken into account. Vegetation, for example, may have to move at least 100 km farther away from the equator to compensate for each one degree rise in temperature.[40] Current projections show that many soil types in the new climate zones would be unable to support intensive agriculture as practised today in the world's main producer countries. In addition, higher sea- levels could inundate farmland and make coastal groundwater saltier.

THE WAY FORWARD

International responses

A Swedish scholar once observed that after the scramble for Africa was over, there was only one more continent to scramble for: the future. Climate shapes our lives, our natural resources and the way societies draw from these resources through socio-economic activities. The harrowing trauma of starvation during the early 1990s remains the most graphic reminder of just how vulnerable we are.

International law has been shaping the way the world deals with issues such as global warming and ozone depletion. Treaties or conventions have become common currency, though many of the obligations set out in these recent instruments are not legally binding on the parties concerned. They are "framework treaties" whose regulations are set in very general principles, leaving technical details to another treaty or one or more protocols.

There are also international laws which provide some general guidance on the legal implications of atmospheric change. Unwritten international rules become customary law if followed over a certain period of time by a significant number of states which accept them, not only as moral but as legal obligations.

Existing customary (unwritten) law affirms the sovereign right of states to manage their own natural resources. The trend now is towards more consideration of how national policies and activities affect the world. Customary law also prohibits a state from allowing activities on its territory to inflict serious damage on the environment of other states or on parts of the environment which do not belong to any state.

More and more, countries are in a position of having to negotiate how much pollution they produce. The days of open access to common resources, such as the atmosphere, are ending. There are choices to be made. Global warming is intrinsically linked to energy use. By switching fuels, the global society can alter the balance of greenhouse gas emissions into the atmosphere. For the same amount of heat produced or electricity generated, natural gas, for example, produces some 40 percent less carbon dioxide than coal and about 25 percent less than oil.[41]

Important new legal principles are gradually emerging and are likely to shape a future climate treaty. International conferences on climate change consistently release political statements, declarations and resolutions that affirm certain

So you think global warming is a problem? Story

Harare (SARDC) — Not everyone is convinced that global warming is a problem. Many people just don't believe in it, they see it as a remote and implausible threat blown out of proportion by irresponsible journalism. Others think it's a good thing (usually those living in cold regions of the globe).

A former president of the US National Academy of Sciences, Dr. Frederick Seitz, says satellite data show insignificant temperature changes in the last 15 years despite high levels of carbon emissions. "The rise and fall of the earth's temperature has more to do with the sun's activity than with emissions from burning fossil fuels," argues Seitz.

Other scientists go so far as to predict the coming of another Ice Age, not a warming. They base this on conclusions that holes in the ozone layer caused by CFC gases will encourage the growth of glaciers.

Gerald Foley of the Panos Institute in London agrees that the concentration of greenhouse gases in the atmosphere is clearly rising. But while the potential impacts of global warming are immense, "the range of uncertainty in the scientific analysis to date means that it is still impossible to say exactly what the impact, even at a global level, is likely to be, or when it will be felt." But he argues that taking measures to reduce the threat of global warming makes good sense environmentally and economically whatever the future holds.

Achoka Awori, Executive Director of the Kenya Energy Non-Governmental Organisations (KENGO), is not convinced of the relevance of global environment and development issues to Africa.

"The only consistent element about these so-called global concerns and crises is that most, if not all, emerge from the North. Africa receives them in carefully prepared information dossiers, scientific studies, seminars and global conferences," he says.

Like him, many policy-makers in poor countries are worried about today, not long-term global issues, which they see as expensive luxury. "Do we stop worrying about availability of drinking water, food, soil depletion and basic energy needs so as to remain pondering about solutions to mirage-like crises that pop up every five years?" Achoka asks.

Cynicism about global climatic change is not unique to developing countries. A US Congressman quipped that global warming and rising sea-levels are "not such a big deal" after all. "We'll have fish where we now have cattle," he said.

Models of global climate-systems are not certain. They rely on estimates of future greenhouse-gas emissions from future industrialisation and deforestation, which are difficult to predict. Yet the models provide the best estimates we have.

There is no consensus in the scientific community regarding global warming, the amounts of greenhouse gases in the atmosphere, the role of oceans and land systems in absorbing greenhouse gases, the role of cloud cover and rainfall, or the lag between emissions and actual warming.

— **James Mpinga** from Foley, G., *Global Warming: Who is taking the heat?*, Panos, London, 1991

Who is turning up the heat? Box 13.4

It is popular to blame most of the world's problems on overpopulation. However, this is a gross oversimplification. The contributions to global warming tell a different story.

Energy consumption

Energy consumption level, related to life-style are more significant than numbers. The United States, home to about four percent of the world's people, is responsible for a staggering 18 percent of the carbon dioxide releases. India, on the other hand, with 16 percent of the world's population, contributes only six percent of the carbon dioxide. South Africa with about one percent of population contributes two percent of carbon dioxide.

South Africa mirrors the unequal distribution of resources worldwide. Each white South African is responsible for about 34 tons of carbon dioxide emissions per year, while the average figure for the entire population is nine tons per capita. The figure for the average US citizen is 16 tons, while for Japan, where energy efficiency is high, it is 7.7 tons, according to Worldwatch figures. The average Indian is responsible for only about 700 kg of carbon dioxide each year. If there is to be a solution it will have to come from the rich countries which produce most of the pollution and from the wealthy in the poorer countries.

Deforestation

The other major cause of global warming is the increasing deforestation of large areas of the developing world. Deforestation is the result of wood-gathering for fuel, largely that sold in urban areas, and forest-clearing for agriculture, as well as commercial logging.

Carbon emissions from the developing world will surpass those from the developed countries in the first quarter of the next century if the South follows existing energy policies.

Solutions must take account of the need for development in these areas and the world's rich must also bear their share of the responsibility for maintaining the world's green lungs.

Altering the pattern requires the transfer of clean technology to the South, which in turn requires an increase in development assistance. Action is needed now to halt the output of greenhouse gases.

SOURCE: Cloete, D. (ed.), "The Greenhouse Effect", *New Ground*, no 9, Spring 1992

fundamental principles and recommend particular policies. These statements are not treaties, and they have not been followed long enough or consistently enough to have the status of customary law. However, they still constitute an important first step to a future climate-change treaty.

Halting global warming

The first time global warming was recognised as a serious problem by an international gathering was during a major climate conference in 1979 which issued a declaration calling on governments to foresee and prevent potential human impact on climate that might adversely impact on humanity. Since then, there have been many international conferences on the subject. More are scheduled for the years ahead. Debate so far has centred on the economics of climate change since any policy response involves economic sacrifices. Measures to reduce greenhouse-gas emissions substantially or to adapt to climate-change impacts will to be paid

What can be done? Box 13.5

The simplest way to slow global warming is to improve energy efficiency, thus reducing fossil fuel use. Experience overseas shows that achieving energy efficiency at national level requires incentives and legislation against inefficient use.

Improvements in the efficiency of coal- and gas-use can produce savings of up to 50 percent. Combined heat and power plants, selling both electricity and domestic hot water or steam for industry, use energy far more efficiently. Energy use in existing commercial buildings can be reduced by up to 50 percent and new buildings can be designed to save up to 75 percent. There have been dramatic improvements recently in the efficiency of energy intensive industries such as steel, cement and fertiliser manufacture. Major improvements can be made in motor vehicle efficiency and through the use of public transport.

Energy alternatives

We also need to look at alternatives to our present coal- and oil-based energy infrastructure. Natural gas, although a fossil fuel, produces 40 percent less carbon dioxide when burnt than coal and 25 percent less than oil. Wood is another potential fuel for the future. Carbon dioxide released by burning wood can be balanced by planting trees to absorb carbon dioxide. Other potentially viable alternative energies are hydro-power and wind-power. Because of waste problems, cost and lack of public acceptability, nuclear power is seen less as a viable alternative.

What is needed is a move towards renewable energies, and the changes in lifestyle that need to accompany this. The table on the next page looks at the relative merits of the alternative energy sources currently available.

The biggest challenge posed by the threat of climate change is its global nature. The greenhouse effect shows us that the planet we live on is small and has limited resources. All the people of the earth must learn to share these resources.

James Lovelock proposes the Gaia hypothesis, arguing that the earth is a single organism which acts to correct imbalances. Could it be that global warming is Gaia's way of telling us to slow down in our race towards self-destruction?

SOURCE: Cloete, D. (ed.), "The Greenhouse Effect", *New Ground*, no 9, Spring 1992

through diverting resources away from other activities.

To establish a basis for international cooperation, the Intergovernmental Panel on Climate Change (IPCC) examined a number of possible future scenarios and concluded that if nothing changes (the "business as usual" scenario) the global mean temperature will rise by 0.3°C per decade. Stabilising the climate would require an immediate 60 percent cut in greenhouse gas emissions.[42] This prompted Britain to announce a commitment to return carbon dioxide emissions to 1990 levels by the year 2005. Other developed countries took similar action.

Since then, an international agreement, the Framework Convention on Climate Change, was signed at the United Nations Conference on Environment and Development in 1992. It is the first international legal instrument to recognise that global warming is of planetary concern. However, it is widely regarded as inadequate and toothless, and reflects a glaring gap between agreement and commitment.[43] It does

Relative merits of currently available alternative energy sources Table 13.4

Alternative	Generating cost (USc/kw/hr)	Carbon reduction (%)	Pollution cost (USc/kw/hr)	Cost of carbon avoidance (USc/ton)
Improved energy efficiency	2.0-4.0	100	0	0-16
Wind	6.4	100	0	95
Geothermal	5.8	99	1	110
Wood	6.3	100	0	125
Steam injected gas turbine	4.8-6.3	61	0.5	97-178
Solar thermal (with gas)	7.9	84	0.2	180
Nuclear	12.5	86	5	535
Photovoltaic	28.4	100	0	819
Combined cycle coal	5.4	10	1	954

SOURCE: *State of the World* 1990, World Watch Institute in Cloete, D. (ed.), "The Greenhouse Effect", *New Ground*, no 9, Spring 1992

not contain any binding commitments to reduce carbon dioxide emissions. It does, however, require signatories to produce a national inventory of greenhouse gases they produce, a description of steps taken to reduce emissions and a detailed plan of action. Developing countries qualify for assistance in compiling this information.

Ozone layer protection

Current international efforts to deal with ozone depletion basically involve limiting the use of CFCs. A global agreement to curtail their production and use, the Montreal Protocol on Substances which Deplete the Ozone Layer, was signed by 24 countries in 1988. This was further strengthened at another gathering in London in 1990 which agreed to achieve the phasing out of CFCs by the year 2000.

Technically, the protocol supplemented the Vienna Convention for the Protection of the Ozone Layer (1987). The Vienna Convention has the status of a treaty while the Montreal is not a treaty but a supplement to the Convention.

While developing countries are allowed to delay by 10 years the phasing out of products which use CFCs, some of these countries feel that the phase-out should be carried out concurrently with the developed countries. They believe a delay would adversely affect the economies of those companies in developing countries continuing to use obsolete equipment. Unfortunately, recent projections show that even if all countries comply with the Montreal protocol the world will still have a 20 percent depletion of the ozone layer by the year 2050.

Regional response

Though the region is inextricably linked to the complex climate system shaping life-forms worldwide, southern African countries have not done much to prepare to deal with global warming or ozone depletion. The preparedness of the peoples of this ecologically diverse region to live in a warmer 21st century will depend on how actively the region's scientific community, governments and policy-makers respond to emerging global environmental issues.

A study of climate scenarios for the Southern African Development Community (SADC)[44] has been carried out by the UK-based International Institute for Environment and Development (IIED) and the Climate Research Unit at the University of East Anglia in the UK. The scenarios consider policy implications, and are based on case studies of specific issues of current concern, such as food production or forestry.

The study says though many of the most serious effects of global warming will be felt in southern Africa, the SADC countries' contribution to global warming is minimal. The historical responsibility for global warming lies with developed, industrialised nations, which must bear the immediate burden of reduction in greenhouse-gas emission.

Developing countries clearly have different priorities from developed, industrialised countries. Even among the latter group of countries, there is no unanimity on emission cuts or timetables.[45] Carbon emissions per person in developing countries currently are one fifth to one fiftieth of those in developed countries, but three-quarters of the world's population live in developing countries so development there will increase emissions, even using the most efficient technology.

Within the region, there are inequitable patterns of development as well. Almost 60 percent of electricity generated in Africa is produced in South Africa,[46] which comprises only four percent of the land area and seven percent of the population. If population and GNP are taken into account, South Africa assumes the rather dubious status of being the third highest carbon dioxide emitter in the world.[47] Yet, some two-thirds of South Africa's population do not have access to electricity.

The SADC study identifies three key areas for priority attention in southern Africa. These include the need to:

- promote awareness of the issue of global warming in southern Africa and enhance the flow of information with industrialised nations;
- identify policies that deal with the impact of global warming that are also consistent with current development priorities; and
- advance recommendations for financial assistance in implementation.

Existing national and regional institutions require strengthening in order to deal with planning and assessment of the predicted effects of global atmospheric changes. Non-governmental research institutions can also help build research capabilities on related issues such as appropriate technology.

Though case studies are being developed in collaboration with southern African authorities, it is instructive that the initiative came from outside the areas of study. Sadly, this seems to repeat itself in many other issues involving the world's "global commons," or common environmental issues.

The need to identify target research areas for southern Africa is more compelling now than ever before. Such regional research programmes could also identify the most feasible areas of cooperation, through existing institutional arrangements, or additional cooperating mechanisms which will seek to improve the flow of information. Selected international assistance that helps to meet the costs of required technology also helps to realign development priorities to take account of global warming.

