PROCEEDINGS OF THE SEMINAR ON WATER RESOURCES MANAGEMENT IN TANZANIA

Tanga, September 12–16, 1994

Rafik Hirji and François-Marie Patorni
Editors

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# Table of Contents

List of Tables v  
List of Figures vi  
Foreword vii  
Acknowledgments viii  
List of Abbreviations and Acronyms ix  

**Chapter One:** Introduction by Mr. Rafik HIRJI and Mr. François-Marie PATORN 2  

**Chapter Two:** Opening Remarks 8  
  i. Welcoming Remarks by the Commissioner for Water Affairs and Chairman of the seminar, Mr. Simon S. MAMBALI  
  iii. Opening Statement by the Principal Specialist - Water Resources Economic Development Institute of The World Bank, Mr. François-Marie PATORN  

**National River Basin Management Case Studies** 13  

**Chapter Three:** Tanzania's water sector review process 14  
  F. Z. NJAU  

**Chapter Four:** Rapid Water Resources Assessment 22  
  M. O. Y. MSUYA  

**Chapter Five:** Ruvu Basin Development Plan and Management 31  
  M. MACHA and I. E. MWAKALINGA  

**Chapter Six:** Rufiji Basin Water Management 45  
  W. J. B. MWARUWANDA  

**Chapter Seven:** Lake Victoria Basin Management, Section 1: Water Quantity and Quality Issues 61  
  D. A. MASHAURI
Chapter Eight:  Lake Victoria Basin Management, Section 2: Cross-Sectoral and International Issues  A. M. DUDA

Chapter Nine:  Pangani River Basin Management  B. A. S. LUHUMBIIKA, J. D. SARMETT, and S. M. KAMUGISHA

River Basin Management Case Studies beyond Tanzania  89

Chapter Ten:  Kagera Basin Management  G. K. LWAKABARE

Chapter Eleven:  The Zambezi River Basin and Its Management  G. W. HOWARD

Chapter Twelve:  Water Resources Management in the Tana River Basin, Kenya  R. HIRJI

Chapter Thirteen:  River Basin Management in the United States  W. B. LORD

Chapter Fourteen:  Water Management in France  presented by J. LABRE

Issues in River Basin Management  167

Chapter Fifteen:  Conceptual Framework for River Basin Management  W. B. LORD

Chapter Sixteen:  Water Resources Information Management  J. I. MATONDO

Chapter Seventeen:  Stakeholder Participation in Water Management  M. R. MUJWAHUZI

Chapter Eighteen:  Working Group Discussions  194

Chapter Nineteen:  Concluding Remarks  210

i. Conclusions by F.-M. PATORNI and R. HIRJI

ii. Closing Statement by Principal Secretary, R. MOLLEL

Annexes  213

A. Seminar Schedule
B. Summary of Site Visits
C. List of Participants
List of Tables

4.1 Livestock Population Projections
4.3 Rate of Urbanization (1986, 1996, and 2006)
4.4 Current Water Requirements for Potential Uses
5.1 Runoff Characteristics
5.2 Mean Daily Flow of selected probability of exceedence
5.3 Comparison of Proposed Dams
5.4 Proposed Irrigable Area Downstream from the Proposed Kidunda Dam
6.1 Mean Annual Rainfall and Evaporation in the Great Ruaha
6.2 Catchment Characteristics of the Great Ruaha
6.3 Flow Characteristics of the Great Ruaha
6.4 Mtera Dam, 1989-1993
6.5 Water Rights in the Great Ruaha Basin
6.6 Water Levels, Mtera Reservoir
7.1 Distribution of Land Use in Lake Victoria Basin
7.2 Water Demand in Mwanza Town
7.3 Summary of Findings
8.1 Cross-sectoral Institutional Challenges in the Lake Victoria Basin
8.2 Priority Basin Strategy -- Lake Victoria Basin
9.1 Hydropower demand and capacity in the Pangani River
9.2 Water abstractions
9.3 Physical inspection of water rights
9.4 Data on rivers, boreholes, and water abstractions
9.5 Sisal effluent measurements
11.1 Africa's four largest rivers
11.2 Three sections of the Zambezi River Basin
11.3 Population of the Zambezi Basin
11.4 Zambezi River offtakes and tributaries
12.1 Hydroelectric Projects on the Tana Cascade
14.1 Water Basins in France
14.2 Water Boards' Budget
14.3 Cost of Water Board Works
14.4 Urban water prices in France
14.5 Water price projections
List of Figures

1.1 Location Map of Tanzania
1.2 Main Drainage System in Tanzania
5.1 Ruvu Basin
5.2 Monthly Rainfall in the Ruvu Basin
5.3 Isohyetal Map of Mean Annual Rainfall
5.4 Summary of River Discharges
5.5 Location of Meteo-Hydrological Stations
5.6 Village Planning Area, Kidunda Dam/Reservoir
6.1 Rufiji basin
6.2 Hydrometric stations and isohyets of mean annual rainfall
6.3 Mtera Reservoir Water Levels (January - August, 1994)
6.4 Mtera reservoir discharge (January - August, 1994)
6.5 Kidatu reservoir discharge (January - August, 1994)
6.6 Discharge hydrograph for Great Ruaha river at Msembe
6.7 Discharge hydrograph for Little Ruaha River at Mawande
7.1 Mwanza Town Population and Projected Water Supply
7.2 Mwanza Estimated Population, 1993
8.1 Kenyan landings of fish
9.1 Pangani River Basin
11.1 Zambezi River Basin
11.2 Dams on the Zambezi River
12.1 Tana River Basin
12.2 Location of Development Schemes
12.3 Elevations of Hydropower Projects
12.4 Tana River Primate National Reserve and Delta Wetlands
14.1 Composition of a French Water bill
Foreword

Over the last few decades, demand for water has increased, its quality has deteriorated, and the costs of developing new water sources have risen dramatically. This, combined with population growth and fragmented water management, has created unsustainable situations in many parts of the world. Consensus on the need for new policies and strategies was recognized at various national and international conferences. The World Bank issued a Water Resources Management Policy paper in September 1993, and the Economic Development Institute (EDI) of the World Bank developed a special initiative, the “EDI Water Resources Management Program”, in collaboration with national and international organizations. The overall objective of the EDI program is to assist countries in preparing and implementing sustainable water resources management policies through seminars and other activities. The first EDI seminar took place in Zimbabwe in 1993, followed by a second seminar held in Tanzania in 1994. The Zimbabwean seminar maintained a regional focus, while the Tanzanian seminar addressed national water policy issues and recommended specific actions to address these issues, including the rationale for these actions and their prerequisites. This publication centers on the Tanzanian case.

The Tanzanian national water policy approach emphasizes two areas that should lead to successful policy implementation: (a) stakeholder participation in all aspects of policy and strategy preparation; and through this interaction, (b) development of a framework for national capacity building in water resources management.

The approach that Tanzania has taken in preparing and implementing its water resources management strategy is an example to be emulated. We look forward to continue working with Tanzania on its challenging undertakings, and to use its experience, as it develops, as a source of useful lessons.

Vinod Thomas
Director
Economic Development Institute

Andrew Steer
Director
Environment Department
Acknowledgments

The seminar organizers, the Ministry of Water, Energy and Minerals, and the Economic Development Institute and the Environment Department of the World Bank are very much indebted to the following persons and institutions which made it possible. We are grateful to Mr. Odira Ongara, the Tanga Regional Development Director, for hosting and opening the seminar on behalf of the Minister for Water, Energy and Minerals, Mr. Frank Malimbwi, the Tanga Regional Water Engineer, for organizing site visits, and to Mr. Shabir Raniwalla, the EDI Consultant, and his team for organizing the seminar logistics in Tanga. We would also like to thank the various staff, particularly Ms. Huba Mannoro, of the World Bank Resident Mission in Dar es Salaam, for the logistical assistance extended by the mission.

We are particularly thankful to Mr. Simon Mambali, the Commissioner for Water Affairs, and Mr. Raphael Molley, the Principal Secretary, in the Ministry of Water, Energy and Minerals, for chairing the seminar and to the various persons who facilitated the overall process of the seminar, and all the contributors, participants, presenters, and resource-persons, too numerous to list here.

We acknowledge the assistance of Dr. Damas Mashauri of the University of Dar-es-Salaam and Mr. Saidi Faraji of the Ministry of Water, Energy and Minerals for compiling the seminar papers and presentation materials from Tanzania. Our special thanks go to Professor Deborah Rubin of the School of International Studies at the University of the Pacific for compiling, editing and preparing the overall seminar proceedings.

Finally, our thanks go to the sponsors of the seminar, the Government of Netherlands, who in addition to the World Bank, provided the financing.

Rafik Hirji
François-Marie Patorni
Editors and Seminar Organizers
List of Abbreviations and Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADB</td>
<td>AFRICAN DEVELOPMENT BANK</td>
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<td>BOD</td>
<td>BIOCHEMICAL OXYGEN DEMAND</td>
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<td>BWO</td>
<td>BASIN WATER OFFICE</td>
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<tr>
<td>CIDA</td>
<td>CANADIAN INTERNATIONAL DEVELOPMENT AGENCY</td>
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<td>CUMECS</td>
<td>CUBIC METERS PER SECOND</td>
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<tr>
<td>DANIDA</td>
<td>DANISH INTERNATIONAL DEVELOPMENT AGENCY</td>
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<td>EIA</td>
<td>ENVIRONMENTAL IMPACT ASSESSMENT</td>
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<td>EKTM</td>
<td>EAST KILIMANJARO TRUNK MAIN</td>
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<tr>
<td>ESA</td>
<td>EXTERNAL SUPPORT AGENCY</td>
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<td>ENV</td>
<td>ENVIRONMENT DEPARTMENT, THE WORLD BANK</td>
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<td>FAQ</td>
<td>FOOD AND AGRICULTURE ORGANIZATION</td>
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<td>GEF</td>
<td>GLOBAL ENVIRONMENT FACILITY</td>
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<td>HTM</td>
<td>HANDENI TRUNK MAIN</td>
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<tr>
<td>IUCN</td>
<td>INTERNATIONAL UNION FOR CONSERVATION OF NATURE</td>
</tr>
<tr>
<td>JICA</td>
<td>JAPANESE INTERNATIONAL COOPERATION AGENCY</td>
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<tr>
<td>KBO</td>
<td>KAGERA BASIN ORGANIZATION</td>
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<td>LCD</td>
<td>LITERS PER CAPITA PER DAY</td>
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<td>L/S</td>
<td>LITERS PER SECOND</td>
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<td>LVEMP</td>
<td>LAKE VICTORIA ENVIRONMENTAL MANAGEMENT PROGRAM</td>
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<td>MCM</td>
<td>MILLION CUBIC METERS</td>
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<td>MCM/D</td>
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<td>MOH</td>
<td>MINISTRY OF HEALTH</td>
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<td>MPWSS</td>
<td>MAKONDE PLATEAU WATER SUPPLY SCHEME</td>
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<td>MWEM</td>
<td>MINISTRY OF WATER, ENERGY, AND MINERALS</td>
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<tr>
<td>NAC</td>
<td>NATIONAL ACTION COMMITTEE</td>
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<td>NCU</td>
<td>NATIONAL COORDINATION UNIT</td>
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<td>NES</td>
<td>NATIONAL ENVIRONMENT SECRETARIAT</td>
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<td>NGO</td>
<td>NON-GOVERNMENTAL ORGANIZATION</td>
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<tr>
<td>NYM</td>
<td>NYUMBA YA MUNGU DAM OR RESERVOIR</td>
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<tr>
<td>OECF</td>
<td>OVERSEAS ECONOMIC CORPORATION FUND</td>
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<tr>
<td>PCPSR</td>
<td>PRESIDENTIAL COMMISSION FOR PARASTATAL SECTOR REFORM</td>
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<td>RBO</td>
<td>RIVER BASIN ORGANIZATION</td>
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<td>RPFB</td>
<td>ROLLING PLAN AND FORWARD BUDGETING</td>
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<td>RWB</td>
<td>RUVU-WAMI BASIN</td>
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<td>RWRA</td>
<td>RAPID WATER RESOURCES ASSESSMENT</td>
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<td>SADCC</td>
<td>SOUTHERN AFRICAN DEVELOPMENT COORDINATION CONFERENCE</td>
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<td>TARDA</td>
<td>TANA AND ATI RIVER DEVELOPMENT AUTHORITY</td>
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<td>TANESCO</td>
<td>TANZANIA ELECTRICITY SUPPLY COMPANY</td>
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<td>TRDA</td>
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<td>TVA</td>
<td>TENNESSEE VALLEY AUTHORITY</td>
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<td>UNCEA</td>
<td>UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA</td>
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<td>UNDP</td>
<td>UNITED NATIONS DEVELOPMENT PROGRAMME</td>
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<td>UNEP</td>
<td>UNITED NATIONS ENVIRONMENT PROGRAMME</td>
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<tr>
<td>WB</td>
<td>WORLD BANK</td>
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<td>WHO</td>
<td>WORLD HEALTH ORGANIZATION</td>
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<td>WM</td>
<td>WATER MASTER PLANS</td>
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<td>WMPCU</td>
<td>WATER MASTER PLAN COORDINATING UNIT</td>
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<td>WSSC</td>
<td>WATER AND SANITATION SUB-COMMITTEE</td>
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<td>WSSR</td>
<td>WATER AND SANITATION SECTOR REVIEW</td>
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<td>WWP</td>
<td>WANGING'OMBE WATER PROJECT</td>
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<td>ZACPLAN</td>
<td>ZAMBEZI ACTION PLAN FOR THE ENVIRONMENTAL MANAGEMENT OF THE COMMON ZAMBEZI RIVER SYSTEM</td>
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Introduction
and
Opening Remarks

EDI & The World Bank
Chairman of the Seminar
Minister for Water, Energy, and Minerals
CHAPTER ONE

INTRODUCTION

Rafik HIRJI and François-Marie PATORNI

OVERVIEW

Past approaches to water resources planning in Tanzania (see Figure 1.1) were fragmented: they were either sector-oriented, regionally based (e.g., Regional Water Master Plans), or project specific, and did not adequately address the conflicts in water use between geographic locations and sectors within a river basin (e.g., in the Ruaha and the Pangani River Basins in Tanzania). Responding to increasing water shortages and water use conflicts, the Government of Tanzania undertook a review of the Water Sector and began preparing a national Water Resources Management Strategy using a phased approach. As the sector review and the first phase of the strategy, comprising the Rapid Water Resources Assessment, neared completion, the Government requested the assistance of the World Bank to hold a seminar on "Water Resources Management in Tanzania" to assist in preparing phase two activities.

The seminar was jointly organized by the Ministry of Water, Energy and Minerals, and the Economic Development Institute and the Environment Department of the World Bank. It was funded by the Government of Netherlands and the Economic Development Institute of the World Bank. The Seminar was held in Tanga at the Mkonge Hotel between September 12-16, 1994. It was opened by the Tanga Regional Development Director, Mr. Odira Ongara, on behalf of the Honorable Minister for Water, Energy and Minerals, Lt. Col. Jakaya Mrisho Kikwete. The fifty-two seminar participants were from sectoral ministries and parastatal organizations in Arusha, Tanga, and Kilimanjaro Regions, and from the University of Dar-es-Salaam in Tanzania as well as from Kenya, France, the United States, and the World Bank. They included government decision-makers, academics, and development experts.

The seminar confirmed the need for a comprehensive approach to water resources management, calling for coordinated land use, pollution control, and meeting environmental needs, balancing cross-sectoral uses of water to manage Tanzania's water resources in a sustainable manner.

SEMINAR OBJECTIVES

The specific objectives of the seminar were to:

- Sensitize decision-makers on the need for managing water resources in a comprehensive manner;
- Share river basin management experiences from within and outside Tanzania; and,
- Assist the government in preparing the second phase of its national water resources management strategy.
SUMMARY OF SEMINAR PROCEEDINGS

The five-day seminar highlighted experiences in River Basin Management in Tanzania and other parts of the world, and included a site visit to projects in the Pangani Basin. The proceedings of the seminar comprise nineteen chapters and annexes. Chapter one provides the background to the seminar, seminar objectives, and a summary of seminar proceedings. Chapter two summarizes the welcoming remarks by the Chairman of the seminar, the opening speech of the Honorable Minister for Water, Energy and Minerals, and the opening statement by the manager of the Water Resources Management Program of the Economic Development Institute of the World Bank. Chapters three through nineteen, comprising presented papers, are summarized below under three categories -- National River Basin Management Case Studies, River Basin Management Case Studies Outside of Tanzania, and Issues in River Basin Management.

National River Basin Management Case Studies

Chapters three through nine focus on national and basin-wide priorities for managing Tanzania's water resources in a sustainable manner. Njau underscores the challenges for meeting Tanzania's goal of supplying clean water to all urban and rural populations by the year 2002 including constraints in institutional building, sector coordination, community participation, and the management of water supply systems. Msuya identifies partially functioning or non-functioning hydrometric networks, poor coordination between cross-sectoral users of water, inadequate attention to public health and the water environment, and a poor institutional framework as key constraints to water resources management in the Pangani, Rufiji/Ruaha, Ruvu/Wami and Lake Victoria Drainage basins. (See Figure 1.2).

Macha and Makalinga discuss the causes of severe scarcity in the Dar-es-Salaam water supply as created by increasing demands from the rapidly growing population, losses in distribution systems, poor maintenance and illegal connections, and identify the Kidunda Dam (subject to an environmental impact assessment) as the preferred alternative for meeting future demands for domestic water supply for Dar es Salaam, irrigation, and hydroelectric power.

Insufficient information on water availability and water use and poor coordination between cross-sectoral users of water are of particular concern in the water-stressed Pangani Basin (Luhumbika, Sarmett, and Kamugisha) and the Rufiji/Ruaha (Mwaruvanda) basins which are experiencing significant conflicts between upstream diversions for irrigation and downstream needs for hydropower generation.

Land degradation caused by a variety of factors, including poor cultivation methods, deforestation and overgrazing, were identified to be accelerating soil erosion and affecting the surface hydrology in the Pangani Basin and water quality in the Sigi River and the Lake Victoria Basins.

Water pollution from domestic, industrial, and agricultural sources is a growing problem in the Pangani, Ruvu/Wami, and Lake Victoria (Mashauri) Basins. Duda discusses the cross-sectoral environmental challenges facing Lake Victoria in a broad framework and an institutional perspective on challenges for international cooperation.

River Basin Management Case Studies Outside of Tanzania

Chapters ten through fourteen are case studies of river basin management from outside Tanzania. No country has yet successfully established an organizing framework to overcome the
complicated planning situation of international river basin management. The cases discussed in this section, however, illustrate both how other countries are approaching this subject and offer as well a variety of examples on water management across shared borders and within national borders.

Lwakabare discusses the set up of the Kagera Basin Organization, the basin's development projects, and salient issues for dealing with shared river basin management. Howard describes the complex ecology and land and water use in the Zambezi River Basin and the challenges of prioritizing development strategies in this international river basin. Hirji describes water resources development in the Tana river basin in Kenya, and discusses the social, ecological, and institutional dimensions of managing water resources comprehensively. Lord summarizes the complex institutional arrangements for river basin management in the United States in three policy arenas: water rights law, water resources development, and water quality control. Labre discusses the institutional and planning aspects of water resources management in France, and the management of urban water supply and sewerage services.

Issues in River Basin Management

Chapters fifteen through nineteen concern the main issues in river basin management. Lord presents a conceptual framework for river basin management, and discusses the following six issues: scope, participation, power, information, decision-making, and benefits and costs. Matondo discusses data needs, data management, and information management tools for water resources planning. Mujwahuzi in a keynote address identifies the main stakeholders in water management, and describes their rationale for participation and levels of involvement in decision making, the latter drawing from experiences from the Ruaha River Basin.

Chapter eighteen is an overview of working group presentations and summaries on the following themes: cross-sectoral uses of water, stakeholder participation, river basin offices, opportunity cost of water, and environmental demands of water. Under each theme specific issues are identified, actions to be taken are recommended, and the rationale for the actions and pre-requisites for taking the actions are listed. Chapter nineteen contains the conclusions of the seminar. The Annexes list the seminar schedule, summary of site visits, and list of participants.

ORGANIZATION OF THE SEMINAR

The seminar was organized to include four days of paper presentations, discussions and working groups, one field day to visit irrigation schemes, a hydropower redevelopment project, a water supply project, as well as some sisal plantations.

The seminar included five sections:

(i) An overview of the Tanzania Water and Sanitation Sector Review (WSSR) and of the Rapid Water Resources Assessment (RWRA);

(ii) Presentations and discussions on water management issues in major river basins in Tanzania: Ruvu/Wami, Rufiji/Ruaha, Lake Victoria, and Pangani;
(iii) Presentation on river basin management practices and issues in other locations such as the Kagera, Zambezi, and Tana river basins in Africa, and in river basins in the United States and France, to discuss their relevance to the Tanzanian situation;

(iv) Specific sessions on the conceptual framework, information needs, and stakeholder participation for river basin planning and management; and,

(v) Working group meetings to define and address the issues.

Dr. Rafik Hirji is a Water Resources Management Specialist with the Environment Department of the World Bank. Mr. François-Marie Patorni is the Principal Water Resources Management Specialist at the Economic Development Institute of the World Bank.
Figure 1.1: Location Map of Tanzania
Figure 1.2: Drainage Basins of Tanzania
CHAPTER TWO

OPENING REMARKS

Welcoming Remarks, Commissioner for Water Affairs and Seminar Chairman, Mr. Simon S. MAMBALI

Honorable Guest of Honor, Distinguished Guests, Seminar Participants, and Ladies and Gentlemen:

The Ministry of Water, Energy, and Minerals, the Government of the Netherlands through the Economic Development Institute (EDI), and the Environment Department (ENV) of the World Bank, jointly organized this seminar with the theme; "Water Resources Management in Tanzania." The Seminar timetable is from 12th - 16th September 1994.

During the seminar, discussions on water resources management in Tanzania are being held. The seminar's objective is to acquire assistance in our water resources management strategy by enhancing the capacity of our own staff to carry out detailed basin assessments.

Already our local experts on an Inter-Ministerial team have carried out a National Water Sector Review and Rapid Water Resources Assessment. It is now intended, first, to share information on issues and activities in each of the major river basins in our country, and, second, to learn from the experiences described in the experts' presentations on river basin management in other countries.

We hope that the outcome of this seminar will translate into practical applications that help to reach the goals of our National Strategy of supplying people with water within easy reach (400 meters from each household) by the year 2002.

Honorable Guest of Honor, the local seminar participants in front of you are from the Ministries of Water, Energy and Minerals, Agriculture, Lands and Urban Development, Tourism, Natural Resources, and Environment, and Health. We also have officials from the National Environmental Management Council, Planning Commission, University of Dar es Salaam, the Regional Administrations of Tanga, Kilimanjaro, and Arusha, and from TANESCO.

The foreign participants are from the World Bank, local and overseas, France, USA, and Kenya. I hope that I did not miss anybody.

This is a very rich gathering in terms of its potential expertise on the subject of Water Resources Management. We hope to have honest and committed discussions to lead us towards progress in developing the major water basins in our country.

Honorable Guest of Honor, may I now request that you officiate in opening our Seminar. Thank you.
Opening Speech of the Honorable Minister for Water, Energy and Minerals,
Lt. Col. Jakaya Mrisho KIKWETE, MP

The speech was delivered by the Regional Development Director,
Mr. Odira ONGARA

Mr. Chairman, Distinguished Guests, Participants, Ladies and Gentlemen:

I have the pleasure of welcoming you all to this seminar on "Water Resources Management in Tanzania." I sincerely hope that those of you who are visiting Tanzania for the first time will find the weather pleasant, the seminar environment conducive to good work, and that you will be able to participate in this seminar effectively.

Over the past twenty years, water resources development has expanded rapidly in most of the developing countries. In many cases emphasis has been placed on exploiting surface water and groundwater resources to support various economic development activities such as irrigation, hydropower generation, and industrial and domestic water supply systems. These development activities have often been implemented without corresponding programs to control the pollution of water sources or to promote resource management. Development efforts have lacked adequate administration of water rights, adequate land management and resources utilization, and coordinated or integrated approaches to various river basin activities. In general, this is the way most projects have been implemented in Tanzania's basins. Lack of sound basin management plans and lack of sectoral or disciplinary coordination has led to over-exploitation or misuse of resources in basins that have endangered the ecosystems and led to now obvious conflicts. This is true for many places, especially in the Pangani and Rufiji/Ruaha basins. Action is needed to bring resource use in harmony with sustainable development.

In addition, poor land use practices and indiscriminate forest clearing have led to severe erosion and to sedimentation in reservoirs. Today nobody knows for sure how much existing storage capacity is left in our reservoirs. It is possible that changing river flow regimes, such as both the increased incidence of floods and the reduced dry season flows we now experience in Usambara and Kilimanjaro, may be a result of our own activities. This is an area which requires attention.

It is gratifying to note the new concern shown for the need for water management and for addressing such issues as rationalizing resource use, reducing environmental degradation and water pollution, and halting the deterioration of aquatic ecosystems. Attention must also be placed on developing programs to address watershed management in its totality. The rapidly increasing population in Tanzania coupled with economic growth will place additional pressure in the future on fresh water supplies that are sometimes already limited by climatic conditions. These possibilities call for urgent steps to be taken.

Several reasons for these conditions may be cited: institutional weaknesses affect overall basin management, the monitoring, collecting, processing and analysis of data for planning, the administration of water rights, and basin resource utilization. The combination of these prevailing constraints with increasing competition for scarce available water resources requires prompt action to be taken to institute basin management programs that will assure that the little water available is efficiently and properly utilized.
I am informed that the seminar participants will deliberate on comprehensive approaches to water resources management calling for coordinating land use, pollution control, and environmental issues with cross-sectoral uses of water to manage Tanzania’s water resources in a sustainable manner. Past approaches to water resources planning in Tanzania were fragmented; they were either sector-oriented, regionally based, or project specific, and did not adequately address conflicts over water use between different geographic locations or different sectoral uses within a river basin. I am sure you will also find time to deliberate on related issues like institutional matters, legislation, peoples' participation, and public information.

The Ministry of Water, Energy and Minerals, in collaboration with the Economic Development Institute (EDI) and the Environmental Department (ENV) of the World Bank, have organized this seminar in an effort to explore possible collaborative approaches towards river basin management. Coordinated management could achieve a rational allocation of water between various competing users within a basin.

Mr. Chairman, I am informed that during the next five days, the seminar is expected to highlight experiences in River Basin Management in Tanzania and other parts of the world. The participants will have an opportunity to visit projects in the Pangani Basin. The results of the recently completed Rapid Water Resources Assessment by an Inter-ministerial Task Force will be presented. Other presentations will dwell on water resources management issues and challenges in the Pangani, Rufiji/Ruaha, Ruvu/Wami, and the Lake Victoria basins. The main findings of the National Water Sector Review will also be presented.

I am sure the wide overview of the various basins will provide important background to the existing situation. Discussions of the experiences from the Tana River Basin in Kenya, the Zambezi River Basin in Southern Africa, and of the French and American River Basins will be of special benefit to the participants.

I wish to take this opportunity to thank you all for agreeing to participate in the seminar and I hope your deliberations will contribute proposals for solving these water resources management problems facing us. I am very optimistic that from your discussions some useful ideas, realistic strategies, and implementable recommendations will emerge.

Mr. Chairman, my sincere appreciation goes to all who have in one way or another contributed to make this seminar a reality. My special thanks go to the World Bank whose Economic Development Institute and the Environment Department have organized this important seminar in collaboration with my Ministry. Thanks are also due to all the resource personnel for their contributions and to the foreign participants who have traveled long distances to participate in this important seminar.

With these few remarks, and with great honor and pleasure, I now declare the Seminar on Water Resources Management in Tanzania officially opened. Thank you.
Opening statement, Principal Specialist - Water Resources  
Economic Development Institute of the World Bank  
Mr. François-Marie PATORNI

Mr. Chairman, Mr. Regional Development Director, Ladies and Gentlemen:

On behalf of the Economic Development Institute of the World Bank, I would like to welcome all of you at this seminar. As you know, the seminar is jointly organized by the Ministry of Water, Energy and Minerals, and the Economic Development Institute and the Environment Department of the World Bank, with financial assistance from the Government of the Netherlands. We are honored to be associated with you in this seminar, and I would like to thank you for your hospitality in your beautiful region.

I would like to take this opportunity to set the stage for the next few days that we are going to spend together in Tanga.

During the next hour, I would like to propose, first, to introduce the Economic Development Institute of the World Bank. Second, I will recall the origins of this seminar which brings us together today. Third, I propose that each of us take the time to introduce herself or himself, so that we start to get to know each other as individuals.

And finally, I propose that we share our expectations from this seminar, so that, as it progresses other the coming days, we can keep ours goals in sight, while exploring new approaches to manage water resources.

So, please let me first introduce the Economic Development Institute, or EDI.

Many of you are familiar with the World Bank, but some of you might not be so familiar with EDI. The World Bank has basically two products to offer to developing countries: one is money, in terms of loans; the other is ideas, in terms or research and training. EDI is concerned with the latter.

EDI is a Department of the World Bank, and therefore it shares its global objective of reducing poverty through sustainable economic development and investing in people. But EDI has a specific mandate: we do not lend money, we do not invest in projects; this is done by the operational arm of the World Bank. Our fundamental objective is to help people - policy makers, planners, managers, community leaders, and many other influential people - to prepare, enact and implement policies in their respective countries, and to manage their own development.

How do we do this? To a large extent through seminars like the present one, through learning together and discussing problems and options to resolve them. An important aspect is that we do not see ourselves as teachers telling people what to do. We see ourselves as partners and facilitators of a dialogue among people facing common concerns in their country; of the sharing of experiences across countries; and of a dialogue among all stakeholders, including donor agencies.

EDI is active in most sectors of economic development, but water is a major focus for EDI’s activities.

As you know, the water crisis which affects Tanzania is practically a worldwide phenomenon. As part of the response to this crisis, the World Bank issued a Water Resources Management Policy paper in
September 1993, and EDI developed a special initiative, the "EDI Water Resources Management Program."

The EDI program focuses on four mutually supporting components, which are central to improving water resources management, have the best potential for impact, and attract the highest demand from countries: (a) national strategy formulation, (b) participatory basin management, (c) reforms and private sector participation in water supply and sanitation, and (d) participatory irrigation management.

I would like now to turn to the present seminar.

As part of the EDI program that I just outlined, a regional workshop for southern Africa countries was held in Victoria Falls in July 1993; some of you participated in that workshop.

At the same time, Tanzania was preparing its national strategy on water resources management. It formed an interministerial multi-disciplinary task force, and an Inter-Ministerial Steering Committee of senior officers from the stakeholder ministries and institutions to guide and coordinate the work. Tanzania also continued its active involvement in international water issues, being a riparian to the three great lakes of East Africa, Lake Victoria, Lake Tanganyika and Lake Nyasa, and will host the Nile 2002 Conference in February 1995.

Following the Victoria Falls seminar, the Government of Tanzania asked EDI to organize a seminar around the themes of national strategy formulation and participatory basin management. The seminar was designed as an intermediate stage between the Rapid Water Resources Assessment phase and the second phase of the water resources assessment, to discuss Tanzania’s situation, learn through sharing information on activities in each major river basin in Tanzania, and benefit from accounts of outside experiences.

I am therefore looking forward to working with you over the next few days, in the hope that the seminar will meet your expectations and will contribute to advancing the preparation of Tanzania’s water resources management strategy.

I thank you for your attention.

*Note: Following this introduction, Mr. Patorni conducted a short session to facilitate individual introduction of the participants, and to give them the opportunity of expressing their expectations from the seminar.*
National River Basin Management Case Studies

Tanzania’s Water Sector Review
Rapid Water Resources Assessment
  Ruvu Basin
  Rufiji Basin
  Lake Victoria Basin
  Pangani River Basin
CHAPTER THREE

TANZANIA'S WATER SECTOR REVIEW PROCESS

F. Z. NIAU

The Ministry of Water, Energy and Minerals in Tanzania recently completed a review of the water and sanitation sector. This chapter highlights findings from the review on the current status of institutional building, sector coordination, community participation, privatization, funding, gender issues, sanitation, and the management of water supply systems.

In 1993, the Ministry of Water, Energy and Minerals (MWEM) initiated a review of the water and sanitation sector. This chapter gives the background to that review, its major findings, the lessons learned from the review process itself, and the proposed follow-up actions.

THE RATIONALE FOR THE WATER AND SANITATION SECTOR REVIEW

Current efforts to improve the water supply and sanitation in Tanzania follow on a series of initiatives which started in 1970. They include:

(i) the declaration of the 20-year Rural Water Supply Programme (1971-1990) in 1970 and the resulting Regional Water Master Plans;
(ii) the adoption of the International Drinking Water Supply and Sanitation Decade (1981-1990);
(iii) holding the Arusha Seminar on Implementation of Rural Water Supply and Sanitation in Tanzania in 1986 and the resulting Action Plan which was adopted by Government;
(iv) holding the Morogoro Workshop on National Strategies for Operation and Maintenance of Rural Water Supply Schemes in early 1988;
(v) the evolving joint National Monitoring System with the Ministry of Health;
(vi) the evolving Strategies and Action Plan for the implementation of the National Water Policy;
(vii) the Ministry's self strengthening project, URT/89/003; and,
(viii) the evolving National Water and Sanitation Programme.

Despite all these initiatives, the rate of delivery of water supply and sanitation services has hardly kept pace with the additional population increase. As of November 1991 only 42 percent of the rural and 53.6 percent of the urban population had access to safe and potable water supply. Not only has coverage been below the target level, but the quality of service is also deficient. The demand for water supply in urban centers has outstripped supply mainly because of population increase and obsolescence of most of the schemes. Shortage of water coupled with inadequate sewerage systems and solid waste disposal facilities has led to serious environmental pollution and health hazards.

The average national sanitation coverage in 1990 in the urban areas was estimated at 79 percent. The widely used traditional pit latrines seldom meet the minimum required health standards. VIP latrines are still not affordable by the majority.
Objectives of the review

The objectives of the Water and Sanitation Sector Review were to build on and support a number of the important ongoing sector initiatives. In particular, the review was to identify constraints; to plan specific additional interventions to facilitate sector progress; to improve information and information sharing as a basis for future planning, and to identify and seek the commitment of external support agencies (ESA) and non-governmental organizations (NGO) to support specific initiatives.

SUMMARY AND FINDINGS

Institutional Capacity Building

The institutions involved in water supply and sanitation delivery are fragmented and are poorly coordinated. For example, while the MWEM is responsible for developing and promoting on-site sanitation in the peri-urban areas, it is the Ministry of Health (MOH) that is responsible for promoting rural sanitation. Similarly, MWEM is responsible for both sewerage investment programs in the urban centers as well as the setting of tariffs, but the responsibility for their operation and maintenance lies with the municipal councils under the local government. Thus there is need to streamline the roles and responsibilities of the different sector agencies for the effective development of the sector in a more sustainable manner.

Programming and implementation take place at three levels -- national, regional, and district -- with most implementation taking place at the regional level. Given an environment where resources (human, funds, equipment and materials) are scarce, it is difficult to build adequate capacity at all these levels to manage the development of the sector in a sustainable manner. Available resources are thinly distributed at these levels, making capacity-building a far fetched dream.

Given the massive task ahead and the decline in both internal and external sector funding, the need to consolidate resources and build adequate implementation capacity at the lowest level is now more evident than before. Capacity-building at the higher levels should be geared towards provision of support services. Capacity-building at the level of implementation should focus on educational, professional, technical, managerial and on-the-job training. Capacity-building should encompass a good working environment and facilities, as well as adequate incentives and motivation.

Sector Coordination

That both inter-sectoral and intra-sectoral coordination is weak has been acknowledged by MWEM. No formal coordination exists between any of the external support agencies (ESA). Although multilateral agencies such as UNDP and WHO have a mandate to coordinate other ESAs, some (especially bilateral agencies) prefer to be coordinated by the Government. However, both UNDP and the other ESAs strongly feel that coordination of ESAs is the responsibility of the Government, and in this particular case, that of MWEM.

A lack of sector coordination has led to:

(i) poor networking and information sharing within the sector and among the sector ministries, ESAs, NGOs, and the private sector;
(ii) fragmented ESA support to Ministry programs;
(iii) duplicated efforts in several key aspects of sector development; and,
(iv) a lack of information sharing from program areas supported by different ESAs to the sector ministries.

MWEM has established different coordination mechanisms at different times but none seem yet to be effective or sustainable. These include the Water Master Planning Coordination Unit (WMPCU), the National Action Committee (NAC), and the Water and Environmental Sanitation Task Force and Sector Liaison Meetings. Initiating and institutionalizing an effective coordination mechanism in MWEM is needed even more than before since at this time external resources are being depleted as the world economic recession affects us all.

In addition to sustaining existing coordination mechanisms, other efforts to improve coordination in the sector include reviving the National Action Committee (NAC), establishing a National Coordination Unit (NCU), and establishing Water and Sanitation Sub-Committees (WSSC) at regional and district levels.

Community Participation

Community participation has assisted in providing labor and cash contributions towards the cost of new construction and the rehabilitation, operation, and maintenance of older schemes. Communities, however, are not yet fully involved at all stages of project identification, appraisal, planning, implementation, monitoring and evaluation. Clear guidelines on community participation are lacking. There is no uniformity in community participation approaches. Each region, even each district, is characterized by its own approach introduced by the ESAs. Most communities are now being gradually introduced to the concept of ownership of their water supply and sanitation services with the ultimate aim of having communities take over their complete management.

The Water Policy should be widely distributed to the communities by using mass media, brochures and posters, and holding seminars, meetings and workshops for creating community awareness of their roles in the sector development.

Involvement of Women and Gender Issues

Women are the major users of water, yet they are least represented in the decision-making process. Women have therefore not been fully involved in the delivery of water supply and sanitation services. There is a lack of initiatives by women to embark on income-generating activities in order to enhance their economic status. There is a saying that if you educate a woman you have educated the whole family. Women should be involved at all stages of project formulation, planning, implementation, operation and maintenance, monitoring, and evaluation. Awareness of women's needs and options should be made through seminars, workshops, group work, and meetings.

Funding

Funding for the sector has primarily been the responsibility of the government, either from its own internal sources or from grants and loans from bilateral and multilateral organizations. Involvement of the private sector or the community as a whole in funding the sector has been minimal.

The sector has received little government priority in funding and ESAs have been directing support to the priority areas accorded by the government. There has been consistent drop in external
assistance allocated to the sector since 1980/81. While the assistance was US$34.6 million in 1980/81, it had dropped to US$2.5 million in 1992/93. During the five Year Plan (1989/90-1991/92) allocation to the sector averaged only 5.9 percent out of the total government development budget. There is an overall decline in the combined recurrent and development budget allocations in the Rolling Plan and Forward Budget (RPFB) from 1993/94 to 1996/97.

Social and political considerations have outweighed economic and financial considerations in the setting of water tariffs. As a result tariffs have remained low and rigid for both urban and rural areas. Service has deteriorated both in quality and quantity. However, it is encouraging that the government is now taking seriously that water is an economic good and is preserving it from further deterioration. To enable the government to raise enough funding for the sector, it is considering introducing user fees. Tariffs are gradually being introduced and revenue accrued from the sale of water can now be reinvested into the system.

Privatization

When water and sanitation services were considered social services and provided free by the government, the potential for the private sector's involvement in the delivery of these services was very limited. Now, government policy is changing. It is now "demand" driven rather than "supply" oriented. It has shifted from providing services to being an enabler, regulator, controller, and monitor. The fact that the private sector and the government are now recognized as partners in development will pave the way for larger private sector involvement in the delivery of water supply and sanitation services. The National Investment (Promotion and Protection) Act, however, discourages the involvement of the private sector in the provision of water, and the comprehensive master plan prepared by the Presidential Commission for Parastatal Sector Reform (PCPSR) is silent on privatizing the water sector. Thus the government should now provide an enabling environment through appropriate legislation for the private sector to participate fully in the delivery of water and sanitation services.

Management of Urban and Rural Water Supplies

Urban Water Supplies are managed at the national, regional, and district levels. All regional water supplies (with the exception of the City of Dar-es-Salaam and the capital city of Dodoma) are under the Regional Water Engineers. The water supply for the City of Dar-es-Salaam is managed by the National Urban Water Authority; that of Dodoma is directly under the Ministry. In district towns, water management is under the District Water Engineers.

All the regional and district towns (except Dar-es-salaam, Dodoma Capital City, and the municipalities of Tanga, Moshi and Arusha) receive budget allocations from the central government for the operation and maintenance of the water supplies. Revenue accrued from the sale of water is directly deposited in the Treasury and is not available for reinvestment into the sector. On July 1, 1994, the three Municipalities of Tanga, Moshi and Arusha began operating on a revolving fund.

The Regional and District Water Engineers are responsible for all aspects of water supply: the production, treatment, and sale of water; the operation and maintenance of the system; quality control; new connections; billing and revenue collection; identification of customers; attending to customer complaints; and the disconnection of defaulters.
Management problems have been many. They range from poor conservation methods and pricing policies, incomplete billing and revenue collection, lack of incentives for revenue collection, inadequate funding, lack of experienced and qualified personnel, low working morale of staff, to dilapidated and out-modeled plant and equipment. Other problems are unplanned and rapid urbanization and industrialization and its resulting pollution in urban areas.

Recommended improvements include forming autonomous bodies which will allow revenue accrued from the sale of water to be reinvested into the sector. Another positive initiative undertaken is involving the stakeholders in managing of their water supplies. The government should strengthen further the already started autonomous water bodies and initiate the formation of similar bodies in the remaining regional and district towns.

Rural Water Supplies have been the responsibility of the government. It provides, operates, and maintains water supply systems to rural communities. The Water Policy now requires that all communities assume complete ownership of their schemes and be fully responsible for their operation and maintenance. The government is still running and maintaining most of the rural schemes except for hand-pumped schemes. Most villages have established Water Committees and Water Funds and are contributing to the funds to help in the construction, operation, and maintenance of their projects.

However, it is now encouraging to see that the government is taking initiatives towards establishing autonomous water bodies like the East Kilimanjaro Trunk Main (EKTM), Makonde Plateau Water Supply Scheme (MPWSS), the Wanging'ombe Water Project (WWP), and the Handeni Trunk Main (HTM). These water bodies will be owned and managed by the stakeholder themselves and the government would assume the role of an enabler and regulator.

Sanitation

Sewerage, septic tanks, and pit latrines are the commonly used sanitation facilities in the urban environment. Only nine out of the twenty regional centers have partially functioning sewerage systems. Untreated sewage pollute natural water courses, coastal zones, and inland waters, causing serious health and environmental pollution problems. The population served by the sewerage systems in these towns is less than 10 percent and the level of service is poor. Another 10 percent use septic tanks and the remaining 80 percent use pit latrines which are poorly maintained.

Pit latrines are the most commonly used sanitary facilities in the rural areas. The level of service has been increasing since the launching of the National Latrinisation Campaign in 1973. Rural latrine coverage improved from 20 percent in 1973 to 53 percent in 1980 and 80 percent in 1991. The development of ventilated improved pit latrines is at its infancy. Nationally, universal latrine coverage has been re-targeted to the year 1997.

Cost recovery on sewerage and sanitation services has not been taken seriously. Tariffs have not been able to sustain the systems and enforcement of the law has been weak. Most municipalities do not know their customers thus making it difficult to bill them.

Combining water supply and sewerage systems under one institution is one of the recommended measures to bring sanitation improvements in the urban areas through reinvesting in the sector. Other recommendations aim to establishing mechanisms in the rural and urban councils where the government, ESAs, NGOs, and charitable organizations can provide credit to poor people for
sanitation improvements. Creating awareness of sanitation issues at all levels and promoting and involving the private sector in service delivery have been recommended.

The Target Year 2002

The year 2002 is the target for providing water service for all, but it is unrealistic. Among the identified constraints impeding its achievement are:

(i) Inadequate financial allocations to the sector;
(ii) A policy of decentralization in which most powers remain at the top, and the roles and responsibilities of the Local Government in the provision of water supply and sanitation services are unclear;
(iii) National and economic restructuring programs whose effects lead to lower priority being given to the social sectors; and,
(iv) A lack of involvement of the private sector, communities, and stakeholders in service delivery.

Two options are suggested. The first is for the Government to restate the target and have a more realistic program that takes into account the existing resources and implementation capacity. The second is to aim at 75 percent coverage by the year 2002. The second alternative is more realistic. It can be achieved through:

(i) Phasing the program so that, first, it concentrates on rehabilitation of non-operating schemes, and second, at a later phase, constructs new projects;
(ii) Involving the private sector;
(iii) Building up community based sector development and management through ensuring that Water Sector beneficiaries are actively involved in fully assuming ownership of schemes right from conception, planning, financing, implementation, and taking up the operation and maintenance;
(iv) Reflecting sector priorities in the RFP with an increased share through budget allocations in line with the Government's resolve to achieve the year 2002 target;
(v) Strengthening sector monitoring and evaluation; and,
(iv) Obtaining continued ESA support in service delivery and capacity building.

This approach should be matched with the following strategies

(i) Improvement of traditional water sources;
(ii) Use of hand pump based schemes;
(iii) Development and promotion of a cheap rain water catchment system;
(iv) Development of gravity piped schemes which cost less to operate;
(v) Use of borehole pumped schemes where necessary;
(vi) Use of surface pumped schemes; and
(vii) Construction of small dams and charcos (earthen dams)

LESSONS LEARNED FROM THE REVIEW PROCESS

The process of carrying out the review has been instructive. Positive outcomes of a nationally led review include its ability to ensure sustainability, replication, ownership and use of the end products. It also builds team spirit within the sector and establishes good inter-sectoral contacts,
linkages and working relationships. The review itself is less costly when done by nationals, and assists capacity-building in the sector. Minor disadvantages which resulted from following this review process were that it took a long time to do and that it was difficult to collate reports written by people from different educational backgrounds. If, however, in the future the team leader selects and manages the team members, these problems could be avoided.

RECOMMENDATION

The report has made major recommendations addressed to the Government, ESAs, NGOs, the private sector, and the community as a whole. The Government should implement the recommendations which can be done immediately without much financial implications. The government should convene a round table meeting of ESAs, NGOs, and the private sector requesting them to identify areas where they are able to direct their support. This should be done as a matter of urgency.

Mr. Frederick Z. Njau is a Principal Executive Engineer for the Ministry of Water, Energy and Minerals in Dar es Salaam.

ENDNOTES

1. All numbers in this chapter are taken from the Water and Sanitation Sector Review unless specifically noted.

REFERENCES

DISCUSSION

QUESTION: What is the role of women in water sector development?

Answer: The role of women is important as they are the collectors and managers of water in the household. Indeed the WSSR has dedicated a chapter to the role of women in sector development.

QUESTION: How is an enabling environment for private sector involvement to be created?

