



PROCEEDINGS | 75

Proceedings of the International Workshop on the Fisheries of the Zambezi Basin

Livingstone, Zambia
31 May - 2 June 2004



Republic of Zambia



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CGIAR

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Fishing on the Zambezi (O.T. Sandlund)

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List of Abbreviations

Table 1. Abbreviations used in text and annexes

ARWG	Aquatic Resources Working Group
AWF	African Wildlife Foundation
C/LB	Chambeshi / Luapula Basin
CAS	Catch Assessment Survey
CEDRS	Catch Effort Data Recording and Storage System – (Kapenta fishery of Zimbabwe)
CLUSA	Co-operative League of the United States of America
CPUE	Catch Per Unit Effort
DoF	Department of Fisheries
DRIFT	Downstream Response to Instream Flow Transformations
ECZ	Environmental Council of Zambia
EFA	Environmental Flow Assessment
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization of the United Nations
FFP	Fisheries Development Fund - Mozambique
GIS	Geographical Information System
GMA	Game Management Area
GPZ	Zambezi Basin Development Planning Office - Mozambique
GWP	Global Water Partnership
HR	Human Resources
IDPPE	National Institute for Small Scale Fishery Development - Mozambique
IFAP	International Federation of Agricultural Producers
IIP	Instituto de Investigacao Pesqueira / National Institute of Fisheries Research Mozambique
IUCN	The World Conservation Organisation
IWMI	International Water Management Institute
KB	Kafue Basin
LB	Luangwa Basin
LKFRI	Zimbabwe Parks and Wildlife Management Authority's Lake Kariba Fisheries Research Institute
MAWRD	Ministry of Agriculture, Water and Rural Development – Namibia
MET	Ministry of Environment and Tourism – Namibia
MFMR	Ministry of Fisheries and Marine Resources – Namibia
MICOA	Ministry of Environmental Affairs – Mozambique
NEPAD	New Partnership for African Development
NGO	Non-Government Organisation
NINA	Norwegian Institute for Nature Research
NORAD	Norwegian Agency for Development Co-operation
SADC	South African Development Community
SAIAB	South African Institute for Aquatic Biodiversity
SAIAB	South African Institute of Aquatic Biodiversity
SPP	Provincial Services of Fisheries – Mozambique
SWB	Small Water Bodies

TBNRM	Transboundary Natural Resource Management
UEM	University of Eduardo Mondalane – Mozambique
ULKRS	University of Zimbabwe’s Lake Kariba Research Station
UNEP	United Nations Environment Program
WHO	World Health Organisation
WorldFish	WorldFish Center (formerly the International Center for Living Aquatic Resources Management - ICLARM)
WWC	World Water Council
WWF	World Wide Fund for Nature
ZAMCOM	Zambezi River Basin Commission
ZB	Zambezi Basin
ZIMOZA	Zimbabwe, Mozambique and Zambia project
ZINWA	The Zimbabwe National Water Authority
ZPWMA	Zimbabwe Parks and Wildlife Management Authority
ZRA	Zambezi River Authority

Structure of Proceedings

This report is divided into two sections with annexes. Section One contains the report of the workshop including the workshop findings and outputs. Section Two contains summary papers of the workshop presentations with a record of any relevant points of discussion. The annexes contain additional information referred to in Section One, such as the participant list, detailed findings and speeches.

1. Introduction

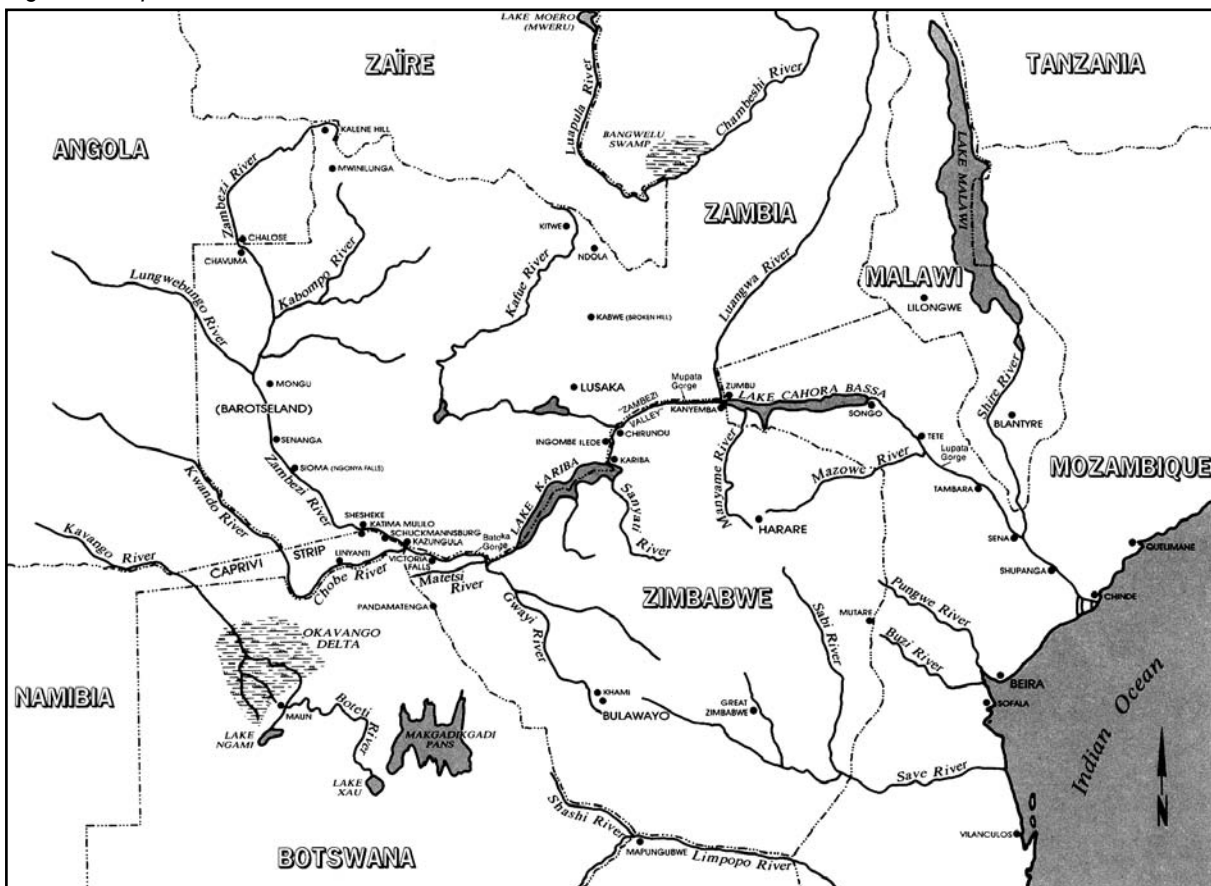
The Zambezi River system is the largest in Southern Africa and one of the most important on the African continent. By providing multiple benefits ranging from water for domestic, irrigation, and hydropower uses, to fisheries and a wide diversity of wildlife products, the river plays a central role in the lives of millions of people in the riparian states. As the countries of the basin place increasing attention on how best to harness these multiple benefits sustainably it is increasingly important that the potential and constraints of different resource uses are understood and factored into the decision-making process.

Amongst the many wild natural resources that the basin provides the fisheries are especially important. Not only are these generally the most

valuable wild resource, but they also play a crucial role in providing high quality nutrition for the people of the basin while also sustaining a diversity of livelihood strategies ranging from those who catch the fish to those who process and trade the catch.

In view of these concerns, and as part of a programme of research and capacity building for improved management of Africa's river fisheries, an international workshop on the fisheries of the Zambezi basin was held in Livingstone, Zambia from 31st May – 2nd June 2004. Convened by the Department of Fisheries of Zambia and the WorldFish Center, the workshop brought together regional and international partners concerned with the fisheries of the Zambezi, and the challenges and opportunities that they face.

Figure 1: Map of the Zambezi Basin



From: *Zambezi, Journey of a river* by M. Main 1990

2. The workshop

2.1 THE WORKSHOP OPENING

The International Workshop on the Fisheries of the Zambezi was officially opened by the Permanent Secretary of the Southern Province Mr. Sylvester Mphishi in Livingstone, Zambia on the morning of Monday 31st May 2004. Introductory remarks were made by Mr. Cyprian Kapasa, Deputy Director, Fisheries Research Branch, Department of Fisheries, who warmly welcomed all participants to the workshop. Mr. Kapasa facilitated the introduction of workshop participants before inviting the Permanent Secretary to make the opening address.

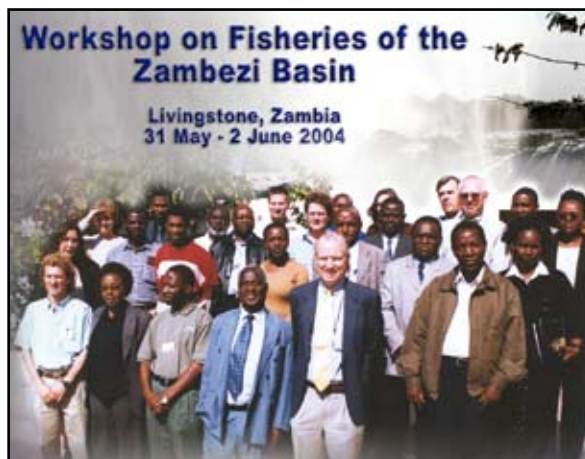
The opening address expressed gratitude to the WorldFish Center for their support in making the workshop possible and stressed the international and regional importance of co-operation in the management of the Zambezi basin. The meeting was informed about the range of benefits and challenges that the Zambezi basin offers the region and the various constraints that the water sector of the Zambezi basin faces. Some of the challenges that the fishery sector faces and needs to overcome if the potential for increased fish production and consumption is to be realised were elaborated. Concern was expressed over the potential degradation of the environment and support given to possible solutions such as the practise of involving stakeholders in a truly participatory manner in the management process. The address also emphasized the need for information flow and communication addressing the challenges being faced by the Zambezi. The Permanent Secretary endorsed the workshop objectives and then officially opened the meeting (speech attached, Annex C).

Dr. Patrick Dugan, Deputy Director General of the WorldFish Center for Africa and West Asia thanked the Permanent Secretary for his informative and supportive opening address before making some brief opening remarks. Dr. Dugan stressed the need to consider the future demands that would be placed on the resources of the Zambezi basin over a fifteen to twenty year time scale and the

implications that these had for fisheries. He noted the complex challenges that the basin faced and in particular the need to manage water so that it yields wider benefits to society in the coming years. Dr. Dugan stressed the importance of incorporating fisheries management into the wider concepts of food security and livelihoods and the need for all involved in the fisheries sector to increase their efforts to do this. The importance of a cross-sectoral approach to such issues within African was demonstrated by the increased emphasis being given to fisheries through NEPAD. Dr. Dugan noted the challenge already faced in sustaining capture fisheries productivity today but stressed our duty to look to the future where the need for an increase in fisheries productivity will be required through more strategic and multi sector approaches.

2.2 THE PARTICIPANTS

A total of thirty seven participants took part in the workshop. The participants included representation from five of the Zambezi basin countries; Malawi, Mozambique, Namibia, Zambia and Zimbabwe. Expertise from a wide range of disciplines was drawn together including the fields of; conservation; ecology; economic valuation; environment; environmental flows; fisheries governance; fisheries research; hydropower development; private sector concerns and involvement; regional and national fisheries management; regional development policy; resource use planning; urban development and impact; and water management. A full list of participants is provided in Annex A.



2.3 THE PROCESS AND AGENDA

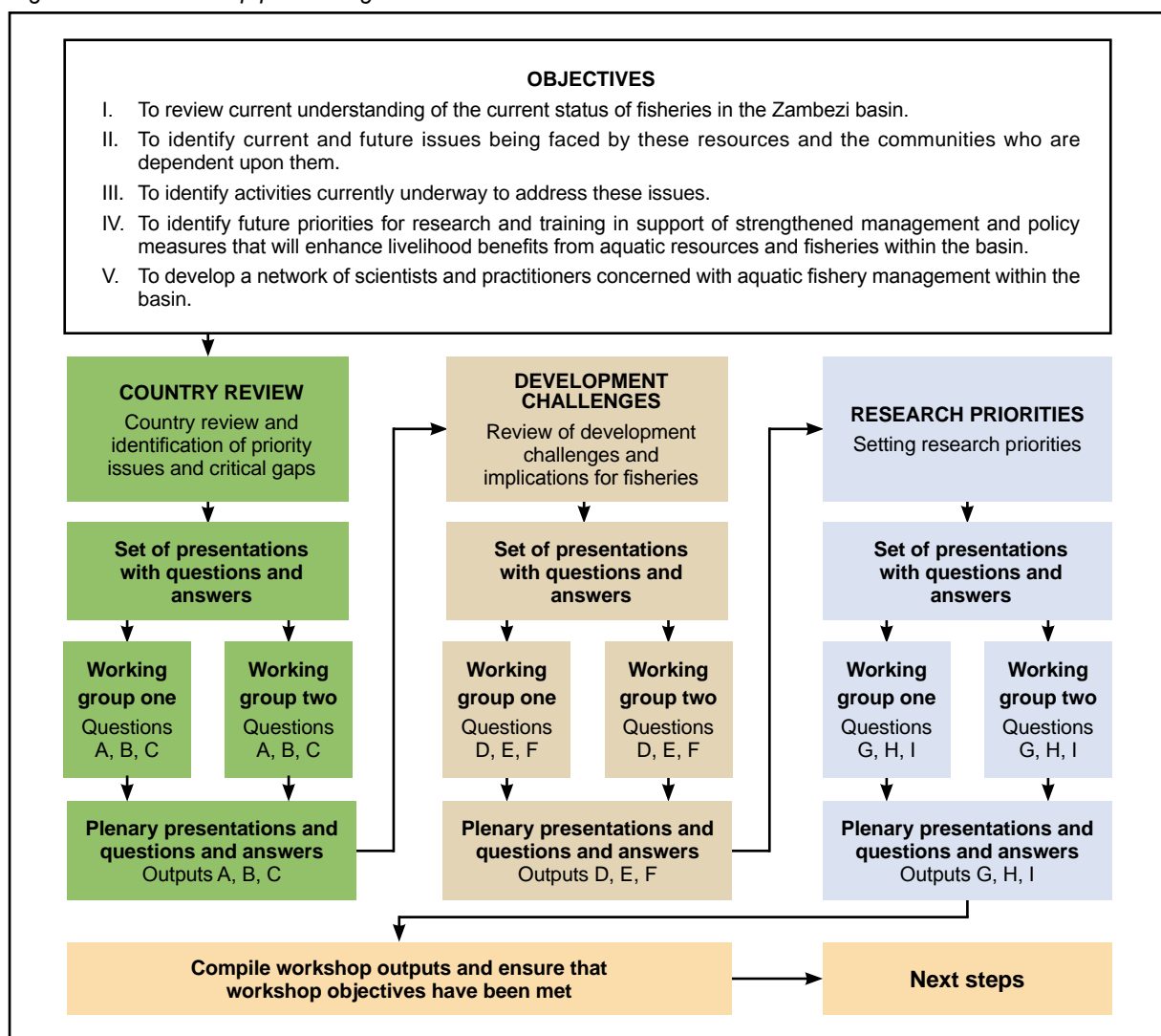
The workshop ran for three days (the agenda is attached, Annex B). The main stages in the workshop process are summarized in Figure 2.

1. **OBJECTIVES:** The five principal objectives of the workshop had been previously circulated to all participants and were presented again at the start of the meeting for concurrence (see Figure 2).
2. **COUNTRY REVIEWS AND ANALYSIS:** Five country reviews were presented (from Malawi, Mozambique, Namibia, Zambia, Zimbabwe). Following discussion of these reviews in plenary the workshop divided into two working groups; group one consisted of participants representing the upper and upper-middle Zambezi - Namibia, Zimbabwe and part of Zambia, while group two consisted of

participants representing the lower-middle and lower Zambezi – part of Zambia, Malawi and Mozambique. Non-country specific experts divided their skills between the two groups. The two groups considered three questions and then presented their findings in plenary. Following a question and answer session the rapporteurs merged the findings into three consolidated outputs: A, B and C.

- A. What are the main management and policy challenges being faced by the fisheries of the basin and its tributaries?
- B. What research has been completed and is currently underway to address these?
- C. How does this research contribute to management and policy processes at national and basin level? (What are the mechanisms?)

Figure 2: The workshop process agenda



3. DEVELOPMENT CHALLENGES:

Five plenary presentations on specific development challenges in the Zambezi basin were followed by questions and answers. The working groups then considered three questions and as on the first day presented their findings in plenary. Following a plenary discussion the rapporteurs merged the findings into three consolidated outputs; D, E and F.

D. What are the major development, processes, pressures and constraints in the Zambezi and its tributaries?

E. What is the relevance and impact of these for fisheries?

F. What development and management investments are being made/are planned to address these? – And where are the gaps?

4. RESEARCH PRIORITIES:

Seven plenary presentations on research issues of importance

for the Zambezi basin were followed by questions and answers. The working groups then considered three questions, presented their findings in plenary and produced outputs; G, H and I.

G. What are the issues where further fisheries research is required in the Zambezi basin and its tributaries?

H. What are the priorities amongst these?

I. How should research be pursued to address these so as to have greatest impact on policy and management?

5. SYNTHESIS:

The nine outputs from the working group process were compiled into an overall output and presented in relation to the workshop objectives. This was followed by a presentation and agreement on the proposed next steps and follow-up to the meeting.



The Zambezi (O.T. Sandlund)

3. The workshop findings and outputs

3.1 COUNTRY REVIEW AND DISCUSSION

The five country reviews provided information on the current status of fisheries within the countries, fisheries policy and management strategies, challenges and threats to the fisheries, past and current programmes and activities, gaps and research issues that needed addressing and the key institutions involved in the fisheries. A table summarising this information is provided in Annex D and an overview of the main discussion points is provided after each of the summary papers emanating from the presentation (Section Two).