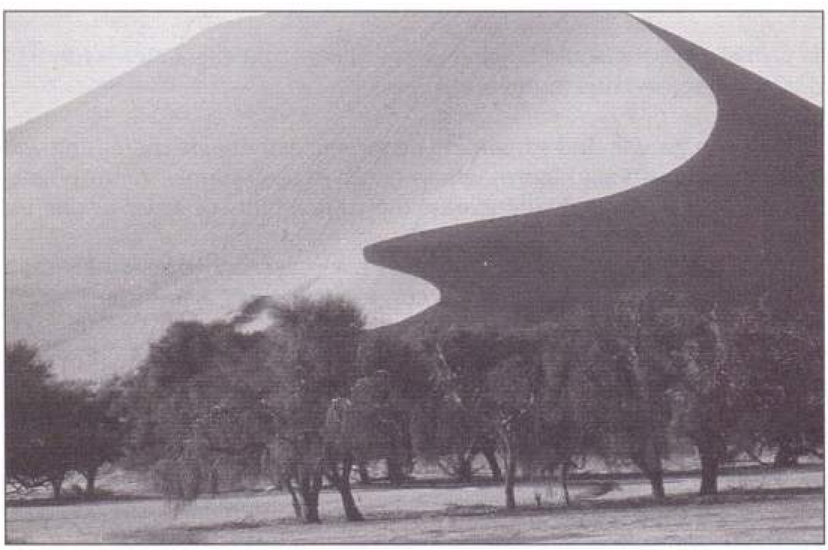


Photo 13.4 NAMIBIA REVIEW

Models of the impact of global warming on Namibia suggest an increase of up to 4° C in summer and winter temperatures. For southern Africa as a whole, slightly drier conditions are predicted, with slightly wetter conditions in coastal areas.

Linkages to other chapters Box 13.6

1 PEOPLE

The lifestyles and well-being of people, and their survival, could be affected by global atmospheric change — yet human activity is causing the change.

2 HISTORY

Global atmospheric change is a phenomenon of the 20th century, mainly because of human activities, although natural forces such as volcanoes have existed throughout history.

3 POLICY

Global atmospheric change is occurring at a time when southern African economies are under stress from a number of internal and external pressures, so it is difficult for the region to prioritise it as a policy issue. Global atmospheric changes, by their nature, require international solutions and policy initiatives, and southern Africa is taking steps to ensure that its own agenda is adequately reflected in the international debate.

4 ECOZONES

Current climatic conditions are a major factor in determining the functioning of ecozones in the region. Global atmospheric change, particularly global warming, could shift these zones, making dry zones drier and moist ones more moist.

5 CLIMATE

Global warming is expected to make weather patterns more variable, increasing the frequency of storms, droughts and the occurrence of *El Nino*.

6 SOILS

Atmospheric changes are expected to have wide-ranging implications for agriculture and land-use, possibly making plants more water-efficient and more productive, while also encouraging the growth of weeds, pests and diseases.

7 WOODLANDS

The impact on forests and woodlands could be significant, with tree growth likely to increase due to more carbon dioxide, but with negative impacts associated with more variable weather conditions and increased pests. Forest and woodland zones could shift from their current locations following changes in temperature and rainfall.

8 WILDLIFE

Wildlife is likely to be affected by changes in rainfall and vegetation, with their ranges expanded or decreased due to these changes.

9 FRESH WATER

Rapid population growth and expanding economic activity are increasing water requirements for households, industry and farms, whose needs exceed supply. Atmospheric changes, particularly global warming, will increase the vulnerability of water resources.

10 MARINE

Heating of the ocean will cause expansion of sea water, concurrent with changes in sea levels and ocean currents. Marine resources, including important fisheries, could be significantly affected, either increasing or decreasing.

11 POLLUTION

Atmospheric changes could increase pollution by increasing the frequency of storms and droughts. Decreases in surface water supplies mean decreased dilution of pollutants.

12 ARMED CONFLICT

Linkages between armed conflict and global atmospheric change is indirect in that population concentrations are in coastal areas which could be affected by rising sea levels.

14 TRENDS

Global atmospheric changes are now attracting more attention in a region where there are many local priorities.

NOTES
CHAPTER 13

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14

TRENDS
and Scenarios

Foretelling the future is an age-old occupation. The future always holds promise of innovation, change, joy or sorrow, and it is human nature to want to know what is to come. Many techniques have been used to predict what lies ahead, from casting bones to reading stars to vast mathematical models incorporating large amounts of data. This chapter does not rely on any of those tools, but instead looks back to find the direction southern Africa has been taking and, with the guidance of a small workshop of regional experts, projects the direction in which this is leading.[1]

From a virtually infinite set of possibilities for the future, a team of knowledgeable, forward-thinking individuals from around southern Africa have pointed toward two of these possibilities. One is an approximation of where the environment will be by the year 2020 if current trends (good and bad) continue more or less as they are. The other is less a prediction than a vision of what things could be, tempered by an understanding of what is possible. This second scenario looks at the decisions and changes which are necessary to reach this goal.

THE CONTEXT

Regional resources

Southern Africa's geographical and geological conditions set certain boundaries on what can or cannot be changed. Written records dating back over a century show droughts have regularly afflicted the region in that period, while geological evidence shows recurring droughts going back many hundreds of years. The natural resource base is largely fixed. Geology determines the location of minerals and, in part, soil types. Soil fertility is rarely high, and typically heavy rains deplete nutrients in the soil. Forests and other vegetation grow where the weather, soil and other natural conditions permit. Water is scarce in many parts of the region, especially in the south and west, and natural sources of supply in those areas are few.

Most energy resources are also limited. The majority of people depend on fuelwood, charcoal or, in some cases, coal for domestic heating and cooking. Access to electricity is largely restricted to major cities, and many people cannot afford to pay for electricity or electrical appliances. Little oil or gas has been found or commercially exploited in the region, except in northern Angola, although several countries are still exploring. Renewable energy sources such as wind and sun are abundant but not widely used, and access to technology to harness them has been limited by cost.

International factors

A number of political and economic interactions in the international arena have an impact on southern Africa. In particular, development loans and trade barriers remove a great deal of control over local economies from national governments. The unmanageable debt burden in most countries has severely limited the availability of government funds to monitor and manage the environment. Many countries in the region have to pay huge sums in interest each year without reducing their debt. Low global commodity prices have reduced export earnings, requiring much higher levels of production to earn sufficient foreign exchange to maintain payments.

The General Agreement on Tariffs and Trade (GATT) recently completed negotiations on the Uruguay Round, with new sections that will affect developing economies, although forecasts are mixed as to the net result. International treaties, such as those on biodiversity and global warming, which were signed in June 1992 at the United Nations Conference on Environment and Development (UNCED), are becoming an increasingly important part of international relations and global environmental security.

Global institutions, from the United Nations to the World Bank (through its Global Environment Facility), are also playing an influential role in environmental policy and management for all countries, particularly those with developing economies. Recently, non-governmental organisations (NGOs) working at the international level have been affecting global policy development, with both positive and negative effects on developing countries. For example, the United Nations Children's Fund (UNICEF), in conjunction with international agencies such as OXFAM (UK), has been able to influence World Bank policy on Structural Adjustment Programmes (SAPs) to provide for a social-support and human-development component. At the same time, groups such as the Environmental Investigation Agency (EIA), the Africa Wildlife Foundation[2] and other "animal-rights" organisations have successfully lobbied to prevent trade in ivory through the Convention on International Trade in Endangered Species (CITES). This removed a potential source of income from southern African countries for environmental management through sustainable utilisation of resources.

Another area of international negotiation is the role of technology and the need for technology transfer. Currently, developing countries often receive obsolete or even unsafe technology from the North, putting industries at a disadvantage. Older technologies also tend to be less efficient and more polluting. Sometimes processes or substances which have been banned for use in producer countries are dumped on developing countries which cannot afford to pay for better products, such as improved pesticides.

Global environmental changes

Events and activities around the world have set in motion several processes that will affect southern Africa's environment. In particular, ozone depletion will have a definite impact that will increase over the next 20-30 years, although research has yet to show what that impact will be. Possibilities include decreasing agricultural productivity, and increasing dangers to human health, such as skin cancer and eye diseases. The health of animals and plants might also be affected. Global warming, while less clearly defined, is likely to cause major, potentially catastrophic changes which could easily dwarf the effects of ozone depletion. These include a rise in sea levels, more diseases and pests, and more extreme weather conditions such as drought. Changes in weather patterns could completely disrupt ecosystems, such as the highly productive Benguela marine system on the southwestern coast of Africa.

ENVIRONMENTAL TRENDS

A scenario is an imagined sequence of future events, based on current trends and selected variables. Each variable used must assist in simplifying the analysis, while encompassing a range of more specific items. This can mean that a variable is seen as largely positive, even though it includes some negative components. To manage the scenario, a judgment has to be made as to whether the overall effect of a particular variable is positive, negative or neutral, considering the effects of all the components together. For example, while the variable called *international relations* has positive impacts on the environment, many southern Africans say international financial relations have had largely negative environmental impacts by increasing poverty and imposing unfair terms of trade.

Positive trends

Several trends are identified as having largely positive effects on the environment at present. These fall into two general categories:

- governance, meaning all the components that determine how decisions are made in society; and
- applied science.

Governance

The trend toward greater stability throughout the region is positive for the environment because it allows governments to more effectively manage the environment and enforce laws. The trend toward greater democracy and public participation in decision-making is a strong positive factor affecting the environment because of wider involvement in the process of policy development, greater commitment to policies once developed and increasing accountability. Public participation should encourage people to take more responsibility for their actions. International relations, such as environmental treaties and conventions, are seen as a dynamic positive force. Government policy is addressing environmental issues more explicitly and more effectively, and environmental areas receiving such attention will benefit strongly. While these trends in governance tend to be positive, it should be recognised that they have yet to substantially increase the access of women and youth to decision-making processes.

Applied science
In the area of applied science, two positive trends have been identified. The first is toward more efficient and non-polluting technology. The second is increased and improved infrastructure such as roads, dams, water and sanitation services, and rural infrastructure.

Negative trends
Current trends considered as having largely negative environmental consequences in southern Africa at present fall into several categories:

- industrial and agricultural production;
- poverty;
- population growth and distribution;
- education and culture; and
- natural disasters and their management.

Production
Industrialisation is considered the most negative trend because of the pollution and other environmental damage caused by largely uncontrolled and unregulated emissions. Current agricultural production systems show negative trends because both commercial and subsistence systems often abuse the living soil, slowly draining its productivity and decreasing biodiversity.

Poverty and population
The continuing trend toward poverty is a destructive force in relation to the environment, often associated with rapid population growth, which is also considered negative, although less strongly than poverty. Lack of government resources also hampers the ability to manage the environment and this can be associated directly with population growth. Increasing urbanisation is also negative in relation to the environment because urban infrastructure is rarely able to service the sanitation, waste treatment and other aspects of environmental quality associated with growing urban populations.

Education and culture
Traditional culture and values are generally seen as positive forces. However, the current non-holistic approaches to formal education and training — which are often foreign-biased and out of touch with local environments, processes and traditions — have overshadowed and disrupted the role of traditional education and culture. The result is that the overall impact of education and culture is largely negative at present.

Similarly, the role of consumption-oriented values in breaking down traditions has worked against the environment. Some traditional, religious and cultural practices and approaches, however, may make it difficult to bring in new ideas, so it will be important to find innovative ways that give due consideration to tradition.

Natural disasters
Trends in preparedness for natural disasters at both national and regional levels were rated strongly negative in terms of environmental impacts. While this variable currently includes droughts and floods, it was also discussed in the context of dealing with the effects of global climate change and ozone depletion.

FUTURE SCENARIO (I) BASED ON CURRENT TRENDS
The current environmental trends fit together to project a picture of the state of the environment in the year 2020, based on the premise that trends will continue more or less as they are. For example, if at present there is a general policy shift toward greater economic integration, the assumption is that this would continue. If biodiversity is declining, this would go on the same way. If industries seem to be polluting unabated, but active policy and legislative initiatives are being taken to curb this, a projection would take into account the combination.

Poverty and population growth
A driving force behind environmental pressures in southern Africa is poverty linked with population growth. When people lack adequate financial and 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. They may be forced to treat their land badly by growing crops without replacing lost nutrients or allowing erosion because they cannot afford the resources and the loss of crop-growing area needed for conservation works. Dung and crop residues, which can add nutrients and structure to soil, may have to be burned for heating and cooking.

Overall population growth in southern Africa is estimated at three percent annually, which means the population will double in about 24 years. By 2020 the region's population is expected to be close to 290 million, unless changes take place in growth rates. Although estimates of the region's population growth rates vary from source to source, all are higher than any other region in the world except the Middle East. Of particular concern is the fact that a large part of the population is young, with many child-bearing years ahead.[3]

It will be very difficult to alter the population growth rate

The scenario-building process Box 14.1

"If the winds keep blowing this way, it will rain tomorrow," a village elder might be heard to say. He or she is painting a likely scenario, only a few hours away, and is probably talking from experience. A meteorologist may rely on instrument readings or weather patterns. An economist may look at business trends. Many people predict the future, some with a certain amount of accuracy, others without.

This is what happened at a two-day workshop of regional participants whose collective goal was to paint a picture of the region's environment as they see it in the year 2020. The idea was to identify consensus or divergence among the group on a variety of issues which affect southern Africa's environment. The group included men and women from six of the region's 11 countries, as well as a few participants from other African nations and elsewhere. Their disciplines included ecology, hydrology, wildlife management, agriculture, forestry, chemistry, geography, economics, population, education and communications. Some were policy-makers, others from the private sector and NGOs, media, academia and the traditional sector. Their common feature was a concern for the environment. This array of experience was intended to provide an integrated, holistic approach to the scenario-building. In order to give each person a common base to work from, draft chapters of this book were distributed in advance.