Answer: The basic thing to be done is to enact laws to allow private sector participation in the water sector.

QUESTION: Please define or elaborate on sector coordination in contrast to inter- and intra-sector coordination?

Answer: There must be both inter- (within ministry) and intra- (across the ministries) ministerial coordination in order to have any meaningful progress in the sector. Coordination between the government agencies and ESAs ought to be improved too.

QUESTION: Why are ESAs specifically mentioned categorically in the WSSR objectives? Why is not the Government of Tanzania not mentioned explicitly?

Answer: ESAs are mentioned as they support the sector, and the start-up workshops put identifying areas for ESA support as one of the objectives of the WSSR. The Government of Tanzania has an obvious contribution, especially in the making of the policies, and in regulating and guiding progress in the sector.

QUESTION: What is the next step after the WSSR?

Answer: The next phase is to follow up on the specific recommendations put forward in the report.

QUESTION: Are the coverage levels in the TARGET 2002 achievable?

Answer: The coverage levels have to be adjusted according to the available resources. It is possible that both coverage levels and services will have to be re-evaluated to take into consideration the new situation. For example the involvement of the private sector will change both coverage and service levels.
CHAPTER FOUR

RAPID WATER RESOURCES ASSESSMENT

M. O. Y. MSUYA

Development of the water sector depends upon accurate information. To guide efforts to implement sustainable water development policies, a Rapid Water Resources Assessment was carried out in Tanzania. Its findings on water use and its identification of national and river basin priority areas are described in this chapter.

WATER RESOURCES DEVELOPMENT AND MANAGEMENT

The various sectoral developments in Tanzania are guided by their respective development policies. The current water policy, launched in 1991, emphasizes the sustainable use of water resources. The policy document however stresses the development of the water supply sub-sector and deals lightly with its management aspects. The general administration of water resources is being dealt with by Water Utilization (Control and Regulation) Act No. 42 of 1974, the principal Act on the administration of grants and water rights.

Water resources management for sustainable development ought to be a multi-sectoral activity involving all related and potential users. Sectoral development policies therefore have to be linked to a maximum and sustainable utilization of water resources. In planning for such an integrated water resources development, the availability of both the quantity and quality of water resources has to take into account the environment and the non-consumptive uses of water like hydropower generation, fisheries, and river maintenance flows.

Regional Water Master Plans

Tanzania is administratively divided into twenty regions. As one of the prerequisites to the twenty-year Rural Water Supply Programme launched in 1971, the Government decided to carry out Water Master Plans for each region. To date, sixteen regions have Water Master Plans (WMP). These master plans vary in both approach and methodology, and above all, lack consistent revision, updating, and implementation.

The reports do however contain vital water resources-related data and information. For comprehensive water resources planning, river basins offer the most appropriate unit for analytic and coordinated water resources management. It is therefore envisaged that the existing regional WMPs will be reviewed and integrated with river basin plans, and be continuously updated.
Water Use Conflicts

The Pangani, Rufiji (especially in Usangu plains and Kilombero valley) and Ruvu river basins, where most of the activities in irrigated agriculture are concentrated, experience frequent water use conflicts. These conflicts result from increased competition between domestic, irrigation, and power generation uses.

Small scale conflicts occur between farmers upstream against those downstream. On a larger scale, the conflicts are between the sectors of agriculture (food production) and hydropower production. In most cases irrigation takes place upstream of hydropower plants. The most affected river basins are the Pangani and Great Ruaha (a sub-basin of Rufiji) drainage basins.

Each of the three major sectoral water users has tended to formulate their water use plans oblivious of the other users. The Regional Water Master Plans which spelled out the implementation of the Rural Water Supply Programme did not consider a river basin as a unit. In general, water utilization plans were not integrated, and now sectoral conflicts are surfacing as noted above.

NEED FOR A WATER RESOURCES MANAGEMENT STRATEGY

Water demand for various activities is continuously increasing, while availability of the resource is rather limited. For sustainable use of the resource, there is a strong need to develop a Water Resources Management Strategy to guide both the medium and long term development and management plans. Building environmental sustainability requires initiating a strategy to encourage cooperation among different relevant Ministries and institutions.

Integrated water resources development plans need to be urgently formulated in the following basins (listed according to highest priority): Rufiji, Pangani, and Ruvu/Wami basin, to be followed later by the Lake Nyasa and Lake Victoria basins, and finally the Internal, Tanganyika, and Southern Coast basins.

The main phases of this process are as follows:

Phase I involves carrying out an integrated Rapid Water Resources Assessment (RWRA) with the overall objective of identifying issues on which to base initiating actions. This phase also includes the specific objectives of:

(i) integrating hydrologic considerations, cross sectoral water uses, land use, water quality and environmental and public health aspects in the country’s water and sanitation sector planning;

(ii) inventorying and analyzing existing information on surface and groundwater availability and sectoral land and water uses including water and environmental issues; and,

(iii) assessing the effectiveness of existing institutions for sustainable management of the country’s water resources.

Phase II involves carrying out detailed comprehensive basin-wide analysis according to priority issues and actions identified in Phase I.

Phase III is an implementation stage focusing on synthesis of complementary actions, funding for priority investment projects, and continued examination and updating of strategic elements.
RAPID WATER RESOURCES ASSESSMENT

The Rapid Water Resources Assessment (RWRA) as outlined above has been carried out. The assessment was carried out using existing data and information. The assessment is aimed at setting up an integrated water resources management strategy.

The RWRA consists of two volumes: Volume I is the main report, targeted mainly to decision-makers. It highlights the general concept of assessment, an overview of Water Resources availability, and the utilization of water and water quality as a constraint. It also looks at the public health aspects related to the quantity and quality of available water. Lastly, it looks into the country's water legislation and related institutional framework. Volume II is a basin report which deals with the details and specific basin water related issues.

OVERVIEW OF ECONOMIC ACTIVITIES AND WATER USE

Some findings from the RWRA which describe the links between Tanzania's economic activities and its water needs are highlighted in this section.

Economic Activities

Tanzania's major economic activities are agriculture and livestock keeping. Over 80 percent of the country's population of about 27 million people (1993 estimate) is engaged in one aspect or another in the agricultural activity. Irrigated agriculture is seen as a protection against drought and a means of establishing and increasing smallholder food production. Currently, irrigated agriculture covers about 150,000 hectares, of which about 80 percent are traditional irrigation schemes. The remaining 20 percent consist of large centrally managed schemes owned by public or private institutions and individuals.

The common practice deployed in livestock keeping is short-range migratory pastoralism that has severe negative impacts on water resources and land use. According to the 1984 census, there were 12.5 million cattle, 6.4 million goats, and 3.1 million sheep in the nation, mostly concentrated in the Northern Central part of the country, i.e., Arusha, Dodoma, Shinyanga, Mwanza, Mara, and Singida Regions. Projected livestock populations are shown in Table 4.1 below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cattle</th>
<th>Goats</th>
<th>Sheep</th>
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<tr>
<td>1984</td>
<td>12,512,000</td>
<td>6,450,000</td>
<td>3,080,100</td>
</tr>
<tr>
<td>1995</td>
<td>13,509,900</td>
<td>10,037,500</td>
<td>3,556,500</td>
</tr>
<tr>
<td>2000</td>
<td>13,989,400</td>
<td>11,739,800</td>
<td>3,557,700</td>
</tr>
</tbody>
</table>

Source: Ministry of Agriculture, Livestock Development, and Cooperatives

Water Use

The major water uses in the country are domestic, industrial, irrigated agriculture, and hydroelectric power generation.
Domestic Water Supply

Tanzania's population is about 80 percent rural. At the end of 1993, about half of the rural population had been provided with safe water. The rest of the rural population depends on what are called traditional water sources such as lakes, ponds, dug wells, rivers, streams and springs. In many cases water from these sources is not safe or clean.

The actual amount of water supplied to the rural population is not known because a good percentage of schemes do not function at all times. However, the demand is estimated by multiplying the population figures by the per capita water use per day (estimated at 45 LCD) for rural areas. Table 4.2 shows rural water supply coverage and the estimated demand in 1993, 2002, and 2012, using the population growth rates from 1978-1988.

### Table 4.2 Rural Water Supply Coverage by Administrative Regions, Selected Years, 1993-2012 (Actual and Projected Demand)

<table>
<thead>
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<tbody>
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<td>Arusha</td>
<td>1510.2</td>
<td>487.4</td>
<td>32.3</td>
<td>3.8</td>
<td>67959</td>
<td>21935</td>
<td>95053</td>
<td>138019</td>
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<td>Coast</td>
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<td>39006</td>
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<td>DSM</td>
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<td>131.0</td>
<td>57.3</td>
<td>4.8</td>
<td>10278</td>
<td>5895</td>
<td>15673</td>
<td>25048</td>
</tr>
<tr>
<td>Dodoma</td>
<td>1142.0</td>
<td>728.5</td>
<td>64.7</td>
<td>2.4</td>
<td>51390</td>
<td>3278</td>
<td>63618</td>
<td>80645</td>
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<tr>
<td>Iringa</td>
<td>1185.9</td>
<td>560.8</td>
<td>47.3</td>
<td>2.7</td>
<td>53365</td>
<td>25237</td>
<td>67825</td>
<td>88531</td>
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<tr>
<td>Kagera</td>
<td>1400.0</td>
<td>392.0</td>
<td>28.0</td>
<td>2.7</td>
<td>63000</td>
<td>176400</td>
<td>80071</td>
<td>104515</td>
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<tr>
<td>Kigoma</td>
<td>882.0</td>
<td>328.6</td>
<td>37.3</td>
<td>2.8</td>
<td>32690</td>
<td>14788</td>
<td>41913</td>
<td>55244</td>
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<tr>
<td>K'Njaro</td>
<td>1243.0</td>
<td>626.9</td>
<td>50.4</td>
<td>2.1</td>
<td>55935</td>
<td>31360</td>
<td>67440</td>
<td>83018</td>
</tr>
<tr>
<td>Lindi</td>
<td>624.2</td>
<td>309.0</td>
<td>49.5</td>
<td>2.0</td>
<td>28089</td>
<td>13906</td>
<td>33569</td>
<td>40920</td>
</tr>
<tr>
<td>Mara</td>
<td>1003.0</td>
<td>543.2</td>
<td>54.2</td>
<td>2.9</td>
<td>45135</td>
<td>24446</td>
<td>58378</td>
<td>77697</td>
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<tr>
<td>Mbeya</td>
<td>1463.7</td>
<td>683.6</td>
<td>47.6</td>
<td>3.1</td>
<td>65866</td>
<td>30764</td>
<td>86694</td>
<td>117646</td>
</tr>
<tr>
<td>Moro</td>
<td>1311.7</td>
<td>600.0</td>
<td>45.1</td>
<td>2.6</td>
<td>59926</td>
<td>27000</td>
<td>75499</td>
<td>97592</td>
</tr>
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<td>Mtwarra</td>
<td>661.9</td>
<td>722.6</td>
<td>83.8</td>
<td>1.4</td>
<td>38785</td>
<td>32517</td>
<td>43955</td>
<td>50511</td>
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<tr>
<td>Mwanza</td>
<td>1785.2</td>
<td>891.3</td>
<td>49.9</td>
<td>2.6</td>
<td>80334</td>
<td>40102</td>
<td>101211</td>
<td>130828</td>
</tr>
<tr>
<td>Rukwa</td>
<td>744.7</td>
<td>434.0</td>
<td>58.3</td>
<td>4.3</td>
<td>33511</td>
<td>19530</td>
<td>48949</td>
<td>74574</td>
</tr>
<tr>
<td>Ruvuma</td>
<td>694.8</td>
<td>372.2</td>
<td>53.6</td>
<td>3.4</td>
<td>31266</td>
<td>16747</td>
<td>42243</td>
<td>59015</td>
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<tr>
<td>Shiny'ga</td>
<td>1840.8</td>
<td>399.0</td>
<td>21.7</td>
<td>2.9</td>
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<td>17935</td>
<td>107141</td>
<td>142597</td>
</tr>
<tr>
<td>Singida</td>
<td>833.3</td>
<td>343.1</td>
<td>41.2</td>
<td>2.5</td>
<td>37498</td>
<td>15440</td>
<td>46830</td>
<td>59946</td>
</tr>
<tr>
<td>Tabora</td>
<td>956.4</td>
<td>307.0</td>
<td>32.1</td>
<td>2.4</td>
<td>43038</td>
<td>13815</td>
<td>53278</td>
<td>67538</td>
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<tr>
<td>Tanga</td>
<td>119.8</td>
<td>715.8</td>
<td>59.7</td>
<td>2.1</td>
<td>53910</td>
<td>32212</td>
<td>64998</td>
<td>80013</td>
</tr>
<tr>
<td>Total/Average</td>
<td>2161.0</td>
<td>991.0</td>
<td>46.0</td>
<td>2.8</td>
<td>965501</td>
<td>575266</td>
<td>1233344</td>
<td>1624811</td>
</tr>
</tbody>
</table>

Source: Selected Regional Water Master Plans.

Urban Water Supply

By December 1993, about 68 percent of the approximately 5.3 million people living in Tanzania's urban centers have gained access to a piped water supply. In 1978 there were about 2.3 million people living in urban centers. This population increased to 4.5 million in 1988; and is estimated to have reached 5.3 million at the end of 1993. The rate of increase is 7-10 percent per
annum. At this rate there will be about sixteen million people living in urban centers by the year 2010. Urbanization rates are shown in Table 4.3 for Dar es Salaam and a few other towns.

### Table 4.3 Rates Urbanization, Selected Years, 1986-2006
(Actual and Projected Rates)

<table>
<thead>
<tr>
<th>City</th>
<th>1986</th>
<th>1996</th>
<th>2006</th>
<th>Growth rates (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dar es Salaam</td>
<td>1,496,000</td>
<td>3,054,700</td>
<td>6,237,596</td>
<td>7.1</td>
</tr>
<tr>
<td>Arusha/Moshi</td>
<td>349,838</td>
<td>512,595</td>
<td>751,501</td>
<td>3.9</td>
</tr>
<tr>
<td>Mwanza</td>
<td>258,000</td>
<td>747,233</td>
<td>2,160,251</td>
<td>11.2</td>
</tr>
</tbody>
</table>

Source: Institute of Resource Assessment, University of Dar es Salaam.

One of the major consequences of rapid urbanization is the escalating water demand. Current water production for urban centers is approximately 494,300 m$^3$/day while the demand is close to 912,600 m$^3$/day.

**Irrigation Water Use and Future Demand**

Approximately 60 percent of the 150,000 hectares currently under irrigation is used for rice cultivation and the rest for other crops. Irrigation water demand is about 600 mm for rice and 400 mm for other crops per season. Thus, total estimated current water use is about 780 million cubic meters (MCM). Using an efficiency rate of about 20 percent, the estimated total seasonal water use becomes about 3900 MCM.

Similarly, the total additional seasonal crop water demand for the identified undeveloped potential irrigable area of about 700,000 hectares is about 3640 MCM, or a gross volume of 9100 MCM when a 40 percent intended irrigation efficiency is applied.

**Hydroelectric Power Generation**

The energy policy emphasizes the use of indigenous energy sources for the country's energy requirements. These sources include hydropower, solar energy, renewable bio-energy, coal, and gas. Currently about 85-90 percent of electrical energy is obtained from hydropower plants.

**Comparison of various water uses and demands**

In general, assuming an irrigation period of 120 days a year, the estimated current water requirements of irrigation as compared to other uses is shown in Table 4.4.
Table 4.4 Current Water Requirements for Potential Uses

<table>
<thead>
<tr>
<th>Water Uses</th>
<th>Supply (MCM/d)</th>
<th>Demand (MCM/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural Water Supply</td>
<td>0.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Urban Water Supply</td>
<td>0.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Irrigation Requirements</td>
<td>33</td>
<td>76</td>
</tr>
</tbody>
</table>


The total potential available surface water resources is estimated to be more than 450 MCM/d. This excludes the amount that is in the fresh water lakes. The overall picture which comes out from the above estimates may suggest that availability is not a problem. However the following factors have to be taken into account:

(i) The distribution of water resources is not even, either in place or time. Water may be available in places and times where and when it is not required.

(ii) A source may not necessarily be a resource - either in quantity or quality.

A realistic picture of the available water resources is usually revealed when water balance is estimated within particular river basin boundaries as a unit.

NATIONAL PRIORITY ISSUES

According to the RWRA report, because Basin Water Offices have not yet been established in all the nine basins as stipulated in the country’s Water Legislation, proposals on National priority issues can be categorized in three groups.

Water Resources Monitoring Activities

Effective water resources management is impossible without knowing the quantity and quality of available water resources, the changes in the resource over time, and the factors affecting the resource and conservation measures.

The basic water resources monitoring network is in a bad shape and needs urgent review and rehabilitation. The RWRA report proposes actions to be taken.

Water Quality and Pollution Monitoring and Abatement

The country has no definitive Water Quality Monitoring Programme. Pollution of water bodies is escalating from both point sources and non-point sources. Actions need to be taken as proposed in the Assessment report.
Water Resources Management Policy and Legislation

Conflicts among water users are surfacing. There is lack of a clear policy addressing water resources in a comprehensive manner. The assessment proposes a thorough review of the Tanzanian Water Legislation to make it more comprehensive.

BASIN-WIDE PRIORITY ISSUES

Basin-wide priority issues are specific to each basin, taking into account its dominating human activities. According to the Assessment, priority basins and respective issues are as follows:

(i) in the Rufiji Basin, to develop a comprehensive water resources management plan including watershed management;

(ii) in the Pangani Basin, to develop a comprehensive water resources management plan including watershed management; a water quality and pollution monitoring program; and to encourage groundwater development as an alternative source;

(iii) in the Ruwu/Wami Basin, to develop a comprehensive water resources management plan that makes the water supply for Dar es Salaam City a priority; and,

(iv) in the Lake Victoria Basin, to carry out a detailed survey of pollution sources and abatement proposals, to develop a plan on the utilization of Lake Victoria waters, and to develop a water quality and pollution monitoring program.

Finally, the follow-up actions required are to:

- agree on the Water Resources Management strategy;
- agree on National and Basin-wide priority issues;
- establish necessary Terms of Reference for agreed actions, and
- establish a time frame of implementation of agreed actions.

Mr. Meraji Msuya is the head of Hydrological Services for the Ministry of Water, Energy, and Minerals in Dar es Salaam, Tanzania.

REFERENCES


United Republic of Tanzania. 1978. Water Master Plan Study for Lake regions


DISCUSSION

QUESTION: What should be done with the outdated regulations and laws dealing with water issues?

Answer: The outmoded laws and regulations are in need of review as currently they deal with only administrative issues of water rights.

QUESTION: What is the status of the regional Water Master Plans (WMP)?

Answer: All WMP should be reviewed and focused to take into consideration the new situations.

QUESTION: What seems to be the main water use conflicts in Tanzania?

Answer: Most of the water use conflicts are a result of uncoordinated and fragmented sector plans. There are conflicting policies which render conditions ripe for conflicts. Information is not properly managed as such effective water use becomes a problem.

QUESTION: What are the follow up actions?

Answer: The next step is to have in-depth evaluation of priority basins and come out with more detailed action plans. There is need to have terms of reference for agreed actions and a time frame for implementation of the same.

QUESTION: What proportion of water is allocated to the environment?

Answer: There is no exact proportion left for the environment. This might be known later when detailed basin-wide studies are done.
Developing and managing a river basin in a sustainable manner involves many different aspects. In the case of the Ruvu/Wami basin, the main activities of river basin management include ensuring adequate water supplies for the cities of Dar es Salaam and Morogoro, supplying water to irrigation schemes and hydroelectric power plants, and maintaining the river flow during both rainy and dry seasons. Pending further Environmental Impact Assessments (EIA), a dam will be constructed at Kidundu to assist in achieving these objectives. Basin-wide planning should help to avoid conflicts of interest.

INTRODUCTION

The Ruvu basin covers an area of 17,900 square kilometers between latitudes 6°05' S and 7°45' S and longitudes 37°15' E and 39°00' E. The main river in this basin is the Ruvu whose headwaters are in the Uluguru mountains 500 - 2634 meters above sea level. According to the 1988 census, the basin supported 610,000 people, divided between an urban population of 147,503 and a rural population of 462,092. The urban centers -- in order of decreasing size -- are Morogoro (117,593), Mlandizi (15,207), Chalinze (6,716), Ngerengere (6,182), and Maneromango (1,805). The rural population was concentrated mainly on the slopes of the fertile and wet Uluguru mountains. Others live along the Dar es Salaam-Morogoro road and surround the central line railway stations. Figure 5.1 shows a location map for the basin.

The major economic activity of the rural population is agriculture. Close to the Uluguru mountains, coffee, bananas, maize, wheat, beans, round potatoes, peas, and various types of vegetables are grown, most of which have a ready market in Dar es Salaam. In addition a number of large sisal estates exist in the basin. Some people engage in livestock keeping (10,000 head of livestock). The urban population is engaged in business and manufacturing. There are thirty-five manufacturing industries in the basin employing 4,000 people most of whom are located in Morogoro town.

HYDROLOGY OF THE BASIN

Rainfall and Flow Regime

Seasonal variation of rainfall in the basin is governed by the general air circulation patterns in Tanzania, the closeness of the area to the Indian Ocean, and local convergence. There are two seasons: the rainy season (November to May) and the dry season. Seasonal variations in monthly rainfall in some subcatchments in the basin is given in Figure 5.2. The great spatial variation, however, is a result of orographic lifting of air masses resulting in an annual rainfall of 1500 to 2500 mm
in the Uluguru mountains and less than 1500 mm in the plains. Figure 5.3 shows an isohyetal map of mean annual rainfall.

The flow regime corresponds closely to the rainfall pattern. Floods occur in April, the wettest month, towards the end of the rainy season. The recession in the rivers starts in May and stops in mid-November as shown in Figure 5.4.

**Basin Water Supplies**

The Ruvu river is currently gauged at nine sites as shown in Figure 5.5. The long term of mean flow, runoff, rainfall, and the runoff coefficient of catchments commanded by the respective gauging sites is shown in the Table 5.1.

**Table 5.1 Runoff Characteristics**

<table>
<thead>
<tr>
<th>Station Code</th>
<th>Catchment Area (km²)</th>
<th>Mean Discharge (m³/sec)</th>
<th>Annual Runoff Depth (mm/year)</th>
<th>Annual Rainfall (mm/year)</th>
<th>Runoff Coefficient (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1H5</td>
<td>420</td>
<td>18.5</td>
<td>1,388</td>
<td>2,620</td>
<td>53.0</td>
</tr>
<tr>
<td>1H8</td>
<td>15,190</td>
<td>65.1</td>
<td>135</td>
<td>1,099</td>
<td>12.3</td>
</tr>
<tr>
<td>1H10</td>
<td>5,870</td>
<td>50.2</td>
<td>269</td>
<td>1,342</td>
<td>20.1</td>
</tr>
<tr>
<td>1HA1A</td>
<td>2,840</td>
<td>4.3</td>
<td>48</td>
<td>970</td>
<td>5.0</td>
</tr>
<tr>
<td>1HA5</td>
<td>1,646</td>
<td>3.9</td>
<td>74</td>
<td>986</td>
<td>7.5</td>
</tr>
<tr>
<td>1HA15</td>
<td>2,370</td>
<td>4.7</td>
<td>63</td>
<td>974</td>
<td>6.5</td>
</tr>
<tr>
<td>1HB1</td>
<td>963</td>
<td>6.3</td>
<td>207</td>
<td>1,080</td>
<td>19.2</td>
</tr>
<tr>
<td>1HB2</td>
<td>101</td>
<td>2.5</td>
<td>768</td>
<td>1,333</td>
<td>57.6</td>
</tr>
<tr>
<td>1HC2</td>
<td>251</td>
<td>9.0</td>
<td>1,131</td>
<td>2,057</td>
<td>55.0</td>
</tr>
</tbody>
</table>


The upper Ruvu above station 1H10 is the major source of water supplies in the Ruvu river. It contributes 77 percent of flow at 1H8. The middle Ruvu contributes 11 cumecs or an annual runoff of 5.3 mm. Based on the analysis of the time series data, the mean daily flow exceeded 90 percent and 95 percent of the time at the three of the key stations are as shown in Table 5.2.

**Table 5.2 Mean daily flow of selected probability of exceedence**

<table>
<thead>
<tr>
<th>Station Code</th>
<th>90% of time flow exceeded</th>
<th>95% of time flow exceeded</th>
<th>No. of Years of complete data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1H8</td>
<td>11.0</td>
<td>9.1</td>
<td>21</td>
</tr>
<tr>
<td>1H10</td>
<td>10.4</td>
<td>8.6</td>
<td>8</td>
</tr>
<tr>
<td>1HA1A</td>
<td>0.07</td>
<td>0.02</td>
<td>7</td>
</tr>
</tbody>
</table>

Water Quality

According to a water quality analysis study recently conducted in the Ruvu, water from some streams in the Lower Ruvu coming from the west is highly saline and therefore unsuitable for irrigation. During the rainy season, the *E coli* count is high for many rivers rendering the water unsafe for drinking unless treated. The Ngerengere river was found to be highly contaminated, as a result of sewer discharges from neighboring towns including Morogoro.

BASIN WATER DEVELOPMENT

Current Water use

Currently the Ruvu is the major source of water to Dar es Salaam (population about 2 million). The Ngerengere river supplies water to Morogoro and Ngerengere towns. The water resources in the basin are also used to supply irrigation and domestic water to numerous villages and small towns.

The irrigated lands in Ruvu Basin are in the Lower Ruvu Valley and on the Western slope of the Uluguru Mountains (Uluguru West). Modern smallholder irrigation projects found in Lower Ruvu Valley, while traditional schemes are found in the mountainous areas. There are about seventeen irrigation farms in the Lower Ruvu of which only five are currently operational; the rest have been abandoned. The present irrigated area is estimated to be 337 hectares. The main crop in this area is rice.

In Uluguru West, there are about sixty-eight traditional unlined irrigation canals with a total length of about 170 km. The canal system along the Mgeta Mountains irrigates about 2060 hectares of vegetables, maize, beans and fruits. Therefore the total area currently under irrigation in Ruvu River Basin is about 2,397 hectares.

The major development undertaken so far is construction of the dam at Mindu on the Ngerengere river. The reservoir is located seven kilometers southwest of Morogoro and is the town’s main source of water supply.

Future Water Use and Development Plan

Investigations in the Ruvu River Basin for irrigation were first carried out between 1956 and 1959 by the Food and Agriculture Organization (FAO). Subsequently a French mission in 1962 estimated that 172,400 hectares and 450,000 hectares respectively could be irrigated. In order to command these areas and reduce floods, river regulation was considered necessary and various dam sites were identified. Later the Ruvu was studied in connection with the Dar es Salaam water supply. The most thorough hydrological studies were done by CBA Engineering during their formulation of the Coast/Dar es Salaam Region water master plan in 1979. More recently, Nippon Koei and Pacific Consultants of Japan have carried out a detailed study (financed by JICA) to formulate a basin-wide resources development plan.

The study call for regulation of the rivers to increase dry season flows. Three dam sites have been proposed: Kidunda, Mgeta, and Ngerengere. The dry season flows will be regulated to 28.2 cumecs, 7.1 cumecs, and 1.8 cumecs respectively. Their potential hydropower capacities are 3.9 MW, 2.9 MW and 0.4 MW respectively, as given in Table 5.3.
Table 5.3 Comparison of the Proposed Dams

<table>
<thead>
<tr>
<th>Description</th>
<th>Kidunda</th>
<th>Mgeta</th>
<th>Ngerengere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam height (m)</td>
<td>26.0</td>
<td>45.0</td>
<td>36.0</td>
</tr>
<tr>
<td>Reservoir (sq. km)</td>
<td>158.5</td>
<td>10.5</td>
<td>30.0</td>
</tr>
<tr>
<td>Yield of water for all purposes (m³/s)</td>
<td>28.2</td>
<td>7.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Hydroelectric power generation capacity (MW)</td>
<td>3.9</td>
<td>2.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Probable construction costs (US $ million)</td>
<td>101.1</td>
<td>110.6</td>
<td>90.8</td>
</tr>
<tr>
<td>Irrigated land area as finally assessed (ha)</td>
<td>14,350.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Construction cost of water (US $ million per m³/s)</td>
<td>3.6</td>
<td>15.6</td>
<td>50.4</td>
</tr>
</tbody>
</table>


After critical analysis the Kidunda dam site was found to be the most economical and was selected, pending the results of detailed environmental impact assessment and other technical studies. The dam will meet the downstream water requirements and also reduce floods. Figure 5.6 shows village planning area in and around the Kidunda dam and reservoir.

Watershed management is proposed to encourage sustainable use of water and to reduce sedimentation of the reservoir.

Projects to be Commanded by the Proposed Kidunda Dam

Five types of projects are proposed, including the Dar es Salaam water supply, the Morogoro water supply, irrigation works, hydroelectric power, and river maintenance. The present water demand for Dar es Salaam, Bagamoyo, Kibaha, and all villages using the NUWA water supply system is about 350,000 m³/day. The future water demand for these areas is projected to be 1,209,600 m³/day (14 m³/sec). It is proposed to rehabilitate and expand the existing Upper and Lower Ruvu water supply systems, including the intakes, treatment plants, and conveyance mains, in order to increase the supply to satisfy present and future demand.

Future water supplies to Morogoro would be met from increasing capacity of the Mindu reservoir by raising the embankment of its dam 2.5 m above the present level.

The plan proposes to rehabilitate existing irrigation schemes and open new schemes in the basin. A total of 84,000 hectares in the basin can be irrigated. Land that can be irrigated by the proposed Kidunda dam however is 14,350 hectares during the dry season and 19,450 hectares in the rainy season. Water requirements are respectively 12.27 m³/sec and 16.38 m³/sec (see Table 5.4).
Table 5.4 Proposed Irrigable Area Downstream from the Proposed Kidunda Dam

<table>
<thead>
<tr>
<th>Irrigation Project Title</th>
<th>Rainy Season Area (ha)</th>
<th>Dry Season Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kidunda Area</td>
<td>15,600</td>
<td>10,500</td>
</tr>
<tr>
<td>Bagamoyo</td>
<td>1,100</td>
<td>1,100</td>
</tr>
<tr>
<td>Lowlift Pump</td>
<td>2,400</td>
<td>2,400</td>
</tr>
<tr>
<td>Ruvu National Service</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Makurunge</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Total</td>
<td>19,510</td>
<td>14,350</td>
</tr>
</tbody>
</table>


The water head created by the proposed dam will be used to generate hydroelectric power. The estimated generation capacity using the proposed Kidunda dam is 3.9 MW.

Water will be required for wildlife, fish, and flora, for navigation, to prevent salt water intrusion, to maintain the ground water table, and for other natural river maintenance uses. The measure of required flow was obtained by observing minimum monthly discharges. The probable minimum mean daily discharges were estimated as 4.3 m³/sec.

**Total Water Requirement**

Water requirement in the basin will rise from the present 3.9 m³/sec to 31.37 m³/sec if all the projects proposed will be realized. This situation calls for regulation of the Ruvu and setting up an overall basin Management Institute. The Kidunda dam project will be a multipurpose and multi-sectoral one requiring an overall project management system. Beneficiaries of the reservoir are expected to form water users associations and pay water user fees for the maintenance of the system.

It is proposed that management of the Multipurpose Kidunda Dam, including operation of the reservoir, should be undertaken by an appointed Government institution under the Ministry of Water, Energy, and Minerals. It would be responsible for

- operating the reservoir
- holding water rights
- maintaining the dam and dam facilities
- maintaining close contact with the dam water users
- collecting user fees
- advising the Basin Water Office (BWO).

**BASIN-WIDE MANAGEMENT**

The Ruvu river basin together with Wami river basin have been declared by the Ministry of Water, Energy, and Minerals as one basin known as Ruvu-Wami Basin (RWB) in regard to basin water management. The basin management has not yet been established. Basin management programs
should be established as soon as possible so that they can be integrated into basin development programs at the early stages.

It is proposed to review the Water Utilization (Control and Regulation) Act No. 42 of 1974. The act was amended in 1989 as follows:

(i) Basin Water Advisory Boards should not only be limited to advisory responsibilities to the Basin Water Offices, but should have final say to all matters related to water apportioning and allocations; and,

(ii) Provision for interested groups to form water user associations to take care of their interests and be represented in the boards.

Water user associations are formed for their own benefit by a group of people or institutions that use the same water supply system. On a large river with several intakes, the associations may be split into smaller units. The definition of the smallest unit is a complete water supply system having an intake or head works in the main water source.

Responsibilities of Water User Associations

Water User Associations have the responsibility for

- allocating water rights (except those under multipurpose dams)
- advising the Basin Water Office (BWO) on matters concerning water use in their area
- collecting revenue
- operating and maintaining their water supply system.

Environmental Elements and Expected Conflicts of Interests

Developing a river basin is a delicate endeavor since there are always a wide diversity of interests to consider. In this, the Ruvu basin is not unique.

The development activities proposed in the basin are expected to affect its catchment areas, the people and their activities, the ground water table, soil conservation, wildlife in the nearby Selous game reserve, forest reserves, other vegetation, wetland areas, aquatic life, and estuarine conditions. Because of the many possible consequences of these activities, it has been recommended that a detailed environmental impact assessment (EIA) be undertaken before further detailed engineering studies follow.

Apart from the expected environmental problems, other conflicts of interests are also foreseen in the following areas:

(i) Proposed Kidunda dam with the Selous game reserve (see Figure 5.6);
(ii) Diversification from traditional agriculture methods and crops to modern agriculture methods and new crops;
(iii) Resettlement of people from the proposed dam site;
(iv) Conservation of forests and the natural environment especially in areas already inhabited because of the already existing economic activities;
(v) Conflict over land may arise in some of the proposed irrigation areas between farmers and livestock keepers; and,
(vi) Declining water quality if the proposed irrigation projects and their agricultural activities contaminate the water with fertilizer and pesticides. Depending on its concentration, such pollution can affect aquatic life and eutrophication processes in the river.

These conflicts and others unforeseen at this stage, will be studied in the next stages, during the detailed environmental impact assessment (EIA). Feasibility studies are expected to follow.

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**REFERENCES**


DISCUSSION

QUESTION: The water policy mentions Water Committees but not Water User Associations (WUA). Will the concept of WUA conflict with the water policy?

Answer: Those mentioned in the water policy are Water Committees for domestic water supplies and mainly for construction, operation, and maintenance of water supply schemes, while Water User Associations are meant to group together all water users taking water from the same source. This implies that Water Committees can be members of WUA. Generally, WUA are formed, for their own benefit, by a group of people or institutions, using the same water supply system. However, a legal status for the WUA is necessary.

QUESTION: Does the answer imply that big water users like TANESCO should also be members of equal status like small irrigation farmers in the WUA?

Answer: Yes, according to the definition of WUA.

QUESTION: Design and construction of the Kidunda dam awaits an EIA study. When will it be done?

Answer: For the time being it is not known when it will be done.
Figure 5.1: Ruvu Basin
Figure 5.2: Monthly Rainfall in the Ruvu Basin

MONTHLY RAINFALL PATTERN IN THE HYDROLOGICAL STATIONS
Figure 5.3: Isoheytal Map of Mean Annual Rainfall
Figure 5.4: Summary of River Discharges

SUMMARY OF RIVER DISCHARGE
Figure 5.5: Location of Meteo-Hydrological Stations
Figure 5.6: Village Planning Area, Kidunda Dam/Reservoir
CHAPTER SIX

RUFIJI BASIN WATER MANAGEMENT

W. J. B. MWARUVANDA

The Rufiji Basin, one of the larger river basins in the country, faces the same management problems as others: uneven seasonal rainfall patterns leading to varying flow patterns in the rivers, a wide range of demands for water by domestic and industrial consumers as well as for farming, herding, and fishing, and finally for hydropower generation. Conflicts over prioritizing the needs of these different users are commonplace and must be managed by the different institutions which coordinate river basin management.

OVERVIEW

The Rufiji River Basin is one of the larger basins in the country. It lies between latitudes 5°35' S and 10°45' S and longitudes 33°55' E and 39°25' E. The basin has its altitude from the highest ranges of about 2800 meters above sea level and 0 m at the Ocean. The basin comprises parts of Singida, Mbeya, Iringa, Ruvuma, Morogoro, Coast, and Lindi regions, and includes the following highlands: Livingstone ranges, Kipengere ranges, the Udzungwa ranges, the Mufindi scarp, as well as some sections in the Morogoro ranges. Figure 6.1 shows the Rufiji basin.

Many people live in the southern part of the Great Ruaha Sub-Basin. Two districts in Iringa Region, Mufindi District and Iringa District, contain a total of about 669,000 people. The Mbarali sub-district has about 170,000 people.

The land use patterns in the basin include both urban and rural settlements, agricultural land, livestock rearing, some industries, mining (in Usangu and Ulanga Districts), forest reserves, and national parks and game reserves for wildlife.

Water is used to carry out a variety of economic activities in the basin including hydropower generation, irrigated agriculture, industries, transport (ferries), livestock watering, and pisciculture in ponds, river and dams. Other water uses include domestic water supply and recreation in ponds and rivers.

WATER BALANCE

Hydrology of the Great Ruaha Basin

The Rufiji River Basin covers a total of 177,420 square kilometers. The Great Ruaha covers 47 percent of that area (83,970 square kilometers). Other waterways include the Kilombero River sub-catchment covering 39,990 square kilometers (23 percent), the Luwegu River sub-catchment covering 26,300 square kilometers (15 percent), and the remaining part of the Rufiji River covering 27,160 square kilometers (15 percent).
The major tributaries of the Great Ruaha River include the Little Ruaha, Kisigo, Mbarali, Kimani, Chimala, Halali, Ndembera, Lukosi and Yovi Rivers. There are number of smaller tributaries some of which are perennial. The remaining rivers and streams are intermittent.

Mean annual rainfall and evaporation recorded at various places in the Great Ruaha Sub-basin is shown in Table 6.1.

Table 6.1 Mean annual rainfall and evaporation at selected stations in the Great Ruaha Sub-basin

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>ANNUAL RAINFALL (MM)</th>
<th>ANNUAL EVAPORATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBARALI</td>
<td>630</td>
<td>1800</td>
</tr>
<tr>
<td>MTERA</td>
<td>450</td>
<td>2200</td>
</tr>
<tr>
<td>MADIBIRA</td>
<td>850</td>
<td>1400</td>
</tr>
<tr>
<td>SAO HILL</td>
<td>900</td>
<td>1580</td>
</tr>
<tr>
<td>KIMANI</td>
<td>830</td>
<td>1500</td>
</tr>
<tr>
<td>IRINGA</td>
<td>650</td>
<td>1600</td>
</tr>
</tbody>
</table>


The Great Ruaha River has its source in the Gofio plateau in Makete District. Most of the rivers start in the Kipengere highlands. Some, like the Little Ruaha, start in the Post African erosion surfaces. The Lukosi River begins in the Udzungwa ranges. The Kisigo starts in the lowlands of the Manyoni District. The Great Ruaha River upstream of the Lukosi confluence flows very low in the dry season and sometimes dries up at Mtera. However the river does not dry up after the Lukosi River confluence. Within the first 20,000 square kilometers, the Great Ruaha traverses through the Utengule swamps, an area of about 520 square kilometers. Most of the rivers except the Kisigo and Lukosi are characterized by swamps, especially where the slope is very gentle.

Some catchment characteristics for the Great Ruaha river and its main tributaries upstream of the Mtera dam are shown in Table 6.2. The location of the River Gauging Stations and isohyets of mean annual rainfall are shown in Figure 6.2.
Table 6.2 Catchment characteristics of the Great Ruaha river upstream of the Mtera dam

<table>
<thead>
<tr>
<th>STATION</th>
<th>CATCHMENT AREA (km²)</th>
<th>MEAN ANNUAL DISCHARGE (MCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little Ruaha/Mawande</td>
<td>5,193</td>
<td>697 (5550 to confluence)</td>
</tr>
<tr>
<td>Kisigo/Kinugulu</td>
<td>24,065</td>
<td>1,063</td>
</tr>
<tr>
<td>Great Ruaha/Mawande</td>
<td>24,320</td>
<td>1,890</td>
</tr>
</tbody>
</table>


Some maximum and minimum flow discharges for Great Ruaha river at Msembe are shown in Table 6.3.

Water Use

The major water uses in the basin are for domestic urban and rural water supply, irrigation, pisciculture, hydropower generation, and industrial supply.

Water for domestic use is supplied to the major urban centers in the Rufiji Basin including Iringa Municipal Town, part of Mbeya Town, Mafinga, Ifakara, and Mahenge.

Irrigation schemes are concentrated in the Usangu Plains, Idodi flats, Pawaga Plains, upper Mbarali river catchment (the Mndandu division) and the Lukosi River Valley in Mahenge Division. There are other minor schemes in the Little Ruaha River. Other areas in the Rufiji Basin include the Great Ruaha river downstream of the Kidatu Hydropower station, the Kilombero River valley, and the Ikiriri area in Rufiji District. It is estimated that about 45,000 hectares are under irrigation upstream of the Kidatu station. Except for the schemes on the large state farms, most of the irrigation schemes have low water use efficiency and thus need improvement.

Pisciculture also requires water. Most fishing is done in both natural and man-made ponds and dams. There are a number of fishing camps along the major Rivers (Kilombero, Great Ruaha, and Rufiji).

There are two major hydropower plants in the basin: the Mtera and Kidatu plants. They are both situated in the Great Ruaha River and have a total installed capacity of 80 MW for Mtera and 200 MW for Kidatu. Table 6.4 shows the condition of the Mtera dam over the last five years.

Figure 6.3 shows Mtera reservoir water level hydrograph while Figures 6.4 and 6.5 show the discharge situation for the Mtera and Kidatu reservoirs, respectively, for the period from January-August 1994. The discharge hydrographs for Great Ruaha at Msembe and Little Ruaha at Mawande are shown in Figures 6.6 and 6.7 respectively.

There also exist some mini-hydropower plants belonging to TANESCO, and some companies and religious organizations in the Little Ruaha, Ruhudji, Mbarali, Chimala, Lukosi and Hagafiro rivers. There are some water right applications pending for this use in the Kihansi and Lukosi rivers.
Industrial uses of water are mainly situated in urban centers, primarily within Iringa municipality. However there are also tea factories in Mufindi and Njombe District, sugarcane factories in Kilosa District, and the pulp and paper factory in Mufindi. In addition to normal industrial water use, the pulp industry uses the river to dispose of treated industrial waste. Table 6.5 shows the number of domestic water supply users and number of water rights issued for various purposes in the Great Ruaha basin.

Table 6.3 Flow characteristics for Great Ruaha at Msembe, upstream Mtera reservoir

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Q MAXIMUM (DISCHARGE)</th>
<th>Q MINIMUM (DISCHARGE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964</td>
<td>388.04</td>
<td>6.98</td>
</tr>
<tr>
<td>1965</td>
<td>75.48</td>
<td>2.29</td>
</tr>
<tr>
<td>1966</td>
<td>192.96</td>
<td>15.57</td>
</tr>
<tr>
<td>1967</td>
<td>166.61</td>
<td>2.65</td>
</tr>
<tr>
<td>1968</td>
<td>1374.87</td>
<td>8.03</td>
</tr>
<tr>
<td>1969</td>
<td>159.36</td>
<td>2.33</td>
</tr>
<tr>
<td>1970</td>
<td>438.98</td>
<td>2.78</td>
</tr>
<tr>
<td>1971</td>
<td>346.34</td>
<td>1.53</td>
</tr>
<tr>
<td>1972</td>
<td>232.44</td>
<td>4.63</td>
</tr>
<tr>
<td>1973</td>
<td>205.24</td>
<td>1.70</td>
</tr>
<tr>
<td>1974</td>
<td>143.83</td>
<td>1.53</td>
</tr>
<tr>
<td>1975</td>
<td>107.33</td>
<td>0.21</td>
</tr>
<tr>
<td>1976</td>
<td>155.36</td>
<td>0.07</td>
</tr>
<tr>
<td>1977</td>
<td>93.46</td>
<td>0.04</td>
</tr>
<tr>
<td>1978</td>
<td>969.62</td>
<td>0.05</td>
</tr>
<tr>
<td>1979</td>
<td>367.33</td>
<td>0.16</td>
</tr>
<tr>
<td>1980</td>
<td>199.64</td>
<td>0.70</td>
</tr>
<tr>
<td>1981</td>
<td>204.34</td>
<td>0.34</td>
</tr>
<tr>
<td>1982</td>
<td>23.20</td>
<td>0.34</td>
</tr>
<tr>
<td>1983</td>
<td>218.75</td>
<td>-</td>
</tr>
<tr>
<td>1984</td>
<td>300.84</td>
<td>-</td>
</tr>
<tr>
<td>1985</td>
<td>141.45</td>
<td>-</td>
</tr>
<tr>
<td>1986</td>
<td>188.13</td>
<td>-</td>
</tr>
<tr>
<td>1987</td>
<td>435.71</td>
<td>-</td>
</tr>
<tr>
<td>1988</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1989</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1990</td>
<td>231.13</td>
<td>-</td>
</tr>
<tr>
<td>1991</td>
<td>206.70</td>
<td>-</td>
</tr>
<tr>
<td>1992</td>
<td>179.16</td>
<td>-</td>
</tr>
<tr>
<td>1993</td>
<td>432.29</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 6.4 Condition of Mtera dam for the period 1989 to 1993

<table>
<thead>
<tr>
<th>Year</th>
<th>Net Inflow</th>
<th>Turbine Outflow</th>
<th>Spill Overflow</th>
<th>Net (storage) (net inflow-outflow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>380.07</td>
<td>475.21</td>
<td>201.75</td>
<td>703.11</td>
</tr>
<tr>
<td>1990</td>
<td>420.21</td>
<td>641.55</td>
<td>1198.18</td>
<td>-419.52</td>
</tr>
<tr>
<td>1991</td>
<td>52.62</td>
<td>792.68</td>
<td>0</td>
<td>-340.06</td>
</tr>
<tr>
<td>1992</td>
<td>08.96</td>
<td>665.28</td>
<td>0</td>
<td>-256.32</td>
</tr>
<tr>
<td>1993</td>
<td>15.20</td>
<td>690.98</td>
<td>0</td>
<td>24.22</td>
</tr>
</tbody>
</table>

Table 6.5 Number of water rights issued for various purposes in the Great Ruaha basin

<table>
<thead>
<tr>
<th>DISTRICT</th>
<th>Number of villages served</th>
<th>Design Population</th>
<th>Domestic</th>
<th>Irrigation</th>
<th>Power</th>
<th>Industry</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mbeya Rural</td>
<td>47</td>
<td>209,430</td>
<td>14</td>
<td>79</td>
<td>1</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Makete</td>
<td>7</td>
<td>53,910</td>
<td>3</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Njombe</td>
<td>51</td>
<td>219,050</td>
<td>30</td>
<td>25</td>
<td>10</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Mufindi</td>
<td>32</td>
<td>171,910</td>
<td>25</td>
<td>41</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Iringa Rural</td>
<td>85</td>
<td>400,880</td>
<td>29</td>
<td>135</td>
<td>5</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>Iringi Urban</td>
<td>1</td>
<td>208,000</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>


Water Demand

The major water uses in the basin are irrigation, hydropower generation, and domestic water supply. Irrigation canals are normally not properly managed resulting in excessive water demands. Irrigation on the other hand is highly consumptive; only between 10-30 percent of the abstracted amount of water in the Great Ruaha is returned to the river system. In many cases there are no conveyance systems to return water to the water courses from the irrigation fields. Although hydropower generation requires large amounts of water, it is a non-consumptive use. The apparent excessive water demands for hydropower production is a result of ignoring or non-compliance with reservoir regulations.