Following the plenary presentation the working groups addressed three questions relating to priority issues and critical gaps and produced their findings in a tabulated form (Annex E). The key findings are summarized below:

Output A: Review of the management and policy challenges faced by basin fisheries

The challenges faced are:

- The need to **implement existing legislation**, commonly fishers are non-compliant to fisheries laws and regulations and there is an inability to enforce existing legislation
- The need for **more or for updated inland fisheries policy development**, in certain countries legislation exists but is outdated or inadequate while in others there is no legislation
- **Inadequate policies and regulations**, including the need to harmonize policies and a lack of integrated approaches to river basin use
- **Lack of capacity to manage the complexity of resource uses and pressures**, including rising population and demand, poverty of the basin communities, challenges of co-management

- **Inadequate knowledge of the resource base**, both biologically and ecologically
- **Inadequate understanding of the economic value of the fisheries**
- **Inadequate resource allocations to manage or research the fisheries**, typically in government human resource and economic institutional capacity
- **A tendency for management objectives that do not reflect today's realities**, including open access of fisheries resources in the basin, the prevalence of HIV/AIDS

Output B: Identification and extent of research currently underway to address challenges

The following research was identified to be addressing these challenges:

- Considerable policy research and development at national level and some transboundary e.g. lake Kariba; ZAMCOM; SADC Fisheries Protocol
- Some integrated water resource approaches e.g. Kafue
- Increased consultation with stakeholders allowing better understanding of complexity of resource management
- Increased biological and socioeconomic surveys – but a limited amount of recent surveys in some countries
- Limited recent work on stock assessment
- Limited research on economic value of the resource
- No/few studies of impact of HIV/AIDS in fishing communities

Output C: Assessment of how research is feeding into management and policy processes

An assessment of how this research is linked in to the management and policy process:

- Protocol exists between Zambia and Zimbabwe on fishery resources of Kariba and transboundary water of the Zambezi to facilitate joint management
- Devolution of management to local level e.g. through co-management of the lakes in Malawi to enable participatory management at a local level
- Increased effectiveness of legislation due to improved legislation having been implemented
- Social, economic research has taken place and this has contributed to the revision of Fisheries Acts in Zambia and Mozambique

3.2 DEVELOPMENT CHALLENGES AND DISCUSSION

Five presentations were given on some of the development challenges in the Zambezi basin: hydropower development and water management requirements; resource-use pressures and conflicts; urban impacts on rivers; opportunities and constraints for private sector investment in Zambezi fisheries; and the Kafue dialogue. Summary papers emanating from these presentations and a summary of the discussion that followed the presentations are attached (Section Two).

Following the presentations the working groups addressed three questions relating to development challenges and the implications for fisheries, their findings are attached as a table in Annex F and summarized below:

Output D: Review of the major development processes, pressures and constraints

The review showed the following key factors:

- **Physical changes:** dams, roads, agriculture, aquaculture
- **Demographic changes:** population increase, HIV/AIDS, urbanization

Output E: An assessment of the relevance and impact of these for fisheries

The impact of these was assessed as follows:

- Dams produce changes in fish production either an increase or decrease and also in the species composition
- Roads increase access for fishers and to markets and they may produce environmental damage or changes to flood cycles
- Agricultural encroachment can cause siltation, impact of increased use of pesticides and nutrient run-off
- Aquaculture often introduces alien species and a spread of disease
- Population increase will increase demand for fish; increase fishing pressure; cause changes to fishing patterns; and increase conflicts among resource users
- HIV/AIDS can increase fishing pressure; result in a loss of expertise; a breakdown of organization and social structures; and a loss of investment
- Urbanization causes an increase in the demand for fish and potential pollution

Output F: Evaluation of development and management investments being made to address the impacts and the gaps

An evaluation of investment being made to address such impacts gave the following results:

- Long term research, monitoring and evaluation of impacts are being pursued as a basis for decision making (but in some cases only)
- Not enough effort is being made in getting ownership by stakeholders in the management process – the processes are more consultative than genuinely participatory
- There is a need for more visionary and comprehensive development processes
- There are some processes to develop national and regional collaboration, but more are needed

3.3 RESEARCH PRIORITIES AND DISCUSSION

Seven presentations were given on the key fisheries research issues of importance for the Zambezi basin: water and fisheries governance: implications for the Zambezi basin, valuation of river fisheries in the Zambezi basin, assessing environmental flows: prospects for the Zambezi basin, flow requirements in the Zambezi delta, inshore fisheries and fish populations in Lake Kariba, research on fish biology in the Zambezi River and fisheries research in the upper Zambezi. The summary papers emanating from each presentation and any relevant discussion points that followed the presentations are provided in Section Two.

The working groups addressed three questions relating to setting research priorities for fisheries and presented their findings in plenary. The combined findings are summarized below:

Output G and H: Research priorities for policy and management

The groups identified the research priorities in teams of two and then merged the findings into a common set of priorities; these were ordered

according to priority and in plenary one consolidated list produced:

- A knowledge management system for the Zambezi basin is required including: baseline information and managing data collection, quality control, harmonization, storage and dissemination
- Improved and increased fisheries research which contributes to sustainable rural livelihoods and food security is required, including:
 - Research into the resource base
 - Research on the socioeconomic context of the fishery (including HIV/AIDS) and the importance of the resource (including valuation, and study of the nutrition value of fish)
 - Transboundary and institutional issues such as; policy and legal frameworks; management plans; institutions; implementation constraints
- Information required for development of an integrated basin management plan including study of the effect of natural environmental variability on fishing stock versus fishing patterns and other human impacts (including upstream/downstream impacts of dams, pollution) on fisheries is needed
- Impact of aquaculture (including exotics) on fisheries of the Zambezi basin is required

Output I: Ways to peruse research to provide the greatest impact on policy and management

Both groups considered this question through a brainstorming session. The combined outcome of the two groups recommends that the following approaches be pursued:

- Shape research so that outputs are easily adopted by the end-users, ensure that fish related research is focused on development research

- Ensure appropriate packaging and communication of research results to make the information assessable to policy makers
- Develop a common vision at the basin level that will help to drive communication of results and impact to a wider audience
- A greater understanding of capacity needs when developing research programmes and incorporating approaches that will assist in building capacity in the region
- Utilise private-public partnerships (and investment) as a means to develop wider participation in basin issues
- Cross-sectoral analysis and multi and interdisciplinary approaches
- Gender sensitivity at all levels and within all approaches
- Inter-country working groups facilitated to develop communication channels for knowledge sharing for example establishment of communities of practice
- Multi-stakeholder identification, participation and feedback in all activities and programmes
- Generation and use of contemporary data rather than relying on analysis of historical data
- Time series approach for principle data generation with complimentary one-off studies on focused research needs
- Foster focused, directed and problem solving research approaches

3.4 OUTPUTS AND OBJECTIVES

At the end of the workshop the findings of the nine outputs addressing the three key areas of the workshop were compiled as presented above and a cross check made to ensure that the objectives of the meeting had been met:

Table 2: Comparison of workshop objectives to outputs

Objective	Output addressing objective
1. To review current understanding of the current status of fisheries in the Zambezi basin	<ul style="list-style-type: none"> • Output A: Review of the management and policy challenges faced by basin fisheries
2. To identify current and future issues being faced by these resources and the communities who are dependent upon them	<ul style="list-style-type: none"> • Output D: Review of the major development processes, pressures and constraints • Output E: An assessment of the relevance and impact of these for fisheries
3. To identify activities currently underway to address these issues	<ul style="list-style-type: none"> • Output B: Identification and extent of research currently underway to address challenges • Output C: Assessment of how research is feeding into management and policy processes • Output F: Evaluation of development and management investments being made to address the impacts and the gaps
4. To identify future priorities for research and training in support of strengthened management and policy measures that will enhance livelihood benefits from aquatic resources and fisheries within the basin	<ul style="list-style-type: none"> • Output F: Evaluation of development and management investments being made to address the impacts and the gaps • Output G and H: Research priorities for policy and management • Output I: Ways to peruse research to provide the greatest impact on policy and management
5. To develop a network of scientists and practitioners concerned with aquatic fishery management within the basin	<ul style="list-style-type: none"> • All and list of participants and list of key institutions in the Zambezi basin (Annex A and D)

4. Next steps and closing remarks

4.1 NEXT STEPS

The workshop agreed on the following next steps:

4.1.1 Reporting of the workshop

- Prepare a draft report that would include summary papers from the presentations and a summary of discussions and conclusions
- Seek comments on the draft from all participants

4.1.2 Policy process

- Reflect the conclusions in the Inland Fisheries section of the NEPAD agenda
- Seek to reflect the conclusion in various policy papers on Fisheries and Food Security at national and regional level and where possible link these to the Millennium Development Goals and other major international policy goals. This was seen as a responsibility of all participants

4.1.3 Programme development

- To develop specific projects to address the key gaps identified in output G, H and I
- To sustain and develop information flow and networking

4.2 CLOSING REMARKS

The workshop was officially closed by Dr. Patrick Dugan of the WorldFish Center. Dr. Dugan highlighted the progress made during the meeting and thanked all participants for their time and effort. He thanked the Ministry of Agriculture and Co-operatives and particularly the staff of the Department of Fisheries for their very warm welcome and excellent support and hospitality throughout the workshop. Dr. Dugan assured participants that the WorldFish Center would make every effort to promote the findings of the meeting and to assist in finding means to pursue the recommendations of the workshop; however he stressed that this was a shared responsibility of all present.

Mr. Cyprian Kapasa from the Ministry of Agriculture and Co-operatives, Department for Fisheries thanked the WorldFish Center for their dedication and efforts to make this a successful and enjoyable workshop.

Mr. Brian Rashidi spoke on behalf of the participants to express gratitude to the organisers of the meeting and to comment on the importance of such regional co-operations for the future of not just the regions fisheries but also the region as a whole.

The meeting was officially closed at 18.30 on Wednesday 2nd July 2004.

5. Country review and discussion

5.1 COUNTRY REVIEW ZAMBIA

Prepared by Mr. Patrick Ngalande

Introduction

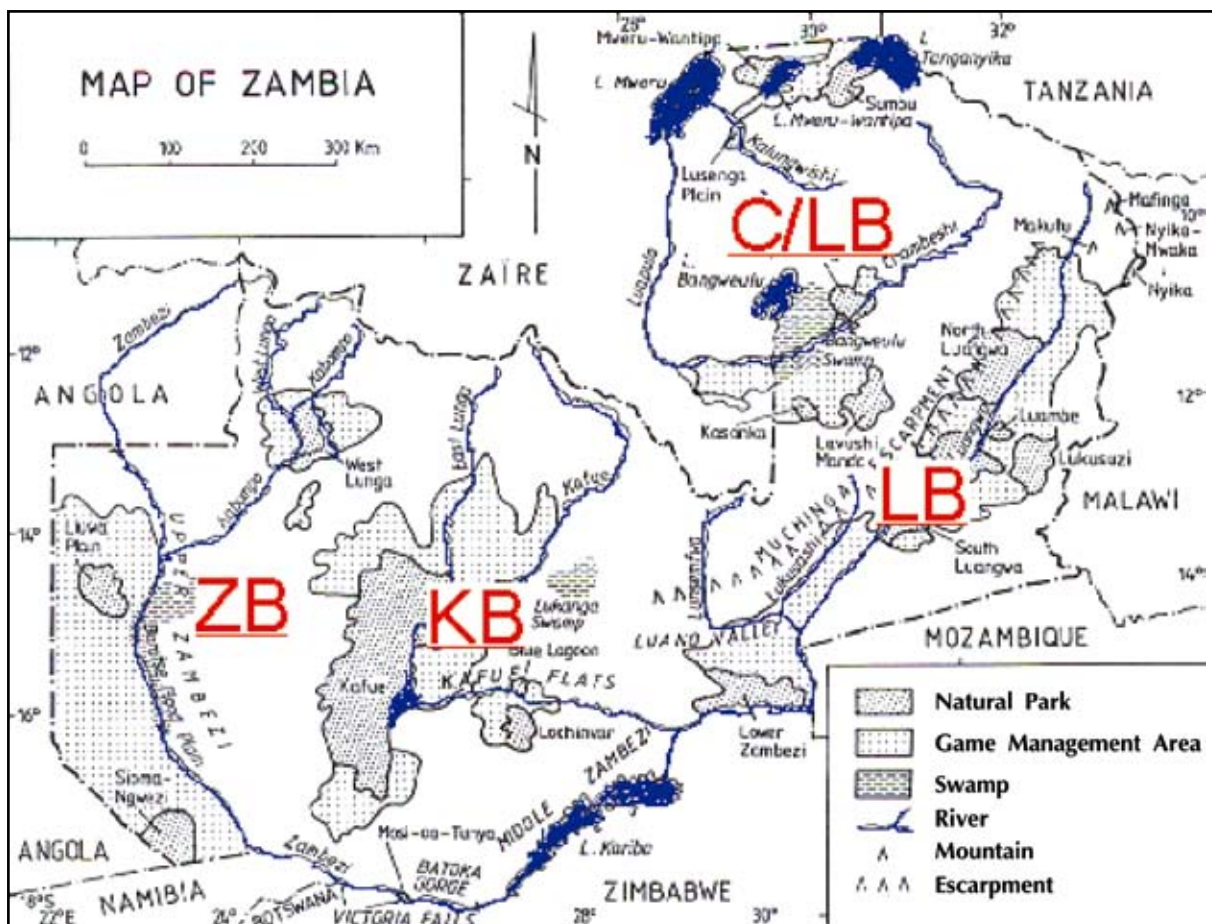
Zambia is a landlocked country covering an area of 752,610 km² and is surrounded by Angola, Namibia, Botswana, Zimbabwe, Mozambique, Malawi, Tanzania and the Democratic Republic of Congo. Zambia has within its boundaries the sources and large parts of two of the largest river systems of Africa; the Congo and Zambezi. The lakes, swamps and floodplains of these river systems together with part of Lake Tanganyika form the greater part of the fisheries of Zambia (Figure 3). Total annual catch is estimated at 70,000 tonnes.

The Zambezi catchment is the largest in the country with an area of 574,875km² covering 76.4% of Zambia's surface area. Three major tributaries flow into the Zambezi River these are; the Kabompo, Kafue and Luangwa. The Zambezi catchment area is home to commercial aquaculture activities, with large-scale fish farms are located in the Kafue Basin and small-scale fish farms in the Super Upper Zambezi and in Luangwa Basin eastern Zambia. Fish farming in cages is also developing at a fast rate on Lake Kariba.

Fisheries monitoring programmes

Fisheries monitoring programmes are carried out by the Department of Fisheries and include data from: experimental gill net data; commercial catch

Figure 3: Zambia river basins



Key: Zambezi Basin (ZB), Kafue Basin (KB), Luangwa Basin (LB) and Chambeshi/Luapula Basin (C/LB)

statistics (gill net catches by fishermen); frame survey data and reports; and Catch Assessment Surveys.

Trends in management of resources

The Department of Fisheries is the custodian of the fisheries in Zambia (Fisheries Act 1974). They licence fishermen and enforce Fisheries Regulations. From 1993 the Department of Fisheries began to involve the fishing communities in the management of the fisheries resources. Arrangements for community participation in fisheries management were created in fishery areas such as Lake Kariba and Lake Mweru-Luapula. In these fishery areas the lakes were zoned, into a stretch of shoreline with a designated number of fishing villages. The fishing villages in the zone have a management committee; these institutions (Zonal Committees and Village Management Committees) lacked legal support because the Fisheries Act of 1974 had no provisions for the formation of such committees or for community participation in the management of the fisheries resources. The Fisheries Act has therefore been revised to include the institutions for community participation in the management of the fisheries resources. Among the benefits to communities in the revised draft bill is that the communities through the above established institutions will receive 60% of the fish licence fees and 60% of the monies collected by the Local Authorities (District Councils) in the form of fish levies. A forum for dialogue between the resource users has been created facilitating more involvement for traditional leaders in the management of Lake Kariba. Currently the Department of Fisheries is also sensitising the fisher communities with the view to involving fisher communities in the management of the fisheries in the Kafue River.

The Zambezi River and its tributaries

The Zambezi River rises in the Kalene hills in north-western Zambia and flows northwards for about 30 km. It then turns west and south to run over about 280 km through Angola and re-enters Zambia. Upon re-entry into Zambia a major tributary Kabompo River flows into the Zambezi. It then flows southwards through marshy Barotse floodplains. In the southwest of Zambia the river becomes the border between Zambia and the

eastern Caprivi region of Namibia for about 130 km. The Zambezi River then forms the border between Zambia and Zimbabwe and reaches its greatest width, over 1.3 km, before its waters plunge over the Victoria Falls. It continues to form the border between Zambia and Zimbabwe after the Victoria Falls with the 277 km stretch of the man-made Lake Kariba. Downstream of Lake Kariba the Kafue River, a major tributary originating in the north of Zambia, flows into Zambezi River with a discharge of about 10 km³/year. Still further downstream, at the border with Mozambique, the Luangwa River flows into the Zambezi River with an annual discharge of over 22 km³. Luangwa River originates in the northeast of Zambia.

- **Super Upper Zambezi**

There is no data on fish landings and the number of fishers is unknown. The area has marked level of fish farming activities by rural communities. There has been no fisheries research or fisheries management in the area except for the recent expedition by the South African Institute for Aquatic Biodiversity (SAIAB) Team of fish taxonomists who undertook 3 expeditions between 2002 and 2003. Introduction of *O. niloticus* is a threat to the fisheries.

- **Upper Zambezi**

This section of the Zambezi River and its flood plain support a large and important fishery. Most of the 225,000 people living on the plain and at the edge of the nearby forest subsist primarily on a diet of maize meal and fish. This area is enumerated but with very low frequency of sampling due to inadequate staffing in the area. There is an increased use of illegal fishing methods mainly kutumpula and small mesh sized gillnets and there is a decline in fish catches (Figure 4).

- **Fisheries Research and Management of the Middle Zambezi (Lake Kariba)**

The fishery on Lake Kariba consists of two sectors; the Artisanal or the gillnet fishery and the Industrial fishery using a mechanized vessel with a lift net exploiting the introduced Lake Tanganyika clupeid *Limnothrissa miodon* locally known as Kapenta.