After careful consideration of the time and information available, the group decided it would be most productive to develop two scenarios. The first would be the future as they saw it unfolding before them, based on current policies and trends. The second would start from the same point of departure, but they would be free to develop any pattern chosen, provided it could be realistically reached given the current situation.

The participants' first task was to define the framework for their glimpse into the future. As in any scenario-building process, it was essential to simplify the many possibilities and narrow them down to a workable set that could produce realistic results. Each person was given the chance to identify the two factors they felt would most affect the state of the environment until 2020. These became the *variables* discussed in the main text of this chapter.

Three working groups each took a set of variables from one of the three areas and applied them to a number of environmental components, or indicators. The workshop had agreed that the main concentration would be effects on environmental quality, productivity, and biodiversity. In each case they were to determine whether the variable would have an impact, ranging from very positive through very negative, if current trends continued. The varied backgrounds and perspectives led to lively discussions and eventually a general set of directions emerged.

The next step was to look at the combined product of the three working groups and identify obvious trends. Some environmental components seemed to be affected much more positively or negatively than others. Some variables were judged to cause almost entirely beneficial or harmful effects on all the indicators. These areas of particular strength and weakness were the areas of focus for the next set of discussions toward a *desired future*.

Each group took a slightly different approach to the development of the desired future scenario. The main concentration in developing this scenario was to consider what the environment should look like in 26 years, and to set out policy changes and decisions that would be needed to reach these various environmental goals. The groups also drew attention to constraints that had to be overcome before the desired policy changes could be realised. This was a difficult task, especially given the rule that the changes and goals must be realistic in relation to the current situation, encouraging the development of a recipe for improvement rather than a "wish-list".

Environmental variables and indicators Box 14.2

The two scenarios presented in this chapter are based on the trends and impacts predicted by the workshop participants.

Setting out a scenario based on current regional trends was, in some ways, the most difficult part of producing this report. There are literally millions of possibilities for the future over the 26-year period to the year 2020, combining hundreds and thousands of different factors, many of which are beyond southern Africa's control. To narrow things down, the scenarios workshop generalised at the regional level and developed a set of variables which combine many of the different forces affecting our environment. Events which cannot be controlled from the region, such as global warming, received less emphasis.

There were a number of variables, or driving forces, that the workshop agreed would affect the environment in some way. The environmental variables were grouped according to a model which shows the components involved in achieving sustainable development. The three sets of variables becaame the subject of discussion by three working groups.

The variables examined included poverty, which was considered to be an issue that cut across all the variables, so was discussed by all groups. The variables were:

1 Socio-political
- Population growth
- Public participation
- Government policy
- Stability
- Land tenure
- Preparedness for natural disasters
- International relations
- Poverty

2 Human resources
- Education and awareness
- Skills and training
- Knowledge and information systems
- Institutional development
- Cultural and religious values
- Poverty

3 Economic
- Agricultural production systems
- Industry and industrialisation
- Urbanisation
- Technology
- Consumption patterns
- Infrastructure
- Poverty

There were also a series of environmental indicators against which to measure the impact of the variables on the physical environment in terms of environmental quality, productivity and biodiversity. These indicators were:

1 Land use
- Agriculture
- Grazing
- Forests and woodlands
- Human settlements
- Protected areas

2 Fresh water
- including impact on availability of fresh water

3 Air

4 Marine environment

SOURCE: Southern African Environmental Scenarios Workshop, Harare, 3-4 Feb 1994 between now and the year 2020, because the people who are going to have children in this period are already born. They and their offspring will face the decision to have smaller families if the growth rate is to decrease. At best the population is not likely to stabilise for several decades, although population growth rates are declining in some southern African countries.[4]

Photo 14.1 PHOTOGRAPHIC TRAINING CENTRE,MAPUTO-S Pintus

Conflict, poverty and population growth have increased environmental pressures in many parts of the region. Here, two children in Mozambique's Tete province collect maize kernels that spilled during food distribution.

Death rates may increase, for some years, as a result of predicted environmental trends, thus lowering overall population growth rates. Increases in the spread of diseases and pests may result from rising temperatures associated with global warming. For example, the range of malarial mosquitoes may be extended. The long-term impact of Acquired Immuno-Deficiency Syndrome (AIDS) is another factor. Some studies suggest that AIDS may significantly reduce population growth rates, even as far as reducing the actual population,[5] although others say that lack of information on the extent of AIDS makes any prediction questionable. The effects of such factors are difficult to estimate and there are variables within variables. For example, statistics show more people died of malaria in Africa in 1993 than have died of AIDS worldwide since the virus was discovered in the early 1980s. But AIDS has a proportionally greater impact on young, skilled professionals and technocrats.

Within the trend to population growth is the strong trend toward urbanisation. Towns and cities are growing at a much faster rate than the population growth rate, about double; so while more people are being born, many more are moving from rural areas. At present urbanisation rates, over half of southern Africa's population will live in towns and cities by the year 2000. This means that population growth will put more direct pressure on urban areas, and the associated services, than on rural areas, as well as drawing heavily on adjacent resources. 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.

The main influence on population growth will be the economy (formal and informal) and its relationship to each person's quality of life. Population studies show that growth rates decline where poverty is reduced. If the region's economies cannot increase the pace of economic development, people will become poorer on average. If distribution of wealth, or programmes enhancing quality of life, do not become more universally available then more individuals will become poor(er). Poverty will have to be addressed before population growth can be expected to drop.

Economic growth

Economic development is key to the future. Governments need funds to manage the environment, and to provide services such as education and health, which have positive environmental spin-offs. Industries need funds to grow, and to install clean, efficient technology. Farmers need money to pay for inputs and to undertake proper soil management and conservation. Access to all these inputs will require a substantial increase in economic growth in the region.

Economic development is difficult to forecast, especially in the turbulent climate created by worldwide recession, intense competition and the rapid shifts in global markets. Forecasters rarely agree on trends for future growth, and are

Population growth and density in perspective Box 14.3

Southern Africa is currently home to about 136 million people with an average density of almost 20 people per square kilometre (sq km). With a growth rate of three percent per year, there will be 272 million people by 2018 and average density will double to 40 people per sq km.

Should that growth rate continue, by the year 2100 southern Africa would have almost 3,000 million people, over 20 times the present population, and density would be over 440 people per sq km.

An analogy would be a small family of four starting out in a two-roomed house of 50 square metres (sq m), 13 sq m per person. By 2018 there would be eight people living in the house, with 6 sq m per person. By the year 2100 there would be 102 people living there with about half a square metre each, barely enough room for everyone to stand.

Like the small imaginary house, land cannot be made to grow and countries cannot expand. Clearly, at some point there will be too many people, although this level will vary from country to country.

SOURCE: Southern African Environmental Scenarios Workshop, Harare, 3-4 Feb 1994

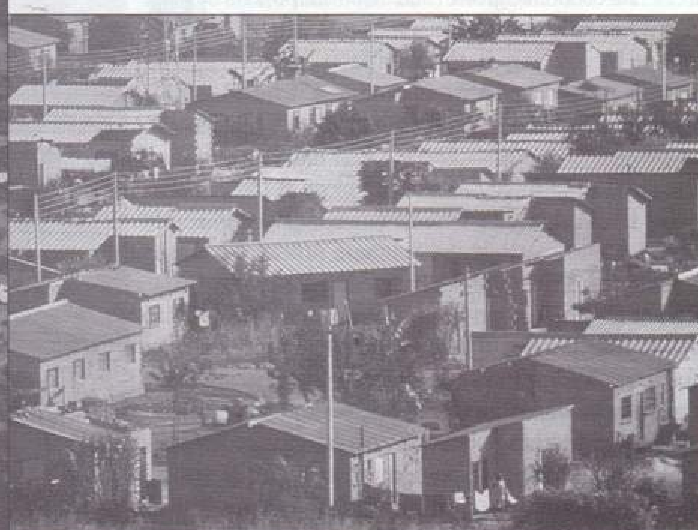


Photo 14.3 IUCN-D Reed

The average population density in southern Africa is about 20 people/sq km, but at current population growth rates this will double to 40/sq km in 24 years. Shown here are the village of Kanye in Botswana (left) and a city "high density" suburb in Zimbabwe.

Photo 14.2 IUCN-D Reed

often caught unawares by global events, although some developments are easier to predict than others. Mineral prices are unlikely to rise significantly in the foreseeable future, but the recent drop in crop prices caught many farmers in southern Africa by surprise. Fluctuating oil prices, often unpredictable due to disagreements among producer countries, can benefit or harm the oil-importing countries of southern Africa.

The general economic trend in the region is slow growth, falling behind the rapidly rising population. If this trend continues, it may result in a decrease in average real income, large-scale unemployment, a decrease in the quality of life, and an increase in the number of poor people. Escalating levels of debt owed to foreign lenders, and declining terms of trade from already unfavourable levels also weaken the economies.

Some countries have opted for World Bank-sponsored SAPs to bring their economies back on track, and often cannot access development loans unless they agree to implement a SAP. While SAPs may improve the economic context, past results indicate they are not enough to accelerate economic growth and eliminate poverty. It is too early to gauge their long-term effects, except by looking at their impacts on the economies of other African countries, which appear to have been largely negative to date.

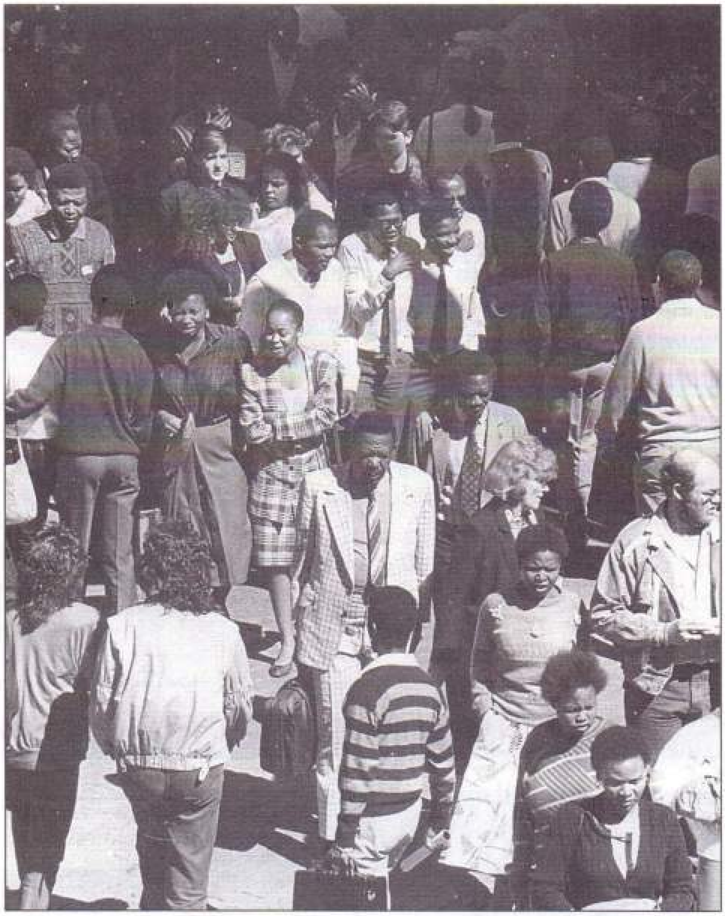


Photo 14.4 SOUTHLIGHT- G Wulfsohn

The economic development challenges facing this region in the foreseeable future include provision of education, health, housing and jobs. These problems are particularly acute in South Africa.

The trend toward regional trading blocs at the global level is likely to have negative impacts on southern African countries, while the Southern African Development Community (SADC) and the Preferential Trade Area/Common Market for Eastern and Southern Africa (PTA/COMESA) should have positive effects. The United Nations Economic Commission for Africa (ECA) believes that regional trade in regionally produced products, where local tariff barriers are removed and exchange rates are coordinated, are key components in stimulating economic growth in Africa.[6]

International economic agreements, especially the GATT, should give developing countries freer access to northern markets. Amendments to the GATT will decrease tariffs and duties on agricultural and industrial products around the world. However, southern African countries which already benefit from duty-free access to some markets will be undercut by the new GATT rules which decrease tariffs and duties on products from other countries as well.

There is a need to create more jobs in southern Africa and to generate wealth at both national and individual levels. Some key trends to be encouraged are in the field of "clean" and efficient technology, and the development of infrastructure, especially in rural areas. These trends can only be strengthened through on-going and increasing financial resources for governments.

Southern African countries can anticipate and resist the temptation to accelerate economic development by depleting their natural resources. Many developing countries have to cut trees and mine large quantities of minerals to pay foreign debts. These resources are all valuable national assets, and their sustainable use is necessary to support people and the environment they depend on.

Governance

Southern Africa seems to be moving toward a more stable and peaceful future. Discussions among SADC member-states in the areas of economics, transportation, electrical energy and water all point to a climate of co-operation. The development of COMESA in 1993 continues the positive thrust toward regional economic groupings.

Recent discussion of a protocol on shared water resources appears set for SADC ratification. SADC is proving to be a credible body for the discussion of shared interests, providing a forum for negotiation and conflict resolution. Its pro-active work in developing and expanding the Zambezi River System Action Plan (ZACPLAN) into an agreement on managing shared water resources throughout the region, before water is in short supply, bodes well for other potential conflict areas. Ad hoc initiatives to smooth national tensions and promote conflict resolution and peace in Angola, Lesotho and Mozambique have also been undertaken by SADC heads of state.

Photo 14.5 SAMSO-T Davies

The Victoria Falls (Mosi-oa-tunya "the smoke that thunders") on the Zambezi river between Zambia and Zimbabwe was once described by the Swedish prime minister, Olof Palme, as the "boundary of human decency" because it marked the border of independent Africa. The Zambezi river now symbolizes regional cooperation and shared resources.