Surface and Ground Water Availability

The basin is characterized by many perennial rivers. The upper catchments of the three major rivers of the Rufiji river basin are especially rich in springs and streams. The central part of the Great Ruaha river, including Usangu, the Northern part of Njombe, and Iringa districts, experience dry spells with the frequent drying of rivers. Major tributaries of the Great Ruaha river are all perennial. The Great Ruaha itself is essentially perennial although some parts of the main river dry up occasionally. With proper management, the surface water sources in the basin can safely serve almost all the water uses.
Most of the ground water in the basin is used for domestic water supply. The Iringa, Mbeya, and Ruvuma Region Water Master Plan identified many areas with high ground water potential. Most of the areas identified are in areas termed the "Basement Complex" which covers most of Iringa region and is characterized by several erosion surfaces. However the Usangu plains are in the so-called Karoos (basically alluvial deposits) which are rich in high quality water supplies. There are very few boreholes used for irrigation especially in the sugarcane plantations in Kilombero area. Some parts of the Great Ruaha, like the Pawaga plains, have aquifers with high chloride contents which renders its water unfit for many water uses, especially for drinking purposes.

WATER AND LAND USE CONFLICTS

There are several conflicting water and land uses in the basin. The irrigation diversions for instance have caused conflicts with downstream users. Livestock herders in Usangu and Pawaga plains when visited recently complained of not having enough water for their herds after water has been diverted for irrigation. In areas like Idodi in Iringa after constructing such diversions and irrigation canals, the river apparently changed course. It has made livestock rearers move to where the river ends in an extensive swamp. Farmers, on the other hand, complain of intense interference and destruction of crops by cattle heads in their fields in Usangu, Pawaga, and in the Morogoro districts within the basin.

Wild animals in the four major national parks (Ruaha, Mikumi, Selous and Udzungwa) tend to move to where there is water, sometimes very close to residential areas and farmlands, as a result of insufficient water supplies in parks and Game reserves.

There exist some conflicts between power generation at Mtera and Kidatu and irrigation practices upstream of the two dams. The problem of low dam levels at Mtera has been partly attributed to increasing irrigation water use upstream. The regulation of the dams, especially at Mtera, may cause a problem (actually or potentially) to aquatic life and water users downstream as a consequence of changes in the hydraulics characteristics in the river regime downstream of the dams. Table 6.6 shows maximum and minimum levels for Mtera reservoir for the period 1980/81 to 1993/94.

Water pollution by industries like the Mufindi Paper and Pulp factory is not very serious in the basin. The paper mill for example disposes its waste in the Kigogo-Ruaha River after some treatment. The major pollution rather is caused by the use of fertilizers and pesticides in agricultural fields.

Some studies done in the upper catchments upstream of the Usangu plains have indicated serious vegetation clearing to increase the area of cultivation. In some cases there have been reports on frequent flooding in irrigation fields but the phenomenon needs hydrological confirmation.
Table 6.6 Maximum and minimum water levels for the Mtera reservoir

<table>
<thead>
<tr>
<th>YEAR</th>
<th>WATER LEVEL (METERS ABOVE SEA LEVEL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MINIMUM</td>
</tr>
<tr>
<td>1980/81</td>
<td>685.22</td>
</tr>
<tr>
<td>1981/82</td>
<td>691.12</td>
</tr>
<tr>
<td>1982/83</td>
<td>693.64</td>
</tr>
<tr>
<td>1983/84</td>
<td>696.28</td>
</tr>
<tr>
<td>1984/85</td>
<td>696.75</td>
</tr>
<tr>
<td>1985/86</td>
<td>696.50</td>
</tr>
<tr>
<td>1986/87</td>
<td>695.92</td>
</tr>
<tr>
<td>1987/88</td>
<td>695.08</td>
</tr>
<tr>
<td>1988/89</td>
<td>695.40</td>
</tr>
<tr>
<td>1989/90</td>
<td>693.98</td>
</tr>
<tr>
<td>1990/91</td>
<td>690.70</td>
</tr>
<tr>
<td>1991/92</td>
<td>690.00</td>
</tr>
<tr>
<td>1992/93</td>
<td>691.70</td>
</tr>
<tr>
<td>1993/94</td>
<td>691.52</td>
</tr>
</tbody>
</table>

INSTITUTIONAL RESPONSIBILITIES TO WATER MANAGEMENT

Various institutions are involved in the water resources management. Each institution has its responsibilities in water management.

The Institutions

The Rufiji Basin Water Board (RBWB) was established under Act No. 10 of 1981 Section 7. Its main functions are to apportion water for water rights applications and to control water pollution for all water bodies in the Basin.

The Local Governments' role in water resources management is enacting and executing bylaws regarding conservation of water sources and related aspects.

Local Level Institutions include individuals, water user associations, companies, religious organizations and the like. In normal circumstances these groups are responsible for water used in their properties. This includes proper distribution system and drainage and pollution control aspects.

The Responsibilities

Coordination The Regional Basin Water Office (RBWO) under the RBWB is responsible for seeing that water use in the basin is well coordinated among the various relevant institutions. The RBWO receives information from all the institutions regarding their activities.
Legislation  The RBWO oversees the various aspects underscored in the water law. It is responsible for the execution of the law. The enacting of the law and its amendments are made by the Parliament.

Regulations  Regulations are provided in the act and are executed by the RBWB for all water bodies within the basin. Some of the regulations are provided to the user by the Water Officer through directions of the RBWB. Users can institute their own regulations to suit their activities.

Enforcement of the Law  The enforcement of the Water Law is vested to the RBWO. The Water Officer will use the different Government personnel and instruments to ensure that the law is abided upon.

Major Challenges of the RBWO

The following are the major challenges facing the RBWO:

- Establish the actual water balance of the basin through construction data banks and conducting researches pertaining to this goal;
- Establish proper management links and routines for various institutions and water users; and,
- Develop operating routines for reservoirs and for handling water applications for irrigation practices in the basin.

In order to be able to face these challenges the office needs sufficient and qualified personnel and proper equipment such as computers and other instruments.

*Mr. Willie J. B. Mwaruvanda is a Water Officer for the Rufiji Basin Water Office in Iringa, Tanzania.*

REFERENCES

DISCUSSION

QUESTION: What kind of assistance would you need in the Rufiji Basin Water Office?

Answer: The assistance needed is that which would enable the Basin to work effectively. This includes provision of equipment, transportation, motivation to staff, technical assistance, training of staff and instituting a good water management program with sufficient operational funds.

QUESTION: Is there any conflict between the Rufiji Basin Water Office and Rufiji Basin Development Authority (RUBADA) in view of the laws that established them?

Answer: Yes. For example, RUBADA had proposed to the Government that it be allowed to collect fees from water users, but this is the jurisdiction of Rufiji Basin Water Office. RUBADA also thinks that the RBWO should be within their authority.

QUESTION: What could be attributed to the large spillway discharge in 1990?

Answer: Mtera reservoir operates like a regulation reservoir for Kidatu, therefore available water for Kidatu depends on releases of water from Mtera. It seems that more water was used in Kidatu for power production than can be seen in operating rules for Mtera. However, the year was very wet and thus spilling was necessary during the heavy rains to safeguard the reservoir.

QUESTION: What action are you taking against water users who abstract more water than granted?

Answer: A thorough survey is planned to determine extent of these abstractions, including unregistered users and traditional furrows. After this exercise, legal measures will be instituted as appropriate.
Figure 6.1: Rufiji Basin
Figure 6.2: Hydrometric stations and isohyets of mean annual rainfall
Figure 6.3: Mtera Reservoir Water Levels (January - August, 1994)
Figure 6.4: Mtera reservoir discharge (January - August, 1994)
Figure 6.5: Kidatu reservoir discharge (January - August, 1994).
Figure 6.6: Discharge hydrograph for Great Ruaha river at Msembe
CHAPTER SEVEN

LAKE VICTORIA BASIN MANAGEMENT

SECTION 1: WATER QUANTITY AND QUALITY ISSUES

D. A. MASHAURI

This chapter provides a background to the water quantity and quality issues that are currently of concern in the Lake Victoria basin. Competing claims of farmers, herders, and small industrialists strain the basin's fresh water resources. Poor sanitation and industrial pollution combine to create poor water quality in the lake. Managing this basin of Africa's largest lake is complicated by its shared borders between three Tanzanian administrative regions and neighboring countries.

GENERAL

Lake Victoria is situated across the equator between latitudes 0°31' N and 3°54' S and longitudes 31°19' E to 34°54' E. It is the largest lake in Africa and the second largest in the world after Lake Superior in the United States. The lake is situated at 1124 meters above sea level. It is rather shallow with a mean depth of 40 meters. Its total surface area is estimated at 69,000 square kilometers. About 52 percent of the lake area and about 46 percent of the total Lake Victoria basin is within Tanzania. Lake Victoria is the source of the White Nile which then joins the Blue Nile from the highlands of Ethiopia at Khartoum in Sudan. (See Figure 7.1.)

HYDROLOGY

The rainfall pattern is bi-modal. The maximum mean monthly rainfall over Lake Victoria occurs in April (280-285 mm) with the secondary maximum during November (170-190 mm). The minimum rainfall occurs in July (65-70 mm) with a corresponding secondary minimum in January.

Variations in total rainfall over the lake's surface area are considerable. In Kagera, the whole region receives a yearly average in the range of 800-1000 mm. Around Bukoba, however, the average is slightly over 2,000 mm. In Mwanza region, the yearly average is 900-1100 mm in the Western and Central parts, but lower in the eastern part, averaging 750-900 mm. In Mara region, the yearly average is 750-900 mm in the southern part and 800-1000 mm in the middle part. In the north it increases to around 1000 mm and in the higher areas around Tarime it reaches around 1600 mm.

Runoff Kagera is drained by three main rivers of Kagera, Ruvuvu, and Mgono. The average yearly runoff is 150-300 mm. In Mwanza the region is drained by the Mbalageti, Duma, Simiyu, Moame, and Magogo rivers. All of these are within the area east of Smith Sound. The runoff east of the Smith Sound is in the range of 30-80 mm/year. Mara region is drained by the Mori, Mara, Inguti and part of the Mbalageti rivers. The runoff in the southern part is 30-80 mm/year.
Potential evaporation by Penman's formula give values around 1500 per year in Kagera region. In Mwanza region potential evaporation is 1600 mm per year in the west, 2000 mm south of Mwanza town and around 1700 mm in the east. In Mara region potential evaporation is around 1800 mm per year in the southeast and around 1600 mm for the rest of the region.

Groundwater availability also varies. The yield potential in the lake regions indicates that about 42 percent of all the successful wells give yields between 0.5-3 m$^3$/h, while 58 percent of all the successful boreholes give yields greater than 3 m$^3$/h.

**LAND USE**

Land use in the three regions is roughly divided between two main uses: grasslands for livestock rearing (about 50 percent) and farmland for cultivation (less than 20 percent). Table 7.1 gives the details of land use distribution in the three Tanzanian regions.

<table>
<thead>
<tr>
<th>Description</th>
<th>Kagera (% total area)</th>
<th>Mwanza (% total area)</th>
<th>Mara (% total area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivated land undifferentiated</td>
<td>.0</td>
<td>1.5</td>
<td>10.1</td>
</tr>
<tr>
<td>Cultivated land on upper pediment</td>
<td>1.4</td>
<td>12.6</td>
<td>-</td>
</tr>
<tr>
<td>Cultivated land on lower pediment</td>
<td>0.3</td>
<td>9.8</td>
<td>-</td>
</tr>
<tr>
<td>Cultivated land on lower pediment (hard pan)</td>
<td>-</td>
<td>3.5</td>
<td>-</td>
</tr>
<tr>
<td>Cultivated land on alluvium and clay</td>
<td>-</td>
<td>3.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Cultivated land undifferentiated West Lake</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cultivated land mixed crops</td>
<td>2.6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cultivated land bananas</td>
<td>3.1</td>
<td>0.09</td>
<td>-</td>
</tr>
<tr>
<td>Plantation</td>
<td>0.05</td>
<td>-</td>
<td>0.01</td>
</tr>
<tr>
<td>Village area with cultivation</td>
<td>0.4</td>
<td>5.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Village area without cultivation</td>
<td>-</td>
<td>0.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Urban area</td>
<td>-</td>
<td>0.1</td>
<td>0.04</td>
</tr>
<tr>
<td>Forest</td>
<td>0.8</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Woodland</td>
<td>14.4</td>
<td>9.8</td>
<td>5.0</td>
</tr>
<tr>
<td>Rice</td>
<td>-</td>
<td>1.1</td>
<td>-</td>
</tr>
<tr>
<td>Grassland</td>
<td>65.8</td>
<td>38.6</td>
<td>71.3</td>
</tr>
<tr>
<td>Grassland seasonally flooded</td>
<td>4.6</td>
<td>8.8</td>
<td>5.4</td>
</tr>
<tr>
<td>Outcrops</td>
<td>0.1</td>
<td>3.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Swamp</td>
<td>4.2</td>
<td>0.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Inland water</td>
<td>1.2</td>
<td>0.01</td>
<td>0.1</td>
</tr>
</tbody>
</table>


There are imminent land use conflicts tied to people needing land and water for both their livestock and for their farms. Livestock trespassing into farming land is a common problem in the area. With few perennial rivers, the area’s water resources are scarce and cannot always serve the competing demands of irrigation and livestock development. Industries are also coming up in the three regions eroding further the available supplies.
POPULATION DISTRIBUTION

According to the 1988 census, the population and birth rates of each region were as follows: Mwanza region, population over 1.8 million; birth rate 2.6 percent; Kagera region, population 1.3 million; birth rate 2.7 percent; and Mara region, population .9 million; birth rate 2.9 percent.

For example the Mwanza town population is growing very fast (average 7 percent per annum). This places an extra strain on the demand for fresh water as well as on controlling pollution in the lake that comes from domestic wastes (liquid, solid, and gaseous). Figure 7.2 projects the population of Mwanza town to the next century and Figure 7.3 show the population distribution in 1993. Since sewers reach only a small percentage of this population unsanitary disposal of excreta is common. The situation is similar in the other Lake zone towns of Bukoba and Musoma.

WATER DEMAND AND POLLUTION SOURCES

Water demand is shown in Table 7.2. On average industrial demand will decrease from about 20 percent in 1991 to about 15 percent in year 2012. However domestic demand will increases from an average of 55 percent in 1991 to about 70 percent of the total demand in year 2012. Other water demands are fairly low and constant throughout the period under review. This trend assumes little industrial development in the area during the period. However recent development shows increased industrial activities, especially in fish processing and leather related industries. It is quite possible that increased industrial activities will put an extra strain on demand for fresh water and likewise on the need for control of pollution from the industries.

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Domestic</th>
<th>School</th>
<th>Inst'1</th>
<th>Com'1</th>
<th>Health</th>
<th>Ind'1</th>
<th>Total Avg.</th>
<th>Peak Day Demand w/losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>277,400</td>
<td>16,020</td>
<td>349</td>
<td>3,855</td>
<td>2,629</td>
<td>56</td>
<td>6,315</td>
<td>29,224</td>
<td>47,345</td>
</tr>
<tr>
<td>1992</td>
<td>297,286</td>
<td>18,238</td>
<td>374</td>
<td>4,132</td>
<td>2,817</td>
<td>60</td>
<td>6,767</td>
<td>32,389</td>
<td>52,478</td>
</tr>
<tr>
<td>1993</td>
<td>318,597</td>
<td>20,725</td>
<td>401</td>
<td>4,428</td>
<td>3,019</td>
<td>65</td>
<td>7,252</td>
<td>35,890</td>
<td>58,156</td>
</tr>
<tr>
<td>1994</td>
<td>341,436</td>
<td>23,510</td>
<td>429</td>
<td>4,745</td>
<td>3,235</td>
<td>69</td>
<td>7,772</td>
<td>39,762</td>
<td>64,436</td>
</tr>
<tr>
<td>1995</td>
<td>365,912</td>
<td>26,625</td>
<td>460</td>
<td>5,086</td>
<td>3,467</td>
<td>74</td>
<td>8,329</td>
<td>44,042</td>
<td>71,379</td>
</tr>
<tr>
<td>1996</td>
<td>392,143</td>
<td>30,107</td>
<td>493</td>
<td>5,450</td>
<td>3,716</td>
<td>80</td>
<td>8,927</td>
<td>48,772</td>
<td>79,052</td>
</tr>
<tr>
<td>1997</td>
<td>420,254</td>
<td>33,994</td>
<td>529</td>
<td>5,841</td>
<td>3,982</td>
<td>85</td>
<td>9,567</td>
<td>53,997</td>
<td>87,528</td>
</tr>
<tr>
<td>1998</td>
<td>450,380</td>
<td>38,329</td>
<td>566</td>
<td>6,259</td>
<td>4,268</td>
<td>91</td>
<td>10,252</td>
<td>59,767</td>
<td>96,887</td>
</tr>
<tr>
<td>1999</td>
<td>482,666</td>
<td>41,901</td>
<td>607</td>
<td>6,708</td>
<td>4,574</td>
<td>98</td>
<td>10,987</td>
<td>64,875</td>
<td>105,172</td>
</tr>
<tr>
<td>2000</td>
<td>517,266</td>
<td>45,788</td>
<td>651</td>
<td>7,189</td>
<td>4,902</td>
<td>105</td>
<td>11,775</td>
<td>70,409</td>
<td>114,147</td>
</tr>
<tr>
<td>2001</td>
<td>554,347</td>
<td>50,017</td>
<td>697</td>
<td>7,704</td>
<td>5,253</td>
<td>112</td>
<td>12,619</td>
<td>76,403</td>
<td>123,868</td>
</tr>
<tr>
<td>2002</td>
<td>594,085</td>
<td>54,617</td>
<td>747</td>
<td>8,257</td>
<td>5,630</td>
<td>120</td>
<td>13,524</td>
<td>82,895</td>
<td>134,397</td>
</tr>
<tr>
<td>2003</td>
<td>636,673</td>
<td>59,620</td>
<td>801</td>
<td>8,849</td>
<td>6,033</td>
<td>129</td>
<td>14,493</td>
<td>89,925</td>
<td>145,798</td>
</tr>
<tr>
<td>2004</td>
<td>682,313</td>
<td>65,059</td>
<td>858</td>
<td>9,483</td>
<td>6,466</td>
<td>138</td>
<td>15,532</td>
<td>97,536</td>
<td>158,143</td>
</tr>
<tr>
<td>2005</td>
<td>731,226</td>
<td>70,972</td>
<td>920</td>
<td>10,163</td>
<td>6,929</td>
<td>148</td>
<td>16,645</td>
<td>105,777</td>
<td>171,509</td>
</tr>
<tr>
<td>2006</td>
<td>783,644</td>
<td>77,397</td>
<td>986</td>
<td>10,891</td>
<td>7,426</td>
<td>159</td>
<td>17,839</td>
<td>114,698</td>
<td>185,978</td>
</tr>
<tr>
<td>2007</td>
<td>839,820</td>
<td>84,380</td>
<td>1,056</td>
<td>11,672</td>
<td>7,958</td>
<td>170</td>
<td>19,117</td>
<td>124,354</td>
<td>201,641</td>
</tr>
<tr>
<td>2008</td>
<td>900,024</td>
<td>91,966</td>
<td>1,132</td>
<td>12,509</td>
<td>8,529</td>
<td>183</td>
<td>20,488</td>
<td>134,806</td>
<td>218,593</td>
</tr>
<tr>
<td>2009</td>
<td>964,543</td>
<td>100,206</td>
<td>1,213</td>
<td>13,405</td>
<td>9,140</td>
<td>196</td>
<td>21,957</td>
<td>146,116</td>
<td>236,940</td>
</tr>
<tr>
<td>2010</td>
<td>1,033,687</td>
<td>109,154</td>
<td>1,300</td>
<td>14,366</td>
<td>9,795</td>
<td>210</td>
<td>23,530</td>
<td>158,356</td>
<td>256,793</td>
</tr>
<tr>
<td>2011</td>
<td>1,107,787</td>
<td>118,871</td>
<td>1,393</td>
<td>15,396</td>
<td>10,497</td>
<td>225</td>
<td>25,217</td>
<td>171,600</td>
<td>278,276</td>
</tr>
<tr>
<td>2012</td>
<td>1,187,200</td>
<td>129,420</td>
<td>1,493</td>
<td>16,500</td>
<td>11,250</td>
<td>241</td>
<td>27,025</td>
<td>185,928</td>
<td>301,519</td>
</tr>
</tbody>
</table>
Point Sources Pollution

**Municipal Sewage** The majority of the Mwanza town population is not reached by sewers. The central sewer area hardly reaches 10 to 15 percent of the total estimated flows. Much of the domestic sewage either flows untreated into Lake Victoria or is led into rudimentary treatment systems such as pit latrines, septic tanks, and soakaways. These systems are inadequate in design and construction, leading to groundwater and lake pollution. Even the sewage from the sewers in many cases ends up raw in the Mirongo river due to non-functioning pumps. The pumps are supposed to lift the raw sewage to the Pasiansi oxidation ponds.

**Industrial Pollution** Most of the industries in Mwanza do not have even simple treatment facilities. The main industries are textile manufacturing, cooking oil production, fish processing, leather tanning and related industries, printing works, soft drinks production, garages, and oil jetties. All of them produce highly polluting wastes with high BOD$_5$, and some release heavy metals in their effluent.

**Public Health** Most wastes from domestic and industrial activities end up in Lake Victoria which is also the main source of fresh water. The health of the residents is then at risk since some of these wastes are known to be detrimental to human health. It is not difficult to conclude that the situation is appalling and needs quick remedial actions. Our conviction is that the authorities are aware of the situation. It is not new laws that are needed, but the will to enforce the existing ones.

Table 7.3 shows the different industries, effluent quality, and proposed waste minimization as well as treatment options. Expected effluent quality after treatment and what it costs is also indicated in the same table.
Table 7.3 Summary of Findings, Recommendations, Costs, and Final Quality of Effluent

<table>
<thead>
<tr>
<th>S/N</th>
<th>Industry</th>
<th>Wastewater Quality</th>
<th>Prevention Options</th>
<th>Treatment</th>
<th>Expected Final Quality (BOD₅)</th>
<th>Cost¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mwatex</td>
<td>BOD³ 330 mg/l</td>
<td>Use counter current washing; Replace rollers; Better housekeeping</td>
<td>pH adjustment tank; Common stabilization ponds for industrial wastewater</td>
<td>19.5-29.5 mg/l About 20% nutrient removal</td>
<td>71.079</td>
</tr>
<tr>
<td>2</td>
<td>Nyanza Bottles</td>
<td>BOD³ 260 mg/l</td>
<td>Reduce backwash water; Re-use M/C cooling water</td>
<td>pH adjustment tank; Screen; Common stabilization pond for Nyakato industrial area</td>
<td>19.5-29.25 mg/l About 20% nutrient removal</td>
<td>6.153</td>
</tr>
<tr>
<td>3</td>
<td>Nile Perch</td>
<td>BOD³ 312 mg/l</td>
<td>Use spring loaded nozzle; Install water meters</td>
<td>Screening; Sedimentation tank; Common stabilization pond for Nyakato Industrial area</td>
<td>19.5-29.25 mg/l About 20% nutrient removal</td>
<td>1.859</td>
</tr>
<tr>
<td>4</td>
<td>New-Era Oil Mill</td>
<td>BOD³ 560 mg/l</td>
<td>--</td>
<td>Oil trap; Aerated Facultative lagoon</td>
<td>19.6 mg/l</td>
<td>2.217</td>
</tr>
<tr>
<td>5</td>
<td>Bibiti Oil Mill</td>
<td>BOD³ 560 mg/l</td>
<td>--</td>
<td>Aerated Facultative lagoon</td>
<td>19.6 mg/l</td>
<td>1.0185</td>
</tr>
<tr>
<td>7</td>
<td>Tan Perch</td>
<td>BOD³ 312 mg/l</td>
<td>Use spring loaded nozzle; Install water meters</td>
<td>Screening; Sedimentation tanks</td>
<td>189.6 mg/l</td>
<td>0.264</td>
</tr>
<tr>
<td>8</td>
<td>Voil</td>
<td>BOD³ 560 mg/l</td>
<td>--</td>
<td>Aerated lagoon; Sedimentation tank; Oil &amp; Water Separator</td>
<td>19.6 mg/l</td>
<td>15</td>
</tr>
<tr>
<td>9</td>
<td>CPPC</td>
<td>Coloured</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>Garage and Workshop</td>
<td>Oil-containing waste</td>
<td>Better housekeeping; Proper collection of waste oil to use in wood protection increasing kiln (furnaces)</td>
<td>Oil &amp; water separator</td>
<td>--</td>
<td>1.418</td>
</tr>
<tr>
<td>11</td>
<td>Africa Trading Company²</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>15.450</td>
</tr>
</tbody>
</table>

1. Cost is expressed in millions of Tanzanian Shillings (TShs.)
2. Formerly Mwanza Tanneries

Non-point Source Pollution

Connected to the problem of point-source pollution is non-point pollution from agricultural and mining activities. Indeed, the washing down of fertilizers and pesticides from farms adds to the eutrophication of the shallow lake. Although a comprehensive study has yet to be conducted, it is certain that this is a source of pollution to the lake.
Uncontrolled deforestation of the landscape leads to excessive soil erosion which adds to the siltation of the lake. It is sad to see the rate at which the forests are disappearing in order to obtain firewood for domestic needs and for drying fish. A revolutionary mechanism must be developed and used as a source of energy for domestic and for fish-curing. Otherwise more forest cover will disappear and more sediment will be carried to the lake.

A worse culprit in the non-point pollution source is mining. There is evidence that mining activities are increasing at a very high rate. Here we refer to gold panning along the tributaries leading to the lake. In all these activities mercury is used to process the gold and the mercury residue is left in the river valleys. The heavy metal ends up in the lake sediment to be taken by the fish which is eventually eaten by the people. The end result is heavy metal foodstuffs unfit for human consumption. Gold purification at the buying/selling point demands that the mercury be evaporated, leaving behind pure gold. This process increases the amount of mercury oxides in the air, which is equally as detrimental to human health as its consumption in food.

Dr. D. A. Mashauri is a Senior Lecturer in the Faculty of Engineering at the University of Dar es Salaam in Tanzania.

REFERENCES

Mwanza, Kagera, and Musoma Regional Water Master Plans.


DISCUSSION

QUESTION: In your presentation you said that average industrial water demand will decrease from 20 percent in 1991 to about 15 percent in year 2012. This seems to be a contradiction to what is shown in Table 7.2 of your paper. Please elaborate?

Answer: The figures in Table 7.2 show that industrial water demand is 6,315 m$^3$/d which is 20 percent. The demand in year 2012 is 27,025 m$^3$/d against a total predicted demand of 185,928 m$^3$/d which is only 15 percent. So it is clear that industrial water demand will decrease with time in terms of the total demand.
MWANZA WATER SUPPLY EXTENSION

Municipal masterplan projections

Year

Population (MILLIONS)


11.05% 7.55% 7.17%
Figure 7.3: Mwanza Estimated Population, 1993
CHAPTER EIGHT

LAKE VICTORIA BASIN MANAGEMENT
SECTION 2: CROSS-SECTORAL AND INTERNATIONAL CHALLENGES

A. M. DUDA

The environmental problems of Lake Victoria are complicated and urgent: pollution is growing, fisheries are declining, and conflicts between competing water uses are expanding. Solutions are hindered by the difficulties associated with coordinating ministries of different governments across sectoral lines and international borders. New efforts funded by the World Bank will permit the formation of a comprehensive approach to address these problems.

This chapter on the Lake Victoria Basin addresses cross-sectoral environmental challenges in a broad framework, providing an institutional perspective on challenges for international cooperation. It builds upon the introduction to the hydrology, land and water use conflicts, and description of pollution sources in the Lake Victoria Basin given in an earlier paper in this volume by A. Mashauri. This chapter introduces the Global Environment Facility which supports the Lake Victoria Project that is currently under preparation. Some of the attendees at the conference are participating in preparation of this important international initiative.

LAKE VICTORIA FACES COMPLEX PROBLEMS

Lake Victoria, with a surface area of 68,800 square kilometers and a catchment area of 184,000 square kilometers is the world’s second largest freshwater lake. It is a source of life and income for tens of millions of people living around it in Kenya, Tanzania, and Uganda. The lake basin is used as a source of food, energy, drinking and irrigation water supply, for shelter, transport, and as a repository for human, agricultural, and industrial waste. Populations of riparian communities are growing at rates that are among the highest in the world. While there are hundreds of settlements in the basin, its major urban centers include Mwanza in Tanzania, Jinja and Entebbe in Uganda, and Kisumu in Kenya. In the 1990s the value of the lake’s landed catch of commercial fish -- with fillets prepared, packaged, frozen, and shipped to Europe and the Middle East -- is approaching US$100 million with market level values in the US$250 million to US$300 million range.

Large lake ecosystems can be extremely complex to understand, very difficult to manage, and, once they are degraded, are very costly to restore. Lake Victoria is no exception. It is experiencing an unprecedented case of ecosystem degradation and mass extinction of its fisheries. Fishing is being overexploited and the lake’s waters polluted by industry, sewage, and agricultural pollutants. Reversing this degradation will be more costly in the future and urgent actions are needed now to prevent more adverse impacts.
The lake ecosystem has undergone substantial changes. While abuse of the catchment (deforestation) resulted in some changes, introduction in the late 1950s in Uganda of a non-native fish, the fast-growing Nile perch, resulted in huge changes in the food web of the ecosystem. In addition, discharges of water pollution in the vicinity of the largest cities, accelerating deforestation and its consequent muddying of waters near shore, and overfishing have added to the degradation. These human activities may well cause a total collapse of the Lake Victoria ecosystem and a drastic reduction in economic benefits and income for basin residents.

Between the unintentional introduction of Nile perch, the accidental introduction of water hyacinth, and increasing concentrations of nutrients and pollution from sewage, industry, agriculture, and deforestation, the lake has erupted in huge blooms of algae, depleting oxygen in its lower depths. In addition, the Nile perch have consumed to mass extinction several hundred small types of fish which used to keep the algae in check. The Nile perch now eat their own young, and the Nile perch fishery is declining. Investments in fish processing plants might be wasted if the overfished population of Nile perch crashes. Over 200 species of fish that were native only to the lake are now thought to have become extinct. This experiment in economic development of a new fishery was unsustainable. The loss of small fish has meant that people living in poverty have had to subsist on protein-poor grains such as maize, instead of protein-rich fish. The poor cannot afford the cost of purchasing the Nile perch, and they are subject to diseases transmitted by eating the rotting perch carcasses discarded from fish processing industries. While a few owners have grown wealthy, the lake ecosystem has been virtually destroyed, species have been extirpated, poor people who depended on fish for food have become more impoverished and small-scale fishermen who invested in equipment will soon lose their investments since the current fishery is unsustainable. The water hyacinth is expanding lakewide, further threatening biological productivity of the lake and impeding lake transportation. The disease bilharzia is on the increase because the little fishes which used to consume the snails have themselves been eliminated by the voracious appetite of the Nile perch.

Kaufman (1992), in describing this irretrievable loss of biodiversity, notes that never before have humans in one action placed so many species at risk of extinction and caused such a widespread change in society in such a large region in an attempt to stimulate economic development. Unfortunately, as shown by Kenyan landings of fish in Figure 8.1, fish biomass did not increase in the lake. Instead, the world's most diverse assortment of fish has been changed to dominance by just a couple types of introduced fish. Kaufman (1992) provides an excellent summary of this situation.

CROSS-SECTORAL INSTITUTIONAL CHALLENGES

Table 8.1 summarizes the cross-sectoral institutional challenges being faced in the Lake Victoria Basin. These challenges cover quality, quantity, health, ecosystem, and international institutional issues. There are linkages between these issues in that different sectoral ministries handle different issues, civil unrest is present, scientific uncertainty and lack of data cloud every issue, and funding is scarce. Nothing less than a comprehensive approach to water resources management is needed in the basin because the issues are linked.
Table 8.1 Cross-Sectoral Institutional Challenges In the Lake Victoria Basin Related to Water

| * Overfishing               | * Water Hyacinth                                          |
| * Pollution Abatement       | * Extinction of Species                                   |
| * Protection of Refuge      | * Kagera Basin Quality                                    |
| * Land Degradation - Erosion| * Riparian Nations International Cooperative Institutions |
| * Establishing Water Allocation for 3 Countries in Nile System | * High Levels of Waterborne Diseases - Kagera and Mara Regions |
| * Lower Than Average (for Tanzania) Rural Water Availability in Mwanza and Kagera Region |

**WORLD BANK'S RECOMMENDED COMPREHENSIVE APPROACH**

After a lengthy process, including consultation with non-governmental organizations (NGOs), governments, and international organizations, the Board of Directors of the World Bank approved a new water resources management policy in May 1993. It represents a new paradigm in mandating Bank support for a more comprehensive approach to water resources management. It signals that the highest levels of government should recognize that water resources and watersheds must be managed as valuable natural resources to meet multiple uses rather than just as inputs to specific sectoral activities. It also seeks to balance the need for holistic, ecosystem-based approaches for sustainable management of water resources and their drainage basins with the advantages of relying on markets, pricing, and economic policy reforms to improve water management. Current practices are simply not sustainable from either economic or environmental perspectives.

The Bank will provide assistance to member countries in developing a comprehensive approach to water resources management suitable for the country's needs, resources, and capabilities. The comprehensive approach stresses incorporation of cross-sectoral and environmental considerations into water resources management, most often river basin by river basin. An emphasis is placed on building effective institutions to protect, enhance, and restore water quality and aquatic ecosystems that have been damaged by pollution or past development projects. Legal and regulatory reforms, emphasis on economic incentives, proper pricing policies, decentralization of water service delivery, and active participation of beneficiaries, stakeholders, and the poor in water resources management activities are stressed.

The Lake Victoria Point Source Pollution Assessment Project described by Mashauri (this volume) and the Rapid Water Resources Assessment (RWRA) described by Msuya (this volume) were both funded by the World Bank to demonstrate that within short time periods, multidisciplinary specialists in a country like Tanzania from different ministries, institutes, and universities can undertake cross-sectoral work in river basins to address priority water resources problems.

The RWRA was a necessary part of the process of identifying cross-sectoral priorities that influence water resources in each river basin. Complementarities exist between certain actions of sectoral programs and projects and positive impacts on the sustainability of water resources for multiple uses. In fact sustainability can be achieved only by having different sectors compromise on their programs and target modified programs to river basins where they are most needed. This may mean a
little less water diverted for irrigation so that downstream aquatic ecosystems in Lake Victoria tributary wetlands can be sustained, or, that agricultural programs for erosion of pollution control should be targeted to certain priority basins. Compromise may mean that funding for proper sewage collection and treatment in Mwanza or Bukoba should take precedence over similar systems in other areas because of multiple pollution control and health benefits. The priority in different basins will be different, and Tanzanians must judge the priorities. This must be done by experts in the country in a participatory manner with stakeholders and the public. The issues of how to involve different sectoral interests in this process, how to identify complementarities between sectoral actions and sustainability of the water environment, and how to make this more comprehensive approach institutionally feasible all urgently need to be addressed now in the Lake Victoria Basin.

GLOBAL ENVIRONMENTAL FACILITY PROJECT FOR LAKE VICTORIA

The Global Environment Facility (GEF) was launched three years ago as a pilot project to provide grant funding to developing countries for programs to protect the global environment. It is jointly run by three partners: the United Nations Environment Program (UNEP), the United Nations Development Program (UNDP), and the World Bank. The GEF has built on the achievements of the Earth Summit of 1992, and in March 1994, representatives of eighty developed and developing nations agreed to transform the pilot GEF into a permanent fund with US$2 billion for its first three years (1994-1997). The four main focal areas are climate change, biodiversity protection, international waters, and ozone depletion. Furthermore, land degradation is also eligible as it relates to one of the four focal areas.

Negotiations began in 1992 about a possible project under the international waters category among the three Lake Victoria riparian nations and the GEF partners. In October 1992, a meeting was held among the three riparian countries in Dar es Salaam about forming an international fisheries commission for the lake, and in April 1994, UNDP chaired a meeting hosted by UNEP in Nairobi which led to agreement on draft objectives, priorities, and activities for preparing the Lake Victoria Environmental Management Program (LVEMP). Again in Dar es Salaam in August 1994, the three countries signed the agreement to proceed in preparing the LVEMP for funding under the GEF.

The project is aimed at establishing and beginning implementation of a joint regional environmental management program that will address fisheries, lake pollution, land use issues, wetlands protection, the water hyacinth problem, and catchments. It will also help to strengthen the capacity of national institutions to support the regional institutions being created to implement the regional program. The US$20 million project will be prepared over the ten month period starting October 1994 and will lead to the four year project. There will be national working groups coordinated by national secretariats, a regional Steering Committee with its secretariat located in Tanzania, and two regional task forces (one led by Uganda on fisheries and water hyacinth and one led by Kenya on water quality and land use). Major elements of the project include:

(i) establishing and operating a fisheries commission, improving fisheries databases, and strengthening national organizations and enforcement;
(ii) managing lake pollution, strengthening and harmonizing regulations, enhancing enforcement, improving water quality databases, and investment priorities;
(iii) better management of wetlands, controlling water hyacinth; and,
(iv) coordinating the planning of catchment development and providing LVEMP Coordination.
Opportunities To Address Basin Needs

The Ministry of Water, Energy and Minerals has begun to utilize the comprehensive approach to water resources management in Tanzania through the Rapid Water Resources Assessment process described by Msuya (this volume). This process is identifying priority water resources related issues in each river basin and priority basins nationwide. The next step would be to express government commitments in a Water Resources Management Strategy. It would describe how these problems will be addressed in each priority basin in a cross-sectoral, comprehensive manner so that both uses and the water environment will be sustained. The Pangani, Rufiji, and Victoria basins have been accorded priority, along with the Ruvu/Wami as a water supply for Dar es Salaam. Basin Boards and Basin Offices have been established for the Pangani and the Rufiji under the 1974 Water Utilization Act, as amended. A similar Basin Board and Basin Office are now needed for the Lake Victoria Basin to show government commitment to a priority for the basin and to coordinate now, not after the fact, with the LVEMP being funded under GEF.

Mashauri (this volume) described the World Bank-funded pilot project in evaluating point source discharge treatment options in the Lake Victoria basin (also see Mpendazoe, Mashauri, et al. 1994). Human sewage was found to be the worst source of water pollution -- especially from unsewered squatter settlements. Industries also contributed to the pollution. Fairly simple, not too costly options were identified for cleanup. In rural, predominantly agricultural areas, nutrients, human sewage, and livestock wastes constitute the major sources of pollution. The Tanzanian interministerial team also identified low cost, small bore sewer options to abate pollution from squatter settlements in Mwanza. If their estimates for Kirumba ward are applicable city-wide, the cost of these innovative sewers would not exceed one quarter (25 percent) of the projected road construction project in Mwanza currently being prepared by Tanzania and the World Bank.³ Are roads a greater priority than the combined needs of protecting human health in Mwanza and reducing human pollution of the lake?

Political decisions clearly need to be made soon. Will the 1974 Water Utilization Act, as amended, be enforced to ensure that industries discharging to the lake employ pollution controls as recommended? Will the Lake Victoria Basin Board and Basin Office be established to show government commitment? Will a Water Resources Management Strategy process be initiated for the basin to show commitments for solving the priority water resources issues, including establishing the allocation of water that Tanzania can withdraw from the lake? Will the Nine Towns Project supported by the World Bank be modified by Tanzanian government officials to include urgent collection and treatment of the squatter settlement sewage that is the biggest pollution source to the lake?

Two options exist: 1) to increase the cost of the Mwanza component by 25 percent, or, 2) to delay for perhaps five years 25 percent of the proposed road construction in Mwanza to allow existing funding to be used for human sewage abatement. Clear choices exist for Tanzanian officials. The World Bank in 1983 noted that the Tanzanian government reduced the proportion of its development budget (including donor funding) that goes to water supply/sewage projects from 6 percent during the Water Decade to less than 1 percent in the late 1980s and early 1990s. The government's stated goals for clean water and health by 2002 cannot be met unless the government once again restores top priority for the funds it receives to be spent on sanitation, sewage treatment, and clean water rather than other types of expenditures. There is no need to delay this priority spending in hopes that the GEF grant will fund it because the GEF will likely not fund sewage or sanitation improvements as they constitute local, not global benefits.
Choices exist for Tanzanians, especially for those leaders in water resources management participating at this meeting, to act now to solve Lake Victoria Basin problems. Table 8.2 presents a general strategy for the basin based on priorities identified by Tanzanians. The only prudent course is to act now on initiatives that will help or that have multiple benefits. The world cares about your three Great Lakes and is expressing this caring by providing each lake with a GEF-funded project. Lake Victoria is clearly first priority among the three. Will Tanzania choose a course of quick, prudent action on behalf of its citizens and the damaged lake ecosystem that will be implemented in parallel with the GEF project and in doing so delay leadership and commitment fitting of its status in hosting the GEF LVEMP Regional Steering Committee Secretariat? Or will Tanzania choose a go-slow, study approach?

Table 8.2 Priority Basin Strategy - Lake Victoria Basin

| * Establish Basin Office and Basin Board |
| Prepare a Water Resources Management Strategy for the Basin |
| (1) Targeting to areas with poor water coverage to meet year 2002 goals for water |
| (2) Integrate strategy with GEF project on Lake Victoria |
| (3) Investigate options for use of Lake Victoria water for irrigation and water supply and conduct environmental assessment for options. |
| * Enforce provisions of Water Utilization Act on industrial polluters in Mwanza, Bukoba, and Musoma to incorporate options identified by Mashauri's investigation (see Chapter Seven). |
| * Install small bore sewers in Mwanza squatter settlements and rehabilitate sewage pumps/stabilization ponds as part of World Bank funded Urban Infrastructure Rehabilitation Project for Mwanza. |
| * Work toward formation of a joint Tanzania-Kenya-Uganda Lake Victoria Environmental Management Commission to address international responsibilities. |

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ENDNOTES

1. This pollution consists of untreated, collected municipal sewage, uncollected sewage from squatter settlements, and industrial wastewater from textile mills, tanneries, vegetable oil, breweries, pulp and paper mills, fish processing sites, all of which drains into the lake.

2. The reference here is to the Mwanza component of the Nine Towns Urban Infrastructure Project with projected roads cost of US$ 40 million.

REFERENCES

Figure 8.1: Demise of the Native Fishes of Lake Victoria

Source: Kenyan Marine and Fisheries Research Institute
CHAPTER NINE

PANGANI RIVER BASIN MANAGEMENT

B. A. S. LUHUMBIKA, J. D. SARMETT, AND S. M. KAMUGISHA

The paper briefly outlines conditions in the Pangani and Sigi river basins. It discusses the present water situation and potential conflicts as well as the steps being taken at different levels to deal with these issues. Major challenges facing river basin management include compiling more complete data on hydrometeorology, developing a management information system, and coordinating water users.

THE PANGANI RIVER BASIN

The Pangani river basin has a total area of 42,200 square kilometers in Kenya, 10,150 square kilometers in Kilimanjaro region, 19,760 square kilometers in Arusha region, and 9,960 square kilometers in Tanga region (see Figure 9.1). The basin contains a big man-made dam called Nyumba ya Mungu (NYM) whose reservoir is led by Kikuletwa river originating from Mt. Meru and Mt. Kilimanjaro as well as the Ruvu river originating from Lake Jipe. Downstream from NYM the river is joined by the Mkomazi river from the South Pare and West Usambara mountains. Further east, the Pangani is joined by the Luengera river before it enters the Indian Ocean, 432 kilometers from NYM dam.

Mt. Kilimanjaro plays a critical role in the hydrology of the Northern Tanzania and especially of the Pangani river basin. The entire population and many agricultural activities and large national projects depend on it. These projects include: Tanganyika Planting Company, Lower Moshi Irrigation Scheme, Nyumba ya Mungu power station (8 MW), Hale power station (21 MW), Old Pangani Falls (15 MW), New Pangani Falls (66 MW), and many abstractions for commercial and industrial uses. The Pangani basin is small compared to other basins in Tanzania but it encompasses numerous economic activities.

The Sigi river is not a tributary of the Pangani but an adjacent river administratively is under the Pangani Basin Water Office (PBWO). Part of its basin lies between latitudes 4°46'S and 5°15'S in northeastern Tanzania. The river is perennial; it rises in the East Usambara mountain at an elevation of about 920 meters above sea level. It has two main tributaries: the Sigi originating from the east and the Muzi which flows southward. After the confluence near Msakazi it flows southward. The Sigi basin is approximately 1,050 square kilometers. Below the Sigi-Muzi confluence, lies the Mabayani dam built in 1978 to provide water storage for Tanga municipality. The basin area above the dam is about 900 square kilometers. The upper basin ranges from mountainous to steep and the lower basin is hilly to undulating. The main water course has a generally moderate to low gradient, falling 950 meters along its 70 kilometer length towards the ocean.
The settlements in the area can be described as scattered. The vegetation cover varies in the basin. In the upper part of the Sigi within the mountains, vegetation consists of dense forest interspersed with tea plantations and areas of traditional cultivation. Down the slopes towards the ocean, there are inactive sisal plantations, dry savanna, bush, grazing land, and coconut palms along the coastal areas.

Economic activities in the area include a few active sisal estates that use water for decortication. Most activities that depend on the Sigi river for domestic and industrial water supply are centered in Tanga municipality. Tea estates in the basin are mainly rainfed.

**WATER SITUATION**

In the Pangani river basin the state of hydrological data (especially discharge) is very interesting. There are a lot of missing data that make the task of analysis very complex. In the Pangani river basin the climate varies widely by both location and altitude. The large flat plains of the Masai Steppe have an annual rainfall of less than 500 mm; while the slopes of Mt. Kilimanjaro are rich and fertile with an annual rainfall exceeding 2,000 mm. More than 50 percent of the basin receives only 500 mm - 600 mm per year of rainfall.