Figure 4: Catch statistics from the Upper Zambezi

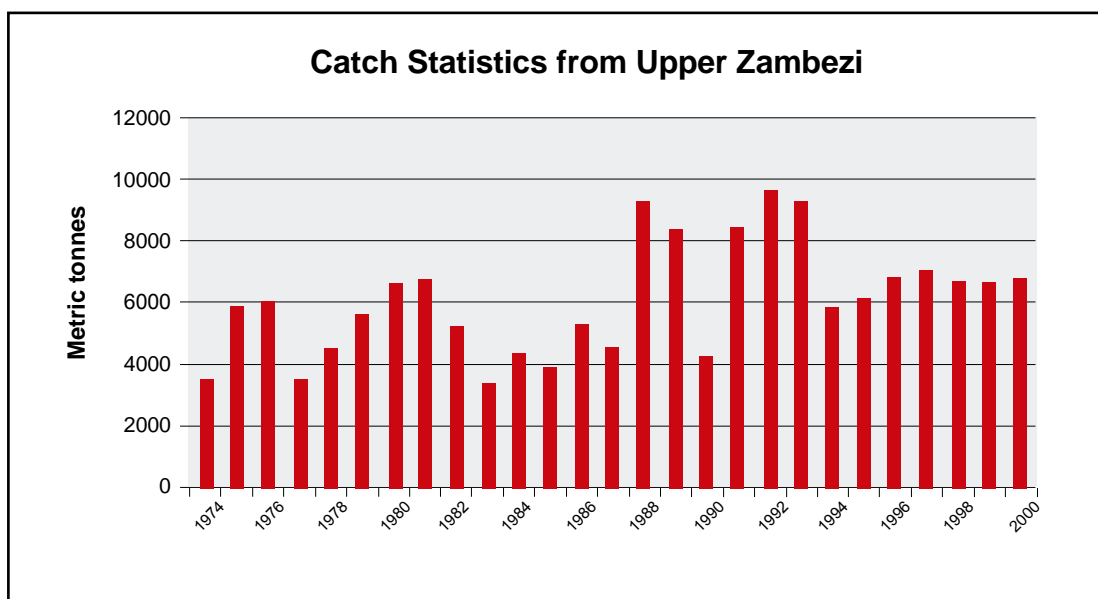
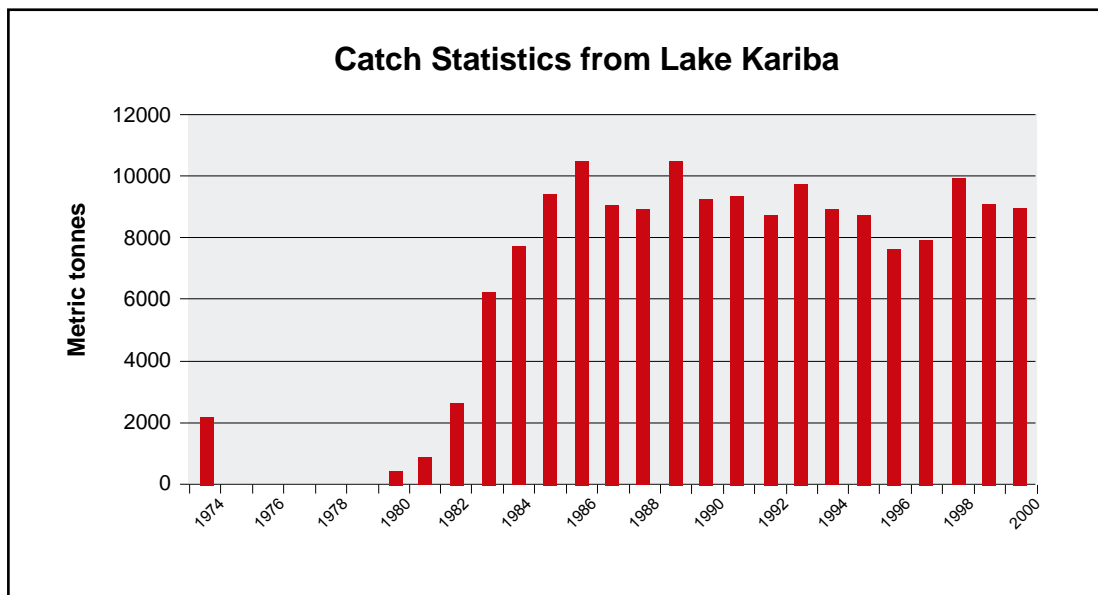


Figure 5: Catch statistics from Lake Kariba



Being a man-made lake, Kariba attracted fisheries research studies in the 60's and 70's. The successful introduction of kapenta in 1969 further attracted more research in the area. Lake Kariba has attracted joint fisheries research and studies in joint fisheries management through the Zambia/Zimbabwe SADC Fisheries Project from 1991 to 1999. A protocol agreement on the joint management of the fisheries resources of Lake Kariba was signed in 1999, however, the protocol agreement has not taken effect due to lack of funds by the two governments and support is needed to implement this protocol.

Co-management of the fisheries resources between the Department of Fisheries, fishers and other stakeholders is going on well except for the lack of legal support. However, the revised fisheries act that has addressed the involvement of the fishing communities needs urgent enactment. Commercial fish farming activities in cages on the Lake is developing at a fast rate and there is a need for training of staff in the Department of Fisheries to regulate this new industry.

- **Lower Zambezi**

This is the area from Kariba dam wall to the Zambezi - Luangwa confluence. The area is not enumerated and most of the area is in Game Reserve and National Park Area.

- **The Kabompo River**

This area is not enumerated.

- **Kafue River**

The Kafue Basin has three commercial fishing areas, the Lukanga Swamps, Lake Itezhi-Tezhi and the Kafue Flats (floodplain fishery). The Kafue River supports subsistence fisheries in the Lukanga Swamps, Lake Itezhi-Tezhi and the Kafue Flats. The Kafue Flats includes the area from Itezhi-Tezhi dam to Kafue Gorge. The 2000 annual fish production estimates for the three commercial fishing areas combined were 9,600 metric tonnes. There are a number of threats to the Basin, including; drought in the Lukanga Swamps; reduced spawning and recruitment due to water level fluctuations in Lake Itezhi-Tezhi and the Kafue Flats due to regulation for electric power generation; and industrial wastewater discharges in the lower Kafue. By far the biggest threat to the fish stocks is the increase in the number of fishers and the use of destructive fishing methods, but also social factors such as closed fisheries due to cholera outbreaks.

- **Luangwa River**

Luangwa River is a major tributary of the Zambezi River. The stretch of the river from the confluence with Zambezi River to Lusaka Road Bridge is enumerated but with very low frequency due to inadequate staffing and financial constraints in the Department of Fisheries. The longer stretch of the river from the road bridge to its source in north-eastern Zambia is not enumerated. There is need to undertake fish taxonomy studies on this river and its tributaries.

Aquaculture

Commercial fish farming is mainly in the Kafue Basin in three provinces Copperbelt, Lusaka and Southern. The annual fish production from fish farms is estimated at about 5,000 tonnes.

Crocodile farms have been developed along the Zambezi River, Lake Kariba and Luangwa River. A large proportion of Kapenta catches from Lake Kariba is used to feed crocodiles.

Workshop discussion following the presentation

Concern was expressed about the lack of fisheries data and statistics available in the last decade and the general decline in availability of such data over the last thirty years. Mr. Ngalande explained that with the re-structuring of the Department of Fisheries in the early part of this decade data collection had been assigned a lower priority, however it was hoped that recent changes would lead to an improvement in data collection. The extrapolation of data points in statistical reports since 1995 was identified as a problem and a potential source of confusion.

Comment was made on the listing of hydropower dams as one of the threats to fisheries and the fact that the construction of these dams also supports fisheries, for example Lake Kariba fishery would not exist if it was not for the dam. Thus, it was noted that hydropower dams represent both threats and opportunities, and the threats should be mitigated through good management, which should include improved environmental flows for downstream systems.

A question was raised about the peak catches recorded in 1992 and 1998 and if these were a response and coping mechanism in relationship to the major drought of 1992. It was stated that this was not the case, but rather than low water levels had made the fish easier to catch. The effects of the drought were really only felt in the following year as high catches and low recruitment in the previous drought year took their toll.

5.2 COUNTRY REVIEW ZIMBABWE

Prepared by Mr. Wilson Mhlanga

Introduction

Zimbabwe, a landlocked country in Southern Africa has an annual rainfall varying from a high of 2,000mm in the Eastern Highlands to a low of 400mm in the low land areas. Annual rainfall in the Zambezi Valley is usually less than 600mm. The major economic activities in the Zambezi Valley are based on the exploitation of the natural resources especially terrestrial wildlife and fisheries and tourism. The highly seasonal nature of the rainfall has resulted in the construction of numerous reservoirs for agricultural purposes and the supply of potable water, especially in urban settlements, while Kariba dam was constructed mainly for hydroelectric power supply. Thus, the development of fisheries in these reservoirs has been a secondary activity. Zimbabwe has no natural lakes: there are over 10,700 reservoirs ranging in surface area from one hectare to more than 100 hectares, and about 130 reservoirs with a surface area greater than 100 hectares.

River systems and fish distribution

There were 132 fish species recorded in Zimbabwean waters, consisting of 122 indigenous species and 10 exotic species. The exotic species were *Limnothrissa miodon*, (Clupeidae), *Parasalmo mykiss* (Salmonidae), *Salmo trutta* (Salmonidae), *Barbus aeneus* (Cyprinidae), *Barbus natalensis* (Cyprinidae), *Carrassius auratus* (Cyprinidae), *Cyprinus carpio* (Cyprinidae), *Gambusia affinis affinis* (Poecillidae), *Lepomis macrochirus* (Centrarchidae) and *Micropterus salmoides* (Centrarchidae). A recent addition to the list of the exotics has been the cichlid *Oreochromis niloticus* (Nile Tilapia).

Institutional and legal framework for fisheries management

Management of the fishery resource falls under the Zimbabwe Parks and Wildlife Management Authority (ZPWMA) a department of the Ministry of Environment and Tourism; they function from several fisheries research stations in different administrative provinces. There is a fisheries unit in the Ministry of Agriculture and Rural Resettlement



Villagers by the River (C Béné)

with the main function of fisheries extension in communities living around Small Water Bodies (SWB). The principal act governing fisheries management is the Parks and Wildlife Act of 1996. The Zimbabwe National Water Authority (ZINWA) has the mandate of regulating water usage, including abstraction. ZINWA also monitors pollution, including industrial effluent, and effluent from sewage treatment works. The Zambezi River Authority regulates the flow regime at Kariba dam.

Management and policy challenges

- **Management of fisheries on water bodies outside the Parks Estate**

Several water bodies are located outside the Parks Estate. Management of the fisheries on these water bodies has been minimal. A major challenge is to develop management structures/mechanisms that will adequately cover these water bodies.

- **Fish production enhancement in small water bodies**

The numerous man-made reservoirs that have been constructed, have a potential to support substantial fisheries production. The challenge is to develop and implement a programme of enhancing the fish production.

- **Review of fisheries management strategy**

Historically, fisheries management interventions have been based primarily on biological

considerations. In recent years, there has been an increased appreciation and awareness of the role of socio-economic factors in the dynamics of any exploited fishery. Thus, there is need to review current fisheries management strategies in order to fully incorporate those socio-economic factors that will enhance the effectiveness of the fisheries management strategies.

- **Development of a fisheries policy (capture fisheries and aquaculture)**

Fisheries managers have acknowledged the need for a fisheries policy for both capture fisheries and aquaculture. Current initiatives to develop a capture fisheries policy should be strengthened and the development of an Aquaculture policy should be promoted.

- **Review of co-management**

Efforts have been made to introduce co-management, mainly in the artisanal fishery. A lot of lessons have been learnt in the process. It is therefore necessary to review the applicability of co-management, also drawing upon experiences from within the region.

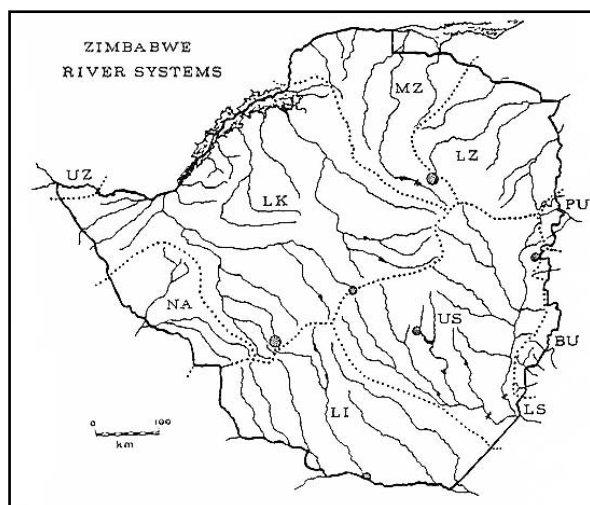
- **Joint fisheries research and management of the Limpopo River**

The Limpopo River is a shared resource. While a lot of work has been done on Kariba, through the Zambia/Zimbabwe SADC Fisheries Project, very little work has been done on the Limpopo River, and it is therefore necessary to initiate programmes to develop joint research and management of the Limpopo among the riparian states.

- **Implementation of joint fisheries research and management**

The Zambia/Zimbabwe SADC Fisheries Project facilitated the setting up of the Institutional and Legal framework for joint fisheries research and management on Lake Kariba and the Zambezi River. While joint research was conducted on Lake Kariba, there is need to expand this to include the sections of the Zambezi River that are shared by the two countries.

Figure 6: Zimbabwe river systems



(after Bell-Cross and Minshull, 1988)¹

1 Bell-Cross, G. and J.L. Minshull. 1988. The Fishes of Zimbabwe. 294 pp. National Museums and Monuments of Zimbabwe, Harare, Zimbabwe.

- **Development of an artisanal fishery on the Zambezi and Limpopo Rivers**

Over 90% of Zimbabwe's fish production from capture fisheries is from Lake Kariba. Artisanal fish production from the waters of the Zambezi River outside Lake Kariba and the Limpopo River is minimal. There is a need to develop these fisheries; and to amend current legislation governing river fisheries.

Fisheries research and management on Lake Kariba

The fishery on Lake Kariba consists of three major sectors; Artisanal (nearshore/littoral), Kapenta (offshore/pelagic) and Recreational. The commercial sectors are the Artisanal (small-scale commercial) and the Kapenta (large-scale commercial); data from the Frame Surveys conducted in the fishing villages shows that the fishers are engaged in fishing to earn a living.

The artisanal fishery is a multi-species fishery. The fishery is based on the exploitation of the indigenous riverine fishes that were able to establish in the Lake. The breams (Family *Cichlidae*) constitute the bulk of the catch. The fishing gear used is the gill-net, and entry into the fishery is regulated.

The pelagic fishery is a single species fishery based on the introduced freshwater sardine (*Limnothrissa miodon*), known locally as Kapenta. The major by-catch species is tigerfish (*Hydrocynus vittatus*). A lot of research has been conducted in both fisheries, both at national level and jointly with Zambia. The research has been either short-term (focused studies) or long-term (resource-monitoring).

Research Issues

- **Fish distribution**

The report by Bell-Cross and Minshull on fish distribution from the late 1980s needs updating in the major rivers.

- **Impact of alien species on the fishery**

There is a need to determine the impact of alien invasive fish species such as *O. niloticus* on the fishery. This could include impact on production, species composition and species diversity.

- **Review of fisheries research programmes**

There is a need to review the research programmes currently underway as well as the planned research programmes so as to ensure that research is management-driven and cross-cutting (e.g. biological, economic, bioeconomic and social)

- **Assessment of fish production potential in the Zambezi and Limpopo Rivers**

The production potential of the fish resources on the Zambezi and Limpopo have to be assessed with a view to develop artisanal fisheries on these rivers.

- **Strengthening of monitoring production**

Monitoring of the fishery (artisanal, kpenta and recreational) is an important tool in management, there are limitations in the current monitoring systems and consequently, there is need to strengthen the programmes.

- **Formulation of a joint fisheries research strategy for the Zambezi River**

While the bilateral agreement on fisheries provides the framework for collaboration, it is

Table 3: Catch estimates for the inshore fishery, Zimbabwe

Year	1998	1999	2000	2001
Catch (tons)	1 083	1 202	2 625	3 400

Table 4: Catch estimates for the inshore fishery, Zimbabwe and Zambia

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Zambia (tons)	2651	2237	1974	986	1196	1732	1938	1748	1886	1857
Zimbabwe (tons)	1530	1116	1747	877	1280	987	1175	958	1115	1083

necessary to develop a joint research strategy that will provide relevant data.

- **Develop mechanism for collaboration/co-ordination of research**

Currently, there are several institutions that are carrying out research on the fisheries of the Zambezi. There is no institutional mechanism for coordinating this research, consequently there is a need to develop a mechanism for collaboration and co-ordination of research initiatives among the different institutions (academic institutions, fisheries management institutions, bilateral institutions, environmental Non-Governmental Organization). This will ensure that research efforts are neither fragmented nor duplicated.

- **Carry out research to assess impact of co-management**

Studies should be carried out to assess the impact of co-management on the dynamics of the fishery (biological, social, economic).

- **Quantitative assessment of illegal fishing**

There has been an increase in the prevalence of illegal fishing in both the artisanal and Kapenta fisheries. Quantification of this is required to determine total catches from the fishery (i.e. both the illegal and legal catch).

Management issues

- Review of fisheries policy (capture fisheries and aquaculture)

- Development of management structures for the fisheries sector of the ZPWMA

- Development of strategies to minimize illegal off-take (stakeholder participation)

- Review of fisheries management strategy (stakeholder participation)

- Incorporation of socio-economic data in the formulation of fisheries management strategies and policies

- Equitable distribution/apportionment of the fisheries resource to competing interest groups (Kapenta fishers, Artisanal fishers, Recreational fishers)

Workshop discussion following the presentation

A question was raised on the small water bodies and Mr. Mhlanga responded that these are all artificial features. Fish production has not been a priority for these, but this is now changing.

A question concerning why an alien species had been used for aquaculture in Kariba lead to an explanation that *Oreochromis niloticus* was already present in the Kafue system prior to the dam being created. Discussion followed with emphasis placed on the need to look at the introduction of alien species within the basin as this has an effect that crosses national boundaries.

5.3 COUNTRY REVIEW NAMIBIA

Prepared by Dr. Clinton Hay

Inland fisheries policy and legislation

Prior to independence, the Inland Fisheries legislation was mainly directed to the state dams in the interior of the country with no regulations covering the important perennial rivers in the north of the country. After independence, effort was made to develop a policy framework to address these shortcomings. The Okavango, Zambezi, Chobe and Kwando Rivers as well as the Cuvelai System play a very important role in the livelihood of a large number of households in those regions. Several meetings were held in these important fishing regions to involve the stakeholders in the development of the policy framework. This led to the following documents:

- White Paper on the Responsible Management of the Inland Fisheries of Namibia – 1995
- Inland Fisheries Resources Act – 2003
- Inland Fisheries Regulations – 2003

The policy emphasizes the following principles:

- Sustainable utilization of the resource
- Protection of biodiversity
- Different management
- approaches are devised for the different river systems
- Subsistence is emphasized over the commercialization of the fish resource
- Protection of the resource is through gear restrictions
- Stakeholder involvement in control measures and the management of the resource
- A need for regional co-operation on all shared river basins

Challenges

All perennial rivers in Namibia are shared with neighbouring countries. The sustainable utilization of the resource and therefore the protection of the resource for future generations are dependent on a joint management approach by all stakeholders, national as well as international. Co-operation with neighbouring countries is therefore necessary to reach the goal of joint management.

Presently the shared resource in the different countries are all differently utilized and managed. This led to different policies and legislations being in place. A joint management approach can only work if the policies and legislations are harmonized.

Presently limited baseline data are available that should form the basis of the Inland Fisheries policy. This can only be addressed by the continued monitoring of the resources as well as the fisheries. Also an improved understanding of the biology of important fish species is needed.

The resource and the fisheries are both very dynamic and it is important to respond to the needs of the people, taking into account the state of the resource. One of the major challenges is the continued availability of funds and human resources (experienced in fisheries science) to address these challenges.