Confrontation and conflict in the region has been dramatically reduced as a result of democratic elections in South Africa in April 1994. African National Congress (ANC) leader, Nelson Mandela, was elected that country's first black president and his party heads the government of national unity. Multi-party systems have replaced single-party ones in Angola, Malawi, Mozambique, Tanzania and Zambia.

Soil degradation

The long-term sustainability of agricultural production is a major area of concern. The past two decades have seen increasing emphasis on intensive agricultural production through expansion of irrigation and use of agricultural inputs such as fertilisers and pesticides, as well as improved seed varieties. This higher production comes at a price. Irrigation can lead to waterlogged soils or salinisation, and rehabilitation of such soil is expensive and often impossible. Heavy use of fertilisers and pesticides destroys soil structure and organisms, leaving the soil lifeless and unproductive or contaminated by chemicals.

Soil exhaustion from intensive cultivation is not expected to become a widespread predicament by 2020, although a crisis could loom later. Soil salinisation and acidification are evident in some parts of South Africa and localised elsewhere. These intensively farmed areas now need more fertiliser to produce the same amount of crops as they did a decade ago.[7]

In the long run, there must be a re-introduction of some traditional methods which also feed the soil, combined with new developments in caring for the soil as part of farming. Fertilisers are now being used more carefully. There is also a declining trend in the use of organochlorine pesticides as a result of policies to phase them out for environmental and health reasons.[8] Community projects in soil conservation and sustainable agriculture, designed to preserve soil productivity, can be found dotted around southern Africa. Active research is underway to adapt traditional methods, such as slash-and-burn/ash fertilisation or mound agriculture, to meet today's needs. Current policy and management trends do not show a great deal of emphasis on these approaches, however, and wider promotion and commitment is necessary if they are to affect more than a minority of producers.

Southern Africa has a few remaining areas of high-potential agricultural soil, such as extensive areas of Zambia and the many small wetlands, known as *dambos*, found throughout the central plateau. These areas can be quite productive on a sustainable basis,[9] but could also be degraded without careful management — as has been happening in South Africa's grassland area.[10]

Since good land is a finite resource, agricultural expansion cannot continue indefinitely. There are some large expanses of unoccupied land in parts of the region which are becoming available through successful tsetse-control programmes. But much of this is in the moist savanna zone, and is wooded, with poorly-structured, low-nutrient soils. These soils erode easily and lose their ability to produce crops quite rapidly. The result of cultivating them would be abandonment of large areas of degraded soils. The amount of land used for agriculture in the region is increasing by about 0.2 percent a year, but much of it is in marginal areas with steep slopes, poor soils and unreliable rainfall.

As cultivation expands to produce more food for the growing population, it will encroach on present grazing areas. At the same time trends show increasing livestock populations, especially sheep and goats. In six countries (Botswana, Lesotho, Malawi, Tanzania, Zambia and Zimbabwe), the population of sheep and goats is increasing faster than the human population.[11] In Malawi, Zambia and Zimbabwe, both cattle and sheep populations have shown large increases over the last decade.[12] With the increase in livestock populations and decrease in prime rangelands, the effects of overgrazing, in terms of soil degradation and bush encroachment, will increase.

An important consideration is the move toward game-farming by some large ranchers in Namibia, South Africa and Zimbabwe. This could decrease livestock populations in such areas, but livestock density is expected to continue to increase in communally held areas.

Overall trends show soil degradation increasing in the region through the year 2020. More arable land will be rendered less productive through intensive agricultural practices over the next 26 years. Degradation will continue as marginal lands are cultivated, with fertility declining, as soil is lost faster than it is produced. Systematic, scientifically defensible studies have rarely been carried out on causes and processes of soil degradation. Fortunately, this may be starting to change. There are signs of greater interest in the study of soil and land degradation processes in the region.

Food production

A more serious trend, resulting partly from soil degradation, and one that is reflected throughout the world, is the decline in per capita food production. Overall agricultural productivity has increased in southern Africa, but has not kept pace with the growing population.[13] The region has produced a net food surplus for several decades, but the drop in per capita production will lead to a net deficit well before the year 2020. Since other areas of the world are also experiencing these declines, they will eventually export less to southern Africa because they will need more to feed their own people.

While a number of new seed varieties and improved agricultural technology holds some promise for increased food production, these are unlikely to enable production to catch up with population growth. A recent Worldwatch Institute *State of the World* report said, "Seldom has the world faced an unfolding emergency whose dimensions are as clear as the growing imbalance between food and people."[14]

Photo 14.6 IRIS-C Thege

Livestock numbers have increased sharply over the last decade, and in six countries the population of sheep and goats is growing faster than the human population. Shown here, children tending livestock in Tanzania.

Photo 14.7 SOUTHLIGHT-P Weinberg

Agricultural productivity has increased in the region, but has not kept pace with population growth. Food security will continue to be a concern for southern Africans, such as this woman in northern Namibia.

Southern Africa still has a long way to go before it has fully exploited the many ways to produce more food from a piece of ground, but there is no doubt that these have their limits. "Achieving a humane balance between food and people now depends more on family planning than on farmers," according to Worldwatch.

Water supply

Access to water will become a major political, social a years and water will be a critical commodity for the majority of the region's countries by the year 2020. As the number of people increases, demand for water will also rise to meet the needs of a growing, developing society — for domestic and industrial use, livestock, irrigation, mining and power generation. Consumption is expected to almost double in the next 26 years. Water deficits have been projected in Botswana, Namibia and South Africa by the year 2020.[15] Projecting a further 26 years at the same rates of growth will see Malawi and Zimbabwe joining the countries with water deficits and Swaziland close to the edge. Supplies of water in Angola, Lesotho, Mozambique, Tanzania and Zambia are quite large and should be adequate for at least the next three generations.

Irrigation consumes about 60 percent of all the water currently used. This use will continue to grow by at least five percent annually (well over the projected population growth rate) until 2020 when it will use 36 cu km, more than all the water currently used in the region. If countries with high irrigation potential, such as Angola, Mozambique and Zambia, decide to concentrate efforts on irrigation, the rise in use would be even higher.

Most countries in the region will continue to build reservoirs for water storage. Botswana, Namibia, South Africa and Zimbabwe rely on large and small dams for water. Other countries make less use of dams, but some are needed for water supply to large settlements, mines and irrigation schemes. Many more dams and associated water-supply schemes will be built in the region, especially in the water-poor countries. At one time Mozambique indicated its intention to dam virtually all of the Zambezi river inside its territory for irrigation schemes.[16]

A serious concern related to water supplies is siltation of dams. It is difficult to say whether the sedimentation trend is increasing, decreasing or simply continuing, although the growing use of marginal agricultural land might be inferred to mean that more erosion will take place, leading to greater levels of siltation.

The beginnings of a regional water strategy seem to be devel-

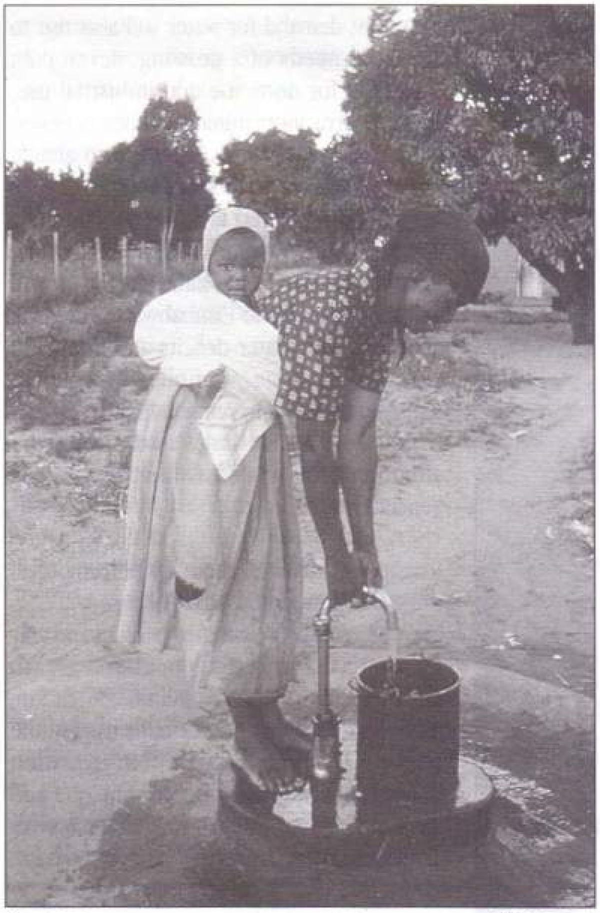


Photo 14.8 IUCN-D Reed

Access to water for domestic and industrial use will be a major issue for southern Africa by the end of the decade. Consumption is expected to double by the year 2020, most of it for irrigation.

oping — a positive trend in any part of the world. Regional transfer and sale of water is being discussed in various forums, including SADC. The discussions on cooperative water management in the region, sponsored by SADC and the United Nations Environment Programme (UNEP), show a trend toward water-sharing arrangements between the water-rich and water-poor countries.

Water transfers and increased use of water storage could have a serious negative impact on the environment. As more dams are built there will be fewer natural rivers and a substantial loss of habitat. Both river and lake water levels will drop, floodplains will be damaged by loss of annual flooding, and estuaries will be disrupted when the mix of fresh to salt water changes. If such projects continue to increase without environmental considerations, eventually freshwater ecosystems will be disrupted, affecting other land ecozones.

While environmental damage from water transfers may become a problem, water is currently a serious limiting factor to agricultural and industrial development in some parts of southern Africa. With its distribution changed through transfer schemes, this limitation could be removed and it may be possible, for example, for Botswana to develop irrigation schemes to meet food security objectives, an idea shelved because of water shortages.

Growing urbanisation and industrialisation will increase levels of water pollution, given current trends in regulation and infrastructure. This will require more complicated and expensive treatment and associated costs, as well as an expansion of municipal and industrial water-treatment infrastructures.

A positive water-supply trend is the interest in water conservation. From recycling of municipal water to improving industrial practices, progress is being made in this area. The low levels of irrigation efficiency and high water-use seem to beg for attention, but little has happened in that area as yet.

The above trends are based on average rainfall and runoff over the region, as well as on existing population growth rates. Changes in population growth or rainfall might improve, or worsen, the situation of any country. Consumption patterns could also change, particularly in relation to irrigation.

Biological diversity

Biological resources outside protected areas will likely suffer most from now until the year 2020. Expansion of cultivation into rangelands and uncultivated woodlands is expected to cut dramatically into available wildlife habitat. Large mammals, and those which range over vast territories, will be the most affected as their habitat shrinks and their migration corridors disappear.

In addition, large areas of relatively untouched vegetation are likely to be cleared and replaced with crops, and may never return to their previous state. Intensive agricultural techniques will kill many small useful organisms in the soil, and widespread use of pesticides may poison certain habitats, such as fresh water in nearby lakes and rivers, or affect certain bird species. Pollution from industry and waste disposal is also expected to take a severe toll on all species in the food chain.

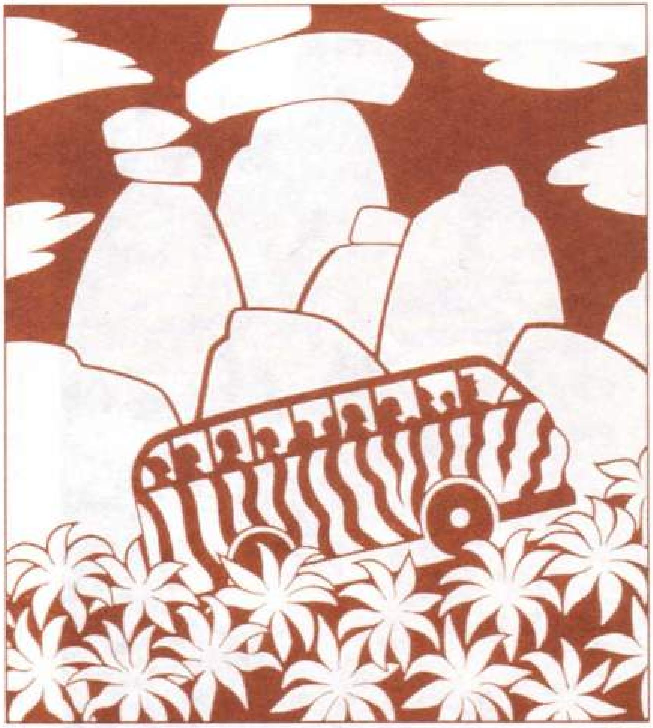
Overexploitation is likely to increase, but will not represent a major threat, except to a few species. With wildlife habitat decreasing, however, overexploitation may further endanger some species. Some plants used for traditional medicines, and certain trees used for furniture or crafts, are already disappearing in parts of the region, as are a few other plant, animal, bird and reptile species through illegal trade.

Fish will come under increasing pressure. Some lakes and rivers (such as parts of lakes Malawi and Victoria and parts of the Shire river) are already overused, with only very small fish left. Mesh sizes of fish-nets are very small, and mosquito-nets have even been used in some places. Marine fish have also been overexploited, particularly by foreign trawlers on the west coast. There are several projects in place to support and encourage better fisheries management in areas of overfishing, which might arrest the problem before it is too late.

Species extinctions throughout the world have reached alarming rates. Current estimates indicate that 40,000 species go extinct each year. At that rate, by 2094, four million species will have been lost. In southern Africa, a few species are threatened directly by hunting and poaching, but many more are under threat from losing their habitat. Threats to wildlife include farming, livestock-grazing, urban and rural settlement, and loss of woodlands to wood-cutting and fuelwood collection for rural-based industries such as tobacco-curing and brick-burning. Afforestation can have the same effect, since pine or eucalyptus plantations are more like farms than forests, and remove the complex habitats which many forest species require.