It is estimated the annual runoff at NYM dam is about 1,000 million cubic meters. The reservoir volume at hill water level is about 11.40 million cubic meters, permitting control of the average runoff upstream. The flow downstream of the dam is very much controlled by the operation of the NYM power plant. Before 1993, the normal release had been around 30.33 m$^3$/s, with exception of from 1976 to 1977. The annual average reservoir losses are estimated at some 6 mm/day, which corresponds to approximately 10 m$^3$/s, for a water surface area of about 150 square kilometers.

Long term observed average flow at Hale, 352 kilometers from NYM, as recorded between 1968-92 was 37.3 m$^3$/s compared with an average flow of 35.9 m$^3$/s between 1940-79, and an average flow of 37.0 m$^3$/s between 1935-82.

Due to increased water abstractions in the basin and the prevailing drought, the release of water from NYM is controlled by PBWO and as such the observed flow at Hale during 1993-94 was 4-10 m$^3$/s.

The hydropower demand according to installed capacity is as shown in Table 9.1.

**Table 9.1 Hydropower demand and installed capacity in the Pangani river**

<table>
<thead>
<tr>
<th>S.NO</th>
<th>Name</th>
<th>Installed Capacity(MW)</th>
<th>Firm Capacity (MW)</th>
<th>Rated Discharge (m$^3$/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nyumba ya Mungu</td>
<td>8</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Hale</td>
<td>21</td>
<td>11</td>
<td>198</td>
</tr>
<tr>
<td>3</td>
<td>Old Pangani</td>
<td>15</td>
<td>5</td>
<td>N/R</td>
</tr>
<tr>
<td>4</td>
<td>New Pangani</td>
<td>66</td>
<td>313 Gwh</td>
<td>45</td>
</tr>
</tbody>
</table>

Water demand for irrigation depends on the type of crops, soil properties, and irrigation system used in the Pangani basin. The average figures fall within the range of 1000 mm/year - 1200 mm/year. The total irrigated area is given as 40,000 hectares, with 400 million - 480 million cubic meters of water abstracted from the rivers every year (IVO-NORPLAN 1990). This does not compare well with the physical inspection done in the basin (see Table 9.2) although that figure also contains domestic water supply abstraction.

Ground water prospects in Pangani basin are very great in Arusha and Kilimanjaro. At the foot of Mt. Meru from where the Arusha municipality draws its water, the presence of springs indicates groundwater potential in Kilimanjaro. The hydrogeological study (JICA 1980) indicates two promising groundwater areas in Mwaleni and in Kiomu. In Tanga the prospects of getting good yielding areas are just along the main river.

In the Sigi basin, the rainfall varies markedly, from 100 mm to 2,000 mm, from the coast to the tops of the mountains. The Mabayani dam has a capacity of about 7.7 million cubic meters. The only main abstraction is the municipal water supply drawing about 20,000 m$^3$/day for about 80,000 people connected to the supply. The present average demand by homes, commercial institutions, and industries is about 40,000 m$^3$/day. The 1995 demand is set at 60,000 m$^3$/day. For the supply beyond 1995, it is proposed to engage another water supply source (Urban Water Supply Engineer). Other uses from the river are yet to be quantified. The groundwater prospects in the basin are very low due to its topography and salinity.

**WATER USES AND LAND USE CONFLICTS**

The cause of the present and potential conflicts regarding water use is the result of continuing development in the country and a difficulty in implementing the existing laws.

**Pangani basin**

*Irrigation Diversions.* Today, most of the streams feeding Kikuletwa and Ruvu upstream of NYM that once flowed throughout the year are dry from September to November during the dry season. Studies undertaken in the basin indicate that a possible cause of this are increased abstractions in the streams (Samett and Faraji 1991). The inspection done by the Pangani Basin Water Office (PBWO) indicates many uncontrolled abstractions (Table 9.2).

<table>
<thead>
<tr>
<th>Region</th>
<th>Abstractions</th>
<th>With control gates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanga</td>
<td>501</td>
<td>89</td>
</tr>
<tr>
<td>Kilimanjaro</td>
<td>1497</td>
<td>170</td>
</tr>
<tr>
<td>Arusha</td>
<td>96</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td>2094</td>
<td>283</td>
</tr>
</tbody>
</table>

Source: Pangani Basin Water Office.
The net abstraction at the time of inspections for the 2094 cases was about $40 \text{ m}^3/\text{s}$. The furrows were not inspected at the same time, however, so the indicated total abstraction might be misleading.

Uncontrolled abstractions could include:

- Unfunctioning intake gates
- Intakes without control structures
- Abstracting more than the demand
- Abstraction without water rights
- Abstracting more than granted water rights.

The physical inspection of water rights was done in the field. The result of this inspection is shown in Table 9.3. The net abstraction at the time of inspection for 171 Water Rights was about $30\text{ m}^3/\text{s}$.

<table>
<thead>
<tr>
<th>Region</th>
<th>River</th>
<th>With control gates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanga</td>
<td>36</td>
<td>31</td>
</tr>
<tr>
<td>Kilimanjaro</td>
<td>28</td>
<td>23</td>
</tr>
<tr>
<td>Arusha</td>
<td>107</td>
<td>61</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>171</strong></td>
<td><strong>115</strong></td>
</tr>
</tbody>
</table>

It has been observed that water is being abstracted to meet the demand of the prepared farm area instead of preparing the farm according to the available water in the river system. Major irrigation projects in the basin are now getting less water than the flow provided at the inception of the projects.

- Lower Moshi Irrigation Project abstracts water from Njoro and Rau river above NYM. Its water right is 804 l/s on Njoro and 1135 l/s on Rau. The upstream abstractions just above the project did not exist before the inception of the project, and have now forced the project management to review their farming plans.
- Mombo Irrigation Project on Soni/Mombo river has the water right of 270 l/s. Abstractions up in the Usambara mountains these days cause the project to get only one-half (or less) of its water requirements in dry months.

**Power Generation.** The Pangani Hydropower System is very dependent on the water stored at NYM reservoir. When the reservoir does not get enough water due to uncontrolled abstractions upstream during the rainy seasons, then the decreased outflow affects the power production in the system. Likewise, the abstractions between NYM and Hale on the main Pangani can affect power production if not monitored and regulated. During the inspections three furrows were identified abstracting about $2.5 \text{ m}^3/\text{sec}$ of water unnecessarily. This could affect the planned release from NYM.
In Pangani river basin, about 70 percent of the energy is produced during the rainy season. For the new Pangani power plant a firm power production of 313 GWh (313,000,000 kWh) would need 745 million cubic meters of water, more than 500 million cubic meters of which comes during the rainy season and has to be stored in NYM. Therefore loss of water in the rainy season is the loss of very valuable water for firm power production.

Historical data have been collected and stored in the database as shown in Table 9.4.

<table>
<thead>
<tr>
<th>Region</th>
<th>From river</th>
<th>Boreholes</th>
<th>Granted water rights (l/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>River</td>
<td>Boreholes</td>
<td>River Boreholes</td>
</tr>
<tr>
<td>Tanga</td>
<td>202</td>
<td>33</td>
<td>4,565.65</td>
</tr>
<tr>
<td>Kilimanjaro</td>
<td>431</td>
<td>55</td>
<td>19,109.15</td>
</tr>
<tr>
<td>Arusha</td>
<td>291</td>
<td>16</td>
<td>6,853.51</td>
</tr>
<tr>
<td>Total</td>
<td>1,028</td>
<td>104</td>
<td>30,528.31</td>
</tr>
</tbody>
</table>

Sigi basin

Before independence, the value of retaining forests in the East/Usambara was stressed to maintain a good tea climate, to protect soils from erosion, and to safeguard the catchment value in the area. After independence, there was some relaxation of forest conservation which downgraded the environmental protection programs. Indiscriminate cutting of forests for energy and agricultural expansion have been the cause of deforestation.

It was reported that from 1954 to 1976, there was a 50 percent reduction of forest in an area of 30 square kilometers around Amani. This is not recorded in East Usambara alone. The FAO/UNDP project on environmental monitoring indicates that the country is losing 2 percent of its forest cover each year. According to World Bank estimates (1984), Tanzania is losing about 500,000 hectares each year. The airphoto study conducted by Soil Erosion Control and Agro-Forestry Project (SECAP) in 1980 shows that the area deforested in the West Usambara between 1954-75 was 16,137 hectare (734 ha/yr).

The removal of soil cover (which accompanies deforestation) and increasing agriculture activities along the river has accelerated soil erosion and the rate of sediment transport in the river, as seen through qualitative assessments such as high turbidity in the water. Sediment load data in the Sigi river are very scarce.

The rains of November and December 1992 caused landslides and soil erosion on the Muzi tributary that had a great effect on the quality of water in the Mabayani dam. The turbidity rose from 20 N.T.U. - 30 N.T.U to as high as 14,000 N.T.U. Aluminum sulphate accounted for about 75 percent of the total cost of chemicals needed for water treatment. To clear this muddy water, aluminum sulphate use rose from 25 g/m³ on the average to over 200 g/m³ without success. The cost of treating water might turn out to be very high due to muddy water if this phenomenon repeats every
heavy rainy season. This year (July 1994), the price of 50 kilos of aluminum sulfate has increased by about 67 percent, from 9,000 Tshs. to 15,050 Tshs.

ENVIRONMENTAL ISSUES

Pollution can be divided into its domestic, agricultural, and industrial aspects. Domestic pollution is found in towns and in the municipalities. Agricultural pollution is found in some areas in Arusha and Kilimanjaro, due to extensive use of agrochemicals such as fertilizers, herbicides, and pesticides. Industrial pollution is found in places where treatment of the effluent is not effective, such as on the Themi river, into which Tanzania Breweries LTD in Arusha discharges, on the Karanga river, into which Kibo March in Moshi town used to discharge, and into other rivers in the Pangani and Sigi basins into which a number of sisal estates discharge directly.

Typical examples are shown on Table 9.5. The data are based on water samples from Sigi and Pangani rivers at Amboni and Ngombezi Estate respectively, as collected and analysed by Ministry of Water, Energy and Minerals Central laboratory in June 1992.

### Table 9.5 Sisal effluents receiving water and wastewater samples

<table>
<thead>
<tr>
<th>River</th>
<th>Parameters</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pH</td>
<td>E.C (us/cm at 25° C)</td>
</tr>
<tr>
<td>Sigi River upstream</td>
<td>7.5</td>
<td>275</td>
</tr>
<tr>
<td>Sisal effluent</td>
<td>4.6</td>
<td>1,047</td>
</tr>
<tr>
<td>Sigi River downstream</td>
<td>6.1</td>
<td>325</td>
</tr>
<tr>
<td>Pangani River upstream</td>
<td>8.5</td>
<td>650</td>
</tr>
<tr>
<td>Sisal effluent</td>
<td>6.0</td>
<td>820</td>
</tr>
<tr>
<td>Pangani River downstream</td>
<td>8.4</td>
<td>710</td>
</tr>
<tr>
<td>Tanzania Temporary Standards</td>
<td>6.5 to 8.5</td>
<td>--</td>
</tr>
</tbody>
</table>

Abstractions in some of the rivers cause certain portions of the river to dry up especially during the dry season. Some water right holders in the 1960s were granted the whole flow in the river even when the flow was very low, like the intake of Hale power station. The minimum flow criteria is not yet established.

Besides the ecosystem problem of turbidity noted earlier, the original river course could change in the rainy period due to agricultural activities in the river valleys. The effect of water abstraction
upstream especially during the dry period may cause the water levels downstream of Pangani to be very low. This may accelerate the saltwater intrusion from the ocean. The phenomena need to be investigated and the minimum flow be defined.

**Water Hyacinth** (*Elchhomia crassipes*) is an exotic aquatic weed normally found floating on stationary or slow flowing water-bodies such as lakes, dam reservoirs, and some rivers. It is said to be a fresh water weed.

The water hyacinth causes a number of environmental problems. It forms a continuous floating mat-like structure which can hinder navigation and creates difficulties for fishermen. It can increase the rate of deoxygenation in water, stressing aquatic flora and fauna. It can reduce a reservoir capacity by occupying space. It causes significant water loss by evapotranspiration. Finally, when it decomposes, dead organic matter accumulates on the reservoir bed.

A survey conducted by IVO-NORPLAN in the Pangani river indicated the existence of the weed in some places from Pangani Falls up to Mkomazi inlet. It was not yet traced way up to NYM. Upstream NYM, however, there is also heavy weed growth at Ruvu and Kikuletwa inlets. The weed has been noted in Mabayani Dam on the Sigi river. This is a potential environmental problem that needs to be addressed by joint efforts including the local residents along the river.

**INSTITUTIONAL RESPONSES**

Under the authority of the Water Utilization Control and Regulation Act No. 42 of 1974, and as amended by Act No. 10 of 1981, the Pangani Basin Water Board and the Pangani Basin Water Office were established in July 1991. This was one of the steps taken to implement the National Water Policy as far as water resource management is concerned. Different departments are required to coordinate their activities to realize the results of the management system.

**Basin Water Board**

The Pangani Basin Water Board on its first meeting directed and instructed the Pangani Basin Water Office to:

- stop granting of new water rights for irrigation projects till the water situation is put under control;
- start a program of creating awareness, a monitoring system, and a database;
- look into the way of introducing the water user fee, thus giving the water a value; and,
- prosecute defaulters of law on pollution and illegal abstraction.

**Local Government**

The responsibility of local government is to collaborate with other government institutions, and to maintain a program for promoting and improving traditional irrigation schemes now in progress. By-laws are being instituted and enforced that are meant to ensure source protection and address other environmental issues.
Local Level Institutions

Managing water resources appropriately at the local level is assisted by forming water users associations, now being implemented. Participation in and awareness of the beneficiaries in the efficient use of water in the basin has been proven to create a sense of responsibility.

Coordination

A good environment has been created especially after the Moshi meeting on the Utilization of Water in the Pangani river basin where different government departments and institutions involved at different levels are cooperating.

Legislation

The existing laws on the environment relating to water sources, water utilization, land use, agriculture, and forestry are being reviewed by different responsible ministries in the Water Utilization Act. The relationship between the Basin and Central Water Board is being looked into. The powers of Principal and Basin Water Officers are being studied, as they are not bound to follow the advice of the boards.

Enforcement

Capacity-building for enforcement of operational water management is being assessed along with other sectors in the ministry responsible for water and the general institutional setup in the country.

MAJOR CHALLENGES

Although many actions are currently being taken to improve water resources management in the basin, a number of challenges remain. These include:

- Improving the poor or inadequate hydromet observational network in the basin. For example, upstream of NYM in Kilimanjaro region, 28 out of 34 (83 percent) of river gauging stations are non-operational. Planning, design, construction, and operation of water projects need reliable data.
- Increasing investment to facilitate data collection and monitoring of the hydrometeorological network.
- Slowing the deterioration and decline of water quality and quantity due to poor sanitation, changes in land use and population growth.
- Allocating scarce water resources among various users and the need to resolve conflicts.
- Building a stronger management information system. As a start PBWO has established an effective management information system using radio calls.
- Improving currently poor coordination and monitoring among water users.

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REFERENCES

DISCUSSION
QUESTION: How will Pangani Hydropower scheme operate at its optimum rates in view of the fact that the reservoir at Pangani is very small?
Answer: The reservoir at Pangani is for daily regulation but the amount of river flow available for power generation will depend on operation of Nyumba ya Mungu reservoir. That is why we need to conserve the catchment upstream Nyumba ya Mungu reservoir as well as ensure that during the rainy season most of the river flow is directed to the reservoir and that unnecessary abstractions are avoided.

QUESTION: Is there any program for solving the hyacinth weed problem?
Answer: Currently there is not a big problem of the weed but it exists to some extent. Generally, physical removal of the weed could be the immediate solution.

QUESTION: Some of the traditional furrows are used for domestic water supply. How can you solve that problem?
Answer: It is true that some of the over 2000 traditional furrows are used for domestic water supply. The best solution is to provide piped water supply schemes or other means of supplying domestic water. Traditional furrows are generally inefficient and cause big water losses.

QUESTION: Do you think groundwater can be a potential alternative of getting water for different purposes?
Answer: Yes, at the moment Pangani Basin Water Office is directing potential investors to look on groundwater for irrigation requirements. However, we have to be very careful not to over pump, especially in Kilimanjaro/Moshi town where individuals are sinking boreholes without Water Rights.

QUESTION: Are there any problems, currently, with pastoralists?
Answer: It is not pronounced but may surface in the context of environmental degradation, especially near water sources where they go to get water for their animals.
Figure 9.1: Pangani River Basin

PANGANI DRAINAGE BASIN
River Basin Management Case Studies Beyond Tanzania

Kagera Basin
Zambezi Basin
Tana Basin
USA
France
CHAPTER TEN
KAGERA BASIN MANAGEMENT

G. K. LWAKABARE

This paper describes the physical setting of the Kagera Basin. It also gives an account of the organizational set up of the Kagera Basin Office, the institution established by the riparian states for the sole purpose of advancing integrated management and developing the basin’s resources. The paper profiles the basin’s development projects, outlines the financial limitations on the projects, and discusses salient issues that need to be addressed when dealing with shared River Basin Management.

THE BASIN AND ITS SOCIO-ECONOMIC CHARACTERISTICS

The Kagera River Basin occupies a total area of 59,675 square kilometers which is distributed among Burundi (22 percent), Rwanda (33 percent), Tanzania (35 percent), and Uganda (10 percent). The Basin has its source in the Western highlands of Burundi and Rwanda and traverses about 800 kilometers to its outlet on the Western shores of Lake Victoria. The Kagera River has two main tributaries, the Ruvuma and the Nyabarongo.

The discharge of the Kagera River into Lake Victoria is about 25 percent of the total inflow to the lake. The mean inter-annual flow is about 200 m³/sec. The ratio between maximum and minimum flow is about 5, indicating that the Kagera River is a naturally well-regulated river. Rainfall ranges between 800 mm and 2,000 mm. Temperatures in the basin usually range between 15°C to 25°C throughout the year.

By the end of 1984 the population of the basin was about 9 million inhabitants. With a population growth rate estimated at 3 percent per annum, the population was predicted to reach 12 million by the year 2000. The distribution of the population is similar in all parts of the basin with more than 90 percent of the population residing on the land they cultivate.

Rwanda and Burundi were the most densely populated countries in Africa with densities reaching 250 people/square kilometer in Rwanda in 1986. These statistics have since been altered drastically in both Rwanda and Burundi with the outbreak of civil strife resulting in many deaths and displacement of the population.

Agricultural activities in the basin are varied. By conventional economic criteria, the basin ranks among the fifteen most impoverished regions of the world, with an average per capita income of about US$25. The rural population is mainly engaged in subsistence agriculture, with the principal food crops being bananas, beans, cassava, sweet and Irish potatoes, maize, and rice. Coffee and tea feature as the main cash crops.
Food production in the basin is basically stagnant; in some cases it is declining with no visible surplus. To sustain a decent standard of living, it is necessary to increase food supplies to at least at the same rate as population growth.

Transport and communications links both within the basin and to the rest of the world are inadequately developed. The basin is landlocked and transportation of goods and people is time-consuming, arduous, and expensive. Transportation of goods to and from the Indian Ocean ports of Mombassa and Dar es Salaam involves rail and road with transshipment of goods at various stages on the routes.

Until recently, telecommunication links between the basin countries were almost non-existent and had to be relayed via European circuits located 10,000 kilometers away, making telecommunications very expensive and unreliable. With the completion of the Kagera Basin Organization (KBO) telecommunication project in 1990, the situation has drastically improved though hitches still exist and relays through Europe are sometimes necessary.

The potential energy sources in the basin include wood, peat, and hydropower. The extensive use of wood as fuel for cooking and heating has resulted in the rapid depletion of forest cover in the catchment areas and serious ecological and environmental degradation. Peat deposits exist in the basin although their extent and quality has yet to be confirmed by appropriate studies.

Extensive studies have been carried out to determine how best to exploit the methane gas in Lake Kivu. Indications are that the most appropriate use for the gas is probably for fertilizer and methanol production. There is also significant potential for hydropower development in the basin. The sites already identified for hydropower development have been estimated to have a total capacity of 700 MW capable of producing about 3,800 Gwh/year.

Health services are poor and insufficient in the region. Malaria is endemic in all the lowlands. Typhus is common in the highlands of Rwanda and Burundi. Intestinal parasites affect a high percentage of the population because drinking water is often polluted. Outbreaks of cholera and amoebic dysentery are a common occurrence.

Human trypanosomiasis is endemic over some portions of the basin. Thus the presence of tsetse fly, which transmits disease-causing trypanosome to both human and livestock, remains a major impediment to the establishment of new settlements and large scale livestock development.

THE KAGERA BASIN ORGANIZATION (KBO)

Background

The KBO is a unique example of regional cooperation as it comprises two former Belgian colonies (Rwanda and Burundi) and two former British ones (Tanzania and Uganda). Prior to the formation of this organization, no meaningful interaction existed among these countries as a group, as a result of infrastructural and linguistic barriers. In the mid-1960s the presidents of Rwanda and Tanzania recognized the need to construct a bridge across the Kagera River at Rusumo to promote
trade between the two countries. Their agreement to cooperate in constructing the bridge and to initiate technical studies aimed at harnessing the hydroelectric power potential of the Rusumo Falls was the germ out of which the Kagera Basin Organization grew.

In 1960 the four KBO countries agreed to form an Inter-governmental Technical Committee consisting of one representative from each country. It was assigned the task of coordinating the development of the basin. At this stage, Uganda was mainly an observer, partly because the main emphasis was on hydroelectric power generation, a resource which Uganda had in abundance. Another factor which could have contributed to Uganda's inability to participate fully right from the beginning was the political and social chaos existing in the country at that time.

The Kagera Basin development studies were started in 1971 with Bukoba, in Tanzania, as the base. The results of these studies confirmed the need for cooperation in basin management and the necessity for more detailed studies. The second phase of the study was launched in 1974 and involved a detailed appraisal of the key sectors of development that should be included in a cooperation arrangement that was to be agreed.

The Rusumo Agreement

The Agreement for the Establishment of the Organization for the Management and Development of the Kagera River Basin, commonly known as the Kagera Basin Organization (KBO), was signed at Rusumo, Tanzania on 24 August 1977. Uganda joined the Organization in May 1981.

When the KBO was established in 1977, the East African Community (EAC) had just collapsed. In an effort to downplay the importance of politics in the day-to-day operations of the organization, the agreement made no provision for the assembly of heads of state and governments to be the ultimate authority of the KBO. Thus, only two principal organs of the Organization were instituted: the Commission -- the policy making organ, and the Secretariat -- the executive arm. In actual practice, however, the Heads of State and governments met several times to deliberate on and direct matters concerning the KBO policies. It was thus realized that politicians were an essential ingredient in creating an efficient and effective decision-making process in the KBO. Consequently, the revision of the Rusumo Agreement of 1990 included, inter alia, two additional organs, the Summit and the Council of Ministers.

The creation of the KBO derived from the need to have a regional institution through which joint efforts towards the realization of integrated development of the basin could effectively be advanced.

KBO Objectives

The objectives of the organization center on the joint development of the basin resources in the fields of:

- Water and hydropower;
- Agriculture, livestock, forestry and land reclamation;
- Transport and telecommunications;
- Mineral exploration and exploitation;
- Disease and pest control;
Fisheries and agriculture;
Industrial development, including exploitation of peat;
Tourism and trade; and
Environmental protection.

Among the major resources of the basin are the waters of the Kagera River and local lakes. Mineral deposits like nickel, tin, iron ore, peat, and methane gas are also major resources known to exist in the basin.

In effect, however, the agreement applies to any activities that may be characterized as relating to development.

A PROFILE OF KBO DEVELOPMENT PROJECTS

Initial preparations

The complexity of drainage basin planning is well underscored by the experience of the Kagera Basin states within a decade and a half of preparatory studies. The Indicative Basin Plan report which preceded the establishment of KBO, summarized the following salient points in the recommendations section:

Firstly, emphasis was placed on the need to promote increased food production in the region at a minimum rate of 3 percent annually, to keep up with the population growth. Secondly, the Plan recommended intensification of subsistence agriculture taking into account that there was no visible surplus and that there was no land reserve on which to increase cultivated area. Accordingly, intensified use of agricultural inputs, particularly inorganic fertilizer to restore and maintain soil fertility, was emphasized. Thirdly, the Plan strongly recommended immediate development of hydropower, which was referred to as "the only known, important undeveloped asset in the region." It was further recommended that an overwhelming share of the harnessed hydropower should be used for fertilizer production, particularly ammonium nitrate and calcium nitrate.

On examination of the Indicative Basin Plan after the signing of the Rusumo Agreement, both the United Nations Development Programme (UNDP) and the member states resolved that the options presented in the Plan did not constitute an exclusive strategy for development acceptable to the member states and the donor community.

Subsequently, a more comprehensive study was carried out covering all the critical sectors affecting the development of the region, including all power resources and identifying transport options for the land-locked region. This study, undertaken with UNDP financing, has often been referred to as "the multi-donor, multi-disciplinary mission report." It is the one that came up with an Action Plan that formed the basis of the development program adopted by the member states.
Identified Projects

Priority projects were chosen taking into account the socio-economic conditions in the region and the KBO development objectives. In the process of choosing, four priority sectors were retained, namely: agriculture, energy, transport and communications, and training. Within these priority sectors, several projects were identified including:

- 19 agricultural projects, including tsetse fly eradication and control;
- 8 large-scale hydropower development sites;
- over 50 sites for small hydropower schemes;
- a railway network totaling 2,200 km;
- 20 road projects totaling 1,633 km;
- a microwave telecommunications network linking the four member states; and,
- a Polytechnic Institute for training high level technicians.

Priority projects

Within the key priority sectors this list of projects was later narrowed down to have a more manageable program that was more likely to attract the necessary funding. The following were identified as priority projects:

**Energy**
- Rusumo Falls Hydropower Project
- Maziba Small Hydropower Scheme

**Transport and Communications**
- Railway projects
- Road projects
- Telecommunications project

**Agriculture**
- Tsetse Fly Eradication and Control Project
- Mulindi Drainage/Irrigation Project
- Rubaare Ranching Scheme
- Afforestation in Rwampara Country

**Training**
- KBO Polytechnic Institute (at Gitega in Burundi)

Work Accomplished

Studies on all the priority projects above have already been carried out at least to feasibility level. Four projects, including Rusumo Falls Hydropower project, are ready for implementation. Only the telecommunications project linking the four KBO member states has already been implemented with ADB financing. A few road projects which were on the KBO priority list, including the Rusumo-Isaka road in Tanzania, have also been implemented. The rest of the projects are yet to secure the necessary financial support.

Projects ready for implementation

Having noted the difficulty KBO was experiencing in securing the necessary funds for the implementation of its priority projects, the Council of Ministers decided to pick a few projects from the
priority list for early implementation. These included the Rusumo Falls Hydropower Project, two of the road projects, and the tsetse fly control project.

To mobilize the resources required sensitization missions, headed by Ministers of member states. They were undertaken in 1993 to meet with already identified donors. The result of the missions were very encouraging; most of the donors have expressed their willingness to participate.

These sensitization missions were to be followed by a donors conference scheduled for June 1994. The civil war in Rwanda that erupted in April 1994 and the violent situation in Burundi have not yet permitted the convening of this donors' conference. All KBO activities have thus come to a standstill and it is not known when the situation will permit resumption of KBO operations.

ISSUES AND LESSONS: THE KBO EXPERIENCE

The Rusumo Falls Controversy

It certainly takes a great deal of study and reconsideration before a well-identified hydropower potential project is accepted for construction. This fact is well illustrated by the controversy which surrounded the Rusumo Dam proposal. Early studies confirmed an installed capacity of 129 MW for a dam at an elevation of 1345 meters above sea level; 105 MW for an intermediate dam at 1,335 meters, and 80 MW for a dam at 1,325 meters.

The capacity of Rusumo Falls dam would correspondingly affect the capacities of Kishanda and Kakono hydropower schemes downstream. But the dam at Rusumo at the level of 1,345 meters was expected to inundate considerable tracts of agricultural land, a situation totally unacceptable to densely populated Rwanda and Burundi. Eventually, the lowest dam, at elevation 1,325 meters, was accepted despite its relatively low energy gains. At that level the dam would displace the smallest number of people and inundate the smallest area of agricultural land. A lot of time was lost before striking this final agreement. While negotiations were going on, there was a lot of tension between some member states and this was detrimental to the spirit of regional cooperation so vital for efficient operations of a regional institution such as KBO.

A lesson was learned from the controversy: technical feasibility of a project has to be supplemented with political acceptability before commencement of procedures leading to actual implementation.

Leadership

Good leadership at the organizational level is very crucial to the success of a river basin organization. The appointments of chief executives for a basin organization should take cognizance of their professional training if these organizations are to have credibility and achieve their objectives. The person chosen to head the organization must have some relevant professional preparation for the job. The issue of leadership is closely related to the appointment of other professionals. Likewise the appointment of the other personnel should follow well defined guidelines and clear job description as well as terms of reference for jobs to be performed.
Contributions by Member States

In the Kagera Basin Organization, financial contribution had been in the initial stages based on ability to pay. By 1981, it was decided that contributions should be equal among the cooperating countries. However, this was again changed in 1984 with the different countries contributing different percentages of the budget: Tanzania contributed 35 percent, Uganda 23 percent, Rwanda 22 percent and Burundi 20 percent. These percentages were based on a number of factors such as Gross Domestic Product (GDP), the country's population, and the percentage of the country covered by the basin. In reality the shares were very much a result of political maneuvering and compromise.

In 1993 another decision was taken in favor of equal contributions by each member state. This time it was clearly stated that when benefits start to accrue, shares of contributions will be in accordance with the distribution of benefits. Whatever proportion of contributions is decided, the overriding factor here is political good-will but this should be supported by a reasonably fair formula particularly in the early stages when benefits have not started accruing.

Distribution of Benefits

Distribution of benefits has been a very contentious point as some donors such as the African Development Bank have insisted that each participating country sign its own portion of the loan. It has been demonstrated time and again that if the benefits are perceived to be unevenly distributed, the success of the organization is critically jeopardized.

If some member states feel that their interests and priorities are not being met by the organization set up for that very purpose, they lose enthusiasm in supporting the organization. In other words, this factor is related to the contribution of member states for the sustenance of these organizations. All states should be seen to benefit fairly equitably.

The Size of the Organization

As the organization increases in size and structure, a significant proportion of the budget gets spent on recurrent costs and not on productive activities. Experience indicates that for institutions like KBO that have long gestation periods before benefits are realized, it is prudent to keep their sizes and structures as small and as manageable as possible.

If a basin organization depends to a large extent on external funding, as KBO does, the donors naturally get concerned about its unchecked growth. The proliferation of sub-set institutions within the main organizing framework also increases the financial burdens shouldered by the cooperating governments, and so should be avoided where possible. Projects may not be able to take off at all unless the initial operating costs are minimized.

Politics and Identification of Needs

Needs are not static, and they may be divided into long and short-term categories. Once a common problem has been identified, there is justification for setting up a basin authority. In the case of KBO, it was the politicians who initially felt the need to set up the regional body. Hence, it has been difficult to divorce the organization from politics.
However, there was a genuine necessity to separate "politicians" from "technocrats" so that the latter could fulfill the advisory role to the former. Whatever the composition of the policy-formulating body, the technocrats should be given the chance to translate the wider objectives into tangible and manageable programs of action geared towards attaining the social and economic development of the people concerned. Projects based on political institution rather than on sound and rational data and technical evaluation and economic analysis are doomed to failure and are bound to prove a waste of the invested resources. In any case over-politicization of drainage basin projects should be avoided as much as possible.

G.K. Lwakabare is the Kagera Basin Office Commissioner. His office is part of the Ministry of Water, Energy and Minerals in Dar es Salaam.

REFERENCES


DISCUSSION

QUESTION: To what extent is KBO involved in the International Environment project for Lake Victoria basin?

Answer: So far KBO is not involved with the project.

QUESTION: Kagera is a major river flowing into Lake Victoria but there is a big problem of water hyacinth in the lake. To what extent is KBO involved in dealing with this potentially big problem?

Answer: KBO has so far not dealt with the problem.

QUESTION: Workshop participants noted that KBO priority projects were energy, agriculture, training, transport and communication, but the people of the member states, living in the basin suffer various kinds of diseases. Why has KBO not considered the health aspect as a priority? How are the priorities set?

Answer: The health aspect is not included directly because KBO does not have the capacity to deal with the health aspect. This component is being dealt with by national health institutions. However, KBO deals with the program of eradicating tsetse fly which causes trypanosomiasis disease. It was not proper to omit the health aspect in the priority list. Priorities are usually set by member states after long discussions.

Further, KBO was basically set up as an economic institution but, during the initial period. It also dealt with hydrological data collection. Later the data collection role was abandoned and left as the responsibility of national institutions.

QUESTION: The Kagera river is one of the major sources of the Nile river but why no mention was made of any collaboration that exists between KBO and other Nile basin countries.

Answer: Collaboration between KBO and the Nile Basin countries has been difficult. On the other, hand liaison between KBO and Lake Basin Authority in Kenya has been better. Stronger cooperation is possible in all aspects.

QUESTION: Are Environmental Impact Studies being considered when planning or implementing the many projects within the under?

Answer: Environmental Impact Assessment is considered on a project-by-project basis. For example, EIA was done on the Rusumo Falls project to see that the choice of the Downstream Low Dam did not have serious effect on the fauna and the ecology in general.

QUESTION: In which Ministry is KBO under in each member state?

Answer: KBO is under the Ministry of Foreign Affairs in all the four member countries.
QUESTION: The Kagera River passes several swamps. What precautions have been considered to protect the wetland?
Answer: Except for the dam, all other projects will not affect the existing wetland.

QUESTION: Considering the priority list of KBO projects, what kind of management problems exist in the basin?
Answer: The biggest management problem is the difference in national priorities.

QUESTION: Are there any water use conflicts within the Kagera basin?
Answer: There are no conflicts so far, except for ecosystem protection viz a viz other uses.

QUESTION: What are reasons that caused KBO to come to a standstill in 1994?
Answer: The civil war Rwanda and the violent situation in Burundi were the main reason for the standstill situation for KBO activities.

QUESTION: Which are the main sources of pollution in the Kagera river?
Answer: Pollution of water sources is not substantial, except for poor cultivation and deforestation over the catchment.

QUESTION: The main causes of deforestation are to clear land for agriculture, livestock keeping, and to cut trees for timber and fuel wood. Why is poor agricultural practice not mentioned as also one of the main factors causing environmental degradation?
Answer: It is true that poor agricultural practices are also a major cause of environmental degradation.

QUESTION: Apart from funding by member states, were there any other sources of funding for KBO activities?
Answer: Operational expenses are being met by Governments of member states while the development budget is mainly covered through external assistance and loans.
CHAPTER ELEVEN

THE ZAMBEZI RIVER BASIN AND ITS MANAGEMENT

G. W. HOWARD

The Zambezi River is the largest in Southern Africa and its basin lies within parts of eight countries and includes more than 20 million people. After describing the complex ecology and land and water use patterns in the basin, the paper discusses the difficulties of prioritizing development strategies in this international context. An international coordinated framework for the river basin known as ZACPLAN is the most comprehensive and wide-ranging of various programs put forth to manage the Zambezi River Basin. It hopes to consider the entire catchment, the environment, and the socio-economics of the region. Trans-boundary management of water resources is difficult, even between two neighboring countries: it becomes much more complex when there are eight basin states and several other potential users outside the basin—not to mention the international requirements of the marine ecosystems that do not "belong" to any state. Nevertheless solutions must be found soon to promote equity and to avoid serious international conflicts over water supply and use.

INTRODUCTION

The Zambezi River is the third largest in Africa by flow and drainage area and the fourth largest in length (Table 11.1) and the main drainage system for the central southern African plateau region. Historically it has been perceived as an enormous water channel with limitless supplies of water for any community that could have access to it. Since the first impoundment on the main channel was closed at Kariba in 1958, the Zambezi and its basin have been increasingly exploited for water supply, agriculture, and hydropower generation. Cahora Bassa dam was built and plans were made for at least three more dams as well as for a water transfer scheme to southern Zimbabwe and another out-of-basin transfer to South Africa. By the early 1980s it was clear that the Zambezi’s waters could not supply all the expectations of its eight basin states as well as their neighbors. In addition, awareness was awakening of the environmental consequences of unplanned and uncoordinated uses of the Zambezi waters—in the basin, in the main channel, and out to sea. As a result the Southern African Development Coordination Conference (SADCC) states combined with the United Nations Environment Programme (UNEP) to consider how best to manage the Zambezi Basin and its waters and to coordinate their development plans in relation to the Zambezi. The result was ZACPLAN, the Zambezi Action Plan for the Environmental Management of the Common Zambezi River System.

Since ZACPLAN was agreed upon in 1987, there have been more plans and projects developed, changes in needs and uses, and increasing pressures upon the Zambezi Basin and its water resources. This paper examines some of those resources and various plans for the Zambezi and the attempts to manage it as a shared resource.
Table 11.1  Africa's four largest rivers

<table>
<thead>
<tr>
<th>River</th>
<th>Approximate length (km)</th>
<th>Approximate area drained ('000 km²)</th>
<th>Mean annual flow at outfall (cumecs)</th>
<th>Number of countries in river basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nile</td>
<td>6,670</td>
<td>2,800</td>
<td>2,500 (at Aswan)</td>
<td>9</td>
</tr>
<tr>
<td>Zaire</td>
<td>4,800</td>
<td>3,600</td>
<td>38,800</td>
<td>9</td>
</tr>
<tr>
<td>Niger</td>
<td>4,200</td>
<td>1,100</td>
<td>6,900</td>
<td>9</td>
</tr>
<tr>
<td>Zambezi</td>
<td>2,500</td>
<td>1,400</td>
<td>3,500</td>
<td>8</td>
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</table>


THE ZAMBEZI RIVER BASIN

The Zambezi River rises in the extreme northwest of Zambia near Kalene Hill at an elevation of around 1,550 meters. It then descends through Angola to re-enter the Western Province of Zambia above the Chavuma Falls. Below the falls, at an altitude of about 1,100 meters; it begins a very slow descent over 200 meters of altitude and at least 800 kilometers of river channel to the Victoria Falls. This first part of the basin up to Victoria Falls is referred to as the Upper Zambezi and has a surface area of about 320,000 square kilometers (Table 11.2). The major tributary in the Upper Zambezi is the Cuando (Kwando) River, mainly from Angola, which enters the main channel by way of the Chobe/Linyanti River and wetlands through Namibia and Botswana (Figure 11.1).

The Middle Zambezi basin has an area of about 860,000 square kilometers and includes much of the drainage in Zambia, Zimbabwe, and eastern Mozambique up to the Cahora Bassa rapids where the Cahora Bassa dam now stands. The major tributaries in this section are the Kafue and the Luangwa Rivers from Zambia as well as several smaller streams from Zimbabwe. Kariba and Cahora Bassa dams are in this middle section (Figure 11.2) where the river descends from around 875 meters above the Victoria Falls to 200 meters.

The Lower Zambezi has a basin of about 220,000 square kilometers which includes much of Malawi, the north-eastern shore of Lake Nyasa in Tanzania (also known as Lake Malawi in Malawi) and the remainder of the basin in Mozambique. The Shire River is the main tributary which drains Lake Nyasa and surrounding areas; very little runoff is gathered from the coastal plain. The outfall of the Zambezi is through several large distributaries in the delta on the central coast of Mozambique.
Table 11.2 Characteristics of the three major sections of the Zambezi River Basin

<table>
<thead>
<tr>
<th>River Section</th>
<th>River Length (km)</th>
<th>Surface area (km²)</th>
<th>Mean Annual flow (cumecs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPPER ZAMBEZI</td>
<td>1,078</td>
<td>320,000</td>
<td>1,240</td>
</tr>
<tr>
<td>source to Vic Falls + Cuanda/Chobe Rivers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIDDLE ZAMBEZI</td>
<td>853</td>
<td>860,000</td>
<td>1,460</td>
</tr>
<tr>
<td>Vic Falls to Cahora Bassa + Kafue &amp; Luangwa Rivers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOWER ZAMBEZI</td>
<td>593</td>
<td>220,000</td>
<td>800</td>
</tr>
<tr>
<td>Cahora Bassa to Indian Ocean + Shire River</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>2,524</td>
<td>1,400,000</td>
<td>3,500</td>
</tr>
</tbody>
</table>


The Zambezi River is the largest in Africa that drains to the Indian Ocean. It has an overall length of around 2,500 kilometers and a mean annual flow, near the ocean, of around 3,500 cumecs. These data are given as rounded and average figures because there have been several and varying estimates of both the length of the river and its flow (see Balek 1977, Handlos and Williams 1985, UNEP 1986, Pinay 1988, and Masundire and Matiza forthcoming). The size of the Zambezi can be compared with two other large and important rivers that flow into the Indian Ocean: the Rufiji River in Tanzania (Ruaha/Rufiji is 800 kilometers long with a mean flow of 900 cumecs) and the Tana River in Kenya (1,000 kilometers and 180 cumecs). The Zambezi is the main drain for the wettest parts of Southern Africa, moving rainfall and runoff from the Central African Plateau to the coast and providing fresh water and nutrients from much of the SADCC Region to the Indian Ocean (Figure 11.1).

The profile of the river (Figure 11.2) shows a gentle decline in the Upper Zambezi region where the channel passes through sedimentary deposits on the plateau overlain with Kalahari sands. The river falls almost 100 meters over the Victoria Falls into a series of deep gorges which it has eroded in the basalt over millions of years. The river elevation continues to decline rapidly through the Batoka Gorge and Devil's Gorge through erosion channels and faults to the present upstream end of Kariba Dam. The change of direction of the river in the middle section towards an easterly flow is thought to be related to the southern end of the Great Rift Valley whose two arms (the Luangwa in the west and Lake Nyassa and the Shire River in the east) join at the Zambezi. Some authors have suggested that the Zambezi originally flowed on south from the Upper Region, by way of the Okavango Basin to the Limpopo and so carried out a similar function as the Nile in north Africa of transferring water from the wetter, topical areas to the dry areas further south (Williams 1985). Whatever its history, the Zambezi now proceeds eastward and denies access to much of Southern Africa by flowing across the plains of Mozambique to the coast.
The Zambezi Basin includes several large tributaries (Cuando, Kafue, Luangwa, and Shire) that flow from the wetter areas in the north. It also includes some of the largest and most important wetlands of Southern Africa, such as the Barotse Plains and the Chobe/Linyanti Swamps of the Upper Zambezi, the Lukanga Swamp, Busanga Plain, and Kafue Flats of the Kafue sub-catchment (Middle Zambezi), and the riverine floodplains of the Middle Zambezi (Mana Pools) and the Luangwa River. Downstream of Cahora Bassa are floodplains associated with the main Zambezi channel, and ending in the intertidal wetlands of the delta. Although in a separate catchment, the Okavango Delta wetlands are connected to the Zambezi system by way of the Selinda Spillway and the Linyanti Swamps and onwards through the Chobe, when there are high floods in the Okavango. All these wetlands act as water storage or regulating components of the basin as well as places for ground water recharge. There is also a suggested groundwater connection flowing towards the Linyanti between the Okavango Basin and the Zambezi (Scudder and others 1993).

The northernmost part of the Zambezi catchment is at 9° S (in the Poroto Mountains in Tanzania) and the southernmost limit is at 20°20' S (near Bulawayo in Zimbabwe) while most of the basin lies between 11° S and 19° S. This places the catchment in the subtropics and within the influence of the Inter Tropical Convergence Zone, but far enough south of the equator to have only one rainy season per year. The rains occur mainly in the southern summer (November to April) and so result in markedly seasonal runoff and river flows. The high flows and floods of the Middle Zambezi occur in May and June when the wet season is at an end — a characteristic that determines many of the special requirements of the flora and fauna of the Zambezi wetlands and riverine ecosystems. The variation in river flows is quite marked during the yearly cycle, as data from the Victoria Falls illustrate: the long-term mean monthly flow for May is around 3,500 cumecs (the mean annual flow is 1,337 cumecs) while the mean low flow in November is 336 cumecs, falling to 142 cumecs in a dry year (Scudder and others 1993).

The Zambezi Basin includes parts of eight countries, all of which are in the SADCC Region. Six of the countries are truly riparian in that they have frontage on the main channel of the Zambezi (see again Figure 11.1), while the territories of Malawi and Tanzania do not touch the river. The area of land within each basin state that contributes runoff to the Zambezi varies greatly, from more than half a million square kilometers in Zambia to 17,000 square kilometers in Namibia (Table 11.3). In addition, the amount of runoff generated in each country within the Basin varies due to rainfall and topography. Thus Zambia, which occupies around 40 percent of the basin area, contributes more than half of the flow of the Zambezi: the Kafue and Luangwa Rivers (whose catchments are entirely within Zambia) together produce 800 cumecs or about 55 percent of the flow to the Middle Zambezi (see Table 11.2) while much of the flow of the Upper Zambezi originates in Zambia. By comparison, Botswana has a very small proportion of the watershed (Table 11.3) in an area of low rainfall and high evaporation, and that is a flat, sandy region with negligible stream flows to the Zambezi. Mozambique, on the other hand, contains almost 600 kilometers of river length but has a proportionately low input to river flows as much of its basin area is on the coastal plain where there are few significant tributaries.
Table 11.3 Population in the Zambezi Basin by country, 1983

<table>
<thead>
<tr>
<th>Country</th>
<th>Area in Basin (km²)</th>
<th>Percent of watershed</th>
<th>Population ('000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANGOLA</td>
<td>260,000</td>
<td>18.3</td>
<td>304</td>
</tr>
<tr>
<td>BOTSWANA</td>
<td>40,000</td>
<td>2.8</td>
<td>8</td>
</tr>
<tr>
<td>MALAWI</td>
<td>110,000</td>
<td>7.7</td>
<td>7,178</td>
</tr>
<tr>
<td>MOZAMBIQUE</td>
<td>161,000</td>
<td>11.4</td>
<td>2,567</td>
</tr>
<tr>
<td>NAMIBIA</td>
<td>17,000</td>
<td>1.2</td>
<td>40</td>
</tr>
<tr>
<td>TANZANIA</td>
<td>28,000</td>
<td>2.0</td>
<td>815</td>
</tr>
<tr>
<td>ZAMBIA</td>
<td>577,600</td>
<td>40.7</td>
<td>4,482</td>
</tr>
<tr>
<td>ZIMBABWE</td>
<td>226,360</td>
<td>15.9</td>
<td>6,560</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,419,960</td>
<td>--</td>
<td>21,954</td>
</tr>
</tbody>
</table>


The proportion of the various countries within the Basin also varies greatly: 94 percent of Malawi lies within the Zambezi catchment, 77 percent of Zambia, 58 percent of Zimbabwe, decreasing to 3 percent of Tanzania and 2 percent of Namibia (Pinay 1988). Human populations (and so human needs) within the basin countries also vary by almost two orders of magnitude (see again Table 11.3), with the highest numbers in Malawi, then Zimbabwe and Zambia, and the lowest in Botswana. The figures in Table 11.3 are based upon estimates from 1983, but the comparisons are still realistic when determining the proportionate densities of people in the Zambezi Basin states.