Past and current activities in the Upper Zambezi System in Namibia

• Biological

The fish resources in the Caprivi that includes the Upper Zambezi, Chobe and Kwando Rivers have been monitored at selected stations since 1995. These stations were selected as representative of each river system in habitat types, fishing effort by the fishing communities and whether these stations were accessible during all periods of the flood cycle. Annual surveys were conducted during the same period of the flood cycle to ensure inter-annual consistency and comparability. The monitoring programme is to identify trends and changes within the fish population over time. During these surveys baseline data are also recorded such as reproduction, migration and movement behaviour, growth and food preferences. Data are collected on the gear used to sample the fish, the species sampled, the length, weight, sex and stage of the gonads. Further information is taken on the habitat where the fish were collected and also water quality. It is important that all species and also all size classes are recorded. This is important for biodiversity and also recruitment and whether breeding for specific species have been successful.

The subsistence fishery is also surveyed to get information on the important species collected by the fishery, also on the size classes, fishing gear used and effort input by the communities. Records of fishing competitions are taken to assess the impact of fishing competitions and recreational fishing on the resource.

Information is presently available on species diversity (Diversity Index), the Index of Relative Importance, gill net selectivity of important species, catch per unit effort for gill nets and species, catches of fishing gear, body length distributions, maturation lengths for selected species and species diversity and catch per unit effort for different habitats and different water levels.

- **Sociological**

Baseline socio-economic studies are done on floodplain fishing communities. Information is collected on the demographics of the fishermen, the number of gill nets and the mesh sizes used, the availability of gears, the fishing methods, the catches by the different gears, the seasonal variations in the catches and the effort and also the habitats fished.

The fish market in Katima Mulilo is surveyed once a week for information on the demographics of the vendors, the supply to the market, species composition and size and fish prices and how this varies with season and the flood cycle.

Two frame surveys along the Zambezi River were conducted to record data on village characteristics, fisher characteristics, fishing methods and gears used, the fishing crafts and traditional fishing management systems. Further ward meetings were held at the villages to document all informal (traditional) and formal (government) management systems.

Stakeholder involvement

It is the policy of the Ministry to involve all stakeholders in the decision making process and in the management of the resources. This process was followed with the development of the Inland Fisheries policy and legislation. Meetings were

held to include comments and important aspects relating to the policy. The stakeholders involved with the policy development and research are the local fishing communities in the different fishing regions, NGO's, line Ministries, traditional authorities, regional and local authorities, the University of Namibia and also the tourism industry.

Regional co-operation

The rationale behind the concept of regional co-operation is due to the shared nature of the fish resources in Namibia. All perennial rivers in Namibia are shared with neighbouring countries. All countries sharing the same resource have different management approaches, also another problem is the lack of co-ordination between stakeholders. Presently the different countries are using different research methodologies, making the data collected in the different parts of the river by the different countries not comparable. Priorities on how the resource must be managed and utilized may also differ between countries.

The regional approach was initiated in November 2000 when four countries, Botswana, Zambia, Zimbabwe and Namibia came together to discuss the issue of collaboration on all shared river systems. At this meeting aims and objectives for such a regional approach were stated. Further similar meetings were held to develop programmes to address gaps and critical areas. An aquatic resources working group was established and two projects were developed, one on the fish biodiversity of the Upper Zambezi River and one on the standardization of the research methodology.

Major gaps and key research issues

The following essential aspects need to be addressed before a regional approach can be considered successful. These are the lack of a harmonized policy, a lack of standardized research methodologies and a lack of baseline data for the region. Data are needed on which a management system can be based. Therefore a standardized monitoring programme for the resource and the fisheries must be developed. Furthermore knowledge of present traditional management systems must also be documented.

Conclusion

The sustainable use of the fish resources is crucial for the daily livelihoods and the survival of the local communities in the Upper Zambezi River catchment area. The shared nature complicates the issue of sustainable utilization. Therefore a regional approach must be followed to ensure the successful management of this very valuable resource.

Workshop discussion following the presentation

A question was asked concerning the availability of data that links catches and the flow regime of the river. Dr. Hay responded that the data on CPUE and species diversity are linked to water levels but that not enough systematic surveys were performed per year to make the data valuable for comparison. It was noted that gauging weirs with daily data were available at Katima and Okavango but that there are none on the Kwando River.

Some discussion on the use of the terms subsistence and commercial fisheries followed and the need for them to correctly reflect the use on the ground. It was confirmed that in Namibia subsistence is strictly used for those fishing for consumption

and semi commercial fishing refers to those who partly use their fish for food and partly for sale. Any fishing involving employment of others is referred to as commercial. A suggestion was made that the rural livelihoods framework be used and the contribution of sustainable fisheries to rural livelihoods emphasised. This would facilitate understanding of how fishing activities contribute not just to subsistence but also how they can generate some income to allow purchase of other goods and services. Namibia confirmed that Namibia's legislation recognizes this, and also looks at other activities.

A question was raised concerning how the survey data are linked to habitats. It was confirmed that Namibia makes a reconnaissance survey to selected sites to survey habitats, fishers, fish resource and species, and use the data obtained to select stations. Stations comprise reaches of 1-10 km of river with a team surveying with all sorts of trapping techniques aiming to collect as many fish, of different species as possible. This is repeated each year at the same time of year. Ideally, more surveys would be performed in order to assess the stock but the information generated from the annual surveys is still valuable for baseline information.

5.4 COUNTRY REVIEW MOZAMBIQUE

Prepared by Mr. Jorge Mafuca and
M.C. Chingoma

Introduction

This paper highlights the major aspects relating to fisheries in the Mozambican portion of the Zambezi River basin. Mozambique bears 11% of the 1,385 million km² surface area of the Zambezi river system and it is the most downstream country of the system. It flows for some 850 km before it empties through a delta of about 8,000 km square in to the Indian Ocean.

As the downstream country it also bears the effects of upstream activities and developments, such as farming, impoundments, irrigation, introduction of alien species, siltation, water shortage and floods; with all the associated effects on fish and fisheries.

The fisheries on the Cahora Bassa reservoir are better known than those of the Lower Zambezi, owing to the research undertaken in the late eighties and early nineties. Fisheries management, however, is just beginning to take shape in the reservoir as a result of the rapid development of the kapenta fishery.

General description of the area

The Mozambique section of the Zambezi basin comprises part of the Middle Zambezi that starts from the Victoria Falls and ends at the Cahora Bassa rapids, and the Lower Zambezi that runs from the rapids to the river mouth. It was the damming of the Cahora Bassa rapids that produced the Cahora Bassa reservoir, the second largest on the Zambezi and second largest freshwater lake in Mozambique (Lake Niassa being the largest). At 326 meters above sea level, the lake is 246 km long and 39.8 km wide. The shoreline length is 1775 km and the total surface area is estimated to be 2,665 km². The lake is East West oriented and it is divided into 7 basins namely Zumbo, Messenguezi, Mágue, Chicoa, Carinde Macanha

and Garganta. There are more than 70 rivers and streams that enter the reservoir most of which are seasonal. The Zambezi and the Luangwa are the main affluents entering the lake and these rivers are responsible for most of the water input to the lake. Other perennial rivers drain into the lake. The Messenguezi and Hunyani on the south shore and the Mucanha and Metamboa on the North.

The river below Cahora Bassa rapids flows across mountains until near Tete Township where it meanders across sandy marshes with lots of sandy banks amidst. The hydrology regime of the Zambezi near the delta seems to be more strongly affected by the Shire River rather than the flow upstream.

The Cahora Bassa Fisheries

Three fisheries are presently operating in the reservoir: artisanal, kapenta and recreational fisheries. The artisanal fishery, which operates mainly surface gill nets, captures a variety of fish species, some 13 in total, of which 6 are commercially important namely Tiger fish (*Hydrocinus vittatus*), Kurper bream (*Oreochromis mossambicus*), Nchenga (*Distochodus nchenga*), Cornish-jack (*Mormirops deliciosus*), Vundu (*Heterobranchius longifilis*) and the Zambezi Barbel (*Clarias gariepinus*). The frame survey done in 1992, listed 927 fishing crafts, 5,371 surface gill-nets and 17 bottom gill nets, 1,362 fishermen (Anon 1993)².

The kapenta fishery targets almost exclusively the kapenta (*Limnothrissa miodon*) though other species occasionally occur in the catches. The recreational fishery is at its incipient stage. So far three annual tournaments have taken place under auspices of the Provincial Directorate of Tourism.

Catch data are available since 1994, when the kapenta fishery started in Cahora Bassa, but effort data only started to be collected in 1996. Both catch and effort have known an increase since the fisheries started, from a annual catch of 800 tons for a fishing effort of 2 boats to 12,000 tons and 122 boats in 2000 with a drop in 2001 to about half, and later another increase.

2 Anon. 1993. Recenseamento da pesca artesanal na albufeira de Cahora Bassa na província de Tete. Relatório final, 33 pp. Instituto Nacional de Desenvolvimento da Pesca de Pequena Escala (IDPPE).

Artisanal catch and effort data available in the Provincial Services of Fisheries are rather unrealistic as there is no catch and effort data collection system, the statistics available refer to records of licenses to transport fish and fishing effort refers to licenses issued. As most of the daily catch is sold fresh, and thence, not requiring license, most of the fish catch is not reported. Kapenta fishing in Cahora Bassa takes place in only three of the seven basins, Garganta, Chicoo and Magué basins.

Fish yields for the Cahora Bassa Reservoir have been the subject of studies such as: Bernacsek & Lopes (1983)³, who estimated potential yield as 6,700 tons for artisanal fishery and 8,000 tons for kapenta. Marshall (1995)⁴, estimated 4,000 tons for “table fish” and 16,000 tons for kapenta. Sustainable yields were calculated at 8,000 tons for kapenta and 6,400 tons for artisanal fishery (Bernacsek & Lopes, 1983). Marshall (1995), proposed a carrying capacity for the lake of 122 fishing rigs that would catch some 12,000 tons of kapenta. Recently, Mafuca (2002)⁵ estimated sustainable yields as 10,000 tons of kapenta for a number of boats of 177 fishing rigs. The current annual catches are around 12,000 metric tones (Mafuca, 2002). Current annual catches for the artisanal fishery as estimated by Barnes *et al.* (2002)⁶, are about 7,600 tons. Given all the discrepancies above, further and detailed studies are required to come up more realistic figures on the yields for Cahora Bassa reservoir.

The Lower Zambezi fisheries

No fisheries statistics are being collected from this part of the Zambezi though a reasonable amount of

fish catch is reported, some of which is sold abroad. The sole reference on the fish caught and fishing gears used in the Lower Zambezi are reported in Rogers (1999)⁷: the fishing gears listed were seine nets, drift nets, fish traps, thrust baskets, hook and line, gill nets, spearing, draining swamps and poisoning, and the species in gill net catches as *Labeo altivelis*, *Hydrocynus vittatus*, *Distichodus schenga*, *Schilbe intermedius*, *Oreochromis mossambicus*, and *Labeo congoro*, while in the hook and line fishery species such as *M. anguilloides*, *Oreochromis* spp., *T. rendalli*, and *H. vittatus*.

Policy and management

Three major objectives are highlighted in the fisheries sector Master Plan, as milestones of the fisheries policy:

- To improve fish protein supply in order to cover part of the food shortage;
- Increase net foreign exchange earning to the national income produced by the fishery sector;
- Improve life standards of the fishing communities (absolute poverty alleviation).

These policies raise a challenge as to how to achieve these objectives while ensuring a sustainable utilization of aquatic resources. As far as inland fishery is concerned, no fishery regulation exists. Not long ago, in 2003, the Ministry of Fisheries, in an effort to tackle the problems that emerged on the kapenta fishery due to the lack of a legal framework, released a Ministerial Diploma that regulates this fishery.

3 Bernacsek, G.M. and S. Lopes. 1984. Investigation into the fishery and limnology of Cahora Bassa reservoir seven years after dam closure. A report prepared for the research and development of inland fisheries project. FAO/GCP/MOZ/006/SWE, Field Document 9. FAO, Rome, Italy.

4 Marshall, B.E. 1995. Biology and fishing activity survey study at Cahora Bassa-Mozambique. 28 pp. FAO, Rome, Italy.

5 Mafuca, J.M. 2002. Avaliação preliminar do estado de exploração de Kapenta (*Limnothrissa miodon*, Boulenger 1906), em Cahora Bassa, com base em dados históricos de captura e esforço de 1995-2000. Revista de Investigação Pesqueira 23: 2-27.

6 Barnes, J.I., J. Meisjord, P.J. Dugan and D.M. Jamu. 2002. Inland fisheries in Mozambique: Importance and potential. Final report, 58 pp. The WorldFish Center, Penang, Malaysia.

7 Rogers, B. 1999. An inventory of the fishes from the Lower Zambezi River, Mozambique. Investigational report no. 62, 59 pp. JLB Smith Institute of Ichthyology.

Management challenges for both Cahora Bassa reservoir and its tributaries are to achieve control; of access to fishery resources and illegal gears; harmony between the socio-economic and resources sustainability needs and between the resource users by reducing conflicts and disputes;

studies on kapenta are just two of the new research efforts. As far as ensuring control over the fisheries, there are plans to implement co-management, to develop Inland Fisheries Regulation, and to establish fishing surveillance for both kapenta and artisanal fisheries.



Subsistence fisher (C Bento and R Beilfuss)

co-ordination and co-operation between institutions involved in different activities in the Zambezi river system.

A problem that has been identified includes the previous focus on marine fisheries rather than inland fisheries. However recent developments in Cahora Bassa have highlighted the importance of inland waters and the need for development research in order to establish for each basin; fishing yields; CPUE; non fishable areas; nurse and reproduction arenas; the importance of different effluent rivers and river mouths for growth and recruitment of fish; and biology and reproduction seasonality of the most important species on the Cahora Bassa reservoir. To tackle these issues, the Ministry of Fishery has started a programme to ensure a sustainable use of fish resources in Mozambican inland waters, including along the Zambezi river system. Efforts are taking place both in research and management and in the establishment of a research station and offices in Songo and Nova Chicoo. Programmes for catch and effort data collection programme and biological

Workshop discussion following the presentation

The discussion started with a comment relating to the fact that there had been no mention of private sector participation in any of the presentations. Mr. Mufuka answered this in relation to Mozambique, stating that there is collaboration with fishing companies especially in the Kapenta fishery where some self-monitoring of catches occurs.

A query as to the possible conflict between the three policy directions mentioned in the Master Plan namely – Food security, foreign exchange maximisation and improved fish standards was raised but it was confirmed that this is not a conflict as the exports are from the kapenta fishery which is not a preferred food species in Mozambique. One speaker noted that the important issue of HIV/AIDS had not been mentioned in any presentations Mr. Mufuka agreed that this was a big issue but that they had no data on it.

5.5 COUNTRY REVIEW MALAWI

Prepared by Dr. Moses Banda

Malawi, a land locked country has a total surface area of 119,140 km² of which 20% is covered by water. The major water resources are lakes and rivers. The lake systems include Malawi, Chilwa, Malombe and Chiuta while the riverine include Songwe, South Rukuru, North Rukuru, Dwangwa, Bua, Linthipe and Shire. All except Shire River are the inflows of Lake Malawi. The Shire River is the main outflow of Lake Malawi and flows approximately 410 km from the lake to Mozambique, where it drains into the Zambezi River. Its reach can be divided into the upper, middle and lower



Nets on the river shore, Malawi (M. Banda)

sections. The Riverine system sustain important fisheries in Malawi. The Mpsa (*Opsaridium microlepis*) and Sanjika (*O. microcephalus*) are both very important fishes in major inflowing rivers of Lake Malawi and caught in large numbers during the spawning migrations in the rainy and early dry season. Although the overall catch of both species is not large in comparison to other lake fishes such as Utaka (*Copadichromis* spp.) and Chambo (*Oreochromis* spp.) the several hundred tonnes landed are very important in the river mouth areas, particularly given the very high beach prices which these fishes command.

The floodplain of Shire River however is the source of approximately 15% of Malawi's fish catch. The fisheries of the Lower Shire are heavily dependent on the perennial marshes and seasonal floodplains of the Shire River. Elephant and Ndindi marshes are the main fishing grounds covering an area of 650 km². The Shire fishing sector provides livelihood for about 4000 people as gear owners or fishing crew members. The fishery is mainly

subsistence in nature with small-scale commercial operations.

The fishery of the Lower Shire is multi-gear and multi-species in nature. The main fishing methods employed include seine nets, gill nets, fish traps, scoop nets, cast nets and encircling fish fence, and dugout canoes and plank boats without engines are the main fishing crafts. The 2003 Frame Survey indicated that the number of gear owners has doubled from 2394, crew members increased by 40% from 741, dugout canoes increased by 28 % from 938, plank boats without engines decreased by 96% from 45, gillnets increased by 58% from 2873, fish traps decreased by 5%, longlines by 223% and scoop nets decreased by 31% to 33 between 1999 and 2003. Generally fishing effort has been high since 1991. More than 60 species are caught in this fishery, but only three namely, Mlamba (*Clarias gariepinus*), Chikano (*Clarias ngamensis*) and Mphende (*Oreochromis mossambicus*) are of commercial importance. These three contribute 90% to the total fish catch.

Fish production has fluctuated between 2,000 and 11,000 tonnes per annum. Total catches increased from 4,000 tonnes in the late 1970's to 11,000 in 1989, which was the peak. Catches dropped to 2,000 tonnes in 1992 and has remained more or less the same. The decline in effort is attributed to overfishing caused by increased effort and drought that started in 1991. The use of illegal gears such as mosquito nets has compounded the situation.

Other key threats to the riverine fisheries apart from overfishing and drought are sediment loads, nutrients inputs, pollutants and contaminants, urbanisation, lack of compliance to regulations and invasive weeds. Sediment loads, nutrients inputs, pollutants and contaminants are all generated from anthropogenic activities and recent water quality studies indicate that sediment deposits, nutrient inputs and pollutants and contaminants are on the increase in rivers. Sediments reduce the habitat of the sedentary fish and affect the productivity of water by reducing light penetration affecting photosynthetic rates. A high nutrient input of important nutrients such as nitrogen, phosphorous and silicon is a symptom of nutrient enrichment and if such high concentrations remain unchecked may increase the occurrence of noxious algae, which may produce toxins harmful to both fish and

human. Contaminants and pollutants, arising from urban and rural sources are mostly chemical in origin and are also harmful to fish. Urbanisation is mostly due to increased human population, which is not only responsible for pollutants but has led to fish habitat destruction and increased nutrient load. Lack of compliance is attributed weak enforcement, which in turn is affected by limited financial and human resources. The alien invasive Water hyacinth is extensive in most rivers, and interferes with fishing activities.

Several policy and legislative measures have been put in place to better manage the aquatic ecosystems and the sectoral policies can be grouped into three broad categories: those related to utilisation of biological resources (e.g. Forestry, Fisheries and Wildlife), those related to soil and water conservation (e.g. Water, Irrigation) and those that influence biodiversity utilisation (e.g. Land tenure, Agriculture). These policies and legislations are complex and at times conflicting. Harmonisation of policies will improve management.