There are no specific statistics on trends in habitat loss in southern Africa. However, the United Nations Population Fund (UNFPA) estimates that one-tenth of a hectare is lost per each additional person and, at that rate, the region is losing almost 4,000 sq km of wildlife habitat each year. With current population growth rates, habitat loss would rise to 8,000 sq km by the year 2020. Cumulative clearing would amount to about 120,000 sq km over the 26-year period — almost two percent of the region's total land area.[17]

The system of protected areas in the region is the only major environmental land-use expected to experience positive changes over the next 26 years. This is largely because of increasing emphasis on tourism in areas such as national parks and game reserves, which should lead to improved protection through increased revenues with which to manage protected areas. Over time, protected areas will contain larger proportions of the region's biodiversity.



Ill 14. 1 C Bass

An interesting regional trend is the rise in privatisation of wildlife, or other schemes which give it value. These include the increasing number of farmers turning to game-ranching, the community-based wildlife schemes in communal lands, and the role of national parks and protected areas in providing a livelihood. This trend can be expected to partially offset the loss of wildlife habitat due to expanding human population.

Environmental quality

It is likely that the quality of air, fresh water, sea water and land will deteriorate significantly from now until 2020. This deterioration relates to inadequately regulated air and water pollution by industry, inadequate sanitation infrastructure leading to sewage pollution, and poor land management practices in all agricultural sectors, including livestock and intensive and dryland farming.

It is difficult to identify any strong trends in environmental quality in the region. This is largely due to a lack of systematic pollution monitoring. The lack of information in both the government and industrial sectors makes it difficult to determine pollution levels and trends at a regional scale.

Increasing urbanisation and industrialisation in most southern African countries will likely increase waste production.

Photo 14.9 PHOTOGRAPHIC TRAINING CENTRE,MAPUTO-Lote

These people using polluted water behind a factory are in Mozambique, but it is a familiar image throughout the region, indicative of the need for anti-pollution legislation and enforcement.

Pollution problems are likely to escalate at the same rate as industrialisation unless action is taken. Most countries in the region identify environmental monitoring and enforcement of anti-pollution legislation as areas of weakness. Substantial increases in staffing and training, as well as backup in the form of analytical technology, are needed to combat pollution.

While the role of infrastructure is regarded as largely positive, it should also be recognised that large amounts of raw materials, energy and waste are involved.[18] Sewerage requires thousands of kilometres of pipe and the digging of trenches, as well as large treatment-works. Road-building uses vast amounts of tarmac, gravel and sand as well as energy and equipment. Some solar electric panels are made from toxic substances, as are the batteries for energy storage.

Energy

Energy demand is rising in the region as a result of increasing population and urbanisation, improved standards of living, and industrialisation. However, there is little indication of change in the proportions of energy used from different sources. Use of fuelwood and electricity are both rising, and both stressing the environment in different ways.

There can be no doubt that as southern Africa industrialises, more energy will be required. The trend toward increased energy consumption will continue, but there are opportunities to control the rate at which this occurs. Energy conservation has become an important field in some parts of the world, and southern Africa can take advantage of this by acquiring energy-efficient technologies as it industrialises.

Some forms of energy are inherently less-polluting than others — solar, for example. These are rarely used in southern Africa and offer considerable potential in reducing pollution from energy production.

Household use of fuelwood, charcoal or coal appears to be a steady, continuing trend. While some policy initiatives are aimed at decreasing the use of these products, there seems to be little impact to date.

Information

Information for comprehensive environmental management is lacking throughout southern Africa. Few countries can afford regular collection and analysis of data on a broad variety of environmental indicators. Information is collected at national or district level, so it is difficult to use it to get an overall picture of a catchment area in the case of water, or an ecozone. Information is often collected on an *ad hoc* basis, using methods that are not consistent from country to country, or even from one research station to the next, making collaboration and comparison virtually impossible. In some cases raw data, such as water samples, are collected regularly, but facilities to analyse them are inadequate or can only perform a rudimentary analysis.

Regional studies are even rarer, largely due to lack of resources. An initiative is being developed within the SADC Environment and Land Management Sector (ELMS) to do regional environmental monitoring. Such a project would have considerable impact, because this is the kind of information needed to manage the region's resources sustainably.

Future policy direction

Environmental policy directions in southern Africa vary considerably. Several governments are involved in developing or implementing National Conservation Strategies (NCSs), while others are working on National Environmental Action Plans (NEAPs). Namibia and South Africa have embarked on "home-grown" initiatives. All governments, except South Africa, participated in UNCED and indicated a general commitment to the principle of sustainable development. At the same time, most governments admit that there is little coordination between those making environmental policy and those involved in economic or social policy.

Several environmental policy areas seem to be receiving attention from a number of the governments in the region. Many are examining forms of environmental planning and impact assessment with a view to requiring all projects to undergo some form of assessment. Coordination and management of regional lakes and rivers has become a priority, with a regional protocol expected to be signed in 1994. Wildlife conservation policy in this region is leading the world through privatisation of wildlife on game-ranches, and community management and utilisation of wildlife.

The sum of the positive and negative trends reveals an overall negative environmental trend. While this is discouraging in itself, the bright side is that the workshop did not see a particularly bleak future — something many forecasters have laid out. Perhaps more encouraging is that these results show that some time remains to break the negative trend and reset the course toward sustainable development in southern Africa.

DESIRED FUTURE SCENARIO (II)

A complex set of socio-political, environmental and other human factors affect southern Africa's environment. Some of these factors are beyond the region's direct intervention, such as ozone depletion or global trade mechanisms. Southern Africa can play a role in influencing these external factors only as part of the global community. While external forces should not be ignored, there are a number of factors within the region's grasp which can be directly influenced and changed by national or regional policy and action, or by more localised measures.

From a practical perspective, it would be preferable to concentrate limited resources on the variables with either largely positive or largely negative impacts. The desired environmental scenario examines the kinds of decisions and actions which the region can take to protect and manage the environment while continuing to improve the lives of people in southern Africa — in other words, sustainable development.

This second scenario points clearly to the need to develop human resources and improve standards of living in the region, to set the stage for sustainable development, while recognising that such changes will not achieve the goal on their own. There are plenty of examples of poor environmental management and abuse of resources in countries with high standards of living.

It is necessary, to address population growth and poverty, which can force people to degrade the environment to meet immediate needs. Aspects of traditional knowledge and culture can be used as the basis for a more holistic approach to environmental conditions. Technology, and industrial and agricultural production, must be improved to support economic growth on a sound environmental footing.

The various factors interact in many ways. Economic growth can improve the standard of living which can, in turn, lower population growth. External factors also play a role. Key elements in economic growth are access to international markets, investment and technology, and these only be influenced within the region but not controlled.

To reach the desired future scenario, there are two imperatives. First, the negative trends currently affecting the region must be stopped, or at least reversed. Second, and equally important, the positive trends must receive continued or increased emphasis to sustain their momentum. The following section dwells largely on reversing negative trends, but these actions must be accompanied by emphasis on socio-political stability, public participation and strong international relations. Positive government policies in areas such as environmental impact assessment or pollution control should continue, with emphasis on clean, efficient technology and appropriate infrastructure.

Major policy priories

The negative environmental trends have already been identified. Some are easier to address than others and linkages between them should be considered since the fundamental problem often results from several factors working together. Environmental policy will have to be carefully drafted to take this into account.

Creating wealth and raising living standards

The causes of environmental degradation in southern Africa can often be traced back to poverty — not to poor people, but to the societal conditions that force them to live in poverty.

Only with improved standards of living will there be any likelihood of a decrease in the rapid population growth and a release of pressure on natural resources. While there may be any number of opportunities to enact legislation to protect the environment, inform people on how and why to protect the environment and develop more efficient, environmentally friendly ways of using the environment's resources, none of these are likely to be effective unless poverty is reduced and population growth declines.

Alleviating poverty requires economic development, coupled with more equitable distribution of wealth and improved standards of living through access to essential services. Investment policies should recognise that it is important to provide an enabling environment for people to participate in the benefits of economic development. A re-examination of some economic adjustment processes may be required, with careful consideration of the kind of development which leads to increased wealth and equitable distribution. Particular emphasis should be placed on development in the rural areas[19] where the majority of southern Africans still live — although urbanisation is the trend in most countries of the region.

Grannies for family planning Story

Harare (IPS) — Florence Chakanyuka clocked about 1,000 kilometres on her rusty black bicycle last year, visiting families in Chinamhora district, a vast communal area north of Harare, the capital of Zimbabwe.

Chakanyuka and several hundred other family planning extension-workers provide information and contraceptives in communities across Zimbabwe. Affectionately called "grannies for family planning" because most are family women, they are an important part of the government's bid to improve access to family planning in a country where 7 in 10 people live in rural areas.

"The single most important attribute we look for in selecting extension workers is that they should be of good standing in their respective communities and have references from community leaders," says Alex Zinanga, director of the Zimbabwe National Family Planning Council (ZNFPC). Seven years' schooling is also required.

The "grannies" are each provided with a bicycle and a back-pack containing condoms, other contraceptives, and a blood-pressure measuring kit.

They undergo three months of training on how to counsel couples on modern family planning methods, how to provide simple contraceptives such as condoms and pills, and where to refer couples seeking more complex options such as surgical contraception. They are able to convince some 15 men a year to have vasectomies, overcoming the mistaken but widespread fear that the procedure is akin to castration, ZNFPC officials say.

Now, the ZNFPC employs more than 700 of these extension workers. Another 300 or so are employed by public and private agrochemical and mining corporations.

Officials at ZNFPC say the grannies have been an instrumental part of their efforts to promote family planning. Preliminary results of last year's census suggest Zimbabwe's annual population growth rate has averaged 3.1 percent over the past decade. ZNFPC officials say they believe the rate is now closer to 2.8 percent. Regardless, they add, the grannies' pedalling will continue to be an important part of the family planning programme in Zimbabwe.

— **Joe Bankole**/IPS, *Populi* magazine, reprinted from *National Conservation Strategy Bulletin*, IUCN and Government of Pakistan, Jun 1993, Vol 5, p. 39

One dilemma faced by many rural subsistence farmers who wish to improve their production and standard of living is their inability to access credit. Their land is communally owned and cannot be used as collateral. Many advocates of the free-market system suggest that individuals should own land so they can receive loans, and as an incentive for proper land management. Others feel this approach is inappropriate for southern Africa, since people have little to fall back on in case of crop failure, which might lead to loss of land to creditors and concentration of land ownership in the hands of a few wealthy individuals.[20] They endorse instead a policy to develop cooperatives, supporting and strengthening traditional systems of collective land tenure.[21] Such policies would ensure access to land, but also provide for credit.

Governments and communities should have better strategies in place in advance of natural disasters, such as drought, to minimise negative impacts. These strategies would include ongoing monitoring for early detection, as well as planning and providing infrastructure to mitigate harmful effects. This approach should also apply to potential global disasters, such as impacts of ozone depletion or global warming.

Without economic development the resources will not be available to implement environmental protection and management. Yet economic development, especially under the current market-driven principles of reducing government regulation and spending, could result in a more degraded environment. Maintaining natural-resource stocks and environmental quality while developing national and regional economies, and meeting the social welfare needs of citizens, will be the major policy challenge for southern Africa.

Consolidating human resources

Education and training, knowledge, culture and religion are key to solving problems of environmental degradation. Other important areas include communication and the media, indigenous methods and languages, and institutions.

Education is a critical factor in the move toward sustainable development, and minimum requirements for universal education levels should be set, with special emphasis on ensuring education of girls and women. A holistic, development-oriented, practical curriculum should be formulated through co-operation between governments, educational institutions and communities. The curriculum should consider indigenous knowledge, language and materials, and gender equality. It should also include components directed toward encouraging smaller families. Both school curricula and agricultural extension should direct more attention to sustainable farming using organic methods, such as permaculture (permanent agriculture) and agroforestry (agriculture using trees).

Teachers, communicators and the media need to be more familiar with environmental information, and research institutions should network to ensure they are meeting the needs of users and communicators of knowledge. Research is particularly needed in the area of sustainable, productive farming and grazing systems, and associated appropriate technology. There is need for the media, governments, NGOs and research institutes to ensure that research results are communicated, and these efforts should include use of indigenous languages and traditional approaches.

The role of religious and cultural institutions, communities, NGOs, the media, and particularly the family, is important. Identifying and encouraging traditional values and practices which benefit the environment, directly and indirectly, can make the best use of appropriate indigenous knowledge and empower people to manage their environment sustainably.

Maintaining a healthy environment

Farming and grazing in the region must move from largely unsustainable systems which deplete nutrients, degrade the land and sometimes poison the soil to sustainable ones which protect and maintain the health of soils. This will require a greater research emphasis, focusing on countering the effects of poverty, which can force farmers to abuse the soil or prevent them from using adequate inputs and taking soil conservation measures. This should include social forestry as well as appropriate, alternative energy to reduce use of dung and crop residues as fuel. Livestock-breeding should be strengthened for the development or improved stock.

In addition to research, there is a need to communicate the results through an expanded network of extension officers. They should be thoroughly trained to promote sustainable agricultural techniques. The research should work in concert with other programmes to provide farmers with better incomes, including improved rural infrastructure and marketing centres, and more employment opportunities to supplement agricultural incomes.

Governments should also develop a comprehensive set of policies, legislation and regulations to discourage pollution. Strict incentives are required for industries to strive for *zero emissions*, and to use environmentally benign production and waste disposal methods, including recycling. Disincentives, including fines and other regulatory instruments, must be strong enough to actively discourage pollution, and monitoring and enforcement mechanisms must be strengthened and expanded.

Vision into reality

The strength of the workshop which guided the development of this chapter lies in a combination of forces. The people came from different backgrounds and countries. Many have worked and studied regionally and internationally. But primarily they are convinced that Southern Africa has the physical and human resources, the tools, the knowledge and wisdom, and the strength to put itself on the path to sustainable development. There is a need for each country to develop solutions for its own environmental problems in its unique national context, and to clearly determine which problems are national, and which require regional solutions. At the same time each country has knowledge, resources, abilities and experiences to share with the region, or other individual members.