So who owns the waters of the Zambezi River and its basin? Should they be owned by all people of the basin equally? Should they be distributed according to contributions to flow, or proportion of the watershed, or access to the main channel? Are the waters of the Zambezi the property of SADCC and so transferable to out-of-basin areas and states within SADCC? Who should decide upon development projects and priorities that will need Zambezi waters? Who will control the necessary watershed management -- especially in Basin states that are not riparian to the Zambezi River?

DEVELOPMENTS IN THE ZAMBEZI BASIN

The main developments in the Zambezi River Basin involve dams for water storage and hydroelectric power generation. The main river channel is dominated by two very large multipurpose dams at Kariba and Cahora Bassa while a smaller hydropower installation at Victoria Falls is hardly noticeable. There are currently no other major developments on the main river but several other impoundments exist on tributaries and there are numerous water extractions within the basin.
Kariba Dam

The Kariba impoundment occupies an area of around 5,250 square kilometers in the Middle Zambezi and covers about 300 kilometers of the river channel. Kariba has a maximum depth of 120 meters and a volume at capacity of $15.5 \times 10^{10}$ cubic meters of impounded water. It was completed in 1959 as a scheme of the former Federation of Rhodesia and Nyasaland and is now owned and operated by Zambia and Zimbabwe. Currently it has an installed capacity of 1,266 MW and is a major contributor to the Interconnected Electricity Supply System that includes Zaire, Zambia, Zimbabwe, Mozambique, Botswana and South Africa.

Lake Kariba is the subject of much literature and discussion and has been studied in detail as it matured from a fresh impoundment to a settled lake with extensive fisheries, its own ecosystem, and an evolved socio-economy (see Balon and Coche 1974, Balon 1978, Williams 1985, Pinay 1988, Scudder 1989, and Machena 1992). The management of the waters of Lake Kariba are now the responsibility of the Zambezi River Authority. It is struggling with competing needs for power production, water storage, and a reduced mean inflow. The lower flow has produced no dam spills since 1981.

Cahora Bassa Dam

The Cahora Bassa impoundment was completed in 1974 and contains about half the volume of Kariba and occupies around 2,740 square kilometers in the Lower Zambezi valley. Cahora Bassa lake is approximately 250 kilometers long with a maximum depth of 151 meters. The entire lake is within the borders of Mozambique which owns the dam together with Portugal. The dam has an installed generating capacity of 2,075 MW but has rarely been able to produce power as there have been security problems that have affected the dam and the power lines for most of the period since its commissioning. An account of the Cahora Bassa dam and lake is given in Pinay (1988). Most of the inflow to the lake is from the outflow of Kariba -- the only other significant inputs being from the Kafue (which is regulated) and the Luangwa. Cahora Bassa is in a low rainfall area of the Zambezi Basin where annual precipitation is around 650 mm while evaporation is at least twice that amount. This means that the water level and management of this lake are very much affected by the management of Kariba (and to a small extent by Kafue Gorge Dam).

Other impoundments and installations in the Zambezi Basin

In Zambia the significant dams in the Zambezi drainage are the Itetshitezhi storage dam and the Kafue Gorge hydro dam (900 MW installed) on the Kafue River (see Howard and Williams 1982), and the Mulungushri and Lunsemfwa dams in the Luangwa basin. There are no dams on the main channel of the Luangwa River despite its being one of the largest tributaries of the Zambezi. After the drought of 1981-82, Zambia constructed scores of water supply dams in the basin, particularly in the Kafue catchment. While these are each quite small, their combined effect on the Zambezi River flow could be quite significant.

Zimbabwe has at least eight impoundments in the Zambezi Basin (Misundire in Matiza and Crafter 1994) including the Ngezi, Mazowe, and Chivero (formerly MacIlwaine) water supply dams in its upper Zambezi catchment. Nkula and Tedzani are small hydropower installations on the Shire River in Malawi. The hydropower plant near Livingstone in Zambia has an installed capacity of 108 MW but
it uses the run of the river and the Mosi oa Tunya Falls for head and so does not impede or store Zambezi waters.

USES OF THE ZAMBEZI WATERS

The main direct human uses of the waters of the Zambezi Basin involve hydropower, water supply for urban and rural settlements, water supply for industry, livestock, agriculture and irrigation, and transport and tourism. Indirect human uses include the extensive fisheries of the Zambezi Basin wetlands and lakes, the support of wildlife and vegetation (especially forests, woodlands, and grasslands), the growth of natural and cultivated pasture for domestic livestock, and the growth of wild plants that people use.

The Zambezi waters also serve significant functions in the hydrological cycle as they pass through the watersheds, runoff areas, tributaries, wetlands, lakes, natural storage areas, and the main river channel before finally contributing both freshwater and nutrients to the coastal and marine environments of the Indian Ocean.

Some of these direct and indirect uses will be considered below together with selected examples of the environmental functions played by the waters of the Zambezi Basin.

Hydropower production

The largest installations on the main channel of the Zambezi are primarily for hydropower development, with Victoria Falls, Kariba, and Cahora Bassa having a total capacity of 3,359 MW. The Kafue Hydroelectric Scheme (involving Itezhitezhi and Kafue Gorge Dams) can produce 900 MW which, together with the smaller hydrostations and the main producers, implies a total installed capacity for the Basin of 4,511 Mw (Dale in Matiza, and others forthcoming). This is far in excess of the demand by 1985 in Zambia and Zimbabwe of around 2,000 MW (Williams in Handlos and Howard 1985) and would be so for the next two decades for those two countries. However the hydropower from the Zambezi is fed into the Interconnected System and so supplies other SADCC states as well as South Africa and Zaire, both of which are outside the Zambezi Basin. There is a predicted increase in demand within and around the Zambezi area which will far outstrip the existing installed capacity in the next three decades. As the Zambezi is the only large river with further hydropower potential in the region, there are several plans to develop new schemes within the basin.

Dale (in Matiza and others forthcoming) maintains that there is potential for the generation of a further 8,000 MW within the Basin and that this would require the development of several large dams on the main river in the near future (see below). The main constraint for the future development of this hydropower potential will be the agreement between basin states as to who owns and manages the Zambezi waters, as well as the critical need that will arise for synchronized management to avoid wastage of water (that will be synonymous with stored energy). The environmental and social consequences of various development projects in the Zambezi basin are the subject of the recent report of Matiza and others (forthcoming).
Water supply

The main channel of the Zambezi River supplies water to many towns along its length including Zambezi, Mongu, Senanga, Seseke, Livingstone, Victoria Falls, Siavonga, Kariba, Chirundu, Luangwa, Zumbo, Tete, and Chemba. Most urban centers in the basin are supplied by its catchment tributaries with the most significant being Harare, Lusaka, Kafue, the Copperbelt towns of Kitwe, Ndola, Luanshya, Mufulira, and Chingola as well as Kabwe, Chipata, Lilongwe, Blantyre, and many others. The overall human population of the Basin approaches 30 million, most of whom are supplied with water from surface flows in the Zambezi catchment. A city such as Livingstone that had a population of 72,000 in 1980 according to Wood (1983) and is now approaching 120,000, uses 45,000 m³/day or around 0.5 cumecs (Kasimona and Makwaya in Matiza and others forthcoming).

Irrigation is a major use of the waters of the Zambezi Basin although details are not available for the total area that uses this source. Zambia currently has around 50,000 hectares of irrigated lands, most of which are in the basin, but only 6,000 hectares of which use waters directly from the Zambezi River or Lake Kariba (Kasimona and Makwaya in Matiza and others forthcoming). The annual use of water by irrigated crops is usually calculated as 4 cubic meters - 10,000 cubic meters for every hectare of land. Mpande (in Matiza and others forthcoming) suggests that 248,000 hectares of land are under irrigation in five riparian states of the Zambezi (Botswana, Malawi, Mozambique, Zambia and Zimbabwe), although not all the irrigated areas are within the Zambezi Basin. These areas are likely to use at least the equivalent of 31.5 cumecs.

Transport

Historically the Zambezi River was used as an artery of transport and communication from the Indian Ocean coast as far upstream as Victoria Falls and then onward through the Barotse Floodplain. This was an important trade route in the eighteenth and nineteenth centuries when central southern Africa was not readily approachable from the Atlantic coast. In recent times the main river is hardly used for longitudinal travel except for tourist-based rafting and canoeing. Considerations were made in the planning of new dams to have a navigable stretch of the main river, but this is no longer a priority. The rivers are still important routes for crossing from Zambia to Zimbabwe and in the Zambia, Botswana, Namibia area adjacent to the Caprivi Strip.

More important to transport are the waters of the lakes, reservoirs, and wetlands of the Zambezi Basin. Many societies associated with water bodies and wetlands use boats and canoes as their main mode of transport and so trade and communication is often dictated by the availability of navigable waters. This is especially true for fishing communities -- both freshwater and estuarine.

Fisheries

The Zambezi Basin has 122 species of freshwater fish, excluding the very diverse fauna of Lake Malawi and the estuarine waters of Mozambique (Beadle 1974). The importance of inland fisheries in the water bodies and wetlands of the Zambezi Basin becomes obvious when it is realized that nearly all of its basin states are landlocked (only Namibia, Tanzania, and Mozambique have access to the coast). In Zambia at least one-third of the annual fish catch comes from the floodplain and swamp fisheries of the Zambezi Basin (especially Kafue Flats, Upper Zambezi, and Lukanga Swamp).
and the waters of Lake Kariba. Lake Kariba is similarly important to Zimbabwe as is Cahora Bassa to inland Mozambique and Lake Nyassa to Malawi and upland Tanzania. Riverine fisheries in the Zambezi, Kafue, Luangwa, Shire and other basin rivers are also important for local consumption. In many communities freshwater fish is the major source of animal protein - both as a fresh dietary input or as a dried or smoked product for transport and storage.

Wildlife

The Zambezi Basin is an important area for wildlife in Africa. It not only contains a large number of national parks and reserves (at least thirty-five), but it also has in the Middle Zambezi area one of the largest remaining areas of contiguous land devoted to wildlife. The Kafue National Park and its surrounding reserves are also important as the second most diverse area after the Serengeti for antelopes in Africa (Groomridge 1992).

The wildlife of the Zambezi Basin is the main resource for an expanding tourist industry in all basin states and, increasingly, is the basis for an alternative to domestic livestock rearing, especially on marginal lands. This is seen in the rapid increase in wildlife ranches and game farms in Zambia and Zimbabwe and in the expansion of schemes for licensed wildlife hunting and the use and sale of wildlife products.

Livestock

The Zambezi Basin is important for domestic livestock, especially cattle, wherever tsetse fly is absent. Thus in Zambia, the floodplains of the Kafue Flats and Upper Zambezi provide grazing for around one million cattle, almost two-thirds of the national herd.

Environmental functions

The environment is a user of water just as humans are. It needs water for the proper functioning of its natural systems, hydrological systems as well as biological systems and ecosystems. The management of a river basin must include serious consideration of those environmental needs if it is to be sustainable and if it is to maintain biological diversity and hydrological function. Some of the environmental needs or functions of the Zambezi Basin are mentioned below.

Groundwater recharge is a necessity in the maintenance of sub-surface waters in any drainage basin. The Zambezi Basin is not in a mountainous area and so springs are not common as the basin topography is dominated by the Central African Plateau. Nevertheless the water table of many wetlands (especially the floodplains and deltas) is close to the surface and is able to maintain its surface vegetation only if it is recharged during floods and high flows. The same is true of the ubiquitous dambos (small wetlands) and widespread mbugas (seasonally flooded grasslands) which require regular "run on" to recharge their sub-surface water stores. Management of the surface waters of the Basin should take this into account and not harvest or control runoff without considering the consequences for groundwater.

Water storage is a natural function of some of the Zambezi Basin wetlands. The best example would be that of Lukanga Swamp in central Zambia which stores the higher flows of the Kafue River in one season and then releases the stored waters during low river flows. Lukanga has an area of around 2,000 square kilometers and a maximum depth of six meters and is said to store at least seven billion
cubic meters of water between its high and low levels (Hughes and Hughes 1992), water which keeps the Kafue River running in the dry season.

The same water storage function can be attributed to the larger floodplains (Upper Zambezi, Kafue Flats, Busanga, Okavango, Upper Luangwa, and Shire) and the Chobe swamps where water flow is slowed and released over a long period which often stretches into the dry season (Howard 1992). This same process absorbs the energy of flowing water and reduces flood damage downstream -- especially in wetter years.

Evapotranspiration is the process during which water is evaporated from open water surfaces and through plant stomata. Water managers often regard this phenomenon as a waste of water that could be used for more tangible human benefits. It is this evapotranspiration, however, that drives the exceptional plant productivity of tropical African wetlands and which contributes essential moisture to the hydrological cycle. There have been suggestions that, for example, the Kafue Flats floodplain should be channelized in order to hasten the flow of water from the Itzizhezi storage dam to the generating plant at Kafue Gorge, and, at the same time, "to save water." While this alteration of the floodplain might speed up the flow of water and make more available for hydropower generation, it would limit all of the processes mentioned above (ground water recharge, water storage and flood damage reduction) as well as severely reducing the amount of vegetation that is produced by the wetlands. This in turn would have deleterious effects on the many systems that depend upon that vegetation and water -- such as the fisheries, cattle grazing, wildlife, and tourism.

Wetlands in general are a feature of the Zambezi Basin and should be considered as important elements for the management of the watershed and the Zambezi waters. The largest wetlands in the Basin are the floodplains of the Upper Zambezi and the Kafue Flats in Zambia and the Okavango Delta in Botswana. There are many other smaller floodplains - all of which have a seasonal cycle of flooding (to a greater or lesser extent) that extends the presence of water into the dry season and which ensures that groundwater is available for plant growth beyond the rains (Howard 1992). This extended period of growth plus the rejuvenation of soils with silt during flooding is combined with high insolation and favorable temperatures within the Basin to produce large amounts of plant biomass (or high plant productivity). It is this plant growth that makes the floodplains and the deltas so attractive to wild and domestic animals and so makes these wetlands valuable to man.

Another remarkable feature of the Zambezi Basin is the widespread distribution of dambos in the catchment. Dambos are small wetlands that retain moisture (often free water) in lower parts of the upper catchments and are places of high biodiversity; they can be cultivated well beyond the rainy season. Dambos are very numerous in the Basin and occupy as much as 15 percent of the land surface in Zambia (Chidumayo 1992) and 1.2 million hectares (or 3 percent) in Zimbabwe (Owen in Matiza and Crafter 1994). The role of dambos in the overall water yield from catchments is uncertain (Mazvimavi in Matiza and Crafter 1994), but they are certainly wetlands of great importance both to people and to the Zambezi Basin environment.

Water for the environment is that amount in a water system that is required to keep the environment functioning. The various processes and systems mentioned above are part of that requirement - but there are many others. One further "obligation" for the Zambezi River is the essential water (and accompanying nutrients) that must flow into the Indian Ocean to sustain the coastal
and marine ecosystems. Freshwater is necessary in marine deltas and estuaries to maintain the
mangroves and other intertidal wetlands which are the breeding and nursery grounds for so many
marine creatures. River water (in the form of average flows and floods) is necessary to maintain the
inshore and intertidal systems that are responsible for many thousands of tonnes of coastal and offshore
fisheries. The same flows provide essential nutrients to coral reefs and seagrass beds which are
themselves necessary for the proper functioning of the coastal system.

Thus in the management of a large river basin such as the Zambezi there is need to consider the
sources of water, the human needs for water, and the environmental needs for water all in the same
system. In the Zambezi Basin this is most essential for the downstream users (people and the
environment) but is also necessary for the entire watershed, including the wetlands, across and between
the eight basin states.

PLANNED DEVELOPMENTS IN THE ZAMBEZI BASIN

Several significant new development projects are planned for the Zambezi Basin that would
affect the basin environment and its users. Most outstanding are the four possible large impoundments
for the main channel at Katombora, Batoka Gorge, Devil’s Gorge, and Mpata Gorge, and the
possibility of navigation locks at Mapanda, Lupata and Mutarara in Mozambique.

The Katombora project would entail the construction of a barrage across the Zambezi upstream
of Mosi oa Tunya (Victoria Falls) at the Katombora Rapids to store sufficient water to supply an extra
500 MW installation at the falls. This would produce a storage dam that would inundate a large area of
Zambia, Botswana, and Namibia with a shallow water body that would be very susceptible to
evaporation.

The Batoka Gorge scheme has already moved beyond the feasibility stage and would consist of
a joint venture between Zambia and Zimbabwe in the gorges below Mosi oa Tunya. It would entail
constructing a dam wall 190 meters high to produce a small lake of about 25 square kilometers which
would stretch upstream almost to the foot of the falls. This scheme would have an installed capacity of
1,600 MW.

Devil’s Gorge is at the upstream end of Lake Kariba and would have an impoundment with the
wall (of around 140 meters high) in the waters of Kariba. It is planned to have a generating capacity of
1,240 MW.

Mpata Gorge is in the Middle Zambezi valley, just upstream of the upper end of Lake Cahora
Bassa and adjacent to Mana Pools National Park in Zimbabwe and the Lower Zambezi National Park in
Zambia. It would produce a lake of about 1,230 square kilometers stretching almost 200 kilometers
upstream to within sight of the Kariba Dam wall and extending 25 kilometers up the Kafue River from
its confluence with the Zambezi (see Figures 11.1 and 11.2). It is planned to be able to produce 1,000
MW for the Interconnected System. There are serious environmental consequences of all of these
plans, some of which are described by Du Toit (1984). This suite of impoundments effectively
captures the Zambezi River for the entire length of the Middle Section as well as a significant length
and area upstream (Katombora) and downstream (Cahora Bassa). It would also require extremely well-
planned coordination of dam operation and lake management to ensure that downstream dams and
downstream users (including the Indian Ocean) were not adversely affected.
Other significant proposed projects involve extraction of Zambezi waters for various supply needs (Table 11.4). Irrigation development in the Middle Zambezi valley in Zambia could be initiated soon to grow wheat and cotton - with an estimated offtake of 9 cumecs. An extraordinary estimate for the irrigable area in five riparian states is quoted by Mpande (in Matiza and others forthcoming) as 7.5 million hectares which would require 30,000 cumecs (or 8.6 times the flow of the Zambezi) in an area with little water apart from that available from the Zambezi Basin.

Table 11.4 Offtakes on the Zambezi River and its tributaries

<table>
<thead>
<tr>
<th>Offtakes</th>
<th>Mean annual amount (cumecs)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EXISTING:</strong></td>
<td></td>
</tr>
<tr>
<td>Zambia: Water supply and Irrigation</td>
<td>6</td>
</tr>
<tr>
<td>Zimbabwe: Water supply and Irrigation</td>
<td>2</td>
</tr>
<tr>
<td><strong>PROPOSED:</strong></td>
<td></td>
</tr>
<tr>
<td>Zambia: Irrigation Development</td>
<td>9</td>
</tr>
<tr>
<td>Zimbabwe: Zambezi Matabeleland Water Project</td>
<td>up to 100</td>
</tr>
<tr>
<td>Botswana: N-S Carrier connection to Zambezi</td>
<td>unknown</td>
</tr>
<tr>
<td>RSA/Botswana/Namibia: Water supply Project</td>
<td>80-95</td>
</tr>
</tbody>
</table>

Source: Mpande in Matiza and others forthcoming

During the 1991-92 drought in southern Africa, both the city of Bulawayo and much of Matabeleland suffered greatly from water shortages for urban, rural, and agricultural supplies. This revived a planned transfer of water from the Zambezi to Matabeleland to alleviate this problem and allow expansion of urban and agricultural developments. The water would come from the Zambezi River at, or below, Victoria Falls and be piped to the city of Bulawayo which has a current water requirement of 1.2 cumecs. The planners, however, look to the Zambezi for irrigation which would require 40, 50, or even 100 cumecs.

Both Botswana and Namibia are short of reliable water supplies. There are existing plans for a scheme to extract Zambezi waters to add to the North-South Carrier project that would link supplies within Botswana. At the same time Namibia is looking at the Chobe/Zambezi waters for augmentation of the water supply in that country by way of their East-West Carrier. In South Africa there will be a shortage of available water by about 2015, despite the inputs from the Lesotho Highlands Water Project. A scheme has been evolving over several decades to move water from the Zambezi River at Katima Mulilo, Kasane, or Victoria Falls through an aqueduct or pipe to the Vaal Triangle in South Africa to supply Johannesburg, Pretoria, and surrounding agricultural areas. This would pass through Botswana, then a beneficiary, as would be Namibia if it is joined to the scheme. The suggested
extraction would be in the range of 80 to 95 cumecs -- which is enough to stop the Mosi oa Tunya in a
dry year (Scudder and others 1993).

Clearly all these schemes cannot go ahead together. Even one of them could adversely affect
downstream users and the environment, to the detriment of other basin states and occupants.
Throughout the planning of these various projects scant consideration has been given to the
environment - especially the effect of reduced flows, limited floods, and increased pollution which
increases with distance down river and becomes most serious for the end users on the coastal plain, in
the delta, and out to sea.

MECHANISMS FOR MANAGEMENT OF THE ZAMBEZI WATERS

The plans for multiple but possibly mutually exclusive development projects discussed above
lead us to the need for a joint management system for the Zambezi Basin and its waters and the need
for a legal arrangement or operating system to decide upon disputes and propositions for new
developments within the basin.

The Helsinki Rules on the Uses of Waters of International Rivers gave the first guidelines
for a management system for any international river basin. This is a set of definitions and guidelines
that was developed by the International Law Association in 1966 in thirty-seven articles. The rules
define an international drainage basin as a geographical area extending over two or more states
determined by the watershed limits of the system of waters, including surface and underground waters,
flowing into a common terminus. The main thrust of the Rules is that each basin state is entitled,
within its territory, to a reasonable and equitable share in the beneficial uses of the waters of an
international drainage basin. The definition of a reasonable and equitable share is to be determined by
such factors as geography, contribution of water by each state, climate, past uses, economic and social
needs of each state, population dependent on the waters and the avoidance of waste in the use of waters
(Kimberley in Matiza and others forthcoming).

The Helsinki Rules state that a basin state may not be denied the reasonable use of waters in an
international basin. The Rules bring to light all the problems already mentioned but give no guidance
as to how to solve them in relation to ownership of the waters and distribution of resources in the basin.
These were the guidelines for the management of the Zambezi Basin where, in some states, there was
metering and allocation of water rights for all territorial waters except for international waters -- that
is, water could be taken from the Zambezi without permission or payment!

The Southern African Development Coordination Conference (SADCC) was founded in
1980 to reduce dependence on outside countries and to foster cooperation between the member states --
which included seven of the Zambezi Basin countries, but not Namibia at that time. Two sectors of the
SADCC organization are especially relevant to the management of the Zambezi: the Food and
Agricultural Sector and the Energy Sector. The former had sub-sectoral program in Soil and Water
Conservation and Land Utilisation as well as other natural resource sub sectors. Among its objectives
were to achieve a coordinated regional approach to environmental protection and to assist member
states to improve their soil and water conservation. Both of these goals were to be pursued through
coordinated sharing of information, training, data, technical expertise and regular joint practical
conservation programs in the field. The energy sector resolved to assist the various electrical grids to
become connected but did not involve itself in hydropower planning. Thus while SADCC had the
potential to assist with the coordination of Zambezi Basin management, it had made no obvious progress to assist the basin states resolve the distribution of basin water resources.

This situation may now change with the development of SADCC and the inclusion of Namibia and South Africa. Conversely, when South Africa was outside SADCC (as well as outside the Zambezi Basin) there were several reasons for resisting the proposed aqueduct as it was an out-of-basin transfer to a country that SADCC was set up to avoid.

In 1985 UNEP initiated the Zambezi Action Plan for Environmental Management of the Common Zambezi River System (UNEP 1986, 1987), which became known as ZACPLAN. This initiative was developed under the UNEP's Environmentally Sound Management of Inland Water and its sub-program the Africa Inland Water Programme. ZACPLAN was developed during several meetings of experts from the eight basin states and set out to assess the available information relevant to water resources management in the Zambezi Basin and then to develop the concept of integrated river basin planning for the Zambezi and to follow this with an international agreement which would ensure equitable distribution of resources and a framework for planning and cooperation.

At the Conference of Plenipotentiaries of ZACPLAN in Harare in May 1987 the entire programme was taken over by SADCC. UNEP no longer had a leading role. To date there is no international legal framework or any agreement except to take ZACPLAN forward. Nevertheless the elements of ZACPLAN remain and it is a great advance to consider the entire basin when planning water management and to preface management with "environmentally sound" as a concept. ZACPLAN takes into consideration the hydrological systems of the basin, the human requirements for water, the environmental requirements of the basin. It also takes into account threats to basin ecosystem sustainability such as water pollution, overgrazing and erosion of the watershed, deforestation, siltation, alteration of ground water quality, aquatic weeds, socio-economic stability, human health in relation to water, over-use of available water supplies, and out-of-basin transfers of water. It has also begun to implement the ZACPROs (projects to begin the process of basin coordination and management) especially those that can assess resources and planned development projects in the basin, coordinate monitoring systems and units for water management between basin states, and survey national capabilities to manage the Basin's resources - with institutional support if necessary. There is hope that ZACPLAN will move forward to achieve its goal of sound management backed up by a legal agreement.

Several other arrangements have been initiated in the intervening years:

- **SADCC, SADC** Regional development
- **Helsinki Rules (1966)** Reasonable use of an international drainage basin
- **Zambezi River Authority** Zambia & Zimbabwe: Management of shared (1987) river and Lake Kariba waters
The Zambezi River Authority was formed in 1987 by the successors of the Central African
Power Corporation: Zambia and Zimbabwe. The intention of the Authority is to manage the shared
Zambezi River and the waters of Lake Kariba for the mutual benefit of those two riparian countries --
especially for the production of hydropower. This Authority now manages the Kariba dam for the most
efficient output of power while retaining a minimum acceptable level of storage and water level for the
users of the lake. It does not specifically consider downstream users or the other basin states.

In 1992 Mr. Tiyanjana Maluwa of the Law Faculty at the University of Botswana developed a
proposal for a Convention on the Common Utilization and Management of the Resources of the
Zambezi Drainage Basin (Kimberley in Matiza and others forthcoming). This is a convention to
follow the intentions of ZACPLAN and it outlines a framework for cooperation between the basin
states based mainly upon consultation. It also suggests the harmonization of national policies and the
formulation of a general basin policy for developments within their Zambezi Basin. A further objective
is to develop a monitoring process to ensure that the agreed policy is adhered to by basin states. One
mechanism to achieve this cooperation is the suggested formation of a Zambezi Inter-Governmental
Monitoring and Co-ordinating Committee which is supervised by a Summit of Heads of State of the
Member States. This proposed convention was drafted for SADCC and was intended to become a
Protocol of the main SADCC Treaty. It still does not solve the practical problem of sharing the
resources of the basin, except by negotiation and cooperation, as there appears to be no workable
formula to decide rightful apportionment.

SADCC commissioned a study of national water legislation within the Zambezi Basin states
which then developed a proposed Protocol on the Zambezi River Basin and Other Shared River
basins in SADCC. This was produced by Mvalo in 1992 (Kimberley in Matiza and others
forthcoming) as an output of ZACPLAN (ZACPRO 2) and emphasizes the cooperation between basin
states that is required to bring about environmentally sound management. The Protocol is applicable to
any shared drainage basin within the SADCC area and requires the development of a SADCC
Monitoring Unit to harmonize activities in the basin, monitor activities and initiate a rational regional
policy for the utilization of both surface and underground waters of the river basin. This Protocol is
for the utilization of resources within shared basins including domestic, industrial, agricultural,
navigational and other economic and social uses.

Two principles of the Protocol are worth quoting (from Mvalo in Kimberley in Matiza and others
forthcoming):

Member States undertake to respect and apply the existing rules of customary
international law relating to the utilization and management of the resources of
international watercourses and, in particular, to respect and abide by the
principles of community interest in international drainage basins and equitable
apportionment of water and related resources.

Member States riparian to or lying within the basin of a shared watercourse
undertake to abide by the obligation to maintain a proper balance between
resource development for a higher standard of living for their peoples on the one hand and preservation and enhancement of the environment on the other.

A final treaty of agreement is awaited which will formalize these principles and allow the Zambezi Basin states to decide upon future water resource development.

CONCLUSIONS

The Zambezi Basin does not have enough water resources to satisfy all the demands and plans that have been tabled and reported here. Water in this and every other large river basin, is first seen as unlimited and then, as development proceeds, it is seen as limiting and then as a source of potential conflict.

The Zambezi Basin states through ZACPLAN and SADCC have taken the view that their Basin cannot be managed for water alone and that planning for management must take into account the whole watershed and its natural resources and its people and their needs. This holistic view is the only way to approach sustainable use of limited (limiting) water resources, but it is very hard to achieve when national aspirations and priorities for development differ and possibly conflict from state to state.

It is worth noting that the Zambezi Basin states have not tried to develop a River Basin Development Authority with powers greater than any component country. Rather they have taken the route of discussion and cooperation and information exchange about potential projects and their effects upon the whole basin. The developing protocols and agreements do not try to develop a formula for water ownership or access by their basin states as in the water apportionment process of a Water Authority. ZACPLAN hopes that any potential conflicts can be solved by prior information about development proposals and by negotiation and agreement between partners.

The main constraint to the success of ZACPLAN (and its successor program) may be the level of understanding of decision makers about the limiting nature of water resources and about the environment as a genuine claimant upon those limited resources. Most often we come to appreciate the value of environmental processes and systems only after we have altered or destroyed them. Sometimes this is because they are not obvious at first sight - such as the needs of marine fisheries for Zambezi waters or the value of swamps for maintaining river flows or the necessity of evapotranspiration. Sometimes it is because decisions are made about resource use that are not based upon a general understanding of environmental values. It is for this reason that this author believes that it is the responsibility of water resource management planners to inform decisions makers not just about the amounts of water available for development, but also about the amounts needed to sustain the rest of the basin and its environment downstream, below the surface, and out to sea.

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ENDNOTES

1. Originally the dam had a capacity of 666 megawatts on the south bank; 600 megawatts were developed on the north bank in Zambia in 1976.

REFERENCES


DISCUSSION

QUESTION: What are the effects of pollution and how severe it is in the Zambezi river?

Answer: A major source of pollution is in the north of Kafue flats, but does not reach the main river because the Lukenga swamps act as natural system of purification.

QUESTION: Very often environmentalists tell more about problems but do not advise on the solution of the problems. Do you have any comment?

Answer: For the Zambezi they are beginning to have solutions, for example release of flood from Itezhitezhi storage dam to the Kafue flats has an important environmental impact.

QUESTION: Pollution was an important issue. Why is it not well addressed in the presentation?

Answer: Pollution is not a serious problem at present because there is no capital city which has a connection to the Zambezi. Further, there are two swamps which help to remove pollution and provide natural purification.

QUESTION: How has impoundment in Kariba affected downstream sediment transport?

Answer: There is a big sediment accumulation in the reservoir and that lack of sediment in downstream river causes erosion and changes the river's course.

QUESTION: Workshop participants wished to know about flow gauging stations and the state of the network in the basin.

Answer: CIDA has been financing the hydromet network operations, for selected stations. The network works well.

QUESTION: Is there any effect of water abstractions on Mozambique?

Answer: I do not know of any effect. However as far as a water quality issue is concerned, some cooperation between countries is essential.

QUESTION: According to Malawi and the map just displayed, the border between Malawi and Tanzania runs along the shores of the lake on the Tanzanian side, which implies that Tanzania does not have any share of the lake. That is not the case. In addition, Malawi uses the Shire river potentially affecting Lake Nyasa levels which can then also affect the Tanzanian side by flooding. What would international law say about it?

Answer: The boundary is according to a map from UNEP. However, the boundary between the two countries does not affect the Zambezi drainage basin boundary. More appropriately, the two countries should sort the border issue and the flooding problem among themselves.

QUESTION: Can you tell more about the Zambezi River Authority?
Answer: The Authority was born in 1987 between Zambia and Zimbabwe, its main function is to ensure sustainable use of the water resources. The management of Lake Kariba is intended to provide for water supply and for hydropower generation.
Figure 11.2: Profile of the Zambezi River showing Existing and Proposed Dams
CHAPTER TWELVE

WATER RESOURCES MANAGEMENT IN THE TANA RIVER BASIN, KENYA

R. HIRJI

The use of river basins as units of analysis for planning and implementation of water resources strategies is being institutionalized. As such organizations multiply, their limitations also become more visible. Simply establishing river basin authorities within the government is not enough to ensure their operation as regional planning agencies. The experience of the Tana and Athi River Authority in Kenya shows that safeguards are needed to encourage such institutions continued commitment to overall basin management in the face of pressure to concentrate on localized project implementation.

INTRODUCTION

The river basin has emerged as the central unit of analysis for planning, developing, and managing water resources within and across nations in order to solve problems of increasing water scarcity and to handle conflicts between different sectoral uses of water. Since 1933, when the Tennessee Valley Authority was established in the United States, many river basin organizations (RBO) have been created around the world with broad mandates for planning, coordinating, developing, and managing water resources. Recent international conferences at Delft (1991), Dublin (1992), and Rio de Janeiro (1992) have underscored the benefits of managing water resources comprehensively on a river basin basis.

Some RBOs have been successful in achieving narrow objectives such as developing water supply systems, irrigation networks, and power generation facilities. Most, however, are poorly equipped to address the more challenging social, ecological, and institutional dimensions of managing water resources comprehensively. Even where the institutional structures are in place to manage water resources on a river basin basis, weak enforcement and conflicts of interests between the different actors in the basin create pressure on the institutions to do what is possible rather than what is necessary. Institutional structures must adopt flexible planning processes for river basin management to work successfully.

This paper discusses water resources development and management in the Tana River Basin of Kenya (see Figure 12.1). Lessons from the Tana Basin experience may be useful for Tanzania as it develops its water resources management strategy.
OVERVIEW OF THE TANA BASIN

The Tana River is approximately 800 kilometers long with a drainage area of 95,000 square kilometers. The Tana originates on the moist and humid slopes of Mt. Kenya and the Aberdare Mountains, and traverses an extensive arid area before emptying into the Indian Ocean near the semi-arid area north of Malindi. Nearly 20 percent of Kenya's population inhabits the river basin, concentrated in the upper catchment area. That region contains much of Kenya's existing agricultural production and its potential for irrigated agriculture as well as the principal sources of hydroelectric power in Kenya (Head 1979). The lower reaches of the basin are sparsely populated except directly along the river and around its irrigation schemes. The Tana River Primate National Reserve and the proposed Tana Delta National Wetlands Reserve are located in the lower Tana south of Hola.

WATER USE

Water use can be categorized as consumptive and non-consumptive. These uses of water in the Tana basin are briefly discussed below.

Non-Consumptive Water Use

Water used to create hydroelectric power is the primary type of non-consumptive water use in Kenya. Prior to 1970, Kenya imported much of its electric power from Uganda. Political instability in Uganda during the Idi Amin era made energy self-sufficiency in Kenya a national priority. This goal was further reinforced by the dramatic increases in global oil prices in the 1970s. As a result, Kenya began developing its hydroelectric power potential, much of it on the Tana River.

Hydroelectric power development in the Tana catchment began in 1925. At first, small hydropower stations were built at Ndula, Mesco, and Sagana Falls. In 1932, development of the Tana cascade started (see Table 12.1). The Wanjii and Tana Projects are located on the tributaries of the Tana River. Figure 12.2 shows the locations of the Masinga, Kamburu, Gtaru, Kindaruma, and Kiambere Dams. Figure 12.3 lists their elevations. The Masinga Dam created the largest reservoir in Kenya with a storage capacity of 1.56 billion cubic meters. It was commissioned in 1981 and has an installed capacity of 40 MW. The dam has created the primary storage structure for flow regulation for a large integrated hydroelectric scheme with an estimated potential of 820 MW (Head 1979).

Table 12.1 Hydroelectric Projects on the Tana Cascade

<table>
<thead>
<tr>
<th>Project</th>
<th>Installed Capacity (MW)</th>
<th>Type of Scheme</th>
<th>Year Commissioned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wanjii</td>
<td>7.4</td>
<td>Run of river</td>
<td>1952</td>
</tr>
<tr>
<td>Tana</td>
<td>14.4</td>
<td>Run of river</td>
<td>1932</td>
</tr>
<tr>
<td>Masinga</td>
<td>40</td>
<td>Surface</td>
<td>1981</td>
</tr>
<tr>
<td>Kamburu</td>
<td>94.2</td>
<td>Underground</td>
<td>1974</td>
</tr>
<tr>
<td>Gtaru</td>
<td>147</td>
<td>Underground</td>
<td>1978</td>
</tr>
<tr>
<td>Kindaruma</td>
<td>44</td>
<td>Surface</td>
<td>1968</td>
</tr>
<tr>
<td>Kiambere</td>
<td>144</td>
<td>Underground</td>
<td>1991</td>
</tr>
</tbody>
</table>
Sustaining the ecosystem requires water. Instream flows for maintaining the Tana floodplain forests, including the Tana River Primate National Reserve, located south of Hola and for the Proposed Tana Delta National Wetlands Reserve north of the Tana Delta Irrigation Scheme have not been well quantified (Figure 12.4).

Consumptive Water Use

Agriculture is a major consumptive use of water. Rainfed agriculture is practiced intensively in the upper catchment, but it is limited in the arid and semi-arid areas except along the floodplains. Irrigated agriculture is practiced in small and large schemes in the basin (Figure 12.2). The Bura Irrigation Scheme (Bura West) was planned to be constructed in two phases. Construction of Phase 1 began in 1979 and was intended to cover 6,700 hectares. The size was later reduced to 3,900 hectares. Phase 2 (5000 ha) is awaiting approval. The 840 hectare Pilot Scheme at Hola is located south of Bura. Further downstream, the 16,800 hectare Tana Delta Irrigation Scheme is currently being constructed to irrigate rice.

Municipal and industrial water supply needs are also large. The total surface abstractions for municipal and industrial use in the basin is estimated to be 595.4 million cubic meter annually. The total amount of domestic and industrial water actually supplied and consumed is not known, since measuring devices do not exist for private systems, and those on the public water supply systems are often broken.

Livestock and Wildlife must also be supplied with water. Livestock have important economic and cultural significance to the Orma and Somali Pastoralists inhabiting the arid and semi-arid areas of the basin. The livestock water demand in the basin was estimated to be 616 l/s in 1990. Almost half this amount is met by surface water. Wildlife demand has been calculated on a district rather than a river basin basis.

LAND USE AND WATER USE CONFLICTS

The major land and water use conflicts in the basin have resulted from increasing population pressure, particularly in the upper catchment, and extensive development for power generation and poor implementation of irrigation schemes. Despite early prediction of these conflicts in environmental impact assessments for the Masinga, Kiambere, and the Tana Delta irrigation schemes, few measures were taken to mitigate a negative outcome.

Poor land use

Poor land use has impacts on water use and storage. Increasing pressures on land in the upper catchment of the Tana has accelerated soil erosion and increased sediment transport and deposition in various impoundments, reducing the effective storage and economic life of the storage facilities. Prior to the construction of the Masinga Dam, Ongwenny (1980) had estimated that the Kamburu Reservoir was filling up at a rate of 4 - 5 million cubic meters of sediment a year. Further downstream at Garissa, the average sediment transport rate was estimated to be 8.5 million cubic meters per year (Dunne 1974). Construction of Masinga dam shifted the impact away from the Kamburu Dam onto the Masinga Dam. The 1976 Masinga Dam environmental impact study had predicted this outcome and had recommended that a soil and water conservation study be carried out and a green belt around the
reservoir be established. These recommendations were only acted upon ten years later after it became clear that reservoir sedimentation was a serious issue.

**Modified hydrology**

Multiple impoundments to regulate flow, to generate hydropower, and to create diversions for irrigation are altering the hydrological regime. The mean maximum flow of the Tana River is 800 cubic meters per second. During the 1961 floods, flows three times that amount had been recorded at Garissa. Large storage reservoirs even out downstream releases and inevitably alter the patterns of low flows (usually between February and March and September and October) and high flows. This unevenness can significantly impact floodplains. River flow regulation reduces not only the frequency and intensity of floods but also the seasonal replenishment of nutrient rich sediments. This latter effect reduces the productivity of floodplains and delta wetlands (Hughes 1984).

**Alienation from water sources**

Hydrological modifications have impacted smallholders and pastoralists downstream. Smallholders in the delta flood plain who have depended on flood recession agriculture have been greatly affected by reduced flows and sediment deposition. Downstream irrigation development has constrained the Orma and Somali pastoralists. The schemes restrict access to water courses and reduce the available supply during the critical dry periods. The interests of pastoralists and smallholders are not well represented nationally, and as a result their needs are sometimes ignored.

**Resettlement**

Reservoirs have inundated large areas and necessitated relocating inhabitants of those and surrounding areas, as in the building of the Masinga and Kiambere Dams. In the Kiambere case, resettlement was handled very poorly and had become a contentious issue during project implementation (Hirji 1990).

**Floodplain Forests**

Settlement of 20,000 people (1987 estimate) at Bura West is stressing the floodplain forests. These forests are the only source of firewood and wood for construction in the area. Tenant families use wood for cooking, while inhabitants from the nearby informal settlements use it for fuelwood and construction. Pre-project estimates of fuelwood use, needs, and available volume of wood in the floodplain forests predicted that large tracts of the 300 kilometer long floodplain forest would be destroyed within five years (Hughes 1988). Although tenant populations have turned out to be lower than projected, the stress remains significant. Similar concerns are being with the construction of the Tana Delta Irrigation Scheme regarding its probable impact on the sensitive ecosystems downstream, including the riverine forests, grasslands, and mangrove forests in that are located in and around the proposed Tana Delta Wetlands (Njuguna 1993).

To inhibit land and water use conflicts, a comprehensive approach to water resources management calls for integration of cross-sectoral uses of water (consumptive and non-consumptive) with land use, and for considerations of water quality, public health, and water dependent ecosystems.
on a river basin basis. Such an approach would identify the various sectoral water use and land use conflicts, and the tradeoffs between them during the planning process, providing data for sound and informed decision-making.

INSTITUTIONAL RESPONSE

Prior to 1974, development in the Tana basin was not coordinated. Power, water supply, and irrigation were overseen by different agencies. Hydropower projects had been implemented by the Tana River Development Company in collaboration with the Kenya Power and Lighting Company. Urban and rural water supply projects were the responsibility of the Ministry of Water development. Irrigation development had been the carried out by the National Irrigation Board.

Creating a Planning Agency

In 1974, an Act of Parliament created the Tana River Development Authority (TRDA) under the Ministry of Water Development to coordinate the development of the Tana River basin resources. It became the principal planning agency whose mandate was to coordinate and integrate development of the basin resources. It had four main goals: first, to balance an historically skewed development pattern on the upper Tana basin; second, to create better access to the Tana Delta Region; third, to control and manage the basin resources; and, fourth, to develop a stable supply of electric power (Little 1988).

From Planning to Implementation

As TRDA evolved, however, it shifted its primary activities to project implementation and away from planning and coordination of the basin as a whole. It began focusing on large projects such as Masinga Dam, Kiambere Dam, and the Tana Delta Irrigation Scheme. TRDA has been successful in implementing hydropower projects. Its success led, in 1981, to the formation of other basin authorities in Kenya which were patterned after TRDA. TRDA also began to diversify geographically and expanded its activities into the Athi basin. It obtained donor funding to carry out a preliminary study for the proposed Munyu Dam-Fourteen Falls hydroelectric power scheme as part of the Athi River pre-investment study. In 1981, while other basin authorities were being formed, TRDA’s mandate was broadened to include the Athi Basin. It then became the Tana and Athi River Development Authority (TARDA), the largest basin authority in Kenya.

TARDA has also promoted irrigation development. It started by assisting the Ministry of Agriculture to plan and design small scale irrigation projects. In 1982, it began implementing its own irrigation project, a pilot irrigation project at Kibwezi on the Athi River. The failure of the Bura Irrigation Project, managed by the National Irrigation Board, enhanced TARDA’s role in irrigation development. In 1986, TARDA’s position was further solidified when it acquired funding from the Japanese aid agency, Overseas Economic Corporation Fund (OECF), to upgrade the Tana Delta Irrigation feasibility study and detailed design even after Dutch aid for the project had been cut off (Hirji and Ortolano 1991b).

Problems of Coordination

The shift from a planning agency to an implementing agency changed TARDA’s relationship with other actors in the basin. It was no longer seen as promoting "balanced" development in the basin
or as an impartial entity for resolving conflicts between interest groups dependent on basin resources. Indeed, the agency itself has become a source of conflict (Hirji 1990).

The legislation calls for TARDA to "ensure close co-operation between all agencies concerned with... use of water within the area..." and to "render assistance to operating agencies..." within the Tana basin. But in promoting national goals (e.g., energy and self sufficiency in rice production), TARDA has coordinated its activities selectively and has mainly interacted with those agencies from which it benefits from directly (e.g., the Ministry of Water Development and the Kenya Power and Lighting Company). It has not maintained ties with community groups that do not assert themselves, or with agencies that it competes with for resources or that constrain its agenda.

TARDA has, for example, ignored the pastoralists who are affected by its schemes. Without political power, the pastoralists were unable to reduce the size of the Tana Delta Irrigation Scheme, for example, or to offset its negative effects on the local economy.

The National Irrigation Board has several large projects in the basin, but TARDA has not collaborated with it extensively. This is perhaps surprising since the National Irrigation Board's water requirements could directly impact TARDA projects.

Despite a national "District Focus" policy begun in 1984 to promote the local districts' participation in national planning efforts, TARDA's attempts to coordinate with the local District Development Agencies have been minimal. Wider participation implies greater accountability for TARDA for its actions. This might mean providing adequate compensation to residents being relocated as a result of dam construction and reservoir filling, at higher costs to the agency.

Finally, TARDA has altogether ignored the insistence of the National Environment Secretariat (NES) that environmental impact assessments (EIA) be carried out for most of TARDA's recent projects. Responsiveness to NES would require that TARDA be more environmentally accountable for its actions. By ignoring NES, which has little enforcement capability, TARDA maintains autonomy and for the time being retains greater control over the type, scale, and timing of its activities (Hirji and Ortolano 1991a).