Responsibilities for managing riverine fisheries resources are under the Fisheries and Conservation Act that has clear provisions for the conservation and management of fisheries through taking necessary protective measures, monitoring compliance and taking enforcement measures and issuance of permits and licenses to regulate fishing. To ensure effective protection, promotion of community participation in the protection of fish is necessary. However, the riverine fisheries are not managed effectively. This is largely due to the state based fishery management system that is still operational in riverine fisheries. The state based fishery management comprise a series of technical regulatory measures including gear restriction (i.e. type, size, mesh size), fishing time (i.e. closed season) or catch characteristics (i.e. minimum landing size). However, compliance with such management regulations is low due to enforcement problems.

Gaps in scientific knowledge of riverine fisheries constrain effective management. Limited studies have been carried out on few fish species due to lack of research agenda and generally there are gaps in knowledge, in particular the taxonomy, distribution, life histories and standing biomass of

the fish. Environmental studies pertaining to water quality are lacking and understanding of the social organisation of the fishery and relationship between fisheries and other livelihood strategies is poor. Public awareness on the value and importance of the riverine fisheries is also poor.

For effective management and development of the riverine fisheries, the Department of Fisheries has put in place a management framework that advocates co-management, a more consultative and participatory approach to fisheries resource management. The Policy and legislation have been revised to accommodate this concept. The co-management initiative started in 1998 and is still in its infancy stage. The main challenge however is to translate the national priorities and targets in action plans and programmes in order to promote effective participation of all stakeholders. The research action plan for Department of Fisheries is also undergoing review to incorporate long-term research on riverine fisheries that will address most of the research gaps. The revision is in line with the National Fisheries and Aquaculture Policy. Recognising the fact that management of rivers requires an integrated management approach the Government of Malawi has initiated a conservation project of the Songwe River Basin through WWF Eco-region Conservation Programme.

An integrated management approach is a solution to river basin management and this calls for the active participation of government departments (such as Forestry, Fisheries, Wildlife, Water, Irrigation, Land tenure, Agriculture and Environmental Affairs), statutory bodies (such University of Malawi, Electricity Supply Company of Malawi, Waterboard), non-government organisation of Malawi and the local communities.

Workshop discussion following the presentation

A question on the divergence in policies between the different government departments was raised and Dr. Banda responded that there are conflicting policies in different ministries. He explained that there is often conflict because one ministry may have policies encouraging actions that have a negative effect on the water resources and that the lack of understanding of the implications of policies on other sectors was a serious concern.



Young fishers, Malawi (M. Banda)

6. Development challenges and discussion

6.1 HYDROPOWER DEVELOPMENT AND WATER MANAGEMENT REQUIREMENTS

Prepared by Ms. Elenestina Mwelwa

Hydropower development

Hydropower refers to generation of electricity using the power of water as a driving force to turn the turbines. Successful hydropower development requires a stable supply of water and a given height difference in the river profile which is referred to as head. Where there is major variations in seasonal river flows, artificial storage of water through construction of reservoirs and water regulation become key components of hydropower development. Hydropower is known to be one of the most environmentally friendly way of power generation and highly preferred where a particular river system has potential.

Some positive aspects of hydropower development

Use of a renewable resource (water) as a major raw material for power generation. Hydropower generation is considered to be a non-consumable water user because water which has gone through the power station can be available for other uses without compromising the needs of power generation.

Construction of dams for water storage may lead to the creation of multipurpose reservoirs leading to development of totally new fisheries, and providing opportunities for economic growth in other sectors such as tourism and agriculture. Artificial water regulation may lead to favourable conditions to enhance fish breeding and therefore increase productivity of a particular fishery. The new fisheries created from new hydropower reservoirs can provide opportunities for research in the new fishery areas.

Some negative aspects of hydropower development

Dam construction on river systems may lead to truncating of fishery areas and disrupting of fish breeding patterns which may lead to extinction of some fish species. Artificial water regulation may lead to significant changes in the flow pattern of a particular river system leading to disruption of fish breeding pattern

Some mitigation measures

One of the major mitigation measures on some of the negative aspects of hydropower development is the adoption of an integrated approach to water regulation. This will require taking into account other water users including fisheries. Where feasible, at the planning stage, consideration of the construction of fish ladders to assist with fish migration and breeding pattern should be given serious consideration. Another mitigation measure is the designing of hydropower water regulation systems in such a way that it allows the mimicking of the natural flow and flooding system as much as possible.

Water management of the Kafue Hydropower system

The Kafue hydropower system comprises: Kafue gorge dam and the Itezhi-tezhi dam, which were primarily constructed in the 1970s to meet the hydropower water needs at Kafue Gorge Power Station (900MW). The Itezhi-tezhi reservoir which is about 350 km upstream of Kafue Gorge dam provides the main water storage to meet the water needs of 1800MW power potential of the Kafue Hydropower system. However these two infrastructures are located upstream and downstream of the highly sensitive environmental area of the Kafue flats. This calls for an integrated approach to the water resource management to meet the needs of other sectors including the environment.

Efforts to achieving an integrated approach to water regulation

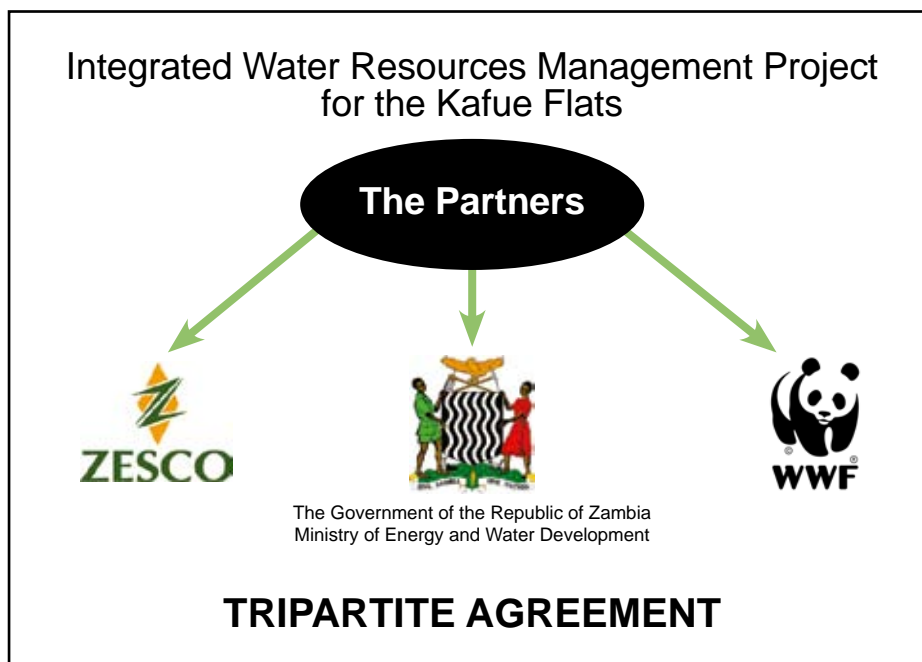
In 2002 ZESCO commissioned a study to carry out a Strategic Environmental Impact Assessment for the Kafue river basin in view of the proposed hydropower developments of the Kafue Gorge Lower Power station (750MW) and Itezhi-tezhi Power Station (120MW)⁸. The project was tasked to highlight the state of environment of the Kafue Basin and to analyse the development scenarios for the power sector, the agriculture sector and the wetlands conservation aspects. In this study, the Kafue Flats was highlighted as one area that needed restoration.

In an effort to improve the water resources management for the Kafue Flats leading to the wetland restoration, A tripartite agreement was signed between the Ministry of Energy and Water Development, ZESCO LIMITED and WWF for the purpose of achieving the Management of the water resources of the Kafue Flats which was recognised in the earlier study as requiring wetland restoration⁹ (Figure 7). The goal of this project was to fine tune the water management rules to mimic the natural flooding pattern in the Kafue Flats, without compromising energy production, as a step towards restoration of the Kafue Flats (Figure 8).

The project output included:

- Improved data collection network (near real time data)
- Database linkages
- Decision support system
- Linkages between decision support system and models
- GIS of the Kafue basin hydrometeorological system
- Simulation and forecasting model for water levels, flows and floodings in the Kafue Flats (The Kafriba model Figure 9)
- Forecasting model for flow into Itezhi-tezhi (Pitman model)
- Improved operation rules for freshet release (Integrated Dam Operating Rules). The integrated dam operating rules were launched on 28th May 2004. One of the speeches was made by the ZESCO Managing Director and in part read – ‘Today we are proud to host this important function which is a clear indication that the Kafue hydroelectric power system is being more responsive to meeting the water needs of the environment in the Kafue Flats’ MD, ZESCO, Speech 2004.

Figure 7: Integrated water resources management for the Kafue Flats strategy



8 Piesold, S.W. 2003. Integrated Kafue River Basin Environmental Impact Assessment Study – Strategic Environmental Impact Assessment. ZESCO Limited, Lusaka, Zambia.

Figure 8: Kafue flats location map

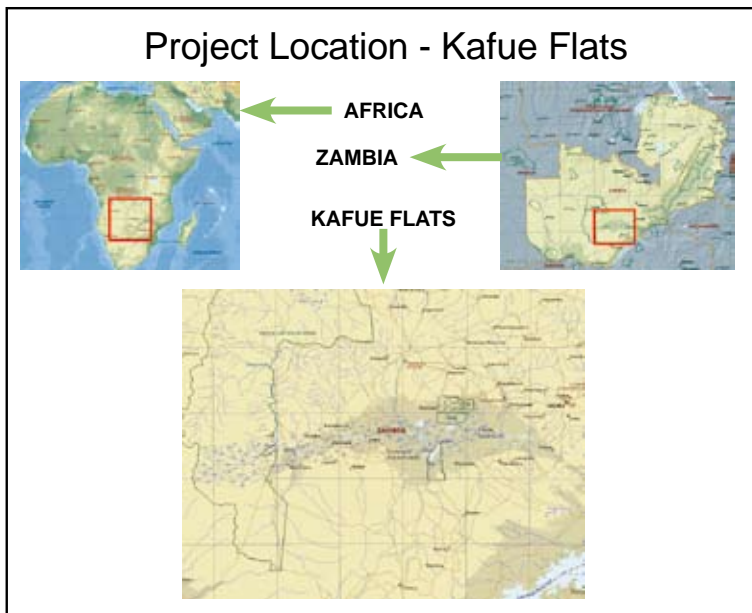
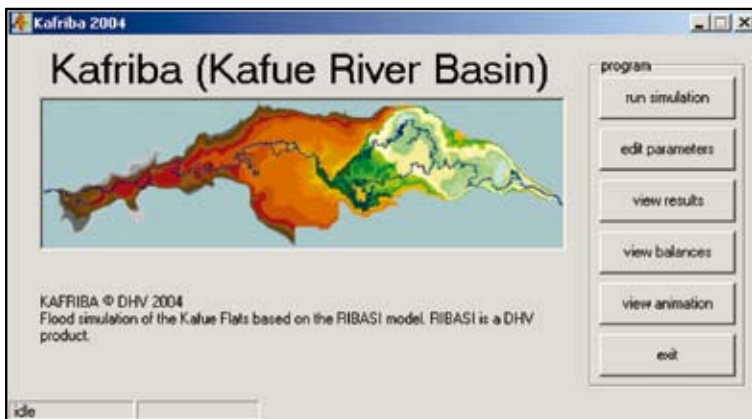


Figure 9: Kariba Model for flood simulation of Kafue flats



Conclusion

Stakeholder collaboration rather than confrontation and accusation is the best route to achieving an integrated approach to water resource management. The aspect of advocacy on issues of conservation and natural resource management need to be enhanced to ensure all major stakeholders understand clearly the major issues at stake. Hydropower development with the help of the EIA facility can still be undertaken in a sustainable manner.

Workshop discussion following the presentation

Following the presentation by Ms. Mwelwa of ZESCO she was questioned on the extent that irrigation can take place in the Kafue area. Ms. Mwelwa informed the meeting that this was discussed during the Integrated Kafue River Basin Environmental Impact Assessment Study commissioned by ZESCO limited and the results are available in this publication. It was commented however that while it is clear that significant efforts are made to bring stakeholders together and discuss the way forward – but that it is still a question whether data are available to make informed decisions.

9 DHV Consultants. 2004. Decision making system for improved water resources management for the Kafue Flats. Integrated Water Resources Management Project for the Kafue Flats – Phase 2. WWF, Lusaka, Zambia.

6.2 RESOURCE-USE PRESSURES AND CONFLICTS WITHIN THE ZAMBEZI BASIN

Prepared by Ms. Lindha Mhlanga

The Zambezi basin plays a significant role for the economic development of the SADC region and is extensively utilized. Increasing current and future resource demand within the basin is creating competition and tensions amongst user groups and sectors on a local, national and sub-regional level. The major driver on resource use demand and pressure within the basin is high population growth rate. The Zambezi basin has a population of approximately 38.4 million people, an average population density of 28 people/km² and an average population growth rate of about 2.9%. At such a growth rate the population is expected to double within the next generation resulting in significant impact on the basin's resources.

The communities within the Zambezi basin are poor and this is attributed to rapid population growth, slow economic growth and a fragile natural resource base. The existing economic hardships increase poverty levels and consequently put pressure on the environment. The communities within the valley depend on agriculture for their livelihoods. Threats on the environment range from opening up new areas of the fragile environment and poor cultivation practices on floodplains and dambos. Other issues of environmental concern include mismanagement of agricultural inputs, which consequently contaminate surface water and poison aquatic biota. Land degradation through overgrazing threatens the environment. Land is rapidly degraded especially when new marginal land is opened up for agricultural expansion.

In the case of water resources this is exacerbated by frequent droughts, erratic and unevenly distributed rainfall and general water scarcity. As such most riparian countries have proposed developments as each state seeks to utilize what it regards as its rightful claims on the shared water and other resources. Water demand is generally increasing in the basin as most riparian countries now recognize the potential to harness the Zambezi water resources for economic development. Riparian countries are consequently eyeing for a stake in the basin's water resources so as to meet their future water requirements for various uses.

Most of the countries have planned projects to harness Zambezi waters for different purposes. For instance Namibia requires 15 cumecs for irrigation, the city of Bulawayo (Zimbabwe) requires 1.2 cumecs for drinking while Zambia's plans are mainly for using water for the development of irrigated agriculture, tourism, fisheries and hydroelectric power generation at Kafue River. There are plans to develop hydroelectric power schemes at Mepanda Uncua (Mozambique) and at Batoka gorge. There is also a possibility of abstractions from the river by Botswana, Namibia and South Africa. Unless these developments are harmonized, conflicts are bound to arise among the stakeholders. Co-operation among riparian states will enable all stakeholders in the basin to benefit.

Over the medium term, the water resources are unlikely to meet the developmental requirements claimed by each riparian state. States have to cooperate and establish integrated water resource management plans to sustainably utilize the basins resources. As pressures especially over the river and other resources increase in the absence of a governing treaty or convention, claims on the waters by the basin states may cause tension or conflicts. The increasing urbanisation, industrial development and expansion of industrial activities are presenting a challenge to the water quality of the Zambezi River. A major challenge is to maintain the water in state where it is acceptable to all users. The resources within the basin are also threatened by pollution from industrial, agricultural and urban waste. The major threats from pollution include eutrophication and aquatic weed invasion, degradation of water quality and its consequent effect on biota. Hydroelectric power generation, through damming of rivers, is another source of environmental pressure. The basin is the major source of hydroelectricity in Southern Africa. The Zambezi River has two major dams (Kariba and Cahorra Bassa) and there are plans to construct other dams at Batoka, Mupata and Devils gorge. Damming of river alters the riverine habitat thereby resulting in loss in biodiversity, depletion of wetland habitats and hydrological changes in river flow.

The different land uses along the tributaries and the main river presents a challenge to water resources within the basin. Information on general water quality and nutrient fluxes within the Zambezi

River system is limited, however there are clear sources of point and non-point sources of pollution. The major challenge is the impact of upstream activities on the marine environment. The delta, which is rich in mangrove vegetation supports marine aquatic resources mainly, fish, shrimps and prawns. Upstream users can significantly impact on the shrimp industry of Mozambique at the Zambezi delta.

The other major challenge to water resources in the Zambezi basin is the large size and diversity of the catchment. Its major tributaries, the Luangwa, Hunyani, Musengezi, Mazoe, Shire and Kafue pass through different land uses which presents threats to the water quality of the river. The Kafue River drains through the copper mining region of Zambia and there are major industrial towns and centers located along the river. The Mazowe River (Zimbabwe) drains the mining operations in the Shamva region. The mining activities along these tributaries eventually affect the water quality of the main river. The Luangwa River basin transports a mean yearly load of 8 million tonnes of silt into the Zambezi. The Shire River (Malawi) is extremely rich in inorganic nutrients thus exerts a considerable effect upon the Zambezi below the confluence. Manyame and Musengezi rivers (Zimbabwe) drain agriculturally and industrially developed parts of Zimbabwe and consequently contribute appreciable quantities of nutrients to the Zambezi. Further expansion of activities along these tributaries will impact water resources of the Zambezi basin.

By just considering water resources it is apparent that there is need for an integrated approach to water resources management within the basin in order to avoid potential tension since water quality will deteriorate as demand increases. Initiations towards the harmonization of resource use within the basin have been made through establishment of a platform for regional cooperation, through the ZACPRO 6. Through its phase II programme ZAMCOM (Zambezi River Basin Commission), has been set up to oversee the implementation and establishment of water resources management systems and an integrated water resources management strategy for the Zambezi River basin. The recent signing of ZAMCOM is a major step forward, where a political platform has been set to enable regional commitment among the riparian

countries to cooperate in the coordinated management of the basin's water resources.

Threats to fish biodiversity within the Zambezi basin arises as human population growth and water demand for agriculture, industry and domestic uses within the basin increases thereby straining water resources and consequently impacting on fish biodiversity. Global warming due to climate changes is likely to result in long-term changes in water resources availability within the basin. Reduction in precipitation and increased evaporation will affect water availability and fish habitats. Further reservoir construction within the upper and lower Zambezi will alter the remaining riverine sections of the river. As experienced at Kariba this will result in a changes in fish composition.

Introduced fish species also present a threat to fish biodiversity. For example *Oreochromis niloticus* now present in Kafue River and Lake Kariba and in the Zambezi River below the dam is a major threat because it is aggressive and tend to competitively exclude other Tilapias and to hybridise with other *Oreochromis* species. Proliferation of aquatic weeds like water hyacinth also threatens fish especially in eutrophic water. Another threat to fish biodiversity include over-fishing that may lead to destruction of important habitats and consequent loss of species. Increased water demand usually results in water abstraction and drainage of wetlands. This results in reduction in flow and leads to restriction of fish habitats in streams and can alter fish breeding patterns when flooding regimes are changed. Pollution and siltation are also major threats to fish biodiversity within the basin. Excessive pollution leads to fish deaths and bioaccumulation of metals and pesticides in fish. Siltation of dams and rivers alters fish habitats and disrupts the breeding behaviour of cichlids.