There is a need to consider how enhanced regional cooperation might alleviate some environmental pressures. The critical role of water, and access to it, is under discussion in the region, and the principle of regional water-sharing is already informally entrenched. This has been extended to include inter-governmental cooperation on environmental impact assessments of international projects, such as the proposed Batoka Gorge hydroelectric dam on the Zambezi river. Regional trade is advancing through the formation of COMESA. SADC's Food Security Programme indicates future direction with the possibility of some countries producing surplus crops while others produce more than their requirement of fish, livestock or game for trade elsewhere in the region. Each ecozone has traits which are better exploited for some types of production than others. Mineral resources are not distributed evenly, and the opportunity to incorporate these into regional production and trade may also exist. Discussions are underway on trans-border wildlife management, including migratory species, and location of parks — with a suggestion for a corridor park from northern Swaziland through Mozambique and South Africa to southeast Zimbabwe. There are many examples and possibilities of regional cooperation.

Much work has been done, and more remains to be done, to overcome the legacies of colonial policies and legislation, and exploitative use of resources, as well as racial and gender inequity. Southern Africa will have to seek to exploit advantages in highly competitive international markets in order to pursue economic development targets. While investments in peace and democracy have largely paid off, there is still potential for further instability if the vigilance lapses. But with commitment to sustainable development strong in the hearts and minds of southern Africans, the direction is clear. Hard work, imagination and cooperation — as well as regional and individual self-reliance — will be the tools to achieve it. The way forward will be challenging.

Photo 14.10 SAMSO-T Davies

"Sustainable development" means meeting the needs of the present without compromising the ability of future generations to meet their own needs.

Linkages to other chapters Box 14.4

1 PEOPLE

Population growth, consumption patterns and industrial development can all impact on overuse of resources, and degradation and pollution of the natural environment. Information and awareness are tools which can be used to define positive approaches to economic and environmental development.

2 HISTORY

Opportunities and challenges are examined from a traditional resource-management perspective.

3 POLICY

Regional trends show movement toward more environmental awareness and involvement at the grassroots, and increasing policy cooperation at regional and international levels.

4 ECOZONES

Savanna is expanding at the expense of closed forest, and human activity is changing the conditions in some ecozones in various ways.

5 CLIMATE

Climatic change and drought are recurrent cycles in most parts of southern Africa, but information systems and early-warning capabilities have improved. Government officials, NGOs and others are beginning to make use of this information for planning purposes.

6 SOILS

The growing numbers of people could cause more land to be cleared for cultivation to meet the region's food needs, including marginal and ecologically sensitive areas, The impacts on land could, however, be minimised as people are getting more information on good land-use practices.

7 WOODLANDS

Information on the condition of the region's remaining forests is often outdated, incomplete, fragmented or misleading, so precise details of speed and extent of deforestation are not available. However, deforestation is having a serious impact on rural-dwellers and their environment.

8 WILDLIFE

Toward more thoughtful and sustainable utilisation of resources. New methods of sharing the land and sustaining the environment have to be found, and progress is being made with innovative programmes on sustainable use of wildlife.

9 FRESH WATER

Clean, fresh water is much in demand in southern Africa, and supplies are diminishing in some parts of the region, as elsewhere in the world. New ways are being explored to conserve and share this essential resource before it is too late.

10 MARINE

All countries in the region with coastal areas are planning to extend protection of marine areas and resources.

11 POLLUTION

Pollution awareness is increasing in most parts of the region, among all sectors of society, and controls and alternatives are being sought.

12 ARMED CONFLICT

Although Angola plunged back into war after the 1992 elections, the peace process is holding in Mozambique, and with the end of apartheid in South Africa, regional prospects for conflict resolution are positive.

13 GLOBAL

Global atmospheric change is being given increasing attention in a region where there are many local priorities.

NOTES

CHAPTER 14

[1] SARDC convened a workshop on the future state of the environment in southern Africa in Harare, Zimbabwe, 3-4 February 1994. The workshop, called the Southern African Environmental Scenarios Workshop, was attended by people from around the region with various backgrounds and experience.

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[4] Ibid., p. 2

[5] Anderson, R.M. and others, "Possible Demographic Consequences of AIDS in Developing Countries", *Nature*, 17 Mar 1988, Vol 332, p. 233

[6] UN ECA, *African Alternative Framework to Structural Adjustment Programmes for Socio-economic Recovery and Transformation: A Popular Version*, UN ECA, Addis Ababa, 1991, p. 9, 30

[7] Scotney, D.M. and F.J. Dijkhuis, "Changes in the Fertility Status of South African Soils", *South African Journal of Science*, Jul/Oct 1990, Vol 86

[8] *Report of the FAO/SADCC Sub-Regional Workshop on Pesticide Management for SADCC Member States: Draft*, FAO/SADCC, Harare, 20-27 May 1991

[9] Faulkner, Richard D. and Robert Lambert, "The Effect of Irrigation on Dambo Hydrology: A Case Study", *Journal of Hydrology*, 1991, Vol 123, p. 147-161

[10] Scoones, Ian, "Wetlands in Drylands: Key Resources for Agricultural and Pastoral Production in Africa", *Ambio*, Dec 1991, Vol 20, no 8, p. 366-371

[11] Hammond, Allen L. (ed.) and others, *World Resources 1992/93: A Guide to the Global Environment*, World Resources Institute, UNEP and UNDP, Oxford University Press, New York, 1993, p. 277

[12] Ibid., p. 276

[13] African Development Bank, *Economic Integration in Southern Africa*, ADB, Abidjan, 1993, p. 31

[14] Worldwatch Institute, *State of the World: 1994*, W.W. Norton, New York, 1994, p. 196

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[16] SADCC Soil and Water Conservation and Land Utilization Sector, *ZACPLAN Zambezi River System Action Plan: Implementation of Category I Projects ZACPRO's 1 - 8*, SADCC, Maseru, 1990, p. 108

[17] UNFPA, *State of World Population 1992*, UNFPA, New York, 1992, p. 30

[18] Kenny, A., "Nuclear Power, Capitalism and Rapid Economic Growth: The Only Way to Save the Environment", in Hallowes, David (ed.), *Hidden Faces*, Earthlife Africa, Scottsville, 1993, p. 47

[19] Southern African Environmental Scenarios Workshop, Harare, 3-4 Feb, 1994

[20] Ibid.

[21] Ibid.

A1 GLOSSARY

2,4-D - Dichlorophenoxy acetic acid, a herbicide
2,4,5-T - Trichlorophenoxy acetic acid, a herbicide

Aa

acacia woodland — a type of dry savanna characterised by thorny shrubs or trees of the acacia species
acid deposition — sulphur dioxide air pollution from industries and coal-powered electric plants, which reaches the ground in the form of dry *oxide* particles and *acid rain* and causes environmental and human health problems
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
acid generation — acidity of certain types of mine tailings continuing to increase for decades after they have been abandoned, due to the action of bacteria which can accelerate the chemical reaction by 20 to 100 times
acid rain — rain or snow contaminated by acids formed when industrial pollutants undergo chemical changes in the atmosphere
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
Agenda 21 — the plan of action to achieve sustainable development which was adopted by world leaders at the UN Conference on Environment and Development (UNCED) in Brazil, in June 1992
Agent Orange — a herbicide used during the Vietnam war to clear jungle plants, made from 2,4-D and 2,4,5-T containing dioxins
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
agro-pastoralists — see sedentary pastoralists
alien plants — plants invading and becoming established in areas in which they do not naturally occur
alkaline — high in certain elements such as magnesium and calcium, or salts such as sodium chloride
alley cropping — a form of agroforestry in which annual crops are cultivated between rows of trees or shrubs, pruned periodically to prevent shading of the crop and to provide leaf "manure", fodder and fuelwood
alum — aluminium sulphate, a chemical added during water purification to clarify the water
anaerobic — non-oxygen-using respiration
annual plants — plants that germinate from seed, grow and die within one year
aquifer — a bounded source of groundwater
arid — area with less than about 250 mm rainfall every year
aridification — the opposite of waterlogging, comprises a drop in local groundwater, levels results from crusting and compaction or overuse of water resources, or the replacement of natural vegetation with a crop needing more moisture which reduces the ability of the soil to store water
asbestosis — lung disease resulting from asbestos fibres
ash-fertilisation — a form of agriculture where a wooded area is cleared and woody material burnt in heaps to kill weed seeds and pests in the soil, fertilise the soil with ash, and heat the soil to release nutrients for plant growth, site abandoned after a few years due to a resurgence of weeds and pests
auxins — plant growth hormones

Bb

Benguela Nino — incursions of warm surface water along the west coast of southern Africa into the cold Benguela system that results in unusually high rainfall in southwestern Angola and northwestern Namibia
bilharzia — a common disease in southern Africa, carried in a parasite found in slow-moving or stagnant waters, and resulting in lethargy and loss of energy
biodiversity — biological diversity, the range of genetic differences, species differences and ecosystem differences in a given area
biogas — energy-rich gas, mainly methane, produced from fermenting organic wastes
biomass — energy sources derived from plants including crop residues, dung, wood
biosphere — where life exists on, in and around the earth

birth rate — the annual number of births per 1,000 population
Botswana Upper High — a high atmospheric pressure cell over southern Africa which creates unfavourable conditions for rainfall
browsers — animals that eat the leaves, pods, twigs and shoots of trees and shrubs
bush encroachment — increase of thorny and unpalatable shrubs at the expense of grass, due to overgrazing and frequent fires which destroy the grass, giving shrubs and trees the advantage

Cc

carbon — a chemical element forming the main building block of all living matter
carbon cycle — the natural cycle of carbon between carbon sources and sinks
carbon sinks — bodies and organisms which absorb carbon from the atmosphere as part of their biological processes, including growing plants and ocean water
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
carrying capacity — the maximum number of livestock, or other living things, which can be sustained by an area without damaging it
catchment — the entire area drained by a particular stream or river, equivalent to drainage basin
chemical fertiliser — non-organic fertiliser produced from ground rock to enhance soil fertility by providing certain nutrients, usually nitrogen
child mortality — number of children dying before age five, expressed per 1,000 births
chemical degradation — changes in soil chemistry resulting from human activities, especially input-intensive agriculture and irrigation, including salinisation, nutrient and organic matter loss, acidification and pollution
chibaro/shibalo — the coercion of black miners from neighbouring countries to work in the South African mines during the colonial period
chilla — a traditional system of communal, seasonal, regulated, selective hunting of lechwe in Zambia in which females and juveniles were spared
chitemene ash garden — a form of traditional shifting cultivation practised in Zambia in which tree branches are cut from a wide area but only a small area is cleared, the branches are piled and burnt to sterilise and fertilise the soil and release nutrients
clean till — agricultural technique common in southern Africa in which weeds and crop residues are removed, leaving the soil bare for much of the year and vulnerable to erosion
chlorofluorocarbons (CFCs) — ozone-destroying chemicals released mainly by cooling systems such as refrigerators and air conditioners
common property resources — resources that are available to everyone and are not privately owned
competition — in a biological sense, the way in which different individuals or species interact in accessing resources such as sunlight and water, and which determines what species dominate under a given set of conditions
conservation — wise use of nature's resources to prevent loss of ecosystem function and integrity
contour terraces — a physical erosion-control method in which soil is moved into parallel flat sections aligned across the slope, to reduce movement of soil downhill
conventional agriculture — agriculture based on standard modern agricultural techniques including annual ploughing, use of fertilisers and pesticides, and monocropping of single crops over large areas
cool burn — burning grass or savanna at the beginning of the dry season, less damaging than a "hot" burn because there is less combustible material and the soil still retains moisture
coppice — a technique to increase the wood production of trees, in which trees are periodically cut off near the base so that new poles can shoot up, regrowth of trees which have had branches removed
cordon fence — long fence designed to separate livestock from wildlife to reduce the transmission of disease
crop residues — portions of plants remaining in fields after the crop is harvested, such as maize stalks
crop yields — the amount of food produced by a given crop, usually expressed as a certain weight per hectare
crysotile asbestos — white asbestos mined in Zimbabwe and South Africa
cubic kilometre — one thousand million cubic metres of water, (or one thousand flow units)
customary law — laws based on customs and traditions

Dd

dambo — a shallow, seasonally or permanently waterlogged, grass-covered depression (*cicbewa* term, known in other southern African languages as *mbuga, molapo, naka* or *vlei*).
DDT — dichloro-diphenyl-trichloroethane, a poisonous chemical compound used to kill insect pests and which is also toxic to other living things
DDE — a less toxic by-product of DDT metabolised in the body
dead storage — water which fills a hydroelectric power dam up to the level of the intake, and which is required for the production of electricity
death rate — the annual number of deaths per 1,000 population
deciduous — trees or other plants which shed their leaves
deforestation — removal of trees from a landscape
desertification — land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities
destocking — removing most or all of the livestock from an area, as a soil conservation measure, thus reducing grazing pressure and allowing the plants to grow back
deve — a Shona word for a habitat once reserved for wildlife and grazing
dioxins — toxic hydrocarbons, by-products in the manufacture of chlorinated phenols
dominance — the species or set of species which occur most frequently and/or cover the most area in a particular ecozone
dormancy — in plants, when the above-ground vegetation dies back usually due to water stress and grows again when rains come
double expropriation — refers to the loss of arable land by indigenous communities during the colonial era, accompanied by pushing them onto marginal lands where wild animals often destroyed crops
drought — a normal periodic occurrence in arid and semi-arid areas, a shortage of water due to prolonged dry period during the rainy season
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
duplex soils — sandy soil over a sodium-toxic clay layer, common in southern Africa and difficult to cultivate
Dust Bowl — refers to the severe soil loss from wind erosion in the 1930s in the central United States and Canada resulting from decades of

poor land use practices followed by drought
dystrophic — nutrient-poor

Ee

ecosystem — all living and non-living components of the environment that interact and influence one another
ecotourism — tourism in which the natural environment is a main interest of the tourist, tourism which is not harmful to the environment
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 from industry, mining, agriculture or domestic use of water
El Nino — warming of Pacific Ocean waters which influences world weather patterns by affecting air and ocean temperatures, and thought to decrease southern African rainfall
emissions — air pollutants
environmental degradation — destruction of the living or non-living things and a reduction of the productivity of an area
environmental impact assessment (EIA) — management tool to predict and mitigate negative environmental impacts and promote positive ones
environmental institutions — organisations tasked with formulating, coordinating and implementing environmental law and programmes
ephemeral — something that lasts a short time
episodic — occasionally, usually memorable, such as a very large flood or severe drought
eutrophic — nutrient-rich
evapotranspiration — process by which water moves through a plant to the leaves (transpiration) and is lost to the atmosphere through evaporation
event-driven — those ecozones where external events, usually climatic, have more influence over ecological functions than the interactions between species
evergreen — trees which retain their leaves year-round
Exclusive Economic Zone (EEZ) — area of national jurisdiction of the sea under Law of the Sea convention, stretching 200 nautical miles off coast
exotics — species not native to a particular area
extensive agriculture — agricultural techniques which require large areas of land, such as pastoralism and shifting cultivation