Reprioritizing basin management

TARDA's alienation of other vital interests in the basin suggests that it is less committed towards river basin management and more interested in project implementation. Although it has prepared well-defined plans for developing the hydropower potential of the basin, TARDA does not have any broad, integrated plans for the overall development of other Tana basin resources as called for in its enabling legislation. In recent years, TARDA has undertaken activities such as livestock and fisheries development as well as river basin management studies, but these are secondary issues and are allocated few resources. In 1987, hydropower and irrigation accounted for nearly all of its budget. TARDA now is working to amend its enabling legislation to reflect its role as an implementing agency.
LESSONS FROM THE TANA BASIN

There are several useful lessons that can be learned from the Tana basin experience. The land and water use issues that characterize the Tana basin are not unique and have common elements with cases in Tanzania. Poor land use is seriously impacting water resources in both Kenya and Tanzania. In the Tana and Athi River Basin, accelerated soil erosion in the upper catchment has serious economic implications on downstream facilities. In 1992, intensive rains in the Sigi River catchment in Tanzania precipitated mudslides on fragile areas already degraded by poor land use and increased siltation at Mabayani Dam. Sediment buildup in the dam reduces its effective storage capacity, while simultaneously imposing greater costs on the treatment of the Tanga Water Supply.

Water use conflicts between water needs for power generation and for farming and livestock herding is also a common issue for Kenya and Tanzania. In the Tana case, smallholders and pastoralists (in the lower Tana and delta area) are affected by flow regulation and the reduced replenishment of nutrient-rich sediments. In the Pangani and Ruaha River basins, upstream farmers and pastoralists (particularly in the Usangu plains) are constrained by downstream needs for power generation. In neither case are the interests of small-scale agriculturists or pastoralists being adequately acknowledged.

Conflicts between water needs for sectoral uses (power generation, municipal water supply, or irrigation) and for meeting conservation goals are challenging issues in Kenya as well as in Tanzania. In the Tana basin, TARDA has not given ecological considerations sufficient priority. It has instead tried to manage the uncertainties of the EIA process through the use of compromise, secrecy, and resource substitution (Hirji and Ortolano 1991a). In the Ruvu basin, the Ministry of Water, Energy, and Minerals (MWEM) is struggling with similar issues over siting the Kidunda Dam in the Ruvu basin to supplement both the water supply for Dar es Salaam and for irrigation. The potential implications of having a large dam in that area include affecting the ecosystem of the Selous Conservation Game Reserve or creating saltwater intrusions in the Ruvu delta.

Sectoral coordination at regional, national, and donor levels is the primary challenge in basin management. At the regional level, it is critical to begin coordinating activities within the river basin that can achieve soil and water conservation on the one hand and successful watershed and floodplain management on the other. At the national level, sectoral plans (such as irrigation development plans, water master plans, hydropower generation plans and environmental action plans) need to be coordinated according to the consequences of water use in all sectors, and by including small and large users. Regional and national level coordination can only be realized through the political process and with a strong commitment from the government. The chances for successful coordination will be enhanced if the relevant actors develop a basin-wide strategy in a participatory manner and avoid a rigidly structured approach. At the donor level, however, it is in the interest of the government to take the initiative and set strict and explicit conditionalities requiring donor coordination in river basin activities.

The Tana River Basin management case provides an instructive example of an RBO that has successfully promoted narrow sectoral objectives, particularly for hydroelectric power development, over the past two decades. The case also illustrates the challenges in addressing the broader river basin management objectives which include the various water use and land use conflicts and the shortcomings of the institutional responses to integrated river basin development. The lessons from the Tana case may be useful for Tanzania as it develops its river basin organizations.
ENDNOTES

1. This appeal is based mainly on hydraulic considerations; inherent is the assumption that the components of a water balance within a catchment can be developed and modeled with relative ease, thus providing a systematic basis for planning and management decision making.

2. The World Bank funded National Irrigation Board managed Bura Irrigation scheme has been plagued with a whole range of social, economic, ecological, and institutional problems (World Bank 1985).

3. In the nearby Athi River Basin, similar land use pressures in the upper and middle catchment are causing serious operational problems at the Baricho Intake of the Mombasa Water Supply. Excessive sediment deposition behind the weir at the intake is constantly reducing the storage capacity at the intake facility, breaking down pumps and also increasing the treatment costs. This impact is so significant that the Mombasa Water Supply extension plans are considering shallow wells along the river as an alternative to surface diversion.


5. These quotations are taken from the TARDA enabling legislation as stated in Chapter 443 of the Laws of Kenya, The Tana and Athi Rivers Development Authority, Act of 1982.

REFERENCES


DISCUSSION

QUESTION: There exist erosion and sedimentation problems in the Tana river system. Is there anything being done to reduce or prevent the problem? Were any Environment Impact Assessments done?

Answer: There are several preventive measures which have to be started now. Unfortunately, there is high population pressure on the upstream catchments, which accelerates the problem. Recommendations to the solution of the problem were made nearly ten years, before solutions are put in place now. Environment Impact Assessments were done in some cases.

QUESTION: Mombasa city needs additional water supplies and groundwater may seem an important alternative. Are there any plans to make Lake Chala an alternative water source?

Answer: I am not aware of the lake Chala being considered as an alternative water source for the Mombasa city.

QUESTION: The coral reef of Tanga is said to have sedimentation problem. Can this problem can be related to erosion taking place in Kenya?

Answer: I am not sure if the supposed sedimentation of Tanga coral reefs are related to erosion taking place in Kenya.

QUESTION: Are there any consideration of stakeholder views or inclusion in Kenya?

Answer: There was only minimum consideration and probably that was the course of the whole problem in the planning process.

QUESTION: Were studies on pollution and environmental issues done for the case of Tana River Basin?

Answer: Some studies were done, for example, on the Tana delta irrigation scheme. There were numerous studies done on pollution issues.

QUESTION: How could the Tana river authority implement the law while it is also a water user?

Answer: Since the authority was planned to be the implementing agency it was not proper for it to do policing functions while it is also a water user. Ideally it has to be one or the other but it can not be both.
Figure 12.1: The Tana River Basin
Figure 12.2: Location of Development Schemes
Figure 12.3: Elevations of Hydropower Projects
Figure 12.4: Tana River Primate National Reserve and Delta Wetlands
CHAPTER THIRTEEN

RIVER BASIN MANAGEMENT IN THE UNITED STATES

W. B. LORD

The history of river basin management in the United States encompasses three different areas: water allocation, water resources development, and water quality. Each component is differently regulated by federal or state legislation and practice. The emphasis has been on "developing" rather than "managing" water, and coordinated management of water has consequently been uncommon. The difficulties that the United States has had in promoting coordinated basin management illuminates possible guidelines for other developing countries.

River basin management in the United States occurs within the context of three policy arenas. The first and oldest arena is that of water rights law, the second that of water resource development, and the third that of water quality control. Water rights law in the US is largely a matter of state responsibility (two exceptions, federal reserved water rights and interstate water allocation, are so peculiarly American that they will not be discussed in this paper). Large scale water resource development is largely a matter of federal responsibility (California, with its massive State Water Project, is the sole exception). Water quality control is a (sometimes) cooperative joint federal-state responsibility. Water rights law is highly decentralized, with the limited government role being largely that of mediating conflicts between individual water users. Water resource development is moderately centralized, with the government role being the proprietary one of planning, constructing, and operating projects. Water quality control is highly centralized, with the government role being the regulatory one of constraining the actions of polluters. Water rights law is basically in the domain of the judicial branch, water resources development is basically in the domain of the legislature (a peculiarly American aspect of our federal system). Water quality control is basically in the domain of the executive branch. Each of these three aspects of river basin development will be discussed in the following paragraphs.

WATER ALLOCATION AND LAW

The eastern United States drew their water laws from the English Common Law. Water allocation follows riparian doctrine, in which there are no water rights, only landownership rights. The rights of owners of riparian land include the right to make reasonable use of adjacent waters, but only to the extent that other riparians are not damaged and water is not transported off-site. Riparian doctrine served tolerably well just so long as there was no scarcity of water and so long as there was no need to use water far from its natural place of occurrence.

With the settlement of the arid and semi-arid western states, riparian doctrine frustrated the need to irrigate many western lands. The western states then followed the rules of the gold mining camps in enacting statutes which abandoned riparian law for the doctrine of prior appropriation.
Appropriation doctrine grants quantitative water rights to those who divert water from a natural water body and put it to a beneficial use. In most states these rights are not appurtenant to riparian land, which means that the water can be transported and used elsewhere, and that water rights can be separated from the rights to land. Such water rights also can be transferred (bought and sold), and can be lost if they are not used. An important feature of appropriation doctrine is that a water right has not only a quantitative dimension but also a temporal one. The date of a right is the date when water was first diverted and used. When water is scarce, the oldest (senior) rights are satisfied first, and in their entirety, before holders of junior rights receive any water. Over time, the transferability of appropriative rights has been progressively restricted, in the interests of protecting other rights holders and such public interests as environmental protection. And, all but one of the western states now allocate appropriative rights by permit from an administrative agency. Many eastern states have recently followed the West in moving from riparian doctrine to permit systems. Few states still cling to strict riparianism.

The technology to exploit groundwater is fairly recent, so that groundwater laws in most states have continued to follow common law riparian principles. This means that the right to pump groundwater is one of the rights of landownership, that there are no quantitative limits on pumping, although other landowners' rights may not be jeopardized, and that groundwater may not be bought, sold, or transported off-site. The result is that in most states groundwater and surface water are legally distinct and only tenuously related to each other, despite modern hydrologic knowledge to the contrary. This disjunction creates a serious obstacle to the coordinated (conjunctive) management of ground and surface waters.

Furthermore, although property rights in water have established the security of expectations which has encouraged private development of water resources, they have also introduced a substantial degree of inflexibility which hinders the evolution of river basin management. This is especially true where the free transferability of water, one of the original objectives of appropriation doctrine, has been progressively curtailed to protect other water users. Indeed, some western states have said forthrightly that they have no state water plan or state water policy except the doctrine of prior appropriation.

WATER RESOURCE DEVELOPMENT

Any analysis of the history and status of river basin management in the United States must proceed from recognition that the United States was largely an undeveloped country throughout the nineteenth century. It bore a closer resemblance to many of today's non-industrialized countries than to the mature economies and societies of Europe. The dominant ethos was to tame an unruly and unsubjugated nature, not to live harmoniously within fixed limits. Consequently, the word "management" appeared far less often than did the word "development." This situation persisted, anachronistically in the later years, until well past the middle of the present century.

The idea of water resource development as the key to regional economic growth has a long history in the United States. In the early years of the republic, before the advent of railroads, canals and other waterways were envisioned as the transportation links which would facilitate regional commerce. Indeed, enthusiasm for investing in this kind of infrastructure was overblown, and many of
the private and state ventures in the canal-building era resulted in bankruptcy, the victims of too much enthusiasm tempered by too little hard analysis.

A new wave of enthusiasm for water resource development arose during the so-called "Progressive Era" in the latter part of the nineteenth century, as John Wesley Powell, the explorer of the Colorado River Basin and first head of the US Geological Survey, promoted the notion of irrigation development as the engine of regional development for the sparsely-settled western United States. Powell concentrated on the technical feasibility of large-scale irrigation development, but he rather glibly inferred from such development an easy transition from a frontier society to a prosperous, agriculturally-based, regional economy.

Irrigation was necessary to cultivate the fertile but semi-arid western plains and the great central valley of California. Farmers and associations of farmers, organized as ditch companies, undertook small-scale local irrigation works, but it soon became obvious that they lacked the financial resources to build large storage reservoirs and long distance water conveyance structures. States, and later the federal government, eventually provided those resources. Irrigation interests soon found that they could be far more adventurous and aggressive when spending someone else's money than when spending their own. Politicians enhanced their reelection chances and their places in history by using their political power to obtain large federal projects in their districts. Massive irrigation projects were developed, many of which have never succeeded in repaying their costs.

Early thinkers responded to Powell's stimulus by generalizing his idea to include other forms of water resource development. The next one of these forms to be included was hydroelectric power generation. Privately-owned power companies in the eastern United States took advantage of their positions as unregulated public utilities to charge high prices for electricity. Power users, besides being indignant at being exploited economically, pointed out that the economic development of their regions was hindered by needlessly high energy costs. Public hydroelectric power development was promoted as a way of advancing regional economies. The intellectual seeds of the idea of integrated or unified river basin development had been planted by the advent of the Progressive Era at the turn of the century.

During the first third of the twentieth century the idea of unified river basin development was discussed, clarified, and developed, although little in the way of implementation occurred. Gilbert White, looking back on the evolution of these ideas, in 1957 identified five central ideas in river basin development. They were the multipurpose storage project, the basin-wide program, comprehensive regional development, articulated land and water programs, and unified administration. These five central ideas were to define the shape of unified river basin development as it began to occur in practice in the United States during the 1930s.

Enthusiasm for development spread across the country as first hydropower and then flood control, navigation, water supply, and recreation joined irrigation as appropriate purposes for investing public funds, and as public works became the dominant prescription for battling the Great Depression. It was at this time that the experiment of the Tennessee Valley Project was undertaken. TVA, alone among American water projects, embodied all of White's five central ideas of unified river basin development.

The Tennessee Valley Project was begun in 1933 in a region of the United States known for its backwardness and isolation. Yet nature had provided abundant water supplies, and the notion of
harnessing the Tennessee and its tributaries for hydropower production and ultimate regional economic resurgence held great appeal for the newly-elected Roosevelt administration. For the first (and last) time in American history, White's ideal of unified administration became reality. The Tennessee Valley Authority was given responsibilities and authorities which, everywhere else in the US, were dispersed among many federal agencies and Congressional committees. To a considerable degree, White's other four ideals were approximated in later developments elsewhere, but the prospect of territorial loss so alarmed existing agencies and committees that they moved rapidly to ensure that unified administration would never again occur.

Even TVA, which began ambitiously as not just a water resource development agency but as a broad-scale regional development agency, ultimately retracted somewhat and became the primarily power production agency which it is today (it does retain certain other water-related functions, and hydropower now takes a back seat to thermal generation and even nuclear power). Whether this retraction is a result of political opposition, agency timidity, or whether it is simply a logical response to having fulfilled its original comprehensive regional development mission can be debated.

The advent of the Second World War brought public works spending up short, as the nation turned its productive capacity to armaments. Post-war prosperity, cuts in military spending, and pent-up demand for politically popular water projects resulted in the great post-war era of water resources development in the US. It was during these two post-war decades that the idea of unified river basin development was to find its greatest expression. Although TVA had provided the most perfect embodiment of the idea, and still remained the model in the view of the proponents of river basin development, an era of experimentation with alternative forms of achieving the ideal was now under way.

Elsewhere in the United States, however, the federal water agencies gave up enough independence to participate in federal interagency river basin committees. These committees expanded the range of data collection and standardization, and they began the process of creating benefit-cost analysis and other technical planning tools, but they produced little in the way of interagency coordination, and still less in the way of basin-wide programs, comprehensive regional development, or articulated land and water programs (multi-purpose projects were already a major part of each individual agency's repertoire).

The ideals of unified river basin development continued to draw support, however, and resulted eventually in the passage of the Water Resources Planning Act of 1965. This landmark legislation created a Water Resources Council, of which all of the federal water agencies were members, and which was charged with establishing uniform project and basin planning principles and standards. These principles and standards were to foster comprehensive basin development, coordinate land and water programs, ensure effective interagency communication, and continue to perfect, and broaden the application of, the tool of benefit-cost analysis. The Water Resources Planning Act also created a system of federal-state river basin commissions, which were to take over the basin planning functions so imperfectly realized under the federal interagency basin committee rubric. A major purpose for these commissions was to bring the states in as equal partners with the federal agencies in river basin development programs and projects.
For the next fifteen years the nation sought to implement the institutional innovations which were represented in the Act. Basin commissions were established in most of the major river basins. Interestingly, the major achievements of the Water Resources Council lay in information collection, processing, and presentation, particularly in the form of two national water assessments, and in continuing the development of benefit-cost analysis. Interagency coordination was far harder to achieve, either nationally, in the Council, or regionally, in the federal-state river basin commissions. Still, the commissions, too, succeeded in amassing and interpreting water-related data to an unprecedented degree. But they failed to rationalize the Congressionally-supported federal project development system. Such water projects as were built during this period were conceived and supported outside of the commission framework. No new projects emerged from within the new system of commissions.

The bubble of unified river basin development in the US was about to burst. A combination of opposition to massive, and economically unjustifiable water projects, growing awareness of the environmental costs of such projects, and the simple fact that most of the good sites had already been developed, was soon to dim public enthusiasm for further development. Most observers grant that few of the remaining authorized reclamation projects in the West will ever be built, nor will ambitious waterway projects such as the Trinity River project, which would create seaports in inland Texas. Some projects already under construction, such as the Cross-Florida Barge Canal, were halted and their evidence erased, while some long-completed projects in the Pacific Northwest are now slated for dismantling, due to their adverse impacts upon fisheries.

Save for the unique example of TVA, the dream of unified river basin development in the United States disappeared before it achieved realization. But this dream was of river basin development, not river basin management. The overriding preoccupation with development had fallen victim to skepticism about its sustainability. Indeed, when Ronald Reagan entered the White House in 1981, he soon took steps to dismantle the Water Resources Council and the joint federal-state river basin planning commissions, as well as to downgrade the Principles and Standards to voluntary guidelines. Strangely, for institutions which had taken so many years and so much political maneuvering to create, there was hardly any opposition.

Every American president since Hoover had sought to wrest some measure of control over federal water project development from the Congress and to diminish its drain on the federal treasury, all with little success. Benefit-cost analysis had seemed to offer a potent tool for revealing uneconomic plans and for justifying their abandonment. The Congress had reacted, however, by writing into law more lenient provisions which would favor project development. Reagan settled this long-standing dispute with the legislative branch by abandoning the effort and turning instead to cost-sharing as the keystone for the control of water project spending. While proclaiming his devotion to the idea of water project development, Reagan simultaneously insisted upon new cost-sharing rules which would require beneficiaries to pay a major share of the costs of projects from which they benefited. Those changes were made, although not easily, in 1986, and since that time the Congressional pressure for new water project construction has diminished.

Interesting experiments in managing the major water resource development projects which were built in the development era are now occurring. All of these experiments seek to broaden the range of objectives for river basin management, to emphasize environmental quality and sustainability in place of unbridled economic development. Some remain largely federally led (as in the Colorado River Basin), while others temper federal control with greater authority for states and Indian tribes (as
in the Pacific Northwest Power Planning Council). But coordinated management of water resource
development systems is almost always difficult and politically contentious. During the recent California
drought the potential efficiency gains of integrated management led the federal government to suggest
turning over the Bureau of Reclamation's Central Valley Project to the State of California, which
manages its own State Water Project. California has now decided to reject this offer because of
overriding political difficulties.

WATER QUALITY CONTROL

Widespread concern for water quality control came much later in the US than did programs for
water rights allocation or water resource development. It was not until after the second world war that
a serious effort was made to combat water quality degradation. Early federal legislation called upon
the states to establish ambient water quality standards and to adopt policies to attain them. Only
meager results flowed from the implementation of this legislation, causing skepticism about relying
primarily upon state action and also upon ambient standards as a regulatory device. The 1972 Clean
Water Act marked a pronounced shift to federal leadership and the use of performance and design
standards for individual polluters, along with substantial federal grants to enable local governments to
construct sewage treatment facilities. The National Pollution Discharge Elimination System subjects all
significant point sources of pollution to emissions permits which are set nationally with the goal of
attaining "swimmable and fishable" waters. Further reductions in emissions (so-called "waste load
allocations") may be required in heavily impacted waters, where the national emissions standards are
insufficiently strict to attain ambient water quality goals.

Industrial pollution, particularly of the commonest types, such as biochemical oxygen demand,
have been substantially reduced by these policies. Funding has been inadequate to fully address
deficiencies in municipal waste treatment, although progress has been made in this area, too.
However, because federal funding has been available only for end-of-line waste treatment, many
observers believe that the gains which have been made have been far more costly than would have been
necessary had policies which applied to all forms of pollution control been adopted.

Despite substantial successes in limiting point source pollution, the list of regulated pollutants
expands more slowly than the list of recognized ones. Regulation still does not extend to a variety of
synthetic organic compounds which are thought to be hazardous. Problems of demonstrating such
hazards, through epidemiologic or laboratory studies, abound, and both complicate and slow the
standard-setting process. Furthermore, little progress has been made in controlling non-point source
pollution, which by its very nature cannot be made subject to emission control permitting. This is
especially significant in the case of groundwater contamination with agricultural fertilizers and
pesticides. Addressing the non-point source pollution problem involves turning from emissions controls
to land use controls, traditionally an area of state and local responsibility in which federal authority is
sharply limited. The magnitude of the groundwater contamination problem has not yet been fully
explored, and the difficulties of addressing it through preventing future contamination, difficult as they
are, are overshadowed by the difficulties of remediating existing contamination.

Although aspects of the Clean Water Act addresses basin-wide planning and coordinated
pollution control (the so-called "208" process), comparatively little success was achieved in this area.
The Environmental Protection Agency is now turning its attention vigorously to what it calls
"watershed management," a process which logically should embrace a broad view of integrated and coordinated resource management, and one founded on the notion of sustainability. It is far too early to assess the prospects of this new overture, but it will certainly face the same obstacles of balkanized responsibilities and authorities which have effectively frustrated the attainment of river basin management in the United States to date.

LESSONS FOR THE NON-INDUSTRIALIZED COUNTRIES

The United States probably has committed more resources to river basin management than any other industrialized country. Yet it has fallen far short of attaining the ideals which that term implies, if White's five central ideas are used as the criteria for evaluation. Impressive achievements have been registered in the development and operation of multipurpose storage projects, yet the wisdom of constructing such projects is increasingly questioned, and few good opportunities remain in any case. Basin-wide programs have been formulated and implemented in only a few basins, and then only for very limited purposes. Comprehensive regional development has occurred only in a single instance, the Tennessee Valley, and that under an institutional arrangement which seems destined never to be repeated. Articulated land and water programs have not been planned, let alone implemented, except in that single exception of the Tennessee Valley. Finally, unified administration, too, can be found only in the Tennessee Valley.

It is easy to attribute the U.S. failure to attain the ideals of river basin management to bureaucratic turf-protection, and certainly that is involved. But some of the root causes lie deeper. The three systems of river basin management in the U.S. (water rights, water development, and water quality control) have different objectives, employ different governmental powers, are assigned to different levels of government, rely upon different branches of government, and respond to different political interests. Coordination is difficult and integration virtually impossible under such circumstances. One is led initially to advocate unified river basin management authorities, such as TVA, for non-industrialized nations, to help them avoid the problems encountered in the U.S.

A deeper view, however, might spring from the realization that multipurpose projects, basin-wide programs, comprehensive regional development, articulated land and water programs, and unified administration are not ends in themselves, but merely means to the end of efficient, equitable, and sustainable resource management. The range of means considered for attaining this lofty goal should be far broader than multipurpose projects, should extend beyond the river basin, should emphasize sustainability no less than development, should focus on the human dimension as well as land and water resources, and should examine coordinating mechanisms beyond the sometimes unattainable ideal of unified administration. Viewed from this perspective, the U.S. experience includes both successes and failures, and has many lessons for nations now embarked on the river basin management enterprise.

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DISCUSSION

QUESTION: Have there been any water resource conflicts between states or between states and the federal government? If so, how are they resolved?

Answer: The United States is normally a federation of sovereign states. As a result, when such conflicts arise, as they frequently have, unique and extraordinary measures are needed to resolve them.

States may reach agreements among themselves and/or with the federal government, and formalize those agreements as interstate compacts.

A second method is for the Congress to enact legislation containing the terms resolving such a conflict.

The third, and most common method is for litigation to be taken to the U.S. Supreme Court, and for that body to determine the terms of resolution.

QUESTION: What is the role of the U.S. Geological Survey, and how does it relate to state hydrologic data collection efforts?

Answer: The U.S. Geological Survey is a bureau within the Department of the Interior. Its mission is confined to the collection and analysis of scientific data, hydrology data included. It maintains a cooperate data collection effort with each of the fifty states.

QUESTION: What are the principal water resource agencies within the federal government?

Answer: The U.S. Army Corps of Engineers, in the Defense Department, has navigation, flood control, hydropower water supply, recreation, and water quality control and wetland responses.

The Bureau of Reclamation, in the Interior Department, builds and operates structures for irrigation, water supply, hydropower, and recreation in seventeen western states.

The Soil Conservation Service, in the Agriculture Department, has watershed management responsibilities and builds and operates small water storage projects.

The Environmental Protection Agency has the principal responsibility for water quality control; including established standards, monitoring compliance, enforcement and watershed planning.

The Federal Energy Regulatory Commission issues licenses for private hydroelectric power facilities, and determines the conditions under which such facilities are operated, and
The Fish and Wildlife Service operates hatcheries and refuges, and reviews water resource development plans to assure compliance with requirements for protecting fish and wildlife. The speaker also said that there are several other agencies which have less important role.

**QUESTION:** What are the current cost-sharing requirements for water project development?

**Answer:** When beneficiaries can be identified they are required to pay at least 25 percent of the costs of the project features from which they benefit, and those costs must be paid "up front." When the benefits of a feature are "widespread and general" no cost-sharing is required.

**QUESTION:** There are several agencies and states in a river basin. What is the arrangement between the various states for interstate basins?

**Answer:** All states have to agree to their plans.
CHAPTER FOURTEEN

WATER MANAGEMENT IN FRANCE

presented by Mr. J. LABRE

This chapter describes the system of water management used in France, drawing particular attention to its specific and original aspects. After describing how the French water management system has changed over half a century, the chapter then highlights two different aspects of it which are original in their development: the management of water resources, in particular the institutional and planning aspects; and the management of urban water supply and sewerage services with, in particular, private operators being brought in.

WATER IN FRANCE

Each year, France receives some 450 billion cubic meters of rainwater, of which 250 evaporate quickly or are absorbed by plants. The other 200 billion cubic meters feed aquifers, rivers, streams, and lakes. Half of this volume is technically and economically usable. About 30 billion cubic meters are abstracted, with about half of this amount used for cooling thermal power plants.

In an average year, overall precipitation is 800 mm, while in a dry year it may be as low as 600 mm. Water shortages can be much more serious in some areas than others, as shown by the droughts of 1976, 1982, and 1989, which successively affected the western and southern parts of France.

Water is a very important economic and social commodity in France: environment-related expenditure concerning water is estimated at about US$10 billion a year, with over half of this amount being spent on pollution control. About 150,000 people are permanently employed in water-related jobs in France.

ADMINISTRATIVE ORGANIZATION OF FRANCE

France covers an area of 549,000 square kilometers and has a population of 55 million. The population density is thus of the order of 100 inhabitants per square kilometer. The smallest administrative unit is the Commune (of which there are about 36,500), followed by the Départements (95), and the Régions (22).

Each Commune, from the largest (Paris) to the smallest (about ten inhabitants) elects a local council and a mayor to take care of the administrative functions of the Commune. The mayor and his local council decide what facilities will be provided in the Commune, particularly with regard to water supply and sewerage services, and are responsible for levying the taxes to finance them. The same
legal rules apply to large cities as to small Communes, as theoretically they assume the same responsibilities.

Each Département in France elects a council which has the power to grant financial aid to the Communes, particularly for drinking water and sewerage services. The Région has essentially a planning role and is administered by a Régional council. It should be noted that the boundaries of Départements and Régions were fixed in accordance with human factors and do not necessarily take into account the courses of rivers and streams, nor their catchment areas. Thus the administrative division of the country into Départements and Régions is not always adapted to a sound consideration of water resources management problems.

WATER POLICY IN FRANCE

Institutional aspects at the end of the 1950s

Until the post-war years, the demand for water remained well within the locally available resource capacity or were easily met, even if conflicts sometimes arose between users. Allocating water to a particular use -- urban, industrial, agricultural or inland waterways -- was generally possible without noticeably prejudicing the other uses. This situation with virtually no competition promoted a user-based management system; even so, this did not in any way hinder the development of water resources in France. Between the two world wars, major dam and irrigation projects were constructed the Compagnie Nationale du Rhone, created in the 1930s, before the Tennessee Valley Authority, paved the way in multipurpose development of a major river.

The responsibilities for water resources were at that time divided between:

- Ministry of Agriculture for rural water supplies (irrigation, water supply and sewerage for rural communities);
- Ministry of Public Works for shipping and flood protection;
- Ministry of Industry for industrial and power requirements;
- Ministry of the Interior, administrative supervisor of the Communes;
- Ministry of Health for aspects relating to hygiene;
- Ministry of Finance for questions of finance.

Legal aspects

French legislation in matters pertaining to water distribution and use has for many years been based on a variety of texts which nonetheless have the same dual aim of fair distribution and, more recently, a certain minimum quality. Until 1964, water rights were dominated by the Code Civil of 1804 and, above all, by the law of 1898. According to this law, the State made a distinction between rivers and streams in the public domain and those not in the public domain, and had the powers strictly required for operating inland waterways and avoiding abusive use of water. This law of 1898 also recognized the right of a landowner -- whether private or public -- to use (but not to own) the water that the land receives and the ground water in the subsoil.

Thus a landowner could use rainwater falling on his land, as well as spring water, within the limits of his requirements. Those occupying land bordering rivers which were neither navigable nor floatable, i.e., not publicly owned, could use the water within certain limits. As for groundwater, it
was considered an "accessory" of the land and the owner was free to use it within certain depth limits, defined by local regulations.

The law of 1917 on "hazardous establishments" was the first of its kind in the developed countries. Its purpose was to restrict and control the harmful effects and pollution caused by industrial activities.

The need for change: the 1964 Act

In the post-war years, France experienced considerable demographic and economic growth (the GNP in constant francs tripled between 1949 and 1969), resulting in a substantial increase in the demand for water and, as a direct consequence a considerable rise in all kinds of pollution. It was at this time that France -- until then a rural nation -- experienced the phenomenon of urban concentration that Germany and Great Britain had known several decades before. Urban water requirements thus quickly increased with, as a result, a corresponding growth in domestic pollution. At the same time, the industrial revival of the country accentuated the pressure on water resources and led to a considerable increase in the pollution of the natural environment. Irrigation needs also grew as extensive areas outside the traditionally irrigated zones of the south became equipped with irrigation facilities. Finally, this period also saw the completion of the hydropower development program -- with a significant impact on river regimes -- and the commissioning of thermal power plants, which are particularly large consumers of water.

Very quickly, a number of difficulties appeared -- water shortages and pollution problems -- resulting from constant, uncontrolled use of water resources and the various types of pollution, especially urban and industrial, affecting the quality of surface water and groundwater. Local conflicts thus became more common on account of these water shortages or pollution problems.

Gradually, a greater awareness of the limits and vulnerability of water resources developed among the public, local officials and the more "sensitive" user groups such as fishermen's associations. The public authorities were therefore confronted with conflicts between users, whether the problems were quantitative, in particular the amounts used in times of drought, or qualitative, especially the industrial pollutant and toxic outfalls in rivers. These user conflicts then developed into conflicts between administrative bodies, often leading to complex and difficult situations.

This increasing number of difficult situations gave rise to the reassessment which began in 1958 and finally resulted in the Water Act of 1964. A Water Commission was set up in 1959, a sort of "think-tank" comprising the various parties involved in water management. This Commission outlined a number of general principles, which at the time were quite innovative even if today they may appear somewhat commonplace:

In the same hydrographic basin, and even more so in the same sub-basin, there is increasing interdependence among users who abstract water in the same natural environment and a strong feeling of solidarity must be developed between users so as to encourage everyone to minimize pollutant outfalls.
Rational water management is only possible if it is recognized that water has an economic value, a notion which has been underlined as a result of competition among uses. Similarly, pollution has a real economic impact.

The water resources of a given basin (groundwater and surface water) must be considered as a single resource and, as such, long-term planning of water development and protection is required, taking into account the needs of all users and the impact of all abstractions and outfalls in the basin as a whole.

It was therefore necessary to change from a user-based water management system to an integrated or holistic approach. To prepare a new water policy based on these principles and instituted by legislation, a Permanent Secretariat for the Study of Water Problems was set up in 1960. The work of this Secretariat resulted in the drafting of a bill at the end of 1963 concerning water distribution and pollution control. The bill was finally adopted at the end of 1964.

France was undergoing important political and administrative changes during this period which made it possible to envisage such profound reforms in water management. While the entire economy was centralized in the hands of the state after the second world war, there was a gradual emergence and growth in the autonomy of local and Regional authorities (the Régions were created in 1963), with the Communes acquiring at that time their own financial resources. One should also take into account the economic forces existing at that period, not only the more traditional groups such as the farmers, but also those of the industrial and town lobbies. Thus, the reform of the water management system owed its success in large part to its adaptability to the economic, administrative and political situation of the time.

The outline law of 16 December 1964 has profoundly modified water policy strategy in France:

- It establishes legislation and regulations for pollution control, introduces the notion of quality objectives and sets time periods in which they are to be met, placing the emphasis on solidarity among users with regard to these objectives.

- It increases the policing and supervisory powers of the State as well as the means for settling disputes, and introduces the notion of the catchment area for dealing with water problems.

- It introduces an economic dimension in order to identify the financial resources necessary for the investments which have to be made, particularly through the creation of the Basin Committees (Comités de Bassin) and the Water Boards (Agences Financières de Bassins).

With this law, the foundations for water management in France were established and put into concrete form. The system is underpinned by three principles of equal importance: regulation, incentives, and dialogue. Effective implementation of the law has since involved two main aspects:

(i) development of government action with respect to anti-pollution measures; and,
(ii) introduction of economic means of intervention through the Water Boards.

The establishment of the Water Boards was followed in 1971 by the creation of a Ministry of the Environment which prepares water policy, fixes regulations and organizes planning. The Ministry
of the Environment is the supervisor of the Water Boards, which in 1990 became known as the "Agences de l'Eau.

Regular updating: the 1992 Act

Since 1968, when the law came into force, considerable improvements have been made in every area of water management in France but none of the basic principles of the 1964 Act have been called into question. However, a certain number of new factors have appeared during this period, namely:

(i) recurring drought lasting several years;
(ii) new types of pollution, related in particular to farming practices;
(ii) insufficient development in the field of wastewater treatment (cleansing rate of the order of 40% in 1989); and,
(iv) inadequate consideration of the problem of stormwater.

In view of these factors it was necessary to renew and upgrade existing facilities, particularly since France has had to meet requirements stemming from European directives on water management in force since 1975. Preparation of the 1992 Act began in 1984. The Act aimed at:

- Remedying the inadequacies and disparity of existing legislation and eliminating obsolete clauses or those no longer applied;
- Improving the effectiveness of water policing;
- Expressing the uniqueness of the water domain (oceans, surface water, groundwater) in the form of appropriate legislation and regulations;
- Facilitating the role of local authorities in water management affairs; and,
- Promoting balanced management of water and aquatic environments.

Among the most innovative aspects of the Act of 3 January 1992, all of which are in line both with past practices and current European and world trends, the following are worthy of mention:

- Recognizing water as part of the nation's heritage;
- Setting up of a unified legal system;
- Introducing of an original system of planning;
- Upgrading the powers of the Communes, particularly with respect to sewerage services; and,
- Increasing consultation with elected representatives and water users, and greater openness towards the general public.

WATER RESOURCE MANAGEMENT

Modern water management practices in France were introduced by the 1964 Act and improved and adapted over the years and specifically by the 1992 Act. Water is now considered as part of the common heritage; its management is based on an integrated and balanced approach which aims both at satisfying users and preserving the natural environment. The present French system involves every level of the administrative machine -- State, Régions, Départements, Communes -- the users, the elected representatives and, at the basin level, the Basin Committees (Comités de Bassin) and the mainstays of
the organization: the Water Boards (Agences de l'Eau). This section successively describes the institutional structure of water management in France, the recently-introduced management planning tools and, because of their importance and originality, the Water Boards.

INSTITUTIONAL STRUCTURE

Central level (State)

The trend over recent years has been to group together the scattered bodies with responsibilities in the field of water management within the Ministry of the Environment or its agencies. A Water Directorate (Direction de l'Eau) was thus set up in 1992 within the Ministry of the Environment, its aim being to strengthen the role of the State in the area of water management, to exercise more effective supervision and coordination of the Water Boards, and to provide fresh impetus for the decentralized external services.

In preparing its water management policy, initiating and monitoring water use regulations, and planning organization, the Water Directorate receives guidance from:

(i) the Mission Interministérielle de l'Eau (Interministerial Water Commission) representing 13 ministries; and

(ii) the Comité National de l'Eau (National Water Committee) which consists of representatives of the different categories of water users, river basin authorities and the government, and expresses opinions on national water management policy.

In 1992, the Ministry of the Environment set up decentralized external services known as Directions Régionales de l'Environnement, or DIREN, (Regional Environmental Directorates). The role of these services in water management is described later. For the moment, however, the Ministry of the Environment calls on the external services of other ministries - Agriculture, Public Works, Health, Industry - for assistance, particularly in its policing role.

Hydrographic basin level

The fundamental concept introduced by the law of 1964 was the creation of an inseparable tandem covering the major river basins: the Comité de Bassin, an authentic river basin "water parliament," which defines the water policy in the basin, and its government, the Agence de Bassin, which implements the policy defined by the Comité de Bassin.

The 1964 Act resulted in the division of France into six hydrographic basins or, more exactly, groups of basins, a division which was formalised in 1966 by decrees relating to the Basin Committees and Water Boards. The six basins (see Figure 14.1) correspond to the following:

(i) the country's four main catchment areas (Garonne, Loire, Rhone and Seine), to which secondary basins were attached; and,

(ii) two specific border basins, in the North and North-East of the country, in areas of dense population and intense industrial activity.
The limits of these basins correspond to the watersheds and are generally not the same as the administrative limits. The main characteristics (area and population) of these basins are as follows:

<table>
<thead>
<tr>
<th>River Basin</th>
<th>Area (km²)</th>
<th>Population (1990)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adour-Garonne</td>
<td>115,000</td>
<td>5,700,000</td>
</tr>
<tr>
<td>Artois-Picardie</td>
<td>20,000</td>
<td>4,600,000</td>
</tr>
<tr>
<td>Loire-Bretagne</td>
<td>156,000</td>
<td>11,500,000</td>
</tr>
<tr>
<td>Rhin-Meuse</td>
<td>31,300</td>
<td>4,100,000</td>
</tr>
<tr>
<td>Rhône-Méditerrannée-Corse</td>
<td>129,000</td>
<td>12,400,000</td>
</tr>
<tr>
<td>Seine-Normandie</td>
<td>97,000</td>
<td>17,700,000</td>
</tr>
</tbody>
</table>

Each basin has its Basin Committee, which defines water management policy for the basin; such committees facilitate dialogue and the expression of solidarity between members. The composition of the Basin Committee is fixed by ministerial order and includes three groups:

(i) users, qualified local dignitaries and representatives of socio-professional groups, making up the largest group (40 to 45 percent of seats);
(ii) representatives of the different authorities (Régions, Départements, Communes), accounting for 36 to 38 percent of seats; and,
(iii) representatives of the State (19 to 23 percent).

The total number of committee members varies between 61 and 114, depending on the basin. This organization, which deliberately limits the influence of the State, reflects the desire to promote the role and responsibility of the different actors in each basin -- users and elected representatives -- and to encourage them to reach agreement. The Basin Committee, which generally meets twice a year, is systematically consulted and must give its approval on fees (redevances) and the basis for their calculation. These are presented by the Water Board along with its action program.

The Basin Committee's executing agency is the Water Board, an administrative public body which comes under the responsibility of the State in two fields: in technical matters it answers to the Ministry of the Environment (Water Directorate), while in financial matters it is responsible to the Ministry of Finance. Each Water Board has a Board of Directors comprising twenty-six members who are generally appointed or elected for six-year terms:

- Eight representatives of the State, for each ministry concerned by water problems;
- Eight representatives of the different user categories elected by the representatives of this same category on the Basin Committee;
- Eight representatives of the regional authorities (Communes, Départements, Régions), elected in the same way;
- One representative (elected) of the personnel of the Water Board; and,
The Chairman of the Board of Directors, appointed by decree for three years. The Water Board directors are appointed by order of the Ministry of the Environment. The Water Boards are the key elements in the organizational structure established to manage French water resources. The tasks and resources of the Water Boards, and the results they have achieved, are analyzed below.

At the basin level, under the 1992 Act, the Prefect of the Région where the Basin Committee has its main offices is assigned the role of Coordinating Prefect for the Basin (Préfet Coordonnateur de Bassin). He implements and coordinates State policy with respect to the policing and management of water resources and ensures that the actions of the State are coherent. He is assisted by the regional Environmental Directorate, which thus acts as Basin Delegate. The Coordinating Prefect therefore has an essential role in providing impetus in water management matters. This is clearly seen in planning, for it is he who takes the initiative in preparing the Water Management and Development Master Plan for the basin.

Regional level

The Région is responsible for regional planning. Consequently it plays an essential role in implementing water policy by integrating the development of water resources in regional development plans. The Régions are represented on the Basin Committees and on the Water Boards. The Régions can allocate subsidies for studies and works related to water management. Most of their operations are carried out within the context of contracts with the State.

At the regional level, State intervention in water affairs is through the Préfet de Région who coordinates the decentralized services of the State in implementing measures which go beyond the limits of the Département. In this role he is assisted by the services of the regional Environmental Directorate (DIREN) and, for industrial problems, the Regional Directorate for Industry, Research and Environment (DRIRE).

The Préfet de Région where the Basin Committee has its head offices plays a particularly important role in coordinating and implementing State policy. He also ensures the unity and coherency of decentralized State actions in the Régions and Départements concerned by the basin.

Département level

The State is represented by a Préfet de Département whose powers have been significantly strengthened by the 1992 Act. Indeed, the recognition of water as part of the nation's common heritage and the fact that its protection has been declared as being in the general interest, with an improved range of administrative sanctions to match, have considerably increased the legal basis for the actions and powers of the Préfets de Département. Furthermore, like the Préfet de Région coordinating the basin, the Préfets de Département are invested with local "crisis powers" in the event of accidents, drought, floods or shortages.

The Département is in fact the basic administrative level for State intervention in the policing and management of water resources and aquatic environments and in preparing and following up planning documents. The Département offices of the ministries concerned (Public Works, Agriculture, Inland Waterways, Industry, Health) come under the authority of the Préfet.
It is worth noting that the increasing amount of domestic pollution has resulted in almost every Département setting up Technical Assistance Services (SATESE) to provide help for the operators of sewage works. The financing of these services is generally shared by the Département council and the Water Board. The technical assistance services cover three main areas:

(i) preparation of reports on the operation of sewage treatment works, and provision of assistance as needed;
(ii) monitoring of structures to ensure that health standards are met; and,
(iii) data collection with a view to awarding purification bonuses, explained later.

The State subsidizes the Départements for works related to water supply and sewerage systems. These funds are drawn from the financial resources of the National Fund for the Development of Water Supply Systems (FNDAE). This fund receives money from a surtax on water consumption, but mainly from a tax on, of all things, the PMU (national tote betting system).

Gradually, and especially since the decentralization legislation of 1983, the Départements have supplemented and subsequently taken over the role of the State. At present, the participation of Départements in the water and sewerage investments of the Communes (in the form of subsidies) accounts for 15 to 25 percent of total investment, depending on the size of the Communes.

Commune level

For more than a century, the Communes benefited from the provisions of the Codes des Communes, which gave them responsibility for the water supply and sewerage services. The law of 1992 defines in greater detail the obligations and financial resources of the Communes with respect to sewerage to enable them to meet the deadlines fixed for respecting European directives, especially the EEC Directive of May 1991 which stipulates that community sewerage systems must be completed over the entire territory by 31 December 2005 at the latest.

With regard to the management of water supply and sewerage services, the Communes have a monopoly which can be exercised directly by the Communes or groups of Communes (local utilities responsible for serving about 25 percent of the population in France) or by delegation to a private operator.

This possibility of delegating the management of water and sewerage services has been written into the local community law (Code des Communes) for more than a century and constitutes an original aspect which is specifically French. It is for this reason that it is the subject of a special chapter.

Through the preparation of Water Management and Development Plans, local authorities now have an important role to play in resource planning. It should be remembered that they are represented on the Basin Committees and consequently on the Board of Directors of the Water Boards.
PLANNING TOOLS

An original system of planning the development and management of water resources was institutionalized by law in 1992. This law lays down the procedures to be followed concerning the policing and management of water resources at two geographical levels, the entire hydrographic basin and the individual hydrographic unit (river or aquifer).

The Water Resources Development and Management Master Plan (SDAGE) thus determines, for a basin or group of basins, policy orientations for sound water resource management. Taking into account the main programs put forward by the public authorities, it defines, in a general manner, the objectives concerning water quantity and quality as well as the development works to be carried out to reach these objectives. It defines the perimeter of the sub-basins corresponding to the hydrographic units.

The SDAGEs are prepared by the Basin Committee at the initiative of the Préfet de Région for the basin, and cover a period of five years. Users and locally elected representatives are thus involved in the preparation of the Master Plans through the Basin Committee. The preparation of the Master Plan also brings together the representatives of the Région and Département.

After the Master Plan has been adopted by the Basin Committee, it has to be approved by the administrative authority, thus underlining a certain pre-eminence of the State in water management matter. Following this, the Master Plan is made available to the public.

The SDAGEs also ensure the coherency of the Water Resources Development and Management Plans (SAGEs). The latter are drawn up for the sub-basins corresponding to hydrographic units or aquifer systems, or for a group of sub-basins, and define the general objectives for the use, development and quantitative and qualitative protection of surface and ground water resources and aquatic ecosystems, as well as the preservation of wetlands.

The preparation, revision and monitoring of a SAGE are the responsibility of a special commission. The commission consists of representatives of the local community, accounting for about half the members, representatives of users, owners, riverside dwellers, professional organizations and associations, accounting for about one quarter of the members, and representatives of the State and its public bodies, including the Water Boards, who account for the other quarter of the group. From its composition, it is clear that this commission aims to involve all the parties concerned by water management as much as possible at the local level, by structuring it around the local community.

The draft of the SAGE is then made available to the public for two months with a view to obtaining their opinions and observations. After any necessary modifications have been made, the SAGE is submitted to the authorities concerned and the Basin Committee for their opinions, then approved by the administrative authority. Following this, the Plan is made available to the public.

To make it easier to meet the objectives of the SAGE, the law provides for the possibility of establishing a public body (Commonauté Locale de l'Eau/Local Water Community) which will act as the Owner for public works, structures and installations executed in the pursuance of the objectives of the SAGE.
This hierarchy in the planning process (SDAGE/SAGE) is to a large extent inspired by urban planning procedures (urban planning and development master plans/land use plans). As with urban planning, it is a relatively complex procedure supervised by the State but involving considerable participation from the different parties concerned, both its preparation and in its implementation.

WATER BOARDS

When they were set up in 1967-1968, the Water Boards (Agences Financières de Bassins, now know as Agences de l'Eau) were assigned a dual role: a main role in taking part in the financing of general works in the basin, and a subsidiary role involving water-related research studies.