A case of conflicts arising due to multiple and competing users exerting high development demands on land and water resources is illustrated with the case of Lake Kariba. Conflicts occur between and within the main resource use sectors namely fishing, tourism and agriculture and between different types of activities within a sector; for instance between inshore and pelagic fishing; consumptive and non-consumptive tourism and

houseboats and hotels. Conflicts are caused by (i) incompatible resource use activities that occur in juxtaposition with each other, (ii) unplanned development of secondary activities, (iii) lack of proper integrated planning, (iv) existence of many planning authorities and (v) presence of diverse and often incompatible interests. Sectoral management and uncoordinated development can result in resource depletion and degradation. Initiatives have been started in order to rationalize

the use of resources and consequently minimize conflicts between resource users through the development of Lakeshore Combination Master Plans.

Workshop discussion following the presentation

There was no major discussion on this paper.



The Zambezi River, Livingstone, Zambia (S. Davies)

6.3 URBAN IMPACTS ON RIVERS

Prepared by Ms. Wizaso Munthali

Introduction

At present the quantity of freshwater on the earth is enough to meet present and future demands, but the only problem is that it is unevenly distributed, meaning certain parts of the world do not have a reliable source of freshwater. In add to this problem these freshwater sources are increasingly being polluted through human activity, leading to the reduction in quality of available freshwater for human, animal and aquatic use.

Water and it's roles

Water is critical to humankind's existence. It plays a vital role in many sectors of economic value and also provides formal employment to people involved in water management and supply/sanitation activities and informal employment to rural communities.

Public Water Supply

- For drinking
- For domestic & industrial use
- For sanitation purposes

Agriculture

- Irrigation

Fisheries and Wildlife

- Water and food source for wildlife
- Medium in which fish/aquatic life thrives and feeds from

Transportation

- Transportation of bulk goods

Energy

- Production of hydroelectric power

Tourism & Recreation

- Boating & sport fishing

Urbanisation/human activity and it's impacts on rivers and lakes

The major sources of pollution to rivers and lakes as a result of urbanisation/human activity are:

- **Sewage effluent:** Rivers/Lakes are polluted by organic matter including human and animal excreta mainly from sewage effluent. The oxygen levels in water reduce as these pollutants are broken down, contributing to increased eutrophication.
- **Industrial processes:** Rivers/Lakes are also polluted by industrial waste produced from industrial processes. These include radioactive chemicals, dangerous organic chemicals, nitrates, heavy metals and oils. These pollutants find their way into Rivers/Lakes through direct discharge, leaching in water aquifers and rainwater run offs.
- **Mining activities:** Mining is one of the major causes of pollution in many Rivers/Lakes. It causes water acidification, releases a variety of highly toxic chemicals such as, Mercury, Lead and Arsenic in its processes and releases leachates from mine tailings dumps.
- **Agricultural activities:** Pollutants from agricultural activity include, nitrogen, phosphorous, insecticide and poisonous residues contained in irrigation seepage water. The uncontrolled handling, storage and application of these agro-chemicals aggravate the situation of water pollution from these chemicals.
- **Deforestation:** Soil erosion due to deforestation to clear land for agriculture and urban growth often leads to sedimentation, which is a serious threat to the longevity and efficiency of surface water storage works. Soil erosion also results in the increased quantities of suspended matter in Rivers/Lakes, hence affecting water turbidity.
- **Air emissions:** The combustion of fossil fuels, results in the increased emission of sulphur and nitrogen oxides. Sulphur dioxide emissions can be deposited back on land as acid rain or dry deposition (on soil, plants and water), destroying plant life, acidifying river/lakes, corroding materials and affecting human health.
- **Solid waste:** Solid waste is a product of domestic, industrial, agricultural and mining activities. It contributes to water pollution due to wash off of solid waste to surface water, or the flow of leachates from open waste dumps to

surface water. Solid waste especially non-biodegradable also disturbs the scenic beauty of water systems.

- **Environmental accidents:** Accidental pollution of river/lakes can arise from many sources such as burst pipes and tanks, major leaks, fires and oil spills. They can cause varying degrees of damage depending on the quantity, toxicity, persistence of the pollutant, size and resilience of the receiving water body.

The effects of water pollution

- **Eutrophication & water weeds:** One major result of water pollution is the increase of eutrophication of Rivers/Lakes. The eutrophication of river enhances the growth of aquatic weeds. Aquatic weeds if not controlled can cause economic and ecological damage to water systems.
- **Human health:** Pathogens, disease-carrying organisms such as bacterium, fungus or viruses are among the organisms found within water

bodies that pose a great threat to public health. These enter Rivers/Lakes mainly through poorly treated sewage effluent.

- **Ecological Damage:** Pollutants reduce water quality and harm aquatic life by interfering with important ecological and biological process such as, photosynthesis, respiration, and reproduction e.g. polluted Rivers/Lakes can impair reproduction in fish, retard their growth and even kill them.

Challenges

- Creating Environmental Awareness
- Development of Sustainable Pollution Control Monitoring Systems
- Development and better enforcement of Water Pollution Control Legislation
- Promoting good Waste Management practices.

Workshop discussion following the presentation

There was no major discussion on this paper.

6.4 OPPORTUNITIES AND CONSTRAINTS FOR PRIVATE SECTOR INVESTMENT IN ZAMBEZI FISHERIES

CLUSA'S experience with small-scale fishers at Sinafala/Bbondo

Prepared by Dr. Angel Daka

A synopsis of the brief experiences of the Co-operative League of the United States of America (CLUSA) with fishers of the Gwembe valley at Sinafala, Bbondo and Chipepo on the Lakeshores of Lake Kariba, is given. The experiences are drawn from two years' interventions with fishers whose fishing as a main occupation is bridged by some crop cultivation to derive their livelihoods. Lake Kariba, which lies in the middle Zambezi river system, is part of the Zambezi basin. Some issues of aquaculture in the upper parts of Kafue river system that is part of the Zambezi basin in the copper belt region of Zambia are highlighted from the private business investment point of view.

Factors of geography, climate, socio-economics and resource endowment affect fishing in various ways. Droughts depress crop production and thus communities resort to fishing. The fishing pressure is exacerbated by the effects of HIV-AIDS wherein inexperienced orphans go into fishing using unorthodox methods of catching fish. This poses a great danger to sustainable fish production. Investment opportunities are one way to uplift the constraints currently affecting the fishers. These include fishing methods, preservation using cold facilities, use of modern boats as opposed to dug out canoes. To disseminate this information, formation of fishers groups is recommended to enhance market access

and promote fishing as an enterprise. Registered fishers groups would be legally recognized entities that can access credit and thus promote the development of sustainable fisheries industry in Zambia.

Workshop discussion following the presentation

One comment emphasised the importance of understanding the value of the fisheries and how to enhance these values. A further comment was made that it may be difficult to group the fishers for analysis purposes, especially once the fishery has been commercialised. This should be done before commercialisation comes into play.



Fish market at Katima Mulilo, Namibia (C Hay)

A question on the level of production of fish in the lakes in the Gwembe valley was asked but Dr. Daka replied that no data is available and therefore there is no knowledge of the fish production. A further comment noted the importance of knowing the level of fish production, for future potential investors.

6.5 KAFUE DIALOGUE

Prepared by Mr. Shadrek Nsongela

Introduction to the Dialogue Initiative

The Dialogue initiative was conceived in 2000 at the 2nd World Water Forum held in The Hague by a group of 10 international players in the field of Water, Food and Environment. These were:

- World Wide Fund for Nature (WWF)
- International Water Management Institute (IWMI)
- *International Commission on Irrigation and Drainage*
- The World Conservation Organisation (IUCN)
- World Health Organisation (WHO)
- Food and Agricultural Organisation (FAO)
- Global Water Partnership (GWP)
- United Nations Environment Program (UNEP)
- International Federation of Agricultural Producers (IFAP)
- World Water Council (WWC)

The development was in response to growing concern over the scarcity of fresh water resources to meet the competing demands in food production, environmental sustainability and other developmental needs. The Dialogue was thus initiated as a process that would provide a forum for sharing water resources management information across sector lines with a view to finding sustainable solutions leading to improved food security, reduced poverty levels and improved human health. This would be achieved through development of a knowledge base of proven Better Management Practices and creating forums for sharing the knowledge base and adoption of sustainable solutions.

The need for Dialogue on the Kafue River Basin

The Kafue river basin transects the country over a distance of about 1,577 km from the North-Western part of Zambia on the border with Congo down to the south on the border with Zimbabwe. It covers about 155,000 km² representing about 21% of Zambia's surface area. The basin is highly populated, with about 40% of the Zambian population settled there. The basin is also a rich resource base with abundant water, fish, wildlife,

agricultural land, forests, wetlands, minerals and other resources. Arising from such a rich resource base it has turned out to be the most dynamic and economically active river basin; it is the host to major mining, manufacturing, tourism and agricultural industries in Zambia. Consequently, the basin is a source of livelihood for many people engaged in various socio-economic activities, all driven by a common resource base.

The diversity of resource use by a multiplicity of people has placed stress on the resources of the basin thereby breeding conflicts. Signs of this stress include reduced water flows and quality, diminishing stocks of fish, wildlife and forest resources, declining soil productivity and loss of wetlands. Consequently, there is competing demand for use of a declining resource base thereby leading to food insecurity, poor health and poverty. The above dilemma need to be resolved and Dialogue has provided a golden opportunity for reviewing alternatives and identifying sustainable solutions.

Update on Dialogue Activities

WWF embarked on the Kafue River Basin Dialogue initiative in October 2003 in collaboration with the Zambia Water Partnership and the Advocacy for Environmental Restoration in Zambia. The main drive for WWF involvement was concern over increased irrigation prospects in the basin and its consequences on fresh water resources. Government identified the basin as having great potential for irrigation that should lead to improved food security. WWF wishes to examine other options to attaining food security alongside the proposed irrigation option. The focus is to identify sustainable options that realize food security without threatening the quality and quantity of freshwater resources.

Work started with stakeholder consultations to establish the status, use and management of the environmental resource base in the Kafue River Basin. Consultations took the form of desk studies, study tours, interviews and workshops. The analysis was focused on understanding issues related to food security and environmental sustainability with water at the center as a key input resource. Consultations were focused on identifying actual or potential environmental resource management

conflicts that may act as barriers to sustained livelihoods, poverty reduction and improvement of health. Every effort was made to present these issues in order of priority. Priority listing was based on analyzing stakeholder views of how prevalent and severe a given issue of concern occurred. Based on this classification the issues were prioritized as:

- Food security and poverty issues
- Environmental issues (including water use and management issues)
- Health issues

However, due to varying environmental, cultural, social, economic and political conditions surrounding each identified issue the process of prioritization could not be conclusive. The problem of food security and poverty was expressed in terms of lack of economically viable and sustainable livelihood options leading to perpetual food insecurity and poverty. Contributing factors identified included:

- Declining soil fertility
- Droughts and lack of agricultural inputs and services
- Prevalence of animal diseases in Kafue Flats that has wiped out large numbers of cattle
- Prevalence of HIV/AIDS thereby depriving communities of the labour force

The problem of environmental sustainability was expressed in terms of a declining environmental resource base. Specific reference was made to:

- Loss of soil fertility
- Diminishing fish stocks
- Conflict with big game especially elephants, hippos and crocodiles in areas close to the parks

Special attention was paid to water use and management issues. Poor accessibility to water by people living far from rivers was generally identified as the main issue of concern while a changed flooding regime due to construction and operation of the Itezhi-Itezhi dam was found to be the main concern negatively affecting people's traditional forms of livelihoods within the flats. Specific issues of concern identified in this regard included; the prevalence of the HIV/AIDS pandemic and

inadequate health services, which was also identified as the main health concern. Other factors identified as contributing to poor health included inadequate nutritional intake and availability of quality drinking water.

Studies are currently underway to look into the identified environmental and food security issues of concern to explore sustainable solutions. This will be followed by a series of Dialogue forums to review and identify acceptable options. The chosen options will then be tested on a pilot scale as a first step in sensitization before full adoption.

Workshop discussion following the presentation

Mr Nsongela's presentation provided more information on the fisheries initiatives of WWF in the basin and in Zambia. He was questioned as to whether the WWF acknowledges the Department of Fisheries in Zambia and if they have had input into the projects. He said that a meeting was held between WWF and the Department of Fisheries at Itezhi-tezhi where the Department gave input.

Another question concerned co-ordination with neighbouring countries concerning water management. He replied that this is not the case at present as the effect of the water management is currently between the two reservoirs and will mainly affect the Kafue flats. However, future co-ordination with other countries will be done as the project develops.

Concern was raised over how any evaluations of productivity could take place when no productivity data is available on the Kafue flats. The response was that the approach will be to conduct interviews in the communities to get a present yield estimate and then to continue with interviews after the change in the flood regime for comparison. A comment was made suggesting that the scale of the operation should be expanded to also include down stream users. It was further stated that presently the flood regime management will be between the two dams in the Kafue and will not have an effect on the down stream users below the Kafue Gorge dam. It was also noted that the inflow from the Kafue into the Zambezi River is minor compared to the total flow of the Zambezi River.



The Kafue Flats (S Nsongela)

7. Research priorities and discussion

7.1 WATER AND FISHERIES GOVERNANCE: IMPLICATIONS FOR THE ZAMBEZI BASIN

Prepared by Dr. Chris Béné

Introduction and concept definition

The objective of this paper is to discuss fisheries in relation to the issue of water governance in the Zambezi Basin. Although governance is now widely used in official documents and reports, the concept is not always clearly defined. Part of the confusion comes from the multitude of different definitions which are proposed in the literature. In this paper we will adopt the definition proposed in a recent discussion paper on Nature, Wealth and Power in Africa where environmental governance is defined “as the distribution, exercise and accountability of power and authority over nature”¹⁰.

Put in simpler terms governance is therefore the way power and decision-making responsibilities are shared amongst different stakeholders. Adapting this definition to the concept of water governance, the latter can be understood as “the distribution, exercise and accountability of power and authority over water resources”.

In these conditions a good governance system could be seen as one where the distribution of power is fair and equal amongst the stakeholders, the exercise of that power is transparent, and there are mechanisms of accountability.

Water and fisheries in the Zambezi basin

Why is water governance important in the Zambezi Basin and why are water governance issues important for fisheries in the Zambezi Basin?

Up to very recently, water governance had not been an issue - except perhaps in some particular areas - because water was perceived as a relatively



Water: a multi-use resource (C Béné)

abundant resource. Things are changing, however, and they are changing rapidly. In the Zambezi basin, for instance, based on the Water Scarcity Index, analysis show that in 1995 only Zimbabwe, Malawi and Tanzania had water quality and dry season problems (Table 5). In 2025, however, it is expected that only Namibia will manage to keep its water situation as it is now. Angola, Zambia, Botswana, Tanzania and Mozambique will be facing quality and dry season problems; Zimbabwe will be under water stress, and Malawi will be facing absolute water scarcity. In addition, South Africa will be also facing absolute water scarcity, which will add pressure on the water in the basin.

Overall in the SADC region while the population will double between 1995 and 2025 from 175 millions to more than 327 million, the total water availability will not increase. This means that per capita water availability will be divided twofold,

¹⁰ USAID. 2002. Nature, wealth, and power – Emerging best practice for revitalizing rural Africa. USAID discussion paper, 35 pp. Environmental and Natural Resources Team, Sustainable Development Offices - Africa Bureau, Washington, D.C., USA.

Table 5: Projected changes in water scarcity index for countries of the Zambezi Basin (1995 and 2025)

Country	Water Scarcity Index	
	1995	2025
Namibia	1	1
Zambia	1	2
Angola	1	2
Botswana	1	2
Mozambique	1	2
Tanzania	2	2
Zimbabwe	2	3
Malawi	2	4

Water scarcity Index legend: 1 = Normal; 2 = water quality and dry season problems; 3 = water stress; 4 = absolute water scarcity; 5 = water barrier

from 10,000 to 5,000 cubic meters per capita per year. In that condition the competition for water will be even stronger than it is now. In particular, to be able to feed these 327 millions, irrigated agriculture will have to play an increasing role in meeting the demand for food. In South Africa (which is the largest irrigator in the region) only 1% of the agricultural land is irrigated, but this produces 30% of the national agricultural production in value terms. Irrigated agriculture, however, uses a very important share of the total water. In South Africa over 70% of the water withdraw is used for irrigated agriculture.

Similarly these 327 millions people will also dramatically increase their demand for electricity and for energy. At the present time, on the Zambezi River 3 new projects have been identified in addition

to the already existing ones: the Batoka Gorge dam, the Devil's Gorge dam, and the Mupata Gorge dam. But for the Zambezi basin as a whole, 40 additional sites have been identified for hydropower production.

There are therefore competing demands for water from the major sectors of the region's economy and this competition will increase in the near future.

Fisheries and water governance

Is fishery perceived as a major economic sector of the region? Are fishery stakeholders given adequate consideration in this context of increasing competition for water? Review of documents reveals unfortunately that fisheries, despite the important contribution that they play in the livelihoods of local populations in the Zambezi basin, are often neglected or even excluded from the decision-making processes both at national and regional (basin) levels. Similarly the fishery sector is rarely included in the planning and management of the water sector. The recent report on water resource management published by SADC is a good illustration of this situation (Box 1).

And yet, at the same time studies show that in the Zambezi Basin fisheries can play a very important role in the livelihood of the population and in the local or even national economy of the country (cf Dr. Jane Turpie presentation in these proceedings section 7.2).

Box 1. Fisheries marginalized in the Zambezi Basin water management

The report on "Environmental Sustainability in Water Resource Management"¹¹ was recently published by SADC with the collaboration of the World Bank, IUCN and Zambezi Basin Authority and funded by the Swedish development agency SIDA. The objective of the report was to propose a state-of-the-art in terms of water management in the Southern Africa region and in particular to identify the major issues relating to water management as they are likely to appear in the near future. The report was also presented as a Guide for water resource policy and investment. This report was therefore a crucial document which is likely to influence both decision-makers and donors in terms of investment and support of the water sector in the future. The analysis of the report content reveals however that no specific chapter had been allocated to fisheries. Chapter 2, which reviews more specifically issues on water and economy, totally by-passes fishery which is not even identified as one economic use of water. In fact the terms "fish" and "fisheries" do not even appear in the glossary of the document.

11 Hirji, R., P. Johnson, P. Maro and T. Matiza-Chiuta (eds.) 2002. Defining and mainstreaming environmental sustainability in water resource management in Southern Africa. SADC Technical Report, 318 pp. Southern African Development Community, SADC (in collaboration with World Bank, Sida, IUCN, and SARDC).

How can one explain this situation, i.e. the fact that fisheries, despite their importance as an economic activity, are still not recognised as a major sector to be integrated in the water management process of the basin? There are two main explanations for this:

- (a) Either scientists and practitioners involved in fisheries research and management have not yet succeed in demonstrating how important the sector is both for the livelihood of the population and the economy of the region; or
- (b) Those scientists and practitioners have not yet put enough effort in trying to improve their understanding of the decision-making process in order to interact more efficiently with those who are part of this decision-making process.