Ff

fallow — allowing cultivated land to "rest" for a period to restore fertility, often with a cover crop
fertile — productive
fertility rate — the average number of children born alive to a woman during her lifetime
floodplain — area beside a river which is seasonally flooded when water levels rise due to high rainfall
flow unit — one million cubic metres of water per year
food import dependency ratio — the amount of food a country imports as a proportion of the total available
food security — assurance that food will be available when needed, either by growing it, storing it or importing it into an area
fossil fuels — mined energy sources like petroleum, gas and coal derived from the remains of prehistoric animals and plants
fuel-efficient stoves — stoves that reduce the loss of heat from fires and channel it to productive use
fungicides — pesticides used to kill fungus
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
government expenditures — expenditures by central government offices, departments or other instruments of the central government, excluding provincial and private expenditures
grass strips — a biological erosion control method in which grass is planted in parallel strips across the slope, to capture soil and slow its movement downhill
grasslands — grass with some trees, but differing from savanna woodland by being generally cooler and drier
grazers — animals that eat mainly grass
greenhouse effect — the warming effect resulting when greenhouse gases trap heat from the sun and prevent it from escaping back to space, in much the same way as horticultural greenhouse glass allows sunlight to penetrate but keeps the heat in
greenhouse gases — gases causing the greenhouse effect, including carbon dioxide, nitrous oxides, methane and ozone
Gross Domestic Product (GDP) — the value of all goods and services produced by all factors of production in an economy by both residents and non-residents over the period of a year, regardless of the allocation to domestic and foreign claims
Gross National Product (GNP) — GDP plus the value of goods and services produced by a country's citizens and their investments in other countries, minus the value produced by foreign residents and their investments in the country where GNP is being measured
groundwater — water found underground
groundwater recharge — replacement of water, usually through rainwater percolating into the ground, to replenish water lost from the groundwater store by abstraction, evaporation or transpiration
gullies — the end result of sheet erosion, usually growing in years of above average rainfall, especially after a period of drought when the plant cover has died

Hh

HADO — the *Hafadhi ya Ardhi Dodoma* project in Dodoma, Tanzania, started in 1973 to rehabilitate 125,000 hectares of badly eroded areas with extensive contouring and terracing, and later including strict destocking to rehabilitate the area
half-life — during a given period, half the substance disappears, then half again during an equivalent period, then half again during a further period, and so on
hectare — a unit for measuring land, equal to 10,000 square metres
Helsinki rules — a basis for international agreements related to water, 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 — chemicals used to kill weeds
herbivores — plant-eating animals
hot burn — grass or savanna burning at the end of the dry season, extremely damaging because of the buildup of dead plant material and lack of moisture
hybridisation — breeding of new variety from two different species of animals or plants
hydrocarbons — petroleum, coal and gas, the fossilised remains of plants

hyporeflexia — reduced reflexes in infants, resulting from illness or pollution

Ii

indigenous — native to an area, occurring naturally
insecticides — chemicals used to kill insects
intensive agriculture — agricultural techniques which intensify production from a small area 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
Intertropical Convergence Zone (ITCZ) — a zone of intense rain-cloud development created when the southeast trade winds collide with the northeast monsoon, it's position largely determined by the seasons and generally affecting the region during summer.
invasive plants — usually unpalatable indigenous or alien species that tend to become established and out-compete native species, eventually dominating
invertebrates — the small water beetles and shrimps that fish feed on

Kk

kanchomba — traditional farming method which stresses the use of dung, crop-rotation and weed-control
kapenta — Lake Tanganyika sardine, a type of fish
karoo — shrubby, semi-desert landscape
kgotla — a system of policy-making among the Batswana of Botswana
kihamba — tree gardens in Kilimanjaro region of Tanzania which feature multi-storey arrangements of trees and plants, permanent cropping and irrigation
kuomboka — a traditional Lozi ceremony held annually on the Zambezi plains to mark the departure of people from impending floods to higher ground

Ll

land allocation — how much land is allocated to people for various uses, which defines 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 — the type of land ownership system
leaching — dissolving and carrying away of substances, usually referring to heavy rains removing soil nutrients
leukemia — cancer of the blood
lipitso — a policy-making institution among the Basotho people of Botswana
litunga — paramount chief among the Lozi people of Zambia
lugiko — a policy—making institution in Sukumaland in Tanzania

Mm

malignant melanoma — a serious skin cancer which begins as a mole but quickly spreads cancer cells throughout the body
malnutrition — eating some food but not enough of the right kinds to ensure a balance of nutrients
manure — organic fertiliser, usually taken to mean animal dung but also including compost made from plant wastes
marginal lands — lands not suitable for cultivation
mesothelioma — cancer of the chest or abdominal lining resulting from asbestos fibres
migratory routes — routes that animals follow on a regular basis between distant areas
miombo — a common type of moist savanna woodland co-dominated by the tree species known in Zimbabwe as mnondo and msasa
moist savanna — a semi-arid area with a partly closed canopy of trees 5-20 m high, often *miombo* species, a few shrubs beneath and an often sparse but continuous layer of grasses and other groundcover
monitor — to record and observe an event, usually over a period of time
monocropping — the planting of a single crop over a large area, a system vulnerable to soil erosion because the soil is left bare and exposed after harvesting
monsoon — seasonal wind usually associated with rainfall
mopane woodland — a type of dry savanna dominated by mopane trees because of their ability to tolerate poorly drained or alkaline soils
mound cultivation — traditional cultivation system in Zambia using grass to enrich soils which are heaped in mounds
mupane/mupani — *vlei* (*dambo*) soils

Nn

nomadic pastoralists — people who rely primarily on livestock to meet their needs, moving to different grazing areas with the seasons
non-renewable resources — resources that will not renew themselves in a human time-scale and cannot be replenished once exhausted, such as fossil fuels and copper
normal drought — dry spells lasting less than one year
no-till tied ridging — a tillage technique to reduce soil erosion, increase yields and at the same time reduce draught-power requirements, in which permanent low ridges are constructed with a plough about 90 cm apart to act as mini contours, and ties are constructed across the ridges like dams, to capture water and soil, fertiliser and seeds and prevent them from washing away
nutrient depletion — type of chemical degradation of soil in which soil nutrients are lost through too-frequent fires, topsoil loss or loss of natural flooding regimes due to dam construction

Oo

offtake — the number of cattle removed from a given area, for local slaughter or sale to another area
open-access resources — resources shared communally, and whose
use is not regulated by outside authorities
organic fertiliser — fertiliser made from natural, plant-based materials such as crop residues or animal dung
organic matter — living organisms or their products, the "glue" that sticks soil particles together in clumps
organochlorine compounds — concentrations of toxic chemicals containing chlorine, mostly used as pesticides and bleaching agents
oshanas — local name for the system of interconnected drainage channels that flow through central Owambo, Namibia
overburden — waste rock and soil dug up during ore extraction
overgrazing — grazing by livestock or wildlife to the point where grass cover is depleted, leaving bare unprotected patches of soil with a corresponding increase in erosion by water and wind, especially on clay soils, and encouraging the growth of poisonous plants and thorny shrubs
overturn — the mixing of layers of water in a lake, often due
to cool air temperatures and strong winds
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

Pp Qq

palatable/unpalatable — plants preferred or avoided by feeding animals
pan — very shallow, often seasonal, body of water, usually salty
particulates — small particles of unburnt minerals and dust that float in the air and settle very slowly, and have been linked to cancer of the respiratory and digestive tracts as well as reduced lifespan and increased infant mortality
pastoralism — the moving of livestock to different grazing areas depending on rainfall and plant cover, often long distances from wet season grazing in arid lands to dry season grazing in semi-arid lands
peace dividend — decrease in defence expenditures which frees revenue for other purposes
perennial plants — plants which live for more than one year, often many years, and established by seeds, roots or shoots
permaculture — permanent agriculture, an 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 in water greater than eight weeks
pH — a measure of how acidic or alkaline 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
photosynthesis — process by which green plants use sunlight to transform carbon dioxide and water into complex substances
physical degradation — a type of 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
plough pan — a compact layer often formed in heavy soils which are regularly ploughed to the same depth, affecting water and root penetration
policy — a set of government or corporate objectives and guidelines deliberately chosen to influence future decisions
pollarding — similar to coppicing (a technique to increase wood production) but the cut through the trunk is made at head height to produce even more wood
pollution — the poisoning of land, air or water with anything that reduces its ability to support life
population density — the total number of inhabitants divided by the surface area
population growth rate — the annual growth rate of the population calculated from mid-year
potential evaporation — the amount of evaporation that takes place from open water
quelea — small birds occurring in large groups which eat vast amounts of grain and are regarded as serious crop pests

Rr

radiation — all life is normally exposed to very low levels of natural *background* radiation energy from the sun, soil and rocks, and the sea, but the large doses of radiation from artificial sources such as uranium mine-sites are extremely hazardous to the environment and human health
rainfall variability — the pattern of rainfall in arid environments where the amount of rain and where it falls differs widely from year to year
raptors — predatory birds
reaforestation — planting trees in an area which previously had trees
renewable resources — resources which renew themselves within a human time-scale, such as trees and fresh water, and have the potential to be used on a sustainable basis without depletion
resilience — capacity for a natural area to recover from disturbance
return flow — waste water from municipal or industrial sewers
Rift valley — a deep valley created by geological faults along the western borders of Mozambique and Tanzania and extending generally toward the southern tip of the Red Sea
riparian — on the banks of a river
roasting — heating of minerals as part of mineral-processing
rough tilling — ploughing the soil in such as 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

Ss

sacrifice zone — the 400-metre area surrounding boreholes and waterpoints in semi-arid and arid lands, where small sand-dunes (less than one metre) result mainly from trampling and local movement of soil
saline — salty, impregnated with salts
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
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
sealing and crusting — 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
seasonality — the seasonal changes in physical and biological processes over the course of a year
sedentary pastoralists — village-based subsistence farmers who grow crops, keeping livestock which graze near the villages, and relying on them to pull ploughs and provide manure
sedimentation — deposition of river-borne sediments in a lake or dam, siltation
semi-arid — areas where mean annual rainfall is between about 250 and 600 mm, rainfall is seasonal and variable, and potential evaporation is high
sheet erosion — rainfall washing evenly over the land and removing the most productive top layer, the most common and widespread type of erosion
shifting cultivation — see ash-fertilisation
silt-hungry — water which is carrying a low amount of silt and has sufficient force to be erosive
slash-and-burn — see ash-fertilisation
smog — brownish haze resulting from the action of sunlight on air pollutants, mainly particulates, nitrogen oxides, carbon monoxide and hydrocarbons
social forestry — involvement of local people in the planting of trees for their own use for shade, fruit, construction, fuelwood or other identified purposes, so that they have a stake in protecting and managing the seedlings
soda lake — lakes with high levels of salt, usually sodium bicarbonate, also known as baking soda
soil — a mixture of living and non-living things containing bacteria,

actinomycetes and fungal hyphae, algal cells, viruses and hundreds of micro-arthropods, nematodes and worms, but with its chief 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 such as inequitable distribution of land

soil degradation (low) — somewhat reduced agricultural suitability with part of the topsoil removed, on rangelands restoration to full productivity is possible with improvement of the agricultural system at farmer level

soil degradation (moderate to high) — land with greatly reduced agricultural productivity, and major improvements are required to restore it

soil formation — usually less than one-third of a tonne per hectare annually

soil nutrients — organic and inorganic compounds, including nitrogen, potassium and phosphorus, found in the soil which are essential to plant growth and maintenance

soil rehabilitation — a high level of technical input or radical restructuring of the land use

solar energy — energy from the sun which can be captured and used

solid waste — wastes disposed of on land

southern Africa — the region encompassing Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe

southern oscillation — a change in global air circulation patterns associated with El Nino

statutory law — laws enacted by a legislative body and contained in a written form

stocking rate — the number of hectares required to support one livestock unit (cow) based on the theoretical carrying capacity of the range

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

substrata — underlying layers or base

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, eg. rivers, dams

sustainable agriculture — agriculture which does not degrade the soil or other resources on which it depends

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

swidden fields — ash gardens produced in the *chitemene* system which are cultivated for three years before being abandoned

Tt

tailings — waste dams and dumps left by mines containing finely ground rock and associated toxic substances

thermoclines — layers of water where there is a sharp decrease in temperature with depth

tonnes — metric measure of 1,000 kilogrammes

topography — natural features on the surface of the earth

topsoil — the top few centimetres of soil, which contains most of the soil organic matter and nutrients

trace metals — metals present in very small qualities 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

transpiration — process by which water moves through a plant to the leaves

tributary — a river or stream which feeds into a larger river

trickle-down — an economic theory where an increase in wealth in society will eventually increase standards of living of all people in society

tropical forest — the 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 groundcover growth

tsetse — fly that carries the disease "nagana" in livestock and or sleeping sickness in humans, inhabiting moist savanna areas

Uu

ujamaa — voluntary programme in Tanzania beginning in the early 1970s, moving rural people into centralised, linear settlements and giving them control over land, social services and resources in defined areas

unpalatable — unpleasant to the taste, see palatable

urbanisation — the movement of people from rural to urban areas

Ww Zz

waste treatment — treatment of industrial or municipal wastes with chemicals or natural organisms to reduce the amount of nutrients and other contaminants in the water before it is released to the environment

water balance — the balance between incoming water and the loss or use of water in a given area

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 concentrate rainwater or other precipitation

water-holding capacity — a measure of how much water soil can absorb and retain

water infiltration — water moving down into the pore spaces in the soil

water table — a more or less horizontal layer in the soil below which all spaces between soil particles are saturated with water

waterlogging — natural flooding and over-irrigation which brings underground water levels to the surface, displacing the air in the soil, with corresponding changes in soil processes and an accumulation of toxic substances which impede plant growth

wetlands — include rivers, lakes and swamps, and change the immediate area due to the presence of abundant water

wind erosion — a process of soil erosion, most severe in dry flat areas where vegetative cover is poor and winds blow strongly

zero emissions — industrial or other waste-producing processes which completely recycle or capture wastes so that none are released to the environment except in completely benign forms

A2 ENVIRONMENT CONFERENCE

Conference on the
State of the Environment in Southern Africa
Mazvikadeyi, Zimbabwe, 31 May-4 June 1993

Participants

Plenary Chairpersons

India Musokotwane, Regional Director, IUCN Regional Office for Southern Africa (ROSA)
Tomas Hertzman, Environmental Advisor, SADC Environment and Land Management Sector (ELMS)
Phyllis Johnson, Director, Southern African Research and Documentation Centre (SARDC)
Mufaro Moyo, Deputy Secretary, Ministry of Environment and Tourism, Zimbabwe
Pelonomi Venson, Executive Director, Kalahari Conservation Society, Botswana

Guest Speakers

Simon Burne, Executive Director, Panos Institute, UK
Bradwell Garanganga, Meteorologist, SADC Drought Monitoring Centre, Zimbabwe
Stephen Kokerai, Legal Consultant, Zimbabwe
Hilary Masundire, Deputy Director, Kariba Research Station, Zimbabwe
Andrew Mathuthu, Lecturer, Department of Chemistry, University of Zimbabwe, Zimbabwe
Liberty Mhlanga, General Manager, Agricultural and Rural Development Authority, Zimbabwe
Keto Mshigeni, Professor, Department of Botany, University of Dar es Salaam, Tanzania
Francis Musonda, Project Director, National Museums Project, Zambia
Willie Nduku, Director, Department of National Parks, Zimbabwe

Air and Water Working Group

Elton Laisi, Controller of Water Services, Water Department, Malawi *(chair)*
Hilary Masundire, Deputy Director, Kariba Research Station, Zimbabwe *(rapporteur)*
Harry Chabwela, Environmental Consultant, Ecosource Africa, Zambia
David Fig, Research Director, Group for Environmental Monitoring, South Africa
Steve Kasere, Journalist, *The Daily Gazette*, Zimbabwe
Paul Larkin, Principal, Aqua Tech Groundwater Consultants, Botswana
Anderson Lema, Senior Lecturer, Geography Department, University of Dar es Salaam, Tanzania
Choma Matale, Senior Water Quality Inspector, Department of Mines, Botswana
Andrew Mathuthu, Lecturer, Department of Chemistry, University of Zimbabwe, Zimbabwe
Tabeth Matiza, Wetlands Programme Coordinator, IUCN—ROSA
John McCullum, Environment Programme Advisor, SARDC
Jennifer Mohammed, Lecturer, Faculty of Law, University of Zimbabwe, Zimbabwe

Victor Mtetwa, Dean, Faculty of Science, University of Swaziland, Swaziland
João Serodio de Almeida, Secretary General, Angolan Environmental Association, Angola
Justina Stephens, Head, Environment Research Section, Tropical Pesticides Research Institute (TPRI), Tanzania

Land Working Group 1

Thomas Mpofu, Director, Department of Natural Resources, Zimbabwe *(chair)*
Doris Mwinga, Legal Counsellor, National Environment Council, Zambia *(rappourteur)*
Andrea Booth, Environment Programme Advisor, SARDC
Luisa Cadete, Deputy Director—General, Department of Forestry, Angola
Caroline Chakawa, Communications Officer, IUCN—ROSA
Qalabane Chakela, Head, Department of Geography, University of Lesotho, Lesotho
Richard Chidowore, Regional Information Coordinator, SARDC
Carlos Figueiredo, Projects Staff Member, Action for Rural Development and the Environment, Angola
Abilio Inguane, Specialist, Geographic Information Systems, Mozambique
Teri Malies, Chairman, Yonge Nawe Environmental Action Group, Swaziland
Patu Manala, ZBC Radio One
Masego Mpotokwane, Lecturer in Environmental Sciences, University of Botswana, Botswana
Ben Siyambango, Director, Directorate of Forestry, Namibia

Land Working Group 2

Lolo Mkhabela, Assistant Planning Officer, Department of Physical Planning, Swaziland *(chair)*
Ebenezario Chonguica, Lecturer in Geography, Eduardo Mondlane University, Mozambique *(rapporteur)*
Killian Butu, ZBC Radio Two
Victor de Carvalho, Head, Wildlife Department, Angola
Costa Chisvo, Researcher/Writer, SARDC
John Hatton, Lecturer in Ecology, Eduardo Mondlane University, Mozambique
M.P. Mamashela, Senior Lecturer, Faculty of Law, University of Lesotho, Lesotho
Joe Matowanyika, Social Science Programme Coordinator, IUCN—ROSA
Mufaro Moyo, Deputy Secretary, Ministry of Environment and Tourism, Zimbabwe
James Mpinga, Director, Environment Press Foundation, Tanzania and Guest Editor, SARDC
Hezekiel Mushala, Head, Department of Geography, University of Swaziland, Swaziland
Aida Opoku—Mensah, Director East Africa and SADC region, Panos Institute, UK
Werner Schellenberg, Physical Planner, UNHCR, Malawi
Mary Seely, Director, Desert Ecological Research Unit, Nambia

Wildlife and Marine Conservation Working Group

Lota Melamari, Director-General, Tanzania National Parks, Tanzania *(chair)*
Christopher Brown, Head, Department of Environmental Affairs, Namibia *(rapporteur)*
David Boyer, Marine Fisheries Officer, Ministry of Fisheries and Marine Resources, Namibia
Milagre Cezerilo, Director, National Directorate for Forestry and Wildlife, Mozambique
Stephen Kokerai, Legal Consultant, Zimbabwe
Ian Macdonald, Director of Conservation, Southern African Nature Foundation, South Africa
Vivian Maravanyika, Journalist, *The Sunday Mail*, Zimbabwe
Ana Marques, Head, Animal Biology, Department of Biology, Agostinho Neto University, Angola
Alfredo Massinga, Marine Biologist, National Commission for the Environment, Mozambique
Mutizwa Mukute, Researcher/Writer, SARDC
Herman Mwageni, Director, Wildlife and National Parks, Swaziland
Henry Mwima, Chief Research Officer, National Parks and Wildlife, Zambia
George Pangeti, Deputy Director, Department of National Parks, Zimbabwe
Aah Sekhesa, Chief Physical Planner, Department of Lands, Surveys & Physical Planning, Lesotho
Achim Steiner, Programme Coordinator, IUCN-ROSA
Russel Taylor, Ecologist, World Wide Fund for Nature, Zimbabwe
Pelonomi Venson, Executive Director, Kalahari Conservation Society, Botswana

Conference Logistics Committee

Marian Mubako, Assistant Administrator, SARDC
Umbee Rogers, Personal Assistant to the Director, SARDC
Memory Sachikonye, Data Processing Manager, SARDC

A3 SCENARIOS WORKSHOP

Southern African Environmental Scenarios Workshop
Harare, Zimbabwe, 3-4 February 1994

Participants

Steering Committee
Tomas Hertzman, Environmental Advisor, SADC Environment and Land Management Sector (ELMS)
Phyllis Johnson, Director, Southern African Research and Documentation Centre (SARDC)
India Musokotwane, Regional Director, IUCN Regional Office for Southern Africa (ROSA)

Facilitator
Achim Steiner, Programme Coordinator, IUCN-ROSA

Scientific Advisory Committee Members
Carlos Figueiredo, Projects Staff Member, Action for Rural Development and the Environment, Angola
Elton Laisi, Controller of Water Services, Water Department, Malawi
Anderson Lema, Senior Lecturer, Geography Department, University of Dar es Salaam, Tanzania
Lota Melamari, Director-General, Tanzania National Parks, Tanzania
Thomas Mpofu, Director, Department of Natural Resources, Zimbabwe

Other Specialists
Caroline Chakawa, Communications Officer, IUCN—ROSA
Ntombei Gata, Deputy Director of Research and Specialist Services, Ministry of Agriculture, Zimbabwe
Solami Mavimbela, Chemist, Water Resources Department, Swaziland
Alfred Opubar, Information, Education and Communication Advisor for Southern Africa, United Nations Population Fund (UNFPA)
Sarah Sakupwanya, Economist (Consultant), Zimbabwe
Jacob Tayo, Statistician for Southern Africa Programme, UNFPA

SARDC Environment Programme Staff
Andrea Booth, Environment Programme Advisor
Munyaradzi Chenje, Editor/Project Coordinator
John McCullum, Environment Programme Advisor
James Mpinga, Guest Editor
Mutizwa Mukute, Researcher/Writer

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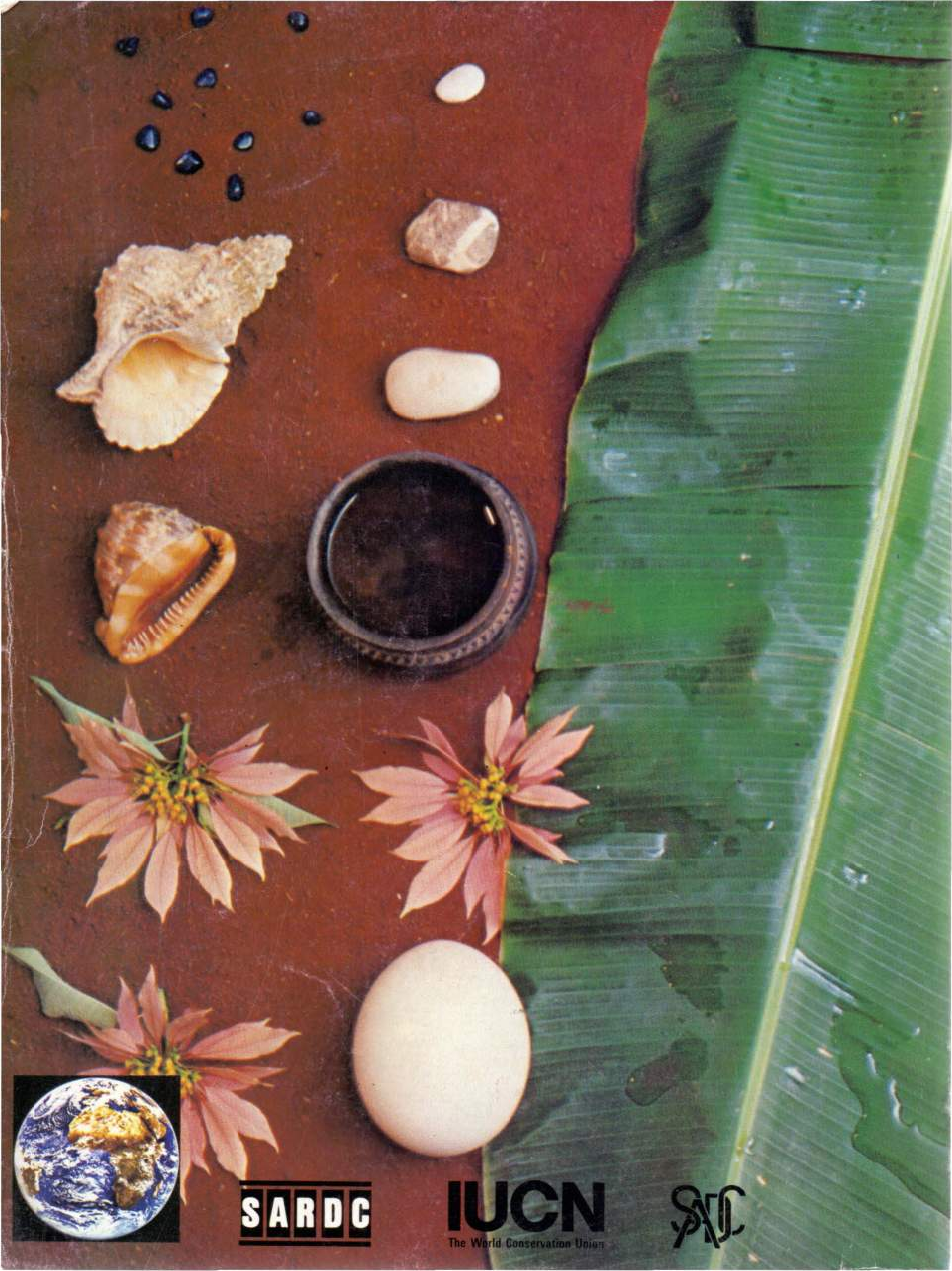
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