This second role, though not of great importance compared with the first, is nevertheless not negligible. Each Water Board operates rainfall and flow gauging networks and data bases, which provide them with detailed knowledge of the basin. The Water Boards conduct individual and joint studies and research projects in certain fields related to their activities, such as nitrate and pesticide pollution, rain water management, accidental pollution, etc. The results of such work are published and distributed to interested agencies and individuals. The Water Board also provides assistance and expertise, particularly with regard to the training of water management personnel.

However, the main role of the Water Boards is still to provide financial incentives. The Water Board is neither owner nor contractor of works implemented for improving and preserving water resource. Its involvement in such cases is purely financial.

The general community must learn that its unacceptable to waste or pollute water. It is not sufficient simply to promote awareness of this precious heritage. The public must be made to see the advantages of not wasting or polluting water -- or at least causing less pollution -- and to achieve this there must be incentives. The Water Boards use two economic instruments to combat wastage and pollution:

(i) On one hand, the fees (redevances) paid by water users and polluters according to the volume of water used or the pollution caused. This is the principle of the "the user/polluter pays."

(ii) On the other hand, financial assistance ("aides"): money collected in fees is reinjected in water-related economic channels to help the public or private sector to save and purify water by helping them invest in water conservation and anti-pollution techniques and equipment. This is the principle of "those who protect water receive help."

Action programs

Financial actions implemented by the Water Boards (collection of fees and distribution of financial aid) are carried out within their pluri-annual action programs (generally five-year programs), which are presented by the Water Boards to their Basin Committees. The decree governing the creation of the Water Boards specifies that the amount of fees levied by a Water Board will have to meet within the context of the pluri-annual action program, and is approved by the Prime Minister upon
recommendation by the Interministerial Water Commission. The action program, which thus legitimizes the fees, is the basic instrument which determines both their nature and their amount.

The action programs must necessarily be in keeping with the socio-economic options taken at the national level, particularly with regard to general water policy. In terms of volume, the action program has no limits other than the level of fees. But these are voted by the Basin Committees of which nearly two thirds of the members are water users and thus subject to the fees. There is thus a form of self-regulation in the process of drawing up the programs.

The action program of each Water Board comprises three sections:

(i) analysis of the problems existing in the basin, hence the value of information provided by the gauging networks and data bases;
(ii) list of type of operations to be carried out, assessment of their cost accompanied by an estimate of the assistance that the Water Board expects to provide; and,
(iii) fee system to ensure the program's financial equilibrium.

The types of action covered by the program may vary considerably from one Water Board to another, depending on their specific characteristics and their priorities. These actions generally concern:

- Development, planning and protection of water resources, through financial assistance for operations such as the protection of water catchment areas, the development and maintenance of rivers, water demand control, etc., or structures of general interest such as regulation dams;
- Water pollution control, regardless of origin, particularly by providing assistance for the construction, extension or refurbishment of sewage works and sewerage networks, but also through help to improve industrial processes with a view to reducing pollution; and,
- Improvement and security of drinking water supplies, for example through financial assistance to establish special treatment procedures and install interconnection systems in areas where the water supply is particularly vulnerable.

The action program does not generally identify each individual operation which may benefit from financial assistance, but identifies the types of operations and structures which are eligible, the level of financial assistance (percentage of the cost of the operation) from the Water Board for each category and the nature of the assistance (grant, interest-free loan), depending on the legal status of the beneficiary, whether public (associations, public corporations, State) or private (industry in particular).

Water fees

Under French law, Water Boards are authorized to collect fees from public or private persons who contribute to the deterioration of water quality, who abstract water from the water resources or who modify the water regime in part or all of the basin. In such cases, these are "active" or "responsibility" fees.

Another type of fee may also be collected from public or private persons benefiting directly or indirectly from works or structures completed with assistance from the Water Boards. Such fees are known as "passive" or "beneficiary" fees.
Anyone who pollutes, abstracts or consumes water is subject to the fee. This includes:

- towns and urban centers which abstract and consume large amounts of water and produce pollutant loads;
- industries which, in general, abstract and consume little water but cause many different types of pollution;
- farmers, who abstract a lot of water during certain periods and cause widespread pollution of rivers and groundwater;
- inland waterways; and,
- the French Electricity Board (EDF), which abstracts and consumes large quantities of water.

The Water Boards distinguish two types of fees, the "pollution" fee, related to discharges into the natural environment, and the "resource" fee, related to abstraction and consumption.

Pollution fee and purification bonus

Pollution fees are based on the volume of pollutant load discharged into the natural environment. For domestic pollution, the fee is based on the total population. Each inhabitant contributes to the cost by means of a surtax on the price of water, which is then transferred by the water utility to the Water Board. For non-domestic pollution, the amount of pollution is either measured or estimated in terms of a lump sum on the basis of the activity concerned.

The above fees are gross fees and correspond to the gross pollutant load before any purification treatment. When, as is most frequently the case, waste treatment plants have been installed, a purification bonus is awarded to the community or industry which is deducted from the gross fee levied to obtain the net fee:

The amount of pollution fees is fixed by each Water Board so as to balance its anti-pollution program. The rates are adjusted geographically according to the quality priorities and objectives defined by the Basin Committee.

In 1987, gross pollution fees amounted to about US$350 million (for all Boards), or 60 percent of the total revenue of the Boards, while purification bonuses accounted for US$75 million, or 15 percent of total Water Board expenditures.

Resource fees

These fees are used to cover part of the program for quantitative water management, financing storage reservoirs, water distribution systems, and irrigation structures. The resource fee is in fact a combination of two fees:

(i) the fee for water abstraction or modification of the water regime, the amount of which is determined according to the volume of water abstracted, measured or estimated; and,
the consumption fee - determined by a coefficient - depending on water usage - applied to
the net consumption. This coefficient is, for example, 0.20 for water distribution and 0.70
for sprinkler irrigation.

Like the pollution fee, the resource fee for the water supply system is collected as a surtax on the
price of water, which is then transferred by the water utility to the Water Board.

Resource fee rates vary considerably, depending on whether they apply to groundwater or surface
water, whether the requirements in the area are high or low, whether abstractions are regular
throughout the year or concentrated in the dry period. In 1987, resource fees collected by the Water
Boards amounted to US$ 85 million, or one quarter of the amount collected in pollution fees.

Water Board budget

For the current sixth five-year program (1992-96), the total budget of the Water Boards amounts to
about US$7.5 Billion (1991 prices), distributed as shown in Table 14.2.

Table 14.2 Water Boards Budget

<table>
<thead>
<tr>
<th>Revenue</th>
<th>Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Board fees:</td>
<td>Financial assistance:</td>
</tr>
<tr>
<td>· pollution fees 68%</td>
<td>· grants 40%</td>
</tr>
<tr>
<td>· resources fees 14%</td>
<td>· loans 25%</td>
</tr>
<tr>
<td>Loan repayments: 18%</td>
<td>· purification bonuses: 12%</td>
</tr>
<tr>
<td></td>
<td>Operation: 9%</td>
</tr>
<tr>
<td></td>
<td>Research, development and</td>
</tr>
<tr>
<td></td>
<td>gauging networks: 14%</td>
</tr>
</tbody>
</table>

The Water Boards' total budget for the sixth five-year program is nearly twice as much as the
budget of the fifth five-year program (1987-91). The total cost of works subsidized by the Water
Boards will increase in the following manner (1991 prices), reflecting the considerable efforts being
made to reduce all types of pollution, whether domestic, industrial, or agricultural (Table 14.3).
Table 14.3 Cost of Water Boards Works

<table>
<thead>
<tr>
<th>Activity</th>
<th>Fifth Five-year Program costs</th>
<th>Sixth Five-year Program Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban and Rural Sewerage</td>
<td>4,100</td>
<td>7,700</td>
</tr>
<tr>
<td>Industrial Pollution Control</td>
<td>1,100</td>
<td>1,900</td>
</tr>
<tr>
<td>Improvement of Agricultural Practices</td>
<td>--</td>
<td>600</td>
</tr>
<tr>
<td>Water Supply</td>
<td>1,700</td>
<td>2,700</td>
</tr>
<tr>
<td>Water Resource Development</td>
<td>700</td>
<td>1,100</td>
</tr>
<tr>
<td>Environment</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7,800</td>
<td>14,400</td>
</tr>
<tr>
<td><strong>Amount of financial assistance provided by Water Boards</strong></td>
<td>--</td>
<td>6,200</td>
</tr>
</tbody>
</table>

1. Costs are expressed in millions of US dollars.

**MANAGEMENT OF MUNICIPAL WATER**

**Supply and Sewerage Services**

The *Code des Communes* stipulates that water distribution is an industrial and commercial public service in the *Communes*. The same is true of waste water disposal and treatment. The *Communes* have the exclusive power to grant the right to use public land within their boundaries. Since this right is granted only to one operator for water supply and/or sewerage, these services are *de facto* monopolies.

For a great many years, neighboring *Communes* and clusters of *Communes* have tried to settle their infrastructure problems by creating joint bodies such as intercommunal associations, urban communities, districts, etc., to which they have delegated their powers, in particular concerning water supply and sewerage services. The result is that there are over 4600 intercommunal services throughout France. Water supply and sewerage services in the community are under the technical, administrative and financial supervision of the State (Ministry of the Interior), while the Ministry of Health is responsible for monitoring the quality of water that is distributed.

Under French law, communities have the power to create and manage water distribution and sewerage services provided to the public. This is known as direct management, and concerned about 25 percent of the French population in 1992 (as opposed to 70 percent in 1945). Communities also have the legal right, where they feel it necessary, to delegate all or part of their task to a private operator. This is known as delegated management, and may be implemented in a wide variety of ways: management contract, lease contract, concession contract, or any combination of these.

When a local community uses a private operator, it may be for a variety of technical or financial reasons but such action often results from:
The increasing complexity of water supply and sewerage tasks: increasingly refined treatment processes in response to the deteriorating quality of raw water; sophisticated purification processes required to meet increasingly higher standards concerning wastewater; management of an increasing number of consumers; and,

The problems encountered by the community in generating sufficient funds to ensure maintenance and replacement of equipment and to finance the development of water and sewerage systems.

Nonetheless, the Communes always have control over the management method selected, without outside interference, in particular from the administrative supervisor.

THE DIFFERENT TYPES OF MANAGEMENT

Direct management

Under this type of management system, the community is responsible for the creation, development and management of its water supply and sewerage services. The community constructs the necessary structures and renews them as required, with work performed by its own personnel. It fixes the rates and is responsible for its own expenditures and revenue. This direct management by the community, without outside assistance - known as integrated management in EEC terminology - is very conventional and will not be discussed here below.

Delegated management

Delegated management, whatever form it may take, involves delegating management to a private operator. However, in every single case, the community always retains ownership of the structures and equipment. In France, delegation concerns only the management of water supply and/or sewerage services and does not involve the transfer of structures and equipment, even when they are financed by the private operator. In certain countries, the involvement of the private sector is accompanied by a transfer of assets, as happened in the case of the British Water Authorities. In such cases, privatization can be said to be virtually definitive but this term cannot be applied to the French situation, where delegation of management responsibilities is reviewed periodically.

Delegated management can generally be divided into two types, depending on whether the possible operating deficit is borne by the community or by the private operator.

When management of water supply and sewerage services is not provided at the risk of the private operator but at the risk of the community, it may be one of two kinds:

(i) "gérance" where the operator ensures the operation of the services only and receives a fixed payment for doing so;

(ii) "régie intéressée" where the operator is also involved in determining the tariffs and where he receives, in addition to his remuneration, an additional sum in relation to the service management results.
These formulas have gradually been replaced by contractor-type contracts where the operator takes full responsibility for proper use of facilities and accepts the financial operating risks for a fixed price within the framework of a long-term contract. Two such contracts may be identified:

(i) lease contract (*affermage*): the most widespread form of delegated management in France. In this type of contract, the operator (*fermier*) is responsible for managing the service, while the community is responsible for building new structures, including related financing; and,

(ii) concession contract: in this case the operator (the concession-holder) is responsible not just for managing the service at his own risk but, in addition, for financing and building structures.

**Lease and concession contracts**

These two types of delegation represent the great majority of contracts involving delegated management in France, and in fact constitute one of the most original aspects of French water management.

For both lease and concession operations, there are model or typical specifications sheets prepared by the government which provide a framework for drawing up the contracts. Each community wishing to lease or grant a concession for its water supply of sewerage services adapts such specifications to its specific characteristics and its own needs. Thus, original contracts have started to make their appearance, "hybrid" contracts somewhere between a lease and a concession. Some leases may include small concessions, where the operator is no longer solely responsible for the building of structures. However, the legality of delegated management contracts is in the end checked by the government, in this case by the *Préfets de Départements*.

The initial contracts for the delegation of management are generally awarded following a call for tender, on the basis of specifications prepared by the local community in accordance with their specific needs. When the contract reaches the expiry date, its extension, with modifications to take into account new conditions, is generally renegotiated with the current operator.

A leasing contract generally lasts for twelve years, a relatively short period, which explaining its popularity. A concession lasts between 20 and 30 years. The length of this type of contract allows the concession holder to cover initial investment costs without resorting to excessive tariffs. The contract may be terminated by the community in the event of a particularly serious offence by the operator. This, however, is extremely rare.

An important aspect of the change from direct management to delegated management concerns the integration into the new system of community personnel, often somewhat numerous in relation to real needs. The integration of all or part of the personnel, and their status in the new structure, may constitute an important criterion in selecting the operator. These considerations concerning community personnel are then specified in the contract.
Contracts also specify which works, within the area covered by the lease or concession are the responsibility of the collectivity and which are the responsibility of the operator (new works, renewal, maintenance, repairs to main structures). They also give details of responsibilities with regard to connections and water meters.

Regarding pollutant outfalls in the natural environment and quality of distributed water, the contracts refer to the regulations in force. In this area, both lease-holders and concession holders come under the control of the Ministry of Health.

Finally, tariffs are determined in the contracts. Tariffs generally include a fixed part (subscription) and a part which is proportional to consumption (binomial tariff). The tariff is established on the basis of the forecast operating statement submitted by the operator in support of his bid and which takes into consideration the foreseeable changes in income and expenditure over the duration of the contract.

This document, which is non-contractual, facilitates contract negotiations. The contracts also include inflation-indexed water tariff revision clauses; revision of water rates takes into account, in particular, the changes in salaries and social charges as well as the cost of energy and chemicals.

THE PRICE OF WATER IN FRANCE

At the present time (1993) in France there are about 13,000 water supply services and about as many sewerage services. There are therefore at least 13,000 different prices for water. Recent surveys revealed differences in average prices between regions of 20 - 50 percent, with an extreme ration of 1:20 between the lowest and highest prices observed (about US$0.17 to US$3.40).

There are several reasons for such price differences, the most important being:

- Presence or absence (rural Communes) of sewage works, the cost of which is reflected in water bills;
- Quality and proximity of available water resources;
- Population served (economies of scale);
- Impact of recovering investment costs for works, which can vary considerably from one Région to the next; and,
- Cost of maintaining structures and equipment, in other words the quality of facilities.

The composition of a water bill in France is shown in Figure 14.4 and Table 14.4 illustrates the wide range of water rates in urban areas in France.
Figure 14.1 The Composition of a Water Bill

![Diagram showing the composition of a water bill]

Table 14.4 Urban Water Rates

<table>
<thead>
<tr>
<th>City</th>
<th>Price¹</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aix-en-Provence</td>
<td>1.07</td>
<td>1992</td>
</tr>
<tr>
<td>Bordeaux</td>
<td>2.68</td>
<td>1992</td>
</tr>
<tr>
<td>Calais</td>
<td>1.61</td>
<td>1992</td>
</tr>
<tr>
<td>Creil</td>
<td>2.70</td>
<td>1993</td>
</tr>
<tr>
<td>Grenoble</td>
<td>1.79</td>
<td>1992</td>
</tr>
<tr>
<td>Lyon</td>
<td>2.50</td>
<td>1992</td>
</tr>
<tr>
<td>Paris</td>
<td>1.79</td>
<td>1993</td>
</tr>
<tr>
<td>Rouen</td>
<td>1.96</td>
<td>1992</td>
</tr>
<tr>
<td>Saint-Etienne</td>
<td>2.45</td>
<td>1993</td>
</tr>
<tr>
<td>Soissons</td>
<td>2.53</td>
<td>1993</td>
</tr>
<tr>
<td>Versailles</td>
<td>1.96</td>
<td>1992</td>
</tr>
</tbody>
</table>

¹ Prices given in US$ per cubic meter, including sewerage and taxes.

The considerable investments that will have to be made in the coming years, particularly in order to comply with European Community directives on sewerage, will also have a significant impact on the price of water by the turn of the century.

A simulation study was carried out using four types of fictitious cases, the results of which are presented in Table 14.5:

(i) a small, under-equipped rural Commune;
(ii) a small town with insufficient sewerage;
(iii) an average-sized town;
(iv) an intercommunal association equipped with standard facilities.
Table 14.5 Water Prices (current and projected)

<table>
<thead>
<tr>
<th>Community</th>
<th>Current Prices</th>
<th>Projected Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water</td>
<td>Sewerage</td>
</tr>
<tr>
<td>Rural Commune</td>
<td>0.36</td>
<td>0.00</td>
</tr>
<tr>
<td>Small town</td>
<td>0.89</td>
<td>0.74</td>
</tr>
<tr>
<td>Average town</td>
<td>1.34</td>
<td>0.79</td>
</tr>
<tr>
<td>Intercommunal association</td>
<td>2.14</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Prices are in US$/cubic meter, excluding taxes.

Increases will be greatest where current prices are the lowest and will thus help reduce the price differences which have been observed up till now.

*Mr. Labre is the Deputy Managing Director of SAFEGE Consulting Engineers in Nanterre, France.*

**ENDNOTE**

1. This paper is an informal report commissioned by the World Bank in 1993 to describe the system of water management used in France. Its aim is not to provide an exhaustive description of the system, but to draw attention to its specific and original aspects.
DISCUSSION

QUESTION: How are the pollution fees and fines efficient in related to cleaning of water sources?

Answer: The French system is based upon two different ways to orient the individual decisions in the sense of collective interests regarding the quality of water as follows:

- A legal and policing way (authorizations for discharge, delivered by the representative of the state; Generally the trespassers can be prosecuted, fined or even jailed).

- An incentive system, managed by the water agencies, based upon pollution fees with purification bonuses.

This dual system proved to be very efficient to reduce industrial pollution, because industrialists are sensitive to economic incentives, and the power of administration on them can be important (a few factories were closed in extreme cases).

The efficiency of the pollution fees and fines was not good as expected to reduce domestic pollution, although a regular and slow improvement exists in the field. The causes are as follows:

- The cost of the improvement of sewerage systems is very high, especially for the sewer networks and the fees were not enough incentive in the past: They have been increased two fold recently,

- The power of the state administration on the municipalities is not very important, because it is not possible to close a municipal sanitation system as it is possible to close, for example, a factory.

The most efficient way to improve the situation for domestic pollution is the awareness of the people, who influence the decisions of the local elected officials.

QUESTION: What is the level of abstraction fees compared to the pollution fees?

Answer: On average the level of the abstraction fees is low compared to the pollution fees (US$ 0.02/cubic meter compared to US$0.12/cubic meter). Further, the proportions can be different in the basins where availability of water is an important issue, for example, in the south-west of France. In any case they remain relatively low, because farmers could not pay very high abstraction fees.

Farmers benefit from the water agencies system. The fees collected are inferior to the subsidies given to them for development of the water resources, e.g., constructing small dams.
QUESTION: What is the composition of the Water Boards in the French system?

Answer: In general, the composition of the boards in the French system reflects all categories of users. The Boards represent the various stakeholder in water management as follows:

- 8 representatives of the State
- 1 representative of the staff
- 8 representatives of the elected officials
- 8 representatives of users (e.g., fishermen) nominated by the Water Committee.

QUESTION: How is coordination achieved between the Ministries in the French water management system?

Answer: Many ministries are involved in water management and resource development. These include, but not limited to, Ministries of Health, Agriculture, Industry, Interior, and Transport. The Minister of the Environment is in-charge of inter-ministerial coordination in the field of water.

QUESTION: How is the hydrological network operated and maintained?

Answer: The basic network (the reference network) is operated by the state. The regional networks are operated by the water agencies. Operators of power or agricultural facilities can also have their own networks. In general, it is better to provide for the reliability of few gauging stations; including good maintenance, frequent calibration, rather than to disperse a great number of stations which cannot be properly maintained.

QUESTION: How are water utilities owned in France?

Answer: It is a tradition in the French legislation that collective facilities must be owned by public authorities. In most cases, the owner is the municipality, but for electricity and navigation it is the state. However, this legal framework does not prevent a strong involvement of the private sector, on a contractual basis, in operation of public facilities, or even in the financing through the concession system.

QUESTION: How is priority of water supply to other uses?

Answer: In case of crisis, for example, drought or pollution, the local representative of the state, can ensure the priority of water supply by limiting the rights of the other users. An insurance system exists to cover agricultural losses due to climate, like drought.
Issues in River Basin Management

Conceptual Framework
Information Management
Stakeholder Participation
Group Discussions
CHAPTER FIFTEEN

CONCEPTUAL FRAMEWORK FOR RIVER BASIN MANAGEMENT

W. B. LORD

A conceptual framework for river basin management, or other public program, should address six issues which determine the substance of such a program. Those six issues are scope, participation, powers, information, decision making, and benefits and costs. This paper is devoted to the definition and discussion of these six issues.

SCOPE

By the scope of a policy, program, or project is meant the range of effects upon human and environmental systems which that policy, program, or project affects, either now or in the potential future. In other words, the scope of an activity consists of all of the significant foreseeable consequences of carrying out that activity.

The scope of any public program should include both the primary and secondary effects of that program. River basin management itself includes both the management of physical resources, most notably but not solely, groundwater and surface waters. It also includes managing the human activities which impact upon and depend upon those hydrologic resources.

The primary effects of river basin management activities are of three types. The first is the provision of water for consumptive uses, such as municipal and industrial water supply and irrigation. The second type of primary effect is maintenance or enhancement of water flows for such non-consumptive instream uses as hydroelectric power generation, fisheries, navigation, recreation, and the protection of aquatic, estuarine, and related environmental resources. The third type of primary effect is the preservation and enhancement of water quality, both surface and sub-surface. The ordering of these three types of effects carries no implication as to their relative importance (and, indeed, water quality is a significant aspect of both types of water uses).

The secondary effects of river basin management are manifold. They include the amount and distribution of monetary income, the non-monetary implications for peoples lives, such as the amount and kinds of work they do, their recreational opportunities, and perhaps most important of all, their health. They include impacts upon the national economy, such as the production of foreign currency-generating export goods and services, demands for health-related and educational services, for transportation and other infrastructure, and the provision of subsidies or the generation of revenue through user charges.
Most fundamentally, river basin management activities help to determine the long-term sustainability of the socio-economic and environmental system of the river basin and of the nation as a whole. Of course, the state of our knowledge at any time severely limits our ability to recognize, measure, and appropriately consider all of these secondary effects, so the scope of river basin management is not static, but is continually expanding.

PARTICIPATION

At one time the participants in river basin management were often narrowly-defined to include only water management technicians, their political superiors, and the people directly affected by what were then largely structural water resource development activities. That day has passed in all countries, with a broadening of the scope of river basin management to include demand management as well as supply enhancement, and resource preservation as well as resource exploitation. With that broadening of scope, which also includes recognition of an increasingly wide range of secondary effects, has come the need to admit a far greater array of participants into river basin management activities.

Today, it is essential that all major stakeholder groups be represented in some way in the river basin management decisions which will affect them. This does not mean that the institutions for managing river basins must be general-purpose governments. In fact, the charters of such institutions must limit them to their primary purposes, as indicated by the primary effects which they produce. Otherwise, they will duplicate and compete with other resource management institutions and with general-purpose governments, a sure route to institutional extinction.

River basin management institutions, then, should provide for the direct participation of stakeholder groups which experience the direct impacts of their activities. Such participation can be organized through a variety of means. The most decentralized of these means is the use of market institutions for distributing costs and benefits. Market institutions provide efficient ways of registering the true preferences of participants, of rationing scarce goods and services, and of drawing upon all available information. They are practical, however, only when the ability to organize participants into functioning markets exists, or can be created. This occurs only when property rights in water, including the right to buy and sell, are well-defined. It may not occur even then, if high transactions costs exist and cannot be reduced. In addition, market institutions are desirable only when the existing distribution of power to command resources, as represented by monetary income and wealth, are distributed in patterns which reasonably approximate a society's norms of fairness and equity.

When the above conditions are not met it may be preferable to use political institutions as avenues for stakeholder participation. Such institutions normally incorporate centralized means, such as the use of hierarchically organized government bureaus and agencies for policy implementation, coupled with decentralized ones, such as the use of representative governing boards, advisory committees, and similar institutions of representative government, for policy adoption.

The participation of stakeholder groups which experience the secondary effects of river basin management activities is usually more difficult to achieve than is effective participation of primary stakeholder groups. The somewhat marginal importance of the effects experienced by individual members of such groups often leads to little motivation to expend the effort needed to participate fully in collective decision making. And, if participation does occur, it sometimes takes the form of the kind
of vote trading and log rolling which can lead to poor collective decisions. For these reasons, the participation of secondary stakeholder groups is usually achieved indirectly, through coordinating mechanisms and through the use of existing general-purpose governments. One way of doing this is to form coordinating councils, on which sit representatives of substantive agencies within whose domains the anticipated secondary effects fall. These representatives should have the power and the duty to review proposed river basin management activities, and to recommend positively or negatively upon them to higher authority. In this way, potential difficulties can be worked out at the interagency level, or can be referred upwards for resolution at the upper executive or legislative level. Similar mechanisms may be useful for inter-basin coordination and dispute resolution. Finally, all proposed river basin management activities should be reviewed at the national level for consistency with national policies and objectives (these, in turn, should be disseminated to river basin management authorities, to forestall inconsistencies in the first instance).

POWERS

The organizations which are assigned the responsibilities for river basin management must have authorities commensurate with their responsibilities. River basin management organizations may be assigned responsibilities for water allocation, for water resource development, and/or for water quality control. These three functions are closely interrelated, thus it is preferable that all three be assigned to the same organization. If this is not done, special efforts should be made to coordinate the decision making and implementation activities of the several agencies involved.

Where water allocation is based upon a system of transferrable water rights, and consequent market allocation, river basin management organizations may administer the system of water rights, although it is more common for courts to do so, as they administer other property rights. Water is usually considered to be a public resource, however, and even private rights are only usufructuary. Where water allocation is by administrative allocation, e.g., through the issuance of water use permits, the responsibility and authority should be lodged in the river basin management organizations. Seldom will the responsibilities of these organizations extend to consumptive uses of the water, although they may often assume responsibility for such non-consumptive uses as hydroelectric power generation, fishery management, and recreation management.

Where water resource development is entrusted to the private sector, the responsibilities of river basin management organizations may be limited to administering property rights in water and regulating private activity in the interests of controlling external costs imposed upon others and protecting the public interest in environmental quality. Far more commonly, however, water resource development is either a public activity or is publicly supported, because many of the benefits of such development are thought to be public goods which cannot be marketed. Additionally, assembling private capital in amounts sufficient to undertake major development projects is difficult in industrialized countries and nearly impossible in non-industrialized ones. In these cases, the river basin management organization is a logical choice for locating development responsibility, and this has been the primary role for many of the world's existing river basin management organizations.

Responsibility for water quality control also can be assigned to the private sector. However, water quality degradation is usually best described as an external cost, which is to say that the generators of pollution do not bear most of the costs of that pollution. For private sector market allocation to work efficiently in such cases, the right to pollute must become a transferable property right, and every effort must be made to reduce avoidable transactions costs (transactions costs are often
so high as to effectively prevent market exchanges in this situation). Reducing transactions costs will often require governmental action to facilitate the organization of cost-bearers into effective bargaining units, and the creation of pollution rights will inevitably depend upon government action, as will the initial assignment of those rights, whether to polluters or to externality-bearers. One great advantage of the market allocation route, if it can be organized successfully, is that it reduces the need for government to acquire costly and sometimes jealously-guarded proprietary information. The crucial initial distribution of rights to pollute must be in accord with societal norms of fairness and equity.

A simpler and more usual, if less efficient, solution to the water quality problem is to assign responsibility and commensurate authority to a public sector entity. This entity then functions in a regulatory capacity, establishing and enforcing rules which limit the right to pollute. Such rules can take the form of either regulations (ambient water quality or effluent standards) or incentives (effluent taxes, fees, or charges). The technical capacity to establish appropriate ambient water quality standards, to set effluent standards consistent with them, and to monitor and enforce compliance is often lacking, even in the most industrialized nations, hence regulatory programs of this kind should be viewed as evolutionary processes. Early regulatory attempts will be awkward and initial standards will be highly approximate. Those who regulate and those who are regulated will be engaged in a learning process which, over time, will approach the goal of optimal pollution control.

INFORMATION

The information requirements for effective river basin management can be quite forbidding, even for the most industrialized nations. For example, the conjunctive management of ground and surface water resources requires both sophisticated groundwater models and a sufficient data base for calibrating those models. Groundwater data can only be obtained from numerous and costly wells, over substantial periods of time. Few places on earth can be characterized by such a data base. Furthermore, advanced geological and mathematical knowledge, together with powerful computers, are needed for the modeling effort. Water quality models and data can be described in similar terms. Even such conceptually less complex tasks as flood forecasting and early warning require costly electronic monitoring networks which are only now being put in place in selected locations in industrialized countries.

Experience has shown that river basin data collection can become a bottomless pit, into which any amount of money can disappear without yielding concomitant benefits. River basin management organizations must obtain sufficient data to discharge their responsibilities, but they must also guard against indulging a technical urge to seek data which are too costly or which are not critical for decision making. Institutional innovation, to make the most of readily available data and to deal wisely with unavoidable uncertainty, is often a better investment than is protracted data collection. Avoiding costly and irreversible commitments is frequently the best strategy for dealing with high uncertainty.

It is also important that residual uncertainty be recognized and dealt with appropriately in river basin planning. Human beings are often uncomfortable with uncertainty and deal with it poorly, hence it is all too easy to work with single planning scenarios, rather than a range of plausible ones. Both water supply planning and flood control planning are particularly vulnerable to extreme events, and probability analysis and/or sensitivity analysis should be basic techniques in such planning.
DECISION-MAKING

There are three basic methods of making decisions about public policies and programs. They are bargaining, command, and representation. Bargaining is a non-hierarchical method in which equals voluntarily exchange goods and services to the benefit of both parties. It is a decentralized method which occurs prominently in market institutions, but also in legislatures, committees, and many other forms of organization.

Command is a centralized hierarchical decision method, in which entities at the top of the hierarchy (often the central government, but also sometimes upper elements of a bureaucracy, corporation, or association) make decisions which affect and are carried out by entities lower down in the hierarchy.

Representation is a decentralized hierarchical method by which entities low in the hierarchy control leaders higher in the hierarchy. Electoral processes for choosing legislators and executives in a democratic political system and worker participation in industrial decision making are examples of this method.

Any successful river basin management system will rely in part on each of the three decision making methods. Bargaining is the method by which competing interests find common ground, command is the method by which society articulates and pursues common purpose, and representation is the method by which that common purpose is defined and by which hierarchies are constrained to seek the common interest.

River basin management will be directed in part from above, as national authorities use command to ensure that local and regional programs do not work against national objectives while pursuing their individual purposes. Within basins, the command method will be used to ensure that certain purposes, such as control of toxic substances and other hazards to public well-being is maintained. It may be used for additional purposes, even though strict accommodation to the public purpose may not be imperative, when employing the more permissive bargaining method (as in the use of economic incentives) is impractical.

An important feature of river basin management is responsiveness to regional needs and objectives. Achievement of this ideal requires use of the representative method. Decision making bodies, such as regional boards or commissions, are composed of representatives of general-purpose governments within the region. They provide the channels through which the goals and policies of these units can shape basin management decisions. Advisory boards or committees, made up of representatives of stakeholder interest groups affected by basin management, are often used to ensure that the views and desires of such stakeholders are not overlooked. Coordinating committees of representatives of agencies whose responsibilities overlap those of the basin management organization are customarily used to assure that interrelated programs are not in conflict with each other.

BENEFITS AND COSTS

River basin management decisions always involve benefits and costs. Consideration of benefits and costs should not be limited to those affecting the budgets of river basin authorities. They should include all of the material consequences, to whomsoever they may accrue, and whether measurable in monetary terms or not, which are expected to result from implementing river basin management decisions.
Three aspects of these benefits and costs are important for river basin management. First, the magnitudes of benefits and costs influence whether proposed programs or projects are economically efficient. Benefit-cost analysis is the analytical tool most often used to assess economic efficiency. These magnitudes also determine financial feasibility (not all economically efficient projects are financially feasible, and not all feasible projects are efficient!). Generally speaking, only efficient and feasible projects should be pursued, because to do otherwise diverts scarce resources from more productive uses. However, economic efficiency is not the only goal, and occasionally modestly inefficient projects may be justified for their distributional, environmental, or other non-efficiency attributes.

The second important aspect of basin management benefits and costs lies in their incidence. Basin management programs are likely to enjoy public acceptance and support when the incidence of benefits and costs is consistent with prevailing social norms of fairness and equity. Otherwise, they may be perceived as unjust, and their implementation resisted and thwarted. Patently inequitable projects should no more be pursued than should highly inefficient ones. It should be noted that estimates of the magnitudes of benefits and costs are not unrelated to the distribution of those benefits and costs. Willingness to pay is the accepted measure, but willingness to pay depends upon ability to pay, which may be very unequally distributed.

The third important aspect of basin management benefits and costs lies in their influence upon behavior. They may be thought of not only as outcomes of basin management activities but also as instrumental elements of such activities. Properly designed cost (and benefit) allocations can create the incentives which motivate persons and groups to work towards the attainment of basin management objectives. Effluent charges and water pricing are examples of the use of such incentives. But it important to think broadly about the aspect of incidence. All of the effects of basin management activities are experienced by persons and groups, and all will affect the behavior of these persons and groups. It is important that the behavior which is so influenced be consistent with basin management objectives, else it is likely to frustrate them. Perhaps the best example of this is the subsidization of water supplies, for irrigation, industrial, or domestic uses, in an attempt to encourage development. Water which is underpriced will be overused, and in a water-short environment this will ultimately constrain development rather than advance it.

SUMMARY

The scope of river basin management programs in Tanzania, as elsewhere, should include the full range of primary water-related effects (consumptive water uses such as municipal and industrial supply and irrigation and non-consumptive uses such as hydropower, navigation, fisheries, recreation, and protection of the aquatic environment), together with the impacts of water quality parameters upon these uses. Moreover, it should also include all significant secondary effects, whether local or national in importance. These secondary effects are often easy to overlook, and special efforts must be made to avoid doing so.

All major stakeholder groups are entitled to participation in river basin management activities of importance to them. Such participation may take various forms, preferably direct in the case of
stakeholders experiencing primary effects and indirect in the case of stakeholders experiencing secondary effects. Direct participation can occur through decentralized market institutions or more centralized political institutions, while indirect participation most often occurs through representative political institutions.

The three principal responsibilities which comprise river basin management are the allocation of water rights, the development of water resources, and the control of water quality. These responsibilities can be discharged through the use of the power to assign property rights and enforce contracts, the proprietary power to manage and develop water resources directly, and the power to regulate the behavior of water users. The choice of what combination of these three powers to employ is a crucial one, and should be made carefully and explicitly.

Efficient, equitable, and sustainable river basin management is based upon adequate information. A river basin management program must include an information collection, analysis, and dissemination component. However, complete information is an unattainable goal. River basin management institutions should be designed to use available information effectively, to avoid excessive expenditures on information collection, and to cope effectively with the uncertainties which inevitably remain.

River basin management will make some use of each of the three decision-making methods of bargaining, command, and representation. Bargaining is non-hierarchical, encourages broad stakeholder participation, and does not rely heavily upon centralized information collection. Command is hierarchical, provides great assurance of compliance, and permits rapid response. Representation is hierarchical, assures consistency with stakeholder values and preferences, and provides legitimacy. All of these virtues are required in successful river basin management, and the mix of the three decision making methods should be consciously and wisely chosen.

The benefits and costs of river basin management provide the rationale for its existence. In general, tests should be performed to ensure that the magnitude of benefits exceed the magnitude of costs, that the incidence of benefits and costs conforms with societal norms of fairness and equity, and that the influence of benefits and costs upon behavior is consistent with the objectives of river basin management.

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DISCUSSION

QUESTION: Does the U.S. employ the UN standards for ambient water quality?

Answer: No. The U.S. standards were set before the publication of the UN guidelines, and they have not been changed to comport with those guidelines, since they are generally more stringent.

QUESTION: How successful has the US been in controlling groundwater pollution?

Answer: We have made very little progress. We do not yet know the full dimensions of the problem and that we possess very limited capabilities for remediating existing contamination. However, it is possible to avoid the most hazardous kinds of pollution.

QUESTION: Can command, representation, or bargaining be used together in a program or are they mutually exclusive approaches?

Answer: Normally, these three decision-making modes are used together in a program, although this need not be the case. For example, stakeholders can provide guidance to decision-makers through representation. Decision-makers can then use command to implement resultant policies. These policies, in turn, can employ bargaining among target groups to achieve policy objectives.

QUESTION: Are there user organizations in the United States?

Answer: There are several organizations, small ones and bigger ones, as well as groups of organizations.
CHAPTER SIXTEEN

WATER RESOURCES INFORMATION MANAGEMENT

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Effective water resources planning requires careful collection and interpretation of data from a wide range of sources and disciplines. This paper identifies the categories of data which are typically collected and offers suggestions for efficient methods of data management and analysis.

WATER RESOURCES PLANNING

Water resources planning is defined as

[T]he creative and analytical process of (a) hypothesizing sets of possible goals, (b) assembling needed information to develop and systematically analyze alternative courses of action for attainment of such goals, (c) displaying the information and consequences of alternative courses of action in an authoritative manner, (d) devising detailed procedures for carrying out the actions, and (e) recommending courses of action as an aid to the decision-makers in deciding what set of goals and courses of action to pursue (U.S. Committee on Water 1966).

The total planning process involves goals, objectives, activities, and resources of all kinds that can seldom be considered independently. Meeting the needs of the people requires consideration of land use, water, housing, transportation, education, and many other sectors of human endeavor. There are four activities in the planning of water resources, namely: planning jurisdiction, scope of planning programs, stages of planning and identifying the planning area.

Planning Jurisdiction: international, ministerial or national, regional, district, and village or local level

Scope of Planning Programs: multi-sectoral, sectoral, and functional

Stages of Planning: policy framework, general appraisal, implementation

Planning area: urban or basin
STAGES OF PLANNING

There are several stages of planning:

(i) **Policy planning**: definition of overall goals and program objectives, policy development, overall budget and priority analysis, dissemination of program guides and evaluation of results.

(ii) **Reconnaissance planning**: identification of general problems and needs, outlining of a range of possible alternative futures, inventory of available resources and general opportunities, assessment of overall adequacy of resources, and determination for further investigations.

(iii) **General appraisal planning**: broad evaluation of alternative measures for meeting hypothesized goals and objectives, with recommendations for action plans and programs by specific entities.

(iv) **Implementation planning**: investigations of a specific structural or non-structural measure, or system of measures, in sufficient detail to determine whether it will serve the intended purposes in a manner consistent with established goals, objectives, and criteria, and if so, that it is physically possible of implementation within estimated costs and within limits of financial feasibility.

DATA NEEDS

Data is required for the following purposes:

- To estimate present and future water needs and environmental needs, and to estimate available water and related land resources;
- To estimate costs, benefits, and consequences of specific alternative projects;
- To evaluate alternative water quality management approaches; and,
- To compare alternative projects.

In summary, data are required to carry out the four stages of planning. The data needs in water resources planning can be categorized into two groups namely: physical and socio-economic data.

**Physical data** consist of information on geology, land resources, hydrology, hydrogeology, physical geography, meteorology, water quality, and other environmental quality topics.

The required **geologic** information include type and thickness of soils, land classifications, data from geologic exploration of major structural sites, and identification of location of construction materials such as earth and aggregates.
The existing pattern of land use in the river basin should be known. This will include the size of land used or suitable for agricultural, forest, livestock, game reserves, and for urban development.

The required hydrogeologic information includes the extent, thickness, capacity hydraulic characteristics, and dependable yield of the aquifer, as well as the existing number of springs.

Information on topography (relief, river networks) of a river basin is usually obtained from topographical maps of different scales depending on the size of the river basin and the scope of planning detail.

Meteorologic data are required on variables such as temperature, wind speed and direction, evaporation, humidity, air pressure, and solar radiation. This information is very important in the estimation of water losses from reservoirs and consumptive use of water.

Hydrologic information is required for planning, management, and operation of water resources projects in a river basin. Such data include: streamflow (water levels and discharge), sediment discharge, and precipitation.

The quality of water is usually defined in terms of the water’s suitability for irrigation, domestic and industrial use, and recreation. Therefore, data on the following water quality parameters are required: dissolved oxygen, biochemical oxygen demand, coliform, temperature, heavy minerals, suspended solids (turbidity), colour, odor, and radio activity.

One of the objectives of water resources planning is environmental quality. The environmental quality objective is enhanced by the management, conservation, preservation, creation, restoration or improvement of the quality of natural and cultural resources and ecological systems in a river basin.

Data on the following components of the environment are needed in water resources planning:

(i) Areas of natural beauty such as, open and green space, wild and scenic rivers, lakes, beaches, shores, mountain and wilderness areas, and estuaries.

(ii) Outstanding archaeological, historical, biological (fish, wildlife habitat), geological resources and ecological systems.

(iii) Quality aspects of water, land and air.

Data on the first two components of the environment are usually collected in terms of size (acres, mileage, number or population estimates, height or depth, or density) and by descriptive-qualitative interpretation. Water quality is determined using the parameters presented above, while the land quality is measured in terms of size of eroded and deforested areas.

Socio-economic data are required in order to quantify the beneficial and adverse effects of a proposed plan. Socio-economic data needs consist of information on institutions, demography, geography, and pollution. In addition, information on the social, economic, financial, and legal aspects of public life is critical.
Many institutions in the country are involved with the collection of socio-economic data. Such institutions include the ministries of Water, Energy, and Minerals, Health, Communications, Agriculture and Livestock, Lands, Natural Resources and Tourism, and of Industries. Other institutions, such as NGOs are also engaged in collecting socio-economic data.

The required demographic data concerns population. The population of an area or river basin is very important in the determination of the present and future needs of the people (as relates to water, industries, schools, hospitals, and food).

The availability of physical and socio-economic data varies geographically. There are hardly any data in remote areas and hydrologic data are always lacking at the point of interest. However, socio-economic data are available in urban centers, where planning for water and power supply has been conducted.

Pollution sources need to be identified. These will include information about both point sources as from industries and non-point sources as from agricultural activities. Other topics include the extent of waste treatment and disposal measures, the quality and quantity of effluent outfall to rivers, lakes, and estuaries, as well as stormwater outfall from combined sewers. Water quality management requires such data.

The economic data required in water resources planning as reported by the Economic Commission for Asia and the Far East (1964) is listed as follows:

- Land ownership and tenure, number, type and size of farms, number of workers per farm, farm investment, number and kinds of livestock, farming methods, farming costs, crops and crop yields, marketing facilities and consumer demands, relation of agriculture to general economy of the area, economic status of the farmer, necessity and opportunity for off farm employment, standard of living and on farm consumption of farm products, skill of farmers, and availability and suitability of farm products;

- Present and future power use potential, population and economic development, power use by significant categories of customers, production costs and power rates;

- Domestic and industrial water consumption, population and economic development, adequacy of existing supplies from standpoints of quantity and quality, production costs, financing and water rates;

- Economic development in area subject to flooding, value of property and extent and magnitude of potential damage at various flood stages, time and duration of floods as related to crop production and resulting crop damage, hazard to human life, inconvenient and delays resulting from floods;

- Use of water for transport, tonnage of shipping, cost of water transport, cost and financing of maintaining waterways; and
• Extent and intensity of fishing industry, fish production, marketing facilities and consumer
demand, recreational values of fisheries, industries, recreational value of water bodies and
waterways.

Planning in water resources should be carried out only when there is a problem and a solution
is required. Therefore, funding organizations should be identified early in the planning process. The
information required for financial analysis include costs allocated to various purposes, annual operation
and maintenance costs, replacement costs, and repayment of capital investment.

The required legal information include number of water rights and the amount of water
abstraction for each water right, international agreements and treaties, land acquisition and rights-of-
way. The above information is very important for the allocation of water among users.

The required information on social-well being include the following:

• Effects on real income (per capita income);

• Effects on security of life, health, and safety (reducing risk of flood, drought, reducing the
number of disease-carrying insects and related pathological factors, reducing the
concentration and exposure to water and air pollution, providing a year-round consumer
choice of foods);

• Educational, cultural, and recreational opportunities (improved opportunities for community
services such as utilities, transportation, schools, and hospitals);

• Effects on emergency preparedness (extending, maintaining, and protecting major
components of the national water transportation system, provision of flexible reserves of
water supplies, provision of critical power supplies, and provision of food production
potential).

Information on other sectors of the human endeavor which utilize water and land resources
should also be collected.

DATA MANAGEMENT

Data management is concerned with data collection, cataloging, evaluation, processing, and
analysis. However, it should be noted that, the standards of data collection, compilation, processing
and filing vary widely.

Data Collection

One of the three pillars of scientific method in hydrology includes observation and
measurement. Most of the hydrologic and meteorologic variables are measured using various
instruments. Streamflow is measured by taking discharge measurements by current meters and by
taking water levels using staff gauges, automatic water recorders, pressure gauges. Telemetry
approach is used to transmit the water levels from automatic recorders to a receiver and into a
computer at a central office. Hydrologic data collection using automatic water level recorders and/or
including telemetry ensures very high quality data but is very expensive and should be used where
hydrologic information is required for flood warning purposes. Hydrologic data collection manually by staff gauges is very cheap. However, there is a high chance of collecting poor quality data if the gauge readers are not well supervised.

Tanzania has about 360 hydrometric stations. However only 50 percent are reporting. Automatic water level recorders that were at some of the hydrometric stations are no longer in operation. Data collection is a continuous process and is a very important investment. Therefore, there is a need to revamp the hydrologic data collection effort in the country. Automatic instruments could be installed at key hydrometric stations while manual data collection should continue at the rest of the stations. Discharge measurements should also be carried out at all gauging stations in order to establish the rating equations for the purpose of converting the water levels into discharge values.

Many Ministries and other organizations collect data (physical and socio-economic). Some data are for general use by other Ministries and other data are for their own use. The most successful of these Ministries are the Ministry of Water, Energy and Minerals on hydrologic data, geologic, and hydrogeologic data (collection of data on water quality parameters and ground water data should however be intensified); the Ministry of transportation for meteorologic data; the Ministry of Lands, Natural Resources, Tourism and Environment for topographic and land-use data. Other Ministries involved with the collection of socio-economic data are noted above. However, it should be pointed out that there is no coordination of data collection among the institutions and duplication of efforts is inevitable. Thus data collection activities should be carefully programmed and coordinated.