In these conditions there is an urgent need:

- (a) To develop more appropriate valuation methods which would in particular better reflect the socio-economic importance of fisheries for the livelihood of rural population of the Zambezi basin; and
- (b) To analyse governance and policy processes in order to better understand those and improve the capacity of the sector to interact with the decision-makers, thereby increasing the chance of small-scale fisheries to be better integrated into the decision-making process.

In the rest of this paper, an example is provided which demonstrates that indeed it is possible to influence the decision-making process and to raise the profile of small-scale fisheries in the agenda of decision-makers. This specific example is not directly related to water governance but to food security, but it is believed that the principle remains the same, i.e. the key factor to raise the profile of small-scale fisheries is a closer interaction between fisheries researchers and practitioners (e.g. DoF) and decision-makers.

A successful example: food security policy and fisheries in Malawi

In August 2003, the Government of Malawi instituted a Task Force to draft a National Food Security and Nutrition Policy. In carrying out its work, the Task

Force scheduled a series of consultations with relevant stakeholders and commissioned a series of studies on key aspects of food security and nutrition. As it is often the case, even if fish was recognised to play an important role in nutritional and food security especially for the poor, in the first place none of the studies clearly articulated the potential contributions of fisheries and aquaculture for food security. Likewise, the consultation process completely by-passed the fisheries stakeholders including the Department of Fisheries.

In early 2004, however, the DoF of Malawi tried to bring fisheries onto the agenda of the Task Force. In this purpose, the DoF engaged in a series of visits to the Task Force coordinator. The DoF also commented on the papers which had been commissioned by the task force and provided additional information.

Secondly, in April 2004 the DoF, in collaboration with the WorldFish Center, organised a National Workshop on Fish and Food & Nutrition Security. The workshop provided the Task Force team with an opportunity for an accelerated consultation with the key stakeholders from the fisheries sector. Because of that direct interaction, it was possible during the workshop itself to develop specific policy recommendations on fisheries in the format and level of detail that permitted their direct integration into the draft policy framework. As a result, fisheries are now explicitly recognised as an important contributor to food security and fish is part of the Draft National policy on food and nutrition security.

Conclusion

The example above illustrates that it is possible to raise the profile of fisheries and to include them into the decision-making process. However, to be successful, researchers and practitioners involved in fisheries will have to clearly shift their perception away from the usual mono-sectoral approach and adopt a much broader multi-sectoral perspective. This multi-sectoral perspective will help them to recognise the multi-use nature of water - which could in some cases be perceived as a threat or a constraint for river fisheries (as it is usually the case for hydropower or irrigation schemes). This multi-use nature of water, however can also represent a positive opportunity because - as demonstrated in the case of Malawi- it can allow

the fishery stakeholders to promote fish and small-scale fisheries through a much broader range of contributions such as food security - as the Malawi example demonstrated - but also rural development or poverty alleviation.

Workshop discussion following the presentation

The discussion began with a comment that supported the presentation of Dr. Béné in stating that in a seven year plan for USAID in Southern

Africa fish or fisheries is not included and that this is not uncommon. Dr. Béné agreed that often fisheries are not included in the guiding policy documents for food security and poverty alleviation and that this is an issue that we need to address. The question was then raised as to why we (as scientists or experts working in the field) aren't promoting fisheries to a wider audience and ensuring that fisheries are considered in approaches to water management and governance. It was agreed that this is important and also that things are improving, note was made of the inclusion now of fisheries into the NEPAD agenda. Comment was made on a common mistake of fisheries practitioners to see fish as an output rather than fish as a contributing factor or input to achieve wider outputs - such as contributing to livelihood and food security demands. The need for information to facilitate this process was seen as important and that without socio-economic information on how fisheries do contribute and play a role in the different food security or livelihood paradigms fish will never be considered at a policy level.



Fishing on the Zambezi (C Béné)

7.2 THE VALUE OF FOODPLAIN FISHERIES IN THE ZAMBEZI RIVER BASIN

Prepared by Dr. Jane Turpie

Introduction

Fisheries were valued in four major wetland areas in the Zambezi Basin as part of an IUCN study investigating the total economic value of these wetlands (Turpie et al. 1999)¹². In addition, similar work was also carried out in a fifth wetland area as part of an environmental impact assessment (Turpie & Egoh 2003)¹³.

Study aims

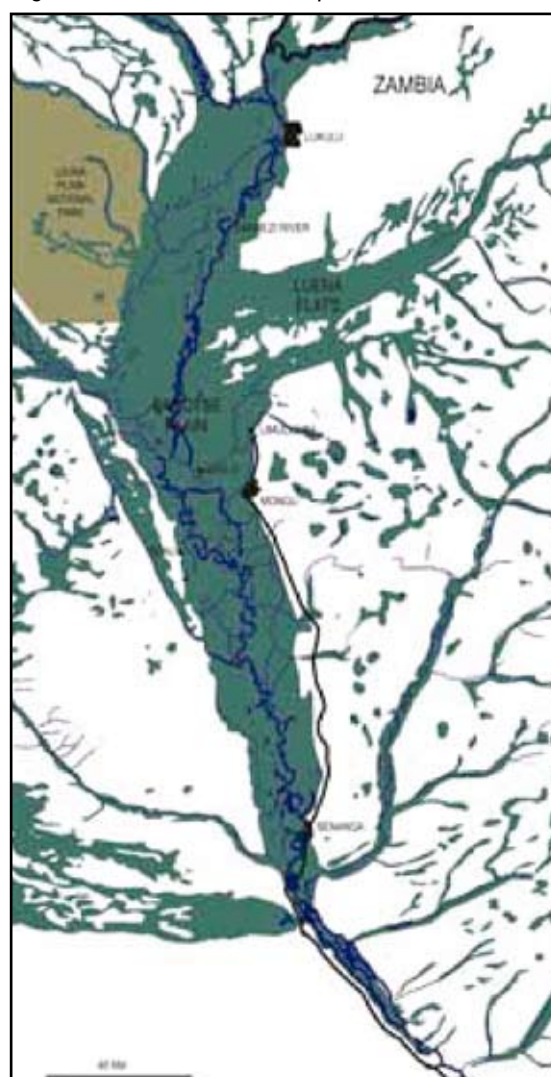
The main aims of these studies included:

- To estimate the total economic value of the wetlands (not just fisheries)
- To estimate their contribution to local livelihoods, and
- To investigate potential impacts of policies and development plans on these values

Study areas

The study areas comprise large floodplain wetlands and a coastal delta within the Zambezi River Basin. All of these wetlands are occupied around their margins and in raised areas within them by rural populations, and the lands are communally owned and managed. The size and population of the study areas are summarised in Table 6.

Figure 10: The Barotse floodplain, Zambia



Whereas the four larger study areas are subject to regular seasonal flooding, Lake Liambezi is an exception in that it is an ephemeral lake which is inundated or dry for long periods. The lake was full from the 1950s to the early 1980s, then supporting

Table 6: Area and population of study areas in the Zambezi Basin

	Barotse floodplain	Eastern Caprivi	Lake Liambezi	Lower Shire	Delta
Area (ha)	550 000	220 000	30 000	160 000	1 275 000
Population	225 000	30 000	9 226	395 000	250 000
Households	28 000	6000	1 845	58 000	61 000

12 Turpie, J.K., B.S. Smith, L.E. Emerton and J. Barnes. 1999. Economic value of the Zambezi Basin wetlands. Report to IUCN-ROSA, 205 pp. Harare, Zimbabwe.

13 Turpie, J.K. and B. Egoh. 2003. Contribution of natural resources to rural livelihoods around Lake Liambezi and Bukalo Channel, eastern Caprivi and impacts of proposed agricultural developments and artificial recharge of the lake. Report to Afridev, for the Government of Namibia.

Figure 11: The Eastern Caprivi and Liambezi wetlands

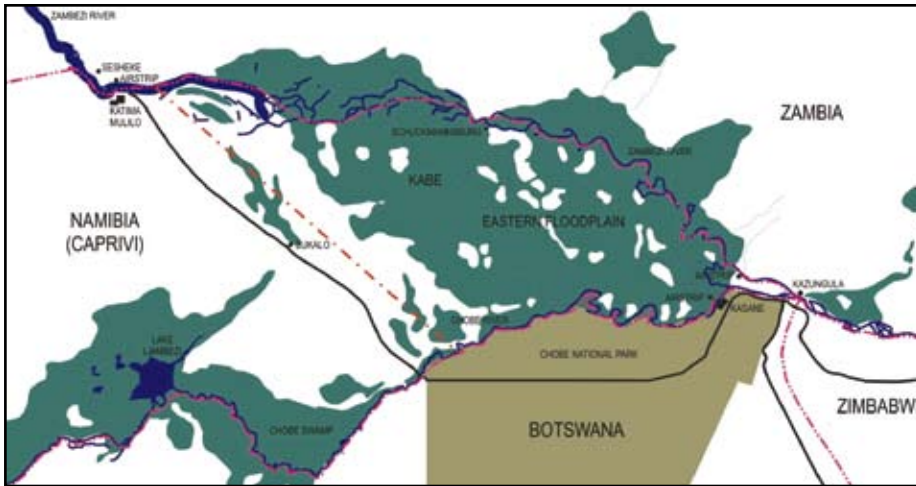
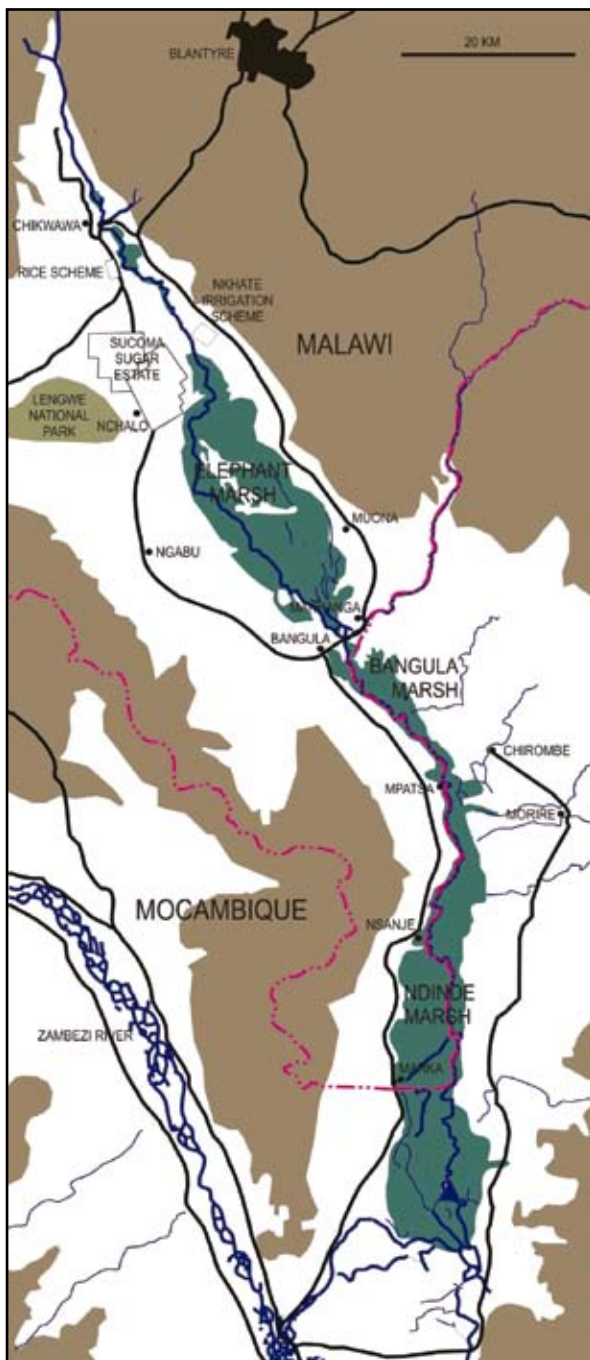


Figure 12: The Lower Shire wetlands, Malawi



a peak of 120 fishers, and catches of 6-800 tons. It dried up in the mid 1980s, remaining dry until 2001. In 2002 the lake started filling again with the advent of a new wet phase in the region. During dry periods, the lake bed is cultivated and grazed.

Approach

The valuation studies involved a variety of social survey methods. Starting with reconnaissance visits and village meetings, these were followed by key informant interviews and focus group discussions, followed by detailed household surveys in which the use of all wetland resources was quantified.

Figure 13: The Zambezi Delta, Mozambique

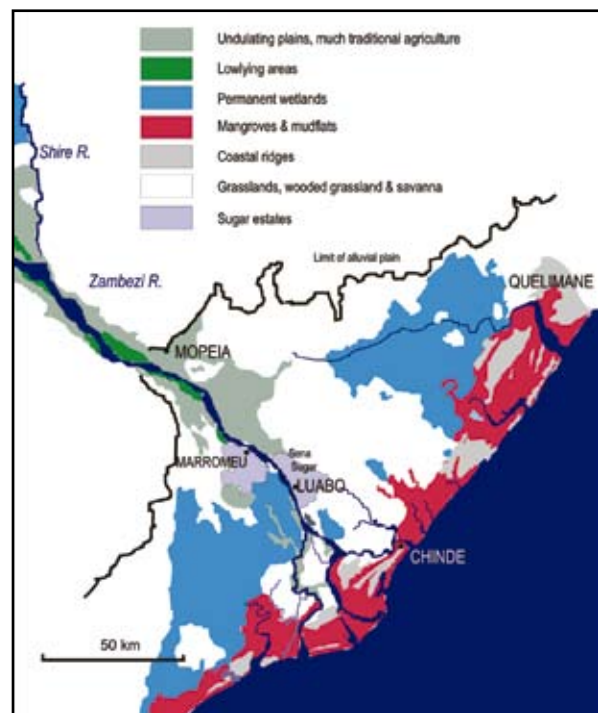
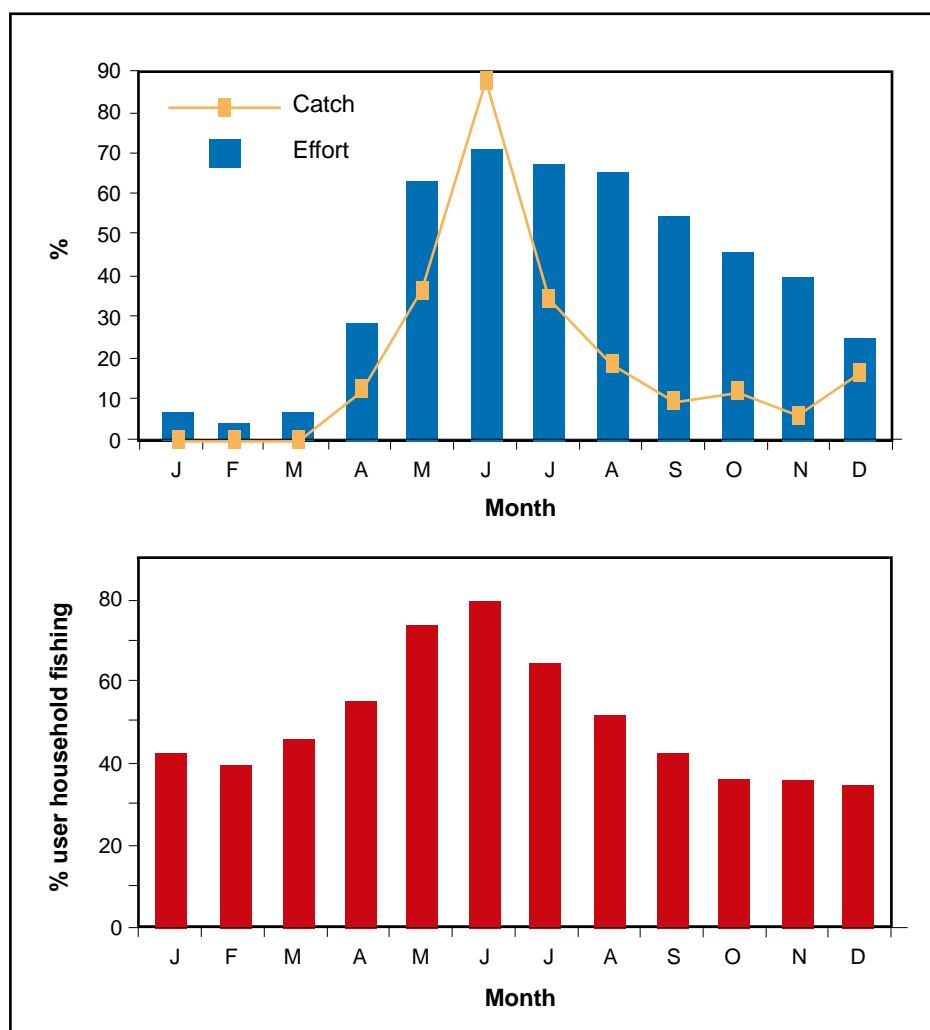


Figure 14: Perceived seasonal changes in catch in the Rivers Barotse and Lower Shire



The fisheries

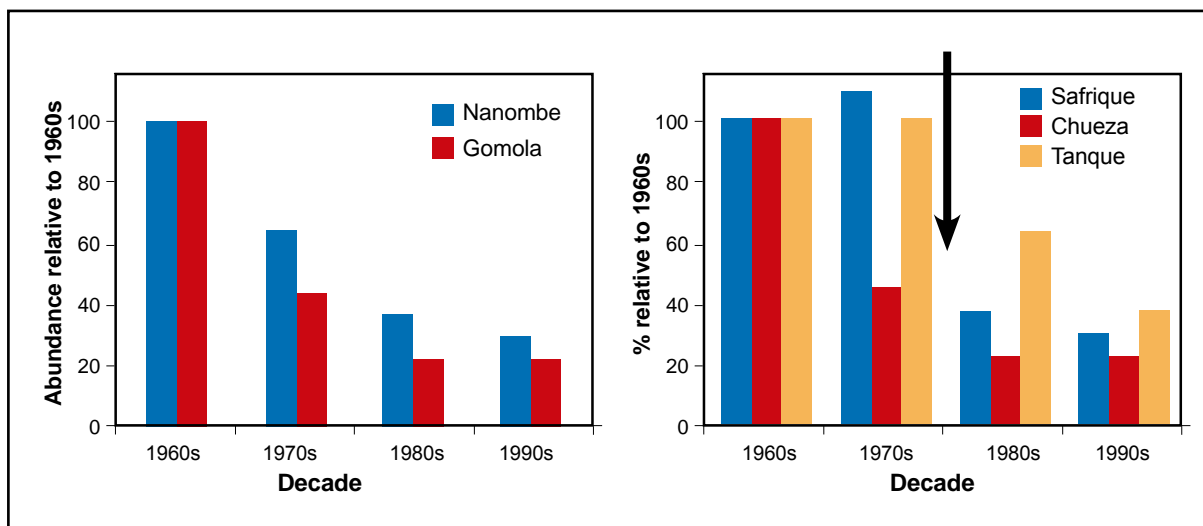
Fisheries were a major feature of each of the wetland areas, except Lake Liambezi, which was studied during a dry phase. The fisheries generally comprised a large proportion of local households, plus 'outsiders' who resided in fishing camps. Fishing was primarily undertaken by men; but women & children help during peak fishing periods, typically using more traditional methods.

- **Fishing gear:** Dugout canoes are the main fishing vessel. Fishing gear has changed considerably over time, with nets having been introduced in the 1970s. All of the fisheries were dominated by gillnets, and seine nets were also common. Some traditional methods, such as fences, traps, and funnels are still commonly used, especially as floodwaters recede, other traditional methods have become relatively

rare. Illegal gear (fine-meshed nets) is becoming increasingly common and openly used.

- **Seasonality:** Fishing is strongly seasonal in all the study areas. Catches peak after floodwaters start to recede. Fishing activities are conveniently complementary to agricultural activities in that peak periods of each do not generally overlap.
- **Dependence on flow:** Fish catches have been correlated with the length of the flood season in the Barotse floodplain, and prawn catches have been correlated with annual flows in the Zambezi Delta. Fishers interviewed in these studies also claimed that there was a significant connection between flood levels and catch.
- **Perceived status of the fisheries:** In most study areas, fishers interviewed in focus groups claimed that fisheries were in decline. These

Figure 15: Perceived trends in fish abundance and catches in Eastern Caprivi and in the Zambezi Delta



The arrow represents timing of the closure of the Cahora Bassa dam.

perceptions are also supported by fisheries data where they exist. In the Zambezi Delta, there was a reported decline that could be associated with the closing of the Cahora Bassa Dam.

Although fishing activity was low at Lake Liambezi due to its being dry, the fact that 59-86% of households own canoes suggests that a large proportion of households fish during wet periods.

- **Catches (1998):** Apart from Lake Liambezi, over half of the households living around floodplain wetlands were engaged in fishing. Catches ranged from 270kg to as much as 1,740kg per fishing household per year. Total catches were generally higher than official statistics, but were within the range of expected offtake based on the work of Welcomme.
- **Trade, processing and marketing:** A large proportion of households sell their catches, with as much of two thirds of catches being sold in the Lower Shire.

Catches are sold fresh where possible. There is some reliance on middlemen, for transportation, cooler boxers etc. The remainder is dried. Most

Table 7: Proportion of households involved in fishing, catches per household and total wetland catch per year for wetland areas

	Barotse floodplain	Eastern Caprivi	Lake Liambezi	Lower Shire	Delta
% hh	54%	75%	7 – 22%	53%	66-78%
Kg/hh/year	700	370	740 – 1740	320	270 – 450
Total (tons/y)	10 500	1280	61	9750	15 600

Values for Lake Liambezi are for households close to the east and north of the lake, respectively. Values for the Delta refer to the inner and outer delta, respectively.

Table 8: Trade in fish in four wetland areas

	Barotse	Eastern Caprivi	Lower Shire	Delta
% of fishing hh that sell catch	70	64	40	69
% catch sold by those hh	30	10	67	50

production is consumed locally (75%), with fish providing a staple relish in the western areas.

- **Value of the fisheries:** Fishing yields a net value of between \$60 and \$325 per household per year. Most of this value is in the form of subsistence value (consumption by the households), and the fisheries yield cash incomes to households of about \$30 – 100 per year. Returns to labour are low, but may be underestimated, given the difficulties of quantifying effort.

The total value of the fisheries ranges from \$1.6 million per year in Eastern Caprivi to \$7.3 million in the Delta. The value per ha was similar for three wetlands, but was much higher in the Lower Shire. Values per ha are correlated to the population density of the four wetland areas.

- **Socio-economic context:** The wetland communities in all the study areas have a semi-subsistence economy, in that they engage in cash-earning activities in order to pay for school fees and other necessities. However, they rely primarily on subsistence activities, and engage in multiple activities in order to spread the risk of failure in any single productive activity, notably agriculture. This type of strategy indicates the high vulnerability of the households to environmental fluctuations and other risks. Fishing is thus one of numerous household production activities.

In addition to wetland resources, households also derive income from the harvest of upland resources (e.g. fuel wood, timber, medicinal plants, food plants), from pensions, remittances, petty business and jobs.

Table 9: Different measures of value of fishing to households in four wetland areas of the Zambezi Basin

US\$ per year	Barotse	Eastern Caprivi	Lower Shire	Delta
Gross value	335	432	106	246
Net value	325	299	56	235
Cash income	98	31	28	81
Return to labour \$/day	1	5	0.4	1-2

Table 10: Total economic value of fisheries in four wetland areas of the Zambezi Basin

US\$ per year	Barotse	Eastern Caprivi	Lower Shire	Delta
Net economic value	4.6 m	1.6 m	3.9 m	7.3m
Cash income	1.45 m	0.7 m	1.0 m	6.4m
Value/ha	8.4	7.3	24.4	6.1

Table 11: Percentage of households engaged in different wetland resource-based activities

% hh	Barotse	Caprivi-Zambezi	Caprivi-Liambezi	Lower Shire	Zambezi delta
Crops	100	98	99	97	99
Livestock	81	87	81	39	0
Fishing	54	75	15	53	78
Hunting	6	22	86	18	10
Reeds & Sedges	93	90	56	66	86
Grass	86	77	97	62	91
Palms	?	62	92	?	61
Mangroves	-	-	-	-	77

According to household survey data, fisheries contributed 16-26% of household income (including subsistence values) in the four main study areas, but only contributed about 1% of income in Lake Liambezi, due to its being all but dry. However, it is important to note that the relative importance of fish, as for other resources, probably fluctuates annually. In particular, fish may become extremely important in years that crops fail. It is also worth noting that with constant fluctuations in demand and supply, prices and values vary. None of these values is set in stone, and a valuation study such as this gives only a rough idea of the relative value of fisheries.

Furthermore, current values do not necessarily reflect future values. For example, overexploited fisheries may be declining in value. Ideally, the status of fisheries needs to be taken into consideration. This is seldom done because of the difficulty in estimating the status of stocks.

Finally, value does not necessarily reflect preference. This was recently illustrated in Namibia when the Lake Liambezi community rejected a proposal to artificially fill the lake and restore the fishery; for fear that agricultural production (in the floodplain) would be compromised.

Workshop discussion following the presentation

The question of migrant workers and the potential conflict that they have with local fishers was raised and Dr. Turpie was asked if this was found to be the case in her studies. She noted that in most study areas there was a movement of fishers into areas to catch fish that they then mostly removed from the area. Comment was made on an impact of these often large fishing camps with migrant fishers: local women often go into the camps to secure fish for their families but during the transaction become vulnerable to HIV/AIDS and to increasing the opportunities for spread of the virus.

A comment was made on the relationship that many households have to fishing in that it is not a primary activity but one that is done more as a back-up activity when no agricultural opportunities are available. This was linked to the droughts of the 1990s and the resultant decrease in the water levels in the lakes and how this impacted on fishing and agricultural activities – the comment aimed to link shifts in fishery activity to environmental and not only demographic causes.



Survey techniques included village meetings and resource mapping (J Turpie)

7.3 ASSESSING ENVIRONMENTAL FLOWS

What is an environmental flow and why is it needed?

Prepared by Dr. Jackie King

What is an environmental flow?

Water that is left in an aquatic ecosystem, or released into it, to maintain it at a specified level of condition (health), is often termed an environmental (or instream) flow or environmental water requirement. Environmental flows are not needed for aquatic ecosystems where no basin or water development has occurred or is planned, because the ecosystems will be functioning efficiently, supported by a natural pattern of flow/inundation from day to day, season to season, and year to year. Where land or water developments could change surface water or groundwater characteristics, however, environmental flows can be used to manage and mitigate the potential degradation of the dependent aquatic ecosystems. Systems already degraded by flow/inundation changes could also be rehabilitated by introducing environmental flows to support some lost or failing ecosystem functions.

Environmental flows are thus a management tool, developed by scientists for use when making decisions about land or water developments that could change the pattern of water movement.

The link between basin development and river degradation

River systems can be managed to be at different levels of condition (health), from pristine, when they provide a range of *natural goods and services* of benefit to humans; through various stages of change from pristine, when the original goods and services disappear and others appear; to serious degradation, when virtually all goods and services essentially disappear. At the different stages of change the goods and services that appear may be more or less welcome than those that disappear, and at every level there are also costs to society. As an example, the *goods* provided by a pristine river ecosystem might be water of good quality, an abundant fishery, extensive floodplains that support abundant wildlife, and a centre of genetic diversity

for future medical and scientific exploitation. The *services* provided might be storage of rains within the undisturbed catchments, thus ensuring year-round river flow and moderate-sized floods; good bank stability brought about by a complex community of riparian trees, and thus low sediment loads in the river; and very high recreational values due to the National Parks type setting. These could collectively be called the *benefits* provided by this river system. Among the *costs* of this system are that the land and water are not in use for agricultural or industrial production, and water may not be assured for any off-stream users during dry periods because flow has not been dammed and stored.

In the early stages of development, water quality, the fisheries, the floodplains and the recreational value might decline and some species disappear even before they are known to science (costs), but the development project, perhaps a dam, that caused this, will have led to increased food or energy production or allowed people to have running water in their homes (benefits). With further off-stream developments that provided more of these kinds of benefits, flow in the river might reduce to the point where the fishery disappears, the floodplains dry out, the riparian trees die and lead to extensive bank erosion and siltation of downstream reservoirs, water quality becomes so poor that expensive water purification plants are needed before people can use the water, and the area is no longer used for any kind of recreation (costs). At this point, the costs may be seen as unacceptably high. Society might feel that too much has been lost, and that a bottom line should have been drawn at some earlier point that represented an acceptable trade-off between development and protection of the river and its natural resources.

The fact that society did not draw a line earlier is now apparent in river systems across the world. As the era of large dams began in the early 1900s, it soon became apparent that flow manipulations away from natural were causing major degradation of river systems. The first scientific moves to address this problem began in about the 1970s, when guidelines were provided on flows needed to maintain good habitat for fish. Since then, the concept has broadened to address wider issues of flow management, river health and natural

resources, under the guise of a range of names such as 'instream flow requirements', 'ecological water requirements', 'integrated basin flow management', 'environmental flow assessments' and similar. In this document the last term is used as an all-encompassing one addressing the issue of flow management for maintenance of the river ecosystem and its valued goods and services.

The concept of environmental flow assessments

River ecosystems have abiotic (non-living) and biotic (living) attributes. The abiotic attributes are the channel from source to sea; the riparian zone on either bank; the groundwater feeding or being fed by the river; any associated wetlands, floodplains, lakes and deltas; the estuary; the near-coastal marine environment if this is dependent on freshwater in any way; and the chemical, thermal, sediment and hydrological regimes of all parts of the system. The biotic attributes include the riparian, marginal and aquatic vegetation; the fish; invertebrates; phytoplankton and zooplankton; micro-organisms; herpetofauna (reptiles and amphibia); water birds and any terrestrial or semi-aquatic wildlife dependent on the river. The concept of environmental flow assessments (EFA) recognizes that as flows change, any or all parts of the river ecosystem could respond by changing also. As the river changes, people who use it will be affected, with subsistence users of the river probably having their lifestyles mostly drastically impacted. The most common forms of flow changes are caused by water-resource developments such as dams and inter-basin transfers, and land-use changes such as deforestation and urbanization. Common forms of impacts on riparian people are decline in or loss of fisheries; decline in or loss of vegetation used for construction, food, grazing, medicines, firewood and nutritional supplements; bank erosion; increased water-related illnesses; poorer quality drinking water due to the reduced ability of the river to absorb and dilute pollutants; shrinking floodplains with all their resources; increased flooding in the wet season and man-made droughts in the dry season; and loss of sites of spiritual or cultural importance.

Such river changes from Basin (catchment) developments can be managed, or left to chance

as in the past. Adherence to the principles of sustainable development requires that the change be managed and kept within acceptable bounds. Recognising this, EFAs produce predictions of how various options for Basin (most often water-resource) development will change the river and thus impact the people who depend on its resources. The assessment can be done for whole river systems, or for any part likely to be affected by development, including floodplains, estuaries and deltas, groundwater-fed ephemeral streams, and river-linked wetlands. The main steps in a comprehensive EF assessment are:

- a multidisciplinary team of river scientists (biophysical) and social specialists (socio-economic) with knowledge of the river of concern is created;
- the specialists develop an understanding of the nature of the river and subsistence use of its resources;
- possible future flow regimes under a range of different Basin developments are simulated;
- the biophysical team describes how each flow scenario would change the river;
- the socio-economic team describes how the river changes would impact common-property subsistence users of the river;
- each flow-river change-social impact scenario can be subjected to a regional macro-economic analysis to complete the picture of the costs and benefits of each scenario.

The scenario chosen represents the agreed level of Basin development with its agreed degree of impact on the river and its resources. The flow regime upon which that scenario is based becomes the agreed flow regime (the environmental flow) for that river. As the scenario is implemented, it can – and should because it is a prediction not a certainty – be monitored in two ways. First, the flow regime itself can be monitored at gauge stations along the catchment for compliance. Second, river condition can be monitored, based on the predictions of river change contained within the scenario. If the environmental flows are being delivered and the

river condition differs from that predicted, then either the agreed flows or the agreed condition could be altered through due process.

Although the above explanation assumes a development with reduced river flows, the EF approach can also be used to guide re-establishment of a suite of flows to rehabilitate a degraded river.

Use of EF assessments in water-resource planning and operation

Until recently, decisions on water-resource developments were mainly based on engineering and economic criteria. The consequences of the developments in terms of ecological degradation of the river and impacts on its subsistence users were largely unknown and unconsidered. The same held for land-use changes, where impacts on drainage patterns to rivers were usually simply not considered at all. In a move toward sustainable development, EFAs complement traditional engineering and economic information, which outline benefits of any development, by providing ecological and social information that outlines the less obvious costs of development. This can be done for any level of land-use or water-resource change.

The EF scenarios, produced as outlined in the bulleted items on the previous page, could describe an incremental range of possible basin development levels and the ecological and social implications of each. Subjected to additional economic analysis in terms of the wider regional economy, they provide a comprehensive picture of costs and benefits. Decision makers can use these to identify an acceptable trade-off between development and resource protection. The chosen scenario will

define not only the required flow regime (environmental flow) and river condition, but also in general terms the amount of basin development still 'available' before unacceptable impacts outweigh advantages. This is a new and advanced approach to basin management which allows genuine planning for sustainable development. The EF approach is now a major water-management tool in more than 50 countries and the list is growing each year.



Cahora Bassa Dam and Reservoir (anon.)

Workshop discussion following the presentation

Following Dr. King's presentation a comment was made on the fact that thresholds need to be established for flows that include maximum and minimum levels for both ecological and social benefits. Dr. King explained that the Environmental Flow Assessment feeds into wider cost-benefit analysis at both the National and Regional level. The process also requires an input of public opinion and comment.

7.4 FLOW REQUIREMENTS IN THE ZAMBEZI DELTA

Environmental flows for the sustainable management of the Lower Zambezi Valley and Delta, Mozambique

Prepared by Dr. Richard Beilfuss and Mr. Carlos Bento

Introduction

The Lower Zambezi River Valley is the lifeline of Mozambique, ancient home to more than a million people and of immense economic, social, and ecological value as one of the most productive and biologically diverse river-floodplain systems in Africa. Over the millennia, the valley floodplains were nourished by the annual spread of Zambezi floodwaters. The fertile floodplains provided recession agriculture, hunting, fishing, and abundant natural resources for its inhabitants. The Zambezi Delta's vast, seasonally flooded grasslands supported diverse and abundant wildlife populations, including African elephant, Cape buffalo, and waterbuck, and numerous threatened and endangered species, including the Wattled Crane. The healthy floodplain provided spawning grounds for riverine and anadromous fishes, and critical dry-season grazing lands for livestock and wildlife. Extensive coastal mangroves and estuaries supported a productive prawn fishery. Over the past forty years, however, the communities and ecosystems of the lower Zambezi have been severely affected by the management of large upstream dams and other development projects. To rehabilitate this great river system for the people and wildlife of Mozambique, we are undertaking an innovative collaboration of hydrologists, social scientists, ecologists, engineers, and resource

managers with stakeholders and decision-makers, to establish ecologically-sustainable methods for managing Zambezi flows and improve living standards in the lower Zambezi Basin.

The problem: large dams and the mismanagement of Zambezi waters

By eliminating natural flooding and greatly increasing dry season flows in the lower Zambezi, Kariba Dam (completed in 1959) and especially Cahora Bassa Dam (completed in 1974) have caused great hardship for hundreds of thousands of Mozambican villagers whose livelihoods depend on the ebb and flow of the Zambezi River. Although these hydropower dams generate important revenues for Zimbabwe and Zambia, and Mozambique, respectively, they are operated to maximize hydropower output at the expense of other water users. Subsistence fishing, farming, and livestock grazing activities have collapsed with the loss of the annual flood. The productivity of the prawn fishery has declined in relation to reduced Zambezi runoff, perhaps by as much as \$20 million per annum (Gammelsrod 1996¹⁴, Hoguane 1997¹⁵) this in a country that ranks as one of the world's poorest nations.

Changes in the flooding regime have also affected the availability of water supplies, fuel wood, building materials, and medicinal plants, as well as general public health and the cultural relationship between local people and the river (Chilundo *et al.* 2002¹⁶). The construction of large dams on the Zambezi River has also greatly diminished the ecological diversity and productivity of the Zambezi Delta, one of the great floodplain systems of Africa. Before Cahora Bassa Dam was constructed, Davies and

14 Gammelsrod, T. 1996. Effect of Zambezi River management on the prawn fishery of the Sofala Bank, p. 119-124. In M.C. Acreman and G. E. Hollis (eds.) Water management and wetlands in sub-Saharan Africa. IUCN, Gland, Switzerland.

15 Hoguane, A. 1997. Shrimp abundance and river runoff in Sofala Bank - the role of the Zambezi. Paper presented at the workshop on the sustainable use of Cahora Bassa Dam and the Zambezi Valley, 29 September - 2 October, 1997, Songo, Mozambique.

16 Chilundo, A., A. Isaacman, W. Mulwafu and R. Beilfuss. 2002. The impact of hydrological changes on subsistence production systems and socio-cultural values in the lower Zambezi Valley. Working paper no. 5 of the Programme for the Sustainable Management of Cahora Bassa Dam and the Lower Zambezi Valley. International Crane Foundation, Baraboo, Wisconsin, USA.

17 Davies, B.R., A. Hall and P.B. Jackson. 1975. Some ecological effects of the Cahora Bassa Dam. Biological Conservation 8: 189-201.

others (1975¹⁷) and Tinley (1975¹⁸) predicted that the hydrological changes imposed by the dam would result in reduced silt deposition and nutrient availability, salt water intrusion, replacement of wetland vegetation by upland species, failure of vegetation to recover from grazing