**Data Cataloging**

The compilation and cataloging of data varies from one Ministry to another. Only the Ministry of Water, Energy and Minerals and the Ministry of Transportation have a well-organized way of data cataloging according to gauging stations and are entering the data into the computer. It is important that other Ministries do the same.

**Data Processing**

Data processing is very important and insures the quality of the collected data. Therefore, data should be processed for ease of storage and removal of inconsistencies to make sure that it represents the actual situation.

**Data Analysis**

The analysis of hydrologic data is carried out in order to determine the magnitude of design flood of required frequency, the dependable yield of a river basin or groundwater aquifer, the future water requirement of an area. Techniques for analyzing hydrologic data are well established (statistical methods and stochastic methods). Techniques of regionalization of hydrologic information are also available. Engineering economy analysis methods are also available and are used in the analysis of socio-economic data in order to establish the most economically attractive course of action (James and Lee 1971). Most of the demographic and economic data used in water resources planning is for forecasting what the future will look like.
Data Interpretation

As stated above, there are many data collection methods including remote sensing. Therefore, the collected information should be well interpreted. This is because, if data is wrongly interpreted, this could lead to a wrong design or management of the water resource, an expensive affair to correct.

The analyzed data should also be well interpreted. Omission of outliers in flood frequency analysis could lead to underestimating flood design and vice versa. Good engineering judgement is required in the interpretation of data and the analyzed information.

INFORMATION MANAGEMENT TOOLS

One major factor of information management is the ability to store and retrieve data. The retrievable information can then be used for different purposes such as planning and design. The information management tools are categorized into two categories: Water Resources Models and Geographical Information Systems (GIS). It should be noted that hardware availability (computers) is a pre-requisite to information management tools.

Water Resources Models

The planning, management and operation of water resource projects requires the utilization of hydrologic and hydraulic models, groundwater models, and water quality models. Today there are many hydrologic and hydraulic models which are used to store and retrieve information: HYDATA, SHE-Model, IHDM-Model, HEC-Models. These models are also used for prediction of streamflows under natural and developmental conditions. Rainfall-runoff models which are used for the simulation of streamflows given the rainfall are as follows: unit hydrograph, rational formula, simple linear model, linear perturbation model, linear difference equation models, constrained linear systems model, soil moisture accounting routing model, Stanford watershed model. These models are also used for determination of the design flood magnitude.

Groundwater models are also available: M.O.C. (for water and solute transport; UNSAT2 (Variably saturated flow model; SWATRE model; SWMS-2D (simulation model for water flow and solute transport; and HYDRUS Version 3-31. These models are used for evaluation of the performance of different water resources plans and/or management alternatives.

Water quality models are also available in the literature. Some include: overland flow and pollution generation model (LANDRUN); unified transport model for toxics (UTM-TOX); and agricultural chemical transport model (ACTMO) (Hosseinpour 1993) and RUNOFF3 (Borah and others 1993). These models can simulate or predict the water quality parameters for different water development plans.

Geographical Information Systems (GIS)

A GIS is a computerized mapping tool which provides flexibility, accuracy and ease of updating capabilities over conventional methods. GIS also provides a cataloging of data found in
tabular format. The data, called attributes, describe the mapped information (Reese and others 1993). A number of GIS packages are available such as, IDRISI and ARC/INFO. GIS has been applied in solving water resources management problems (Woodbury and Jawed 1993, Shamsi 1993, Reese and DeBarry 1993).

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DISCUSSION

QUESTION: Very often no post-implementation plan for data collection or monitoring of performance is made. Such a plan may also include operation and maintenance, training and technology transfer. For example, problems existing in large water supply schemes were lack of operation and maintenance planning.

Answer: Post-implementation plans are important. Operation and maintenance plans, especially, should be considered when other schemes are operating either upstream or downstream of a project.

QUESTION: The tools shown by the speaker on data management are mainly computer oriented. Is there not a need for standardization of software?

Answer: Standardization of technology or software is an important aspect. Thus the Ministry of Water, Energy and Minerals which is responsible for data collection processing and analysis should consider this issue.

QUESTION: Is there not a need now to have modern technology of data collection, such as telemetry, in this country?

Answer: The technology of data collection depends on resources availability. Telemetry is more expensive than a simple automatic water level recorder. However, updating the system of data collection will depend on need and what time the data is required. There is need, however, for the MWEM to attach importance and emphasis on data collection and thus allocate adequate resource for the purpose.

QUESTION: Who has access to data?

Answer: Data are usually made available to any consultants or institutions upon request. Traditionally data have been given free of charge but it has to be realized that data collection is an expensive exercise, and hence resources are not adequate to ensure availability of good continuous data at all stations. It is felt that it is high time now that these policies are revised so that an element of cost recovery some contribution to the cost of data collection and processing can be taken into consideration:
CHAPTER SEVENTEEN

STAKEHOLDER PARTICIPATION IN WATER MANAGEMENT

M. R. MUJWAHUZI

People and organizations with an interest in water resources in a specific region are stakeholders in the management of those resources. This paper identifies the categories of people and groups which make up stakeholders, and describes the issues to be addressed when developing participatory approaches to water management.

Water management, in the context of this paper, will be understood as a dynamic process of devising alternative sequences of interventions, and selecting the sequences or activities that will optimize the achievement of the objectives of water resources.

Under the above definition water management implies the existence of actors who in one way or other have to be involved in decision-making in the different aspects of the water resources such as: the alternative uses of water resources, who can use the resource and for what purposes, and how the resources can be sustained. Proper and effective water management, therefore, has of necessity to involve participation of different actors in decision-making and in the implementation of the decisions pertaining to the water resources. It should, however, be pointed out that the presupposed participation does not require every actor to be involved in decision-making and implementation of all water management aspects. What is meant here is that different actors are expected to be involved in different aspects of the resource and at different levels. What is central is that proper management of water resources requires the participation of different groups of people who in one way or the other have an interest in the resource.

In what follows an attempt will be made to define who are the actors, or in other words, who are those people with interest in water resources who have to participate in the management of water, that is, who are the stakeholders? The paper will further explore the benefits to be derived from stakeholder participation before making an attempt to identify the different types of stakeholders using Rufiji basin as an example.

STAKEHOLDERS: WHO ARE THEY?

Stakeholder is a word which is formed by combining two words: "stake" which in this particular context means a share or interest, and "holder" which stands for a person(s) who possesses or keeps. The literal translation of the word stakeholders is those people who possess a share or interest in something. In the water sector, stakeholders have been defined as "people and organizations with a continuing interest in water resources."
From the above definition it is clear that stakeholders do not necessarily consist of only one person or one category of people. Furthermore stakeholders are expected to have a continuing interest in the resource and that is why stakeholder participation is viewed as a process which involves continuously those who are affected by and who have an interest in water resource in the formulation and implementation of water management strategies.

WHY STAKEHOLDER PARTICIPATION?

Because of the increasing conflicts in the demand and use of water many countries have come to realize the need for cross-sectoral water resource management. It is also realized that this desired cross-sectoral water resource management cannot be achieved without involving all those who have an interest in the resource. Involvement of stakeholders is necessary for the following reasons:

Identification and clarification of interests at stake

To plan is to choose. Planning the management of water resources in a river basin entails decision-making on water uses in the basin. It involves allowing certain uses of water to take place as well restricting other uses. It means choosing from among competing uses within a given area. This exercise of choosing presupposes availability of information on the existing and future interests and needs for water as well as the positive and negative consequences which may emanate from satisfying or not satisfying those needs and interests in a given basin.

Acquisition of such vital information is not easy. In Tanzania, for example, there is no place where one can find information on the water use requirements of the people in a given river basin. Although it is a known fact that people living in the river basins in this country do use water for different economic and social activities, no one knows approximately how much water is used or is needed for the different activities. Furthermore, because the existing water uses are sectorally fragmented and uncoordinated, interests of the different users are not known and this state of affairs is a potential source of conflicts. The only sure way of obtaining such vital information is by involving all those interested in the resource. It should, however, be pointed out at the outset that all stakeholders do not have the same interests in all water resource management functions, from the national to the local levels and it is not possible for all stakeholders to be involved in every thing. In information generation, therefore, stakeholders are expected to be involved in only those aspects in which they have direct interest and at the level which affects them. How to involve stakeholders in data generation is discussed in the second part of this paper.

Minimization of Conflicts

The conflicts experienced in water management stem partly from non-involvement of stakeholders in decisions pertaining to the use, preservation, and conservation of a given body of water. Water is a valuable and finite commodity. There are very few places on this globe where people have access to unlimited amounts of water. In many countries water supply is limited compared to the demand. In such countries, when water use is planned without involvement of water users, the end result is conflict. Each water user thinks that his needs are more important than the needs of others. This way of thinking may be the product of selfishness, but in many cases it stems from ignorance. When stakeholders are not involved chances of knowing water demands of other people are slim. And this
has been the case in Tanzania. For example, the recent shortage of water in the Mtera reservoir was blamed by the electric power producers on the farmers in the Usangu plains. At the same time the small farmers in the Usangu plains complained that they do not get enough water for their small irrigation farms because of the big irrigation farms in the area. The big farms on their part did not accept the responsibility of having caused the decreased amount of water in the Mtera reservoir. All these accusations and counter accusations stem from the fact that management of the water resources of the river basin has been undertaken without involvement of the stakeholders. Stakeholders in this basin do not know the needs of each other and consequently do not appreciate each other's demand for water.

On the other hand involvement of stakeholders in formulating the management strategy of the resource would have the following results:

- Stakeholders would be aware of the limited nature of the available resource and would in the process appreciate the fact that some difficult choices may have to be made in order to manage the limited water resources effectively;

- Stakeholders would be aware of the possible options and would therefore be in a better position to participate in the formulation of a well-informed water management strategy which would have a good chance of being implemented;

- Stakeholders, having participated in the formulation of the management strategy, would be more willing to support the implementation of the decisions concerning proper management of the water resources in the basin.

Generation of resources for operational needs

Water resource management involves use of resources. These resources can be financial, or human. Willingness among the people to support the implementation of the agreed upon management measures is an important prerequisite for achieving an effective and sustainable water resource management system. This willingness can only be obtained when people understand what is intended to be done and the benefits which are to be derived from such actions. The required transparency, accountability and understanding regarding management decisions and the process by which the decisions are taken can only be acquired through stakeholder participation.

WHO ARE STAKEHOLDERS?

In the preceding paragraphs the nature of stakeholders was defined. In this section different types of stakeholders are identified. Once again the Great Ruaha sub-basin of the Rufiji basin will be used in the identification of the different types of stakeholders.

As noted, stakeholders are people or organizations with continuing interest in water resources. These then can be individuals, organizations or groups. Consequently stakeholders include, besides individuals other categories of interested parties in the four categories described below.
Public sector agencies involved in water resources such as departments of water, agriculture, industry, transportation, energy, recreation, fisheries, and tourism

In the Great Ruaha basin stakeholders under this category are, for example, the state farms of Mbarari and Kapunga rice farms, Tanzania Electric Supply Company (TANESCO), Ruaha National Park, The Mufindi Paper Mill, The Sao Hill Forest project, The Wanging'ombe Rural Water Supply and other water supply projects supported by the government and External Aid Agencies (ESAs).

Taking into consideration the recent conflicts in water use in the basin, it is not clear whether when planning the management of the water resources of this basin the above stakeholders were involved.

Private sector organizations and companies

In a system with centralized planning the tendency is usually to ignore the private sector and private companies although it is recognized that the actions of this group have an impact on the resource. For example, water resource management involves catchment protection. Looking at the activities that going on in the Ruaha basin by the private sector organizations and companies, catchment protection cannot be achieved with the cooperation of this group. Again cooperation presupposes understanding of the reasons behind the proposed action.

In the Rufiji basin, there are numerous water related activities which are being carried out by individuals and private companies. This group need to be involved in water resource management decisions. The groups include charcoal burners, companies dealing with wood trade, large and small scale farmers, and pastoralists.

Environmental and other professional nongovernmental organizations

HIMA group and CONCERN in Iringa are examples of nongovernmental organizations which have an interest in environmental and water resource management in the basin. They should be involved in the development of the water resource management system.

Representatives of those people likely to be affected by certain water use activities, especially including people who may have little knowledge of the effects of strategy and who may lack the means to participate

There is in some parts of the Ruaha basin the practice of growing vegetables and maize along the embankments of the rivers and streams using water from these sources to irrigate their small farms (Vinyungu). The recent reduction of water in the Mtera reservoir was partly blamed on this activity. The immediate reaction was to try to prevent people from growing vegetables and maize along the river banks. The proposed measures were, however, taken without referring to this group which supplements its major harvest with this supplementary activity. As a result the concerned group has ignored the restriction orders and the activities are going on as usual. The situation would have been different if the stakeholders in this category would have been involved in the decision-making process. Who knows, perhaps with stakeholder involvement the decision to restrict the growing of vegetables and maize by irrigation along the river banks would not have been taken in the first place. It is possible that other more effective water management strategies would have been chosen.
Future generations is another category of stakeholders whose interests in the water resources have to be protected by the present generation so that management decisions which are taken now would be of benefit even in the future.

How to identify Stakeholders

As pointed out above there are different types and categories of stakeholders and these are at different levels. In planning water resource management one of the important tasks is to identify the stakeholders so that the benefits of their participation outlined in the preceding paragraphs of this paper can be achieved. There are many different methods which can be used to identify stakeholders. Three of the simplest approaches have been listed as (a) self-identification, (b) third-party identification, and (c) staff identification.

The method of self-identification involves individuals or groups of people with an interest in the management of the water resource to step forward and express their intent to participate in the formulation of the management strategy of the resource. It is not difficult to identify such a category of stakeholders. The demand for water in the Ruaha basin is a clear expression of who is interested in the resource. Identification of such a group is therefore easy.

Third-party identification relies mainly on other knowledgeable parties to identify people or groups which have a stake in the resource. These knowledgeable parties can be one of the following: advisory committees, community leaders and elders, representatives of interest groups such as women groups, pastoralists or even researchers etc.

Staff identification is used when people entrusted with the responsibility of planning the management of water resource in a given basin or area systematically assume the responsibility of identifying the stakeholders and invite them to participate in charting out the strategies of managing the resource.

The above methods of identifying stakeholders in a given area are not exclusive of each other. In fact they compliment each other and they should therefore be used together when trying to identify all the stakeholders.

INvolVEMENT OF STAKEHOLDERS

In the preceding paragraphs the importance of involving stakeholders was pointed out but what was not made clear is how stakeholders should be involved. Involvement of stakeholders will therefore be the subject of the following paragraphs and will be examined in terms of intensity and level of involvement.

Intensity of involvement

The intensity of stakeholder participation is partly a function of the level of interest in those management functions the stakeholder has in the water resources. Therefore, since all stakeholders do
not have the same interest in all water resource management functions, from the local to the national level, even the intensity of participation varies accordingly from low to high.

Using the criteria of the intensity of participation a recent study on this aspect has grouped the stakeholders in the following categories of listeners, reviewers, advisors, originators, and decision-makers depending on the intensity of their involvement in the formulation of the management policies and strategies.

**Listeners** are stakeholders who have to be informed on what is intended to be done but they do not feel any necessity of being involved actively in policy formulation or in project implementation. However, their being informed is important because it would help in eliciting their reactions and provide certain vital information which the planners would have otherwise not have had access to.

**Observers**, on the other hand, are those people or groups who, besides having an interest in access to information, keep a watchful eye on the whole process of policy formulation. They are normally not actively involved but they are usually ready to spring into action if and when they see that the decisions which are about to be taken are not going to serve their interests. The group of **Reviewers** consists of those who are actively involved in watching the process of management policy formulation and constantly review ideas being presented. **Advisors** are those stakeholders who are actively involved in giving advice on the formulation of the management policies and strategies. They spend a lot of their time and energy in these activities. **Originators** are those who assist in creating options while **Decision-makers** are actively involved in deciding on exactly what has to be done.

From the above description of the intensity of stakeholder involvement it is obvious that different stakeholders perform different activities and at different levels. Depending on the interests different stakeholders have their involvement in the management of water resources can consist of performing different functions such as development of water resources, allocation of water, quality control, source protection, water conservation, and environmental protection.

**Levels of Stakeholders involvement**

One expert on stakeholder participation has observed that "realistic and serious stakeholder involvement cannot be separated from decentralization of water resource management, i.e., management at the lowest appropriate level, which is to a large extent defined by the level of the directly involved stakeholders." Consequently since the levels of competing interests is different among stakeholders so are the levels of involvement since the levels of operation are dictated by the levels of interest.

Stakeholder participation in water resources management can therefore take place at different levels. It can take place at basin level, at a sub-basin level, at a local level and even at a household level.

**Prerequisites for stakeholder involvement**

The government approach in water resource management has not been involving stakeholders. Introduction of stakeholder participation in planning water resource management will require recognition and safeguarding of the position of stakeholder in the whole planning process. There will therefore be a need of providing a legislation for the right of individuals or groups to be heard. In
addition to the legislation, it will be necessary to devise an efficient way of disseminating information concerning the resource so that all the interested parties can know what is going on and can therefore be motivated to participate. Information dissemination can be done through mass media such as radio, TV, newspapers, public meetings, and formal and informal consultations.

LOCAL LEVEL WATER RESOURCE MANAGEMENT IN THE RUAHA RIVER BASIN

The water resource management system existing in the Ruaha River Basin is sectoral in nature. That explains the water use conflicts which are being experienced in the basin. The energy sector, for example, considers the management of the resource in the basin in terms of sustainability of energy production. The agricultural sector plans water management in terms of increased agricultural production and is not much concerned or has no mandate to consider energy issues and needs. The lumberjacks in the forested areas of the basin are least concerned with issues of catchment protection. Their main preoccupation is how to get more timber without realizing that their activities affect other sectors which depend heavily on water. Pastoralists in Ismani area and Utengule swamp are interested in the pasture lands and not on the impact of overgrazing on the ecology of the areas.

Management of the water resources of the Ruaha river basin requires urgently a cross-sectoral approach. This will only be achieved by involving all those who have an interest in the resource as defined above. It is through this approach that solutions to the current water conflicts can be resolved and potential future conflicts can be avoided. It is also through stakeholder participation that appropriate levels of resource management can be identified.

Conclusion

For people who are used to bureaucratic planning processes it is not easy to abandon the highly centralized government dominated management system and adopt the approach which is being suggested in this paper. It is now realized that there is need for cross-sectoral water resource management. It is also recognized that for this approach to be sustainable it is necessary to adopt stakeholder participation at all levels. Under these conditions there is no choice other than to get interested parties involved in water resource management and at all levels.

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DISCUSSION

QUESTION: What is a clear definition of stakeholder?

Answer: All the people with a share or interest in something, for example, a particular water source. In the water sector stakeholder have been defined as "people and organizations with a continuing interest in water resources". Further, there is another group which can not speak by itself but require us to ensure that their interests are taken care of by the stakeholder. These are the plants, wild animals, or birds.

QUESTION: Could you explain further what you saw in Ruaha basin? What is your advice and how will stakeholder be involved?

Answer: The Ruaha basin water is being managed by various groups but actual management and coordinated approach is lacking. Further, the basin has been invaded by pastoralists who are causing some degradation of the catchment. The best way of dealing with this problem is to have some kind of dialogue with them and possibly offering them various alternatives.

QUESTION: What are the roles of politicians towards stakeholders?

Answer: Politicians have a big role to play. This is in respect of legal frameworks, legislation and sometimes a big decision role.

QUESTION: On beneficiary involvement, what are the gender issues and what is women's involvement in water management affairs?

Answer: Women must be fully involved in decision-making as they bear the bulk of responsibility in many cases.

QUESTION: Very often there has been mention of stakeholder but what is it in terms of cost involvement that would accrue from them?

Answer: Involvement of stakeholder can result in delay or failure of projects. He further said that stakeholder can cause disaster if not properly handled.

QUESTION: Which external organizations have interest with respect to Lakes Victoria, Jipe, and Chala?

Answer: There are definitely many external organizations which have an interest in the lakes mentioned above, for example, UNEP, FAO, WHO and others.
QUESTION: Generally there is always a mention of failure of stakeholder participation but no successful cases are indicated, would you give an example of successful cases of stakeholder participation?

Answer: The way the smallholder irrigation farmers distribute equitably water in Kimani irrigation area without creating any conflicts is but one example how stakeholder participation can lead to proper management of the water resources.
CHAPTER EIGHTEEN

WORKING GROUP DISCUSSIONS

Presentation of Group One on the theme of Cross-Sectoral Uses

**Topic #1: Allocation across consumptive use**

Identified Issue: Water is a finite resource. The demand for it exceeds the supply in the Pangani and Ruaha basins; therefore there is need for a rational allocation of water.

Recommended Actions:

- **ACTION 1.1**
  - Make water rights transferable
  - Restrict water uses administratively and equitably
  - Eliminate illegal extractions
  - Regularize extra legal water resources

Necessity for action: (Not mentioned)

Prerequisites to action: (Not mentioned)

- **ACTION 1.2**
  - Augment water supply through ground water use and recharge
  - Adopt increasing block prices or other conservative measures for electricity
  - Establish water use fees

Necessity for action: • To balance supply and demand

Prerequisites to action: • Political will and support at all levels
  • Public awareness and acceptance
  • Legislation
  • Administrative capacity

**Topic #2: Pollution vs. other uses**

Identified Issue: The need for pollution control in the Pangani and Lake Victoria basins and in the city of Dar es Salaam.

Recommended Actions:

- **ACTION 2.1**
  - Raise water pollution penalties to deterrent levels
Raise public awareness on pollution problems
Improve monitoring and issue periodic publications of pollution levels and health consequence

Necessity for action: • Create incentive to reduce pollution
Prerequisites to action: (Not mentioned)

ACTION 2.2
• Improve sewerage and drainage systems
• Improve extension services to promote the use of organic fertilizers and pest control
• Review standard for permissible pollutants

Necessity for action: • Create incentive to reduce pollution
Prerequisites to action: • Political will and support at all levels
• Public awareness and acceptance
• Legislation
• Administrative capacity
• Motivation of the actors

Topic #3: Water for the ecosystem vs water for every other use

Identified Issue: Any use of water should be constrained to protect the ecosystem

Recommended Actions:

ACTION 3.1: • Prepare environmental impact assessments (EIAs) for any proposed intervention in a river basin
• Raise public awareness on the importance of protecting the ecosystem

Necessity for action: • To ensure that effects on the ecosystem are taken into account
Prerequisites to action: (Not mentioned)

ACTION 3.2: • Maintain minimum flow in the rivers
• Carry out a constant ecosystem assessment

Necessity for action: (not mentioned)
Prerequisites to action: • Capacity availability
• Public awareness and acceptance
• Motivation of actors
Table 18.1 Identified responsible institutions, collaborators, and time frame

<table>
<thead>
<tr>
<th>ACTION NUMBER</th>
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<th>COLLABORATING INSTITUTION</th>
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<td>MWEM</td>
<td>MTNRE (NEMC), MOA, NGOs, STAKEHOLDER</td>
<td>IMMEDIATELY</td>
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</table>

DISCUSSION

QUESTION: What kind of motivation did the group have in mind?

Answer: Conditions that act to motivate include good salaries, good communication facilities, good office working facilities and equipment, such as computers, photocopiers, and telephone service as well as social recognition for work.

QUESTION: Do the proposed activities have definite time frames or are they continuous?

Answer: The time frame is dependent on nature of the activities. Monitoring, for example, is a continuous process. Furthermore, most of the activities are dynamic, depending on the parameters of the project.
Presentation of Group Two on the theme of Stakeholder Participation

**Topic #1: Identification of stakeholders**

Identified Issue: Identification is important so as to enhance the stakeholders' participation to minimize subsequent conflicts and to ensure transparency.

Recommended Actions:

**ACTION 1.1** ➔ Carry out information collection and survey of stakeholder and verification of the stakeholders

Necessity for action: • Will help in identification process

Prerequisites to action: • Transparency
  • Resources

**ACTION 1.2** ➔ Carry out dialogue with stakeholder

Necessity for action: • To fill gaps and update information.

Prerequisites to action: • Transparency
  • Resources
  • Willingness to participate

**Topic #2: Level and intensity of participation**

Identified Issue: Depending upon a particular conflict and opinion the level and intensity of investigation will be defined

**ACTION 2.1:** ➔ Dissemination, collection, and analysis of information

Necessity for action: (Not mentioned)

Prerequisites to action: • Funds and efficient communication system

**ACTION 2.2:** ➔ Conduct dialogue at appropriate level

Necessity for action: (Not mentioned)

Prerequisites to action: (Not mentioned)
**Topic #3: Modalities for effective participation**

**Identified Issue:** Development of legal framework or guidelines on the modalities that facilitates effective stakeholder participation in the planning and development process.

**Recommended Actions:**

**ACTION 3.1:** Development of legal framework or guidelines

**Necessity for action:**
- To formalize stakeholder participation in national system

**Prerequisites to action:**
- Willingness and transparency of concerned organs

**Table 18.2 Identified responsible institutions, collaborators and time frame**

<table>
<thead>
<tr>
<th>ACTION NUMBER</th>
<th>RESPONSIBLE INSTITUTION</th>
<th>COLLABORATING INSTITUTION</th>
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<th>PROPOSED END DATE</th>
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<td>MWEM</td>
<td>STAKEHOLDER</td>
<td>AFTER TOPIC 1</td>
<td>BEFORE DESIGNS ARE STARTED</td>
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<td>4</td>
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<td>STAKEHOLDER</td>
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<td>BEFORE PLANNING N/A</td>
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<td>5</td>
<td>MWEM</td>
<td>MINISTRY OF JUSTICE</td>
<td>IMMEDIATE</td>
<td>WHEN LAW PASSED</td>
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DISCUSSION

Comments: Transparency and trust are two very important aspects to take into account in stakeholder participation as they are the determining factors for success. To achieve the overall objective of stakeholder participation information sharing and dissemination has to be emphasized.

On stakeholder participation and transparency, workshop participants observed that this issue requires proper handling. It is not expected that everybody would participate at all levels. In some cases stakeholder would participate in decision making; in other cases, they would assist in information giving, mobilization or on another level.

Another constraint to stakeholder participation has been the transfer of departments between various ministries.
Presentation of Group 3 on the theme of River Basin Offices

TOPIC #1: Functions of River Basin Offices, their legal basis and mandate, and their institutions and operations

Identified Issue: To strengthen river basin management by improving and strengthening River Basin Offices so that they can achieve the objectives of monitoring, controlling, regulating, apportioning, and otherwise conserving water resources while monitoring and controlling pollution.

Recommended Actions:

ACTION 1.1: Review and define the ideal functions of an RBO
Necessity for action: • Existing functions are not comprehensive enough
Prerequisites to action: • Agreed Budget

ACTION 1.2: Analyze existing legislation and enact any additional legislation required
Necessity for action: • To adequately establish RBOs
Prerequisites to action: • Action 1.1

ACTION 1.3: Identification of areas where additional or expanded mandate are required and enact accordingly
Necessity for action: • To adequately empower RBOs
Prerequisites to action: • Action 1.2

ACTION 1.4: Establish functional procedures
Necessity for action: • To define operations and provide a monitoring baseline
Prerequisites to action: • Action 1.1 and available management expertise

ACTION 1.5: Preparation of manpower development plan, including job descriptions, training requirements, and recruitment
Necessity for action: • To make RBOs functional
Prerequisites to action: • Actions 1.1 to 1.4

ACTION 1.6: ➔ Preparation of an equipping and resourcing plan

Necessity for action: • To make RBOs functional

Prerequisites to action: • Actions 1.1 to 1.5

ACTION 1.7: ➔ Develop capital and recurrent budget

Necessity for action: (Not mentioned)

Prerequisites to action: • Actions 1.1 to 1.6

Table 18.3 Identified responsible institutions, collaborators, and time frame

<table>
<thead>
<tr>
<th>ACTION NUMBER</th>
<th>RESPONSIBLE INSTITUTION</th>
<th>COLLABORATING INSTITUTION</th>
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<th>PROPOSED END DATE</th>
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<td>MWEM-CWA</td>
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<td>Jan 1995</td>
<td>June 1995</td>
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<td>June 1995</td>
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<td>Nov 1995</td>
</tr>
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<td>6</td>
<td>MWEM-PWO</td>
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<td>Feb 1995</td>
<td>Nov 1995</td>
</tr>
<tr>
<td>7</td>
<td>MWEM-PWO</td>
<td>NONE</td>
<td>Apr 1995</td>
<td>July 1995</td>
</tr>
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</table>
DISCUSSION

QUESTION: Proposals are given for four priority basins. What would be the status of the remaining five basins?

Answer: All the basins will eventually be considered but it is has been considered more appropriate to deal with this issue step by step. At this stage it has been found logical start with the priority basins.

QUESTION: What would be the possibility of making the River Basin Water Offices autonomous and financially self supporting?

Answer: Financing can be achieved from all sources instead of going only to budgets. One of the ways would be to look into water use charges, pollution charges, and other similar avenues which can finance basin activities. Cost recovery from stakeholder may also be emphasized.

QUESTION: Water Boards and the Water Offices do not show linkages between farmers, urban dwellers, and the Boards. Can you comment on that?

Answer: It was appropriate to review the terms of reference and possibly the composition of the boards to reflect the proposed linkages.
Presentation of Group 4 on the theme of Opportunity Cost of Water

TOPIC #1: Assessment of water resources in the basin

Identified Issue: Inadequate information on water resources

Recommended Actions:

ACTION 1.1: Reviewing existing literature and establish Data Base

Necessity for action: To ascertain what data and information is available and to identify gaps

Prerequisites to action: Availability of resources

ACTION 1.2: Verifying, updating, and obtaining additional information through field studies

Necessity for action: To improve information required for assessment of available water resources

Prerequisites to action: Availability of resources

ACTION 1.3: Strengthening the capacity for continuous data and information monitoring and collection

Necessity for action: Data and information are key input to any assessments

Prerequisites to action: Availability of resources

ACTION 1.4: Analysis of data to determine available water resources

Necessity for action: To understand the available water resources

Prerequisites to action: Computers and appropriate water resources software

Training of personnel

Technical assistance
TOPIC #2: Setting priorities for various uses of water

Identified Issue: Competing demands of water uses which require prioritization; and, making the best use of available water resources

Recommended Actions:

ACTION 2.1: Identification of demands and objective of various uses of water

Necessity for action: • To facilitate proper allocation of water

Prerequisites to action: • Resources and Government commitment

ACTION 2.2: Determination of cost benefit and setting of priorities

Necessity for action: • To optimize the use of water resources

Prerequisites to action: • Availability of resources

TOPIC #3: Proper management of water resources

Identified Issue: Poor management of water resources leading to misuse of the resource

Recommended Actions:

ACTION 3.1: Enforcing legislation on land use, environment, agriculture, and other sectors using water

Necessity for action: • To make more water available.

Prerequisites to action: • Political will
• Government commitment
• Resources availability

ACTION 3.2: Strengthen monitoring and supervision capacity

Necessity for action: • To minimize abuses of and ensure sustainable use of water

Prerequisites to action: • Commitment by Government and ESAs
Table 18.4 Identified responsible institutions, collaborators, and time frame

<table>
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<tr>
<th>ACTION NUMBER</th>
<th>RESPONSIBLE INSTITUTION</th>
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<td>ESAs, NGOs</td>
<td>Oct 1994</td>
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</tr>
<tr>
<td>4</td>
<td>MWEM</td>
<td>INTER-SECTOR TEAM</td>
<td>Jan 1995</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td>MWEM</td>
<td>STAKEHOLDER, INTER-SECTOR TEAM</td>
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<td>Mar 1995</td>
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<td>Oct 1994</td>
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</table>

DISCUSSION

**QUESTION:** Who is going to be responsible for the actions proposed by the group as it appeared that responsibilities have been broadly assigned? It is necessary to show the line of command for the various actors.

**Answer:** At this stage it is not possible to give specific assignments, because traditionally when tasks go to a Ministry they are then assigned to the relevant authority. For example, if one looks at a basin it may be seen that there are many Acts or Legislation pertaining to various related activities in the basin, in which case an inter-ministerial approach is required to ensure that the desired objectives are achieved.
Presentation of Group 5 on the theme of Environmental Demand

Topic #1: Policy and environmental protection

Identified Issue: Lack of direction and non-integrated approach for dealing with environmental issues

Recommended Actions:

ACTION 1.1: Approval of Environmental Policy and Environmental Protection Bill

Necessity for action: To provide clear guidelines and direction on how resources can be managed in an integrated manner

Prerequisites to action: Workshop, Parliament session

ACTION 2.1: Prepare strategies and Action Plan for approval

Necessity for action: It is a major implementation tool

Prerequisites to action: Workshop

Topic #3: Need for Environmental Impact Assessment (EIA) in all projects

Identified Issue: In the past, EIA was not done regularly and the result has been increasing environmental pollution. Mandatory EIA will prevent further degradation of the environment

Recommended Actions:

ACTION 3.1: Review and approve Environmental Protection Bill

Necessity for action: To strengthen the Bill

Prerequisites to action: Public awareness campaign, Parliament session

ACTION 3.2: Formulate guidelines and set standards

Necessity for action: To set Terms of References

Prerequisites to action: Inter-sectoral meeting
**Topic #4: Pollution Abatement**

**Identified Issue:** Prevention of deterioration of water quality and to maintain the bio-diversity

**Recommended Actions:**

**ACTION 4.1:** Establish and strengthen Water Management in four priority basins: Pangani, Rufiji, Lake Victoria and Ruvu/Wami.

Necessity for action: These basins are of major concern with respect to pollution and water use conflicts

Prerequisites to action: Financial and Technical assistance

**ACTION 4.2:** Establishing Water Quality Monitoring Program

Necessity for action: To check magnitude or extent of pollution with an objective of preventing it

Prerequisites to action: Financial and Technical assistance

**ACTION 4.3:** Need for international cooperation in shared water bodies

Necessity for action: To conserve the shared water bodies for sustainable use

Prerequisites to action: Multilateral and Bilateral organizations
### Table 18.5 Identified responsible institutions, collaborators, and time frame

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<th>ACTION NUMBER</th>
<th>RESPONSIBLE INSTITUTION</th>
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<td>MWEM</td>
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<td>MWEM, MOA AND ALL SECTORS</td>
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<td>5 YRS INITIAL PHASE</td>
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</table>
**DISCUSSION**

**QUESTION:** How will consultants report fairly on the Environmental Impact Assessment (EIA) rather report in the way that those who paid for it would like to hear?

**Answer:** Generally, when developers apply for a license or clearance, they will be asked to produce an EIA report which has to be done by the professional body. Alternatively, an independent consultant would undertake the study and give their report to the professional body for recommendation to the Ministry.

**QUESTION:** How are environmental uses, and water demands for the ecosystem and other needs going to be taken into consideration?

**Answer:** The speaker observed that environmental demands will be adequately taken care of. However, political stability is a prerequisite.
CHAPTER NINETEEN

CONCLUDING REMARKS

Seminar Conclusions

François-Marie PATORNI and Rafik HIRJI

MEETING SEMINAR OBJECTIVES

The seminar started out with three specific objectives. These were to: (a) sensitize decision makers on the need for managing water resources in a comprehensive manner; (b) share river basin management experiences from within and outside Tanzania; and, (c) assist the Government in preparing the second phase of national water resources management strategy. In addition, seminar participants were challenged by the chairman of the seminar to come up with practical and implementable recommendations for the Government to follow for addressing the water resources management challenges facing Tanzania.

The participation of decision makers from various sectoral ministries and parastatal organizations (see the list of participants in Annex C), the presentations on issues in river basin management (see chapters fifteen through seventeen), the five working group discussions, and specialist presentations on national river basin management case studies (see chapters three through nine) and river basin management case studies from outside of Tanzania (see chapters ten through fourteen) and video presentation on the Senegal River Basin Management indicate that the first two objectives were fully met.

Measuring the success of the final objective is not straightforward since the preparation of the second phase of the national water resources management strategy is an ongoing process. However, to that effect the seminar brought together team members from the Ministry of Agriculture and the Ministry of Water, Energy and Minerals, and from the World Bank, who are preparing the River Basin Management and Small Holder Irrigation Improvement Project for two of the four priority basins identified during the first phase. This team is also deeply involved in the preparation of the National Water Resources Assessment. In addition, EDI made a commitment to continue collaborating with the Government of Tanzania to assist in building national capacity for managing its water resources.

FUTURE COLLABORATION WITH THE ECONOMIC DEVELOPMENT INSTITUTE (EDI) OF THE WORLD BANK

At the end of presentations, participants had an opportunity to suggest possible areas of future collaboration with EDI. Workshop participants articulated the following areas of possible collaboration:
1) Environment
   Developing Principles, Guidelines, and Frameworks for the Environmental Impact Assessment

2) Water Law and Environmental Legislation

3) Human Resources Management and Development
   · Training, seminars and workshop e.g. in Geographical Information Systems, training of more hydrologists etc.
   · Career development
   · Motivation of staff
   · Streamlining of Management Structures

4) Institutional Strengthening
   · In particular on the design of river basin organizations.

5) Development of pricing mechanism for various water uses, now it is accepted that water has a value.

6) Information and data collection and dissemination.

PRACTICAL AND IMPLEMENTABLE RECOMMENDATIONS

The challenges posed by the chairman of the seminar were addressed in the context of five working group discussions. Each group comprising of ten to twelve participants focused on one of the following themes: Cross sectoral Uses of Water, Stakeholder Participation, River Basin Offices, Opportunity Cost of Water, and Environmental Demand. Each group met for an entire afternoon and discussed different topics within each theme (see chapter eighteen for details on group discussions) and identified key issues and recommended specific actions to be taken to address the issue (including the rationale for the action as well as the pre-requisites for taking the action). Each group also identified the responsible institutions, collaborating institutions and the time frame for taking each action. Overall, the chairman was fully satisfied with the recommendations produced.

At the conclusion of this discussion, the Principal Secretary, Ministry of Water, Energy and Minerals, presided over the handing out of certificates of participation.

François-Marie Patorni is the Principal Water Resources Management Specialist of the Economic Development Institute of the World Bank. Rafik Hirji is a Water Resources Management Specialist with the Environment Department of the World Bank.
Closing Statement

Principal Secretary for Water, Energy, and Minerals,
Mr. R. MOLLEL

Mr. Chairman, Seminar Participants, Ladies and Gentlemen:

I have had the great pleasure of being honored to be here with you on the closing day of the seminar, "Water Resources Management in Tanzania." First, may I take this opportunity to congratulate you all for having dedicated almost all your time during the past five days to deliberate on the important issues pertaining to water resources development and management in Tanzania.

Mr. Chairman, I have been informed that seminar participants have heard the experiences and problems of water resources development and management in Tanzania and other parts of the world, and that this has helped in identifying five pressing themes necessary for comprehensive and sustainable approaches to water resources development and management.

These are:
- cross-sectoral uses of water
- stakeholder participation
- establishment of river basins
- opportunity cost of water; and
- environmental demands for water.

For each of these five themes you have come up with appropriate actions to be taken in order to address them. I am very gratified to learn that having perceived the unfavorable current state of water resources management in the country, and you have recommended that these actions be initiated within the coming six months.

Mr. Chairman, I am glad to inform you that the government will take your recommendations and ensure that they are implemented with the urgency that they deserve. It is my sincere belief that the implementation of your proposed actions will lead to proper and efficient management of water resources in the river basins throughout the country.

Mr. Chairman and seminar participants, I understand that you have gone through a tight schedule lasting from morning till late evenings. On that account it will not be fair for me to bore you with another lecture.

I wish to take this opportunity to thank the seminar organizers. My sincere regards go to the Economic Development Institute of the World Bank and the Government of the Netherlands who sponsored this Seminar. I wish to thank resource persons both from Tanzania and other countries, seminar participants, observers and guests, whose contributions have made this seminar a success.

I with you all safe journeys back home, and hope that we shall meet again in future in such or other similar gatherings.

With these few remarks I now declare the seminar closed. Thank you.
Annexes

Seminar Schedule
Site Visits
List of Participants
### SCHEDULE OF THE SEMINAR: WATER RESOURCES MANAGEMENT IN TANZANIA

**TANGA, TANZANIA, SEPTEMBER 12-16, 1995 AT THE MKONGE HOTEL**

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<th>Tuesday September 13</th>
<th>Wednesday September 14</th>
<th>Thursday September 15</th>
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<tr>
<td><strong>Morning 1</strong></td>
<td>Introductory session:</td>
<td>Feedback on seminar objectives</td>
<td>Day's overview</td>
<td>Paper: Lord Discussion</td>
<td>Evaluations</td>
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<td>Opening remarks</td>
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<td>Working Groups to identify priority issues</td>
<td>Paper: Matondo Discussion</td>
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<td>Expectations</td>
<td>Paper: Rwakabare Discussion</td>
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<td>Presentations by working groups</td>
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<td>Paper: Njau</td>
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<td><strong>Morning 2</strong></td>
<td>Paper: Msuya Discussion</td>
<td>Field Visit to Mabayani Dam</td>
<td>Paper: Howard Discussion</td>
<td>Paper: Mujwahuzi Discussion</td>
<td>Concluding remarks: Patorni</td>
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<td>Paper: Njau</td>
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<td>Paper: Rwakabare Discussion</td>
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<td>Closing Statement: Principal Secretary</td>
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<td><strong>Afternoon 1</strong></td>
<td>Paper: Mwaruwanda Discussion</td>
<td>Field Visit to Pangani Hydro Power Station at Hale</td>
<td>Paper: Lord Discussion</td>
<td>Working Groups</td>
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<td>Paper: Mashauri Discussion</td>
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<td>Paper: Duda Discussion</td>
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<td><strong>Afternoon 2</strong></td>
<td>Paper: Kamugisha</td>
<td>Field Visit continued</td>
<td>Paper: Labre Discussion</td>
<td>Working Groups</td>
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<td><strong>Evening</strong></td>
<td>Video on Senegal River Valley</td>
<td>Planning for working group sessions</td>
<td>Planning for working group sessions</td>
<td>Video on California Water Crisis</td>
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ANNEX B

SUMMARY DESCRIPTION OF SITE VISITS

During the seminar, the participants were able to visit two sites: the Mabayani Dam site on the Sigi River, which is the primary source of water supply for the municipality of Tanga, and the Pangani Redevelopment Hydro-Electric Power Station at Hale. The site visit was organized by the Tanga Regional Water Engineer, in collaboration with the Pangani Basin Water Office and the Tanzania Electricity Supply Company.

Mr. Futakamba, the Tanga Regional Irrigation Engineer, gave a brief presentation on two other sites during the workshop. He spoke about irrigation schemes in Tanga Region, using the examples of the Chekelei and the Mombo Irrigation Schemes.

CHEKELEI IRRIGATION SCHEME

Chekelei is one of thirty-one irrigation schemes in Tanga Region. It is situated in the southern end of the lower Mkomazi Valley on the right bank of the Vuruni River.

Scheme information

Relevant data on the scheme are as follows:

Area: 200 hectares, potentially
       110 hectares, under irrigation

Number of farmers: 400

Plot size: 0.5 ha

Cropping intensity: 100 percent
   The introduction of irrigation advisory services have shown that it is possible to have a 200 to 300 percent intensity.

Production: 3 - 4.5 t/ha

Crops grown: Mostly paddy. Maize and beans are also grown.

Water requirement: 110 l/sec

Organizational set up: This is under the Water Users Association which is responsible for all the day-to-day activities. The officers of the WUA include a chairman, secretary, and treasurer.
O & M: This is done by the farmers themselves. The government offers a technical input by assigning the irrigation technician to execute his duties in that area or zone.

Water management: In this scheme, irrigation is scheduled to be eight hours. This is more pronounced when the flow is enough to cater for the whole area, but during the dry season an intermittent or rotational system is adopted.

Management strategy at the scheme level

The contact body for the scheme is the WUA which is held responsible for any mismanagement of water in the scheme. Advisory services are done by technical personnel to the WUA on how to take care of their scheme, e.g., canal cleaning, gate lubrication, and other aspects. This is facilitated by an expectation that each farmer contributes produce or cash to the O & M fund.

Problems

There are a number of abstractions occurring without water rights, leading to insufficient water for the scheme. Also, environmental degradation is leading to excessive sediment transport. Finally, there is no serious O & M program, leading to a remarkable deterioration of the scheme. The breakdown in turn leads to uncontrolled water losses.

Plans to tackle the problems

(i) To have each abstraction drawing the allowed amount of its water rights;

(ii) To educate the farmers in the WUA to take the O & M program seriously; and,

(iii) To integrate different institutions involved with water utilization to curb the environmental degradation.

MOMBO IRRIGATION SCHEME

This scheme is located in the Lower Mkomazi Valley, at 4°55′ S and 38°17′ E, 400 meters above sea level in Korogwe District. The scheme was rehabilitated so that it can function as a rice pilot scheme for the development of the Lower Mkomazi Valley. The valley has a potential area 10,000 hectares for rice cultivation.

Scheme information

Relevant data on the scheme are as follows:

Area: 220 hectares

Number of farmers: 429

Cropping intensity: 150 percent
Production: 2 - 2.5 t/ha [before floods this figure was 4-6.0 t/ha]

Crops grown: Paddy. Beans can also be grown.

Organizational set up: Cooperative Society

O & M: Self-help basis. Farmers contribute in the form of farm produce.

Water management: This scheme is farmer-managed with some input on technical management and advise from the government.

Present situation

The scheme has been greatly affected by the exceptional floods of January 1993 during which the areas surrounding the intake weir were completely destroyed. This caused the river to take a new course which headed towards the scheme's fields. In addition, the intake weir was completely covered in sediment.

As a result, water management and field preparations at the scheme have been proved to be very difficult, as water cannot be easily controlled.

Cause of the problem

The flooding and the damage have been attributed to:

- Environmental degradation upstream in the Usambaras;
- Absence of a silt exclusion arrangement at the intake weir;
- Abandonment of the river dredging program which controlled sedimentation build-up.

Steps proposed

- To prepare a new design of an intake weir, coupled with a silt exclusion arrangement;
- Carry out a thorough study on sediment transport for Soni River;
- Reestablish the river dredging program to maintain continuity of water flow.
Conclusions

Seeing the two schemes provides some insight into working out a water management strategy. Issues such as a thorough study of sediment transport, soil and water conservation, and a good program of O & M should not be given a deaf ear. In conclusion, recommendations include:

(i) Educating water users on issues of water management;
(ii) Prohibiting uncontrolled abstractions;
(iii) Having each scheme establish serious plans for O & M; and,
(iv) Training technical personnel involved in water management to provide workable advice to WUA.
ANNEX C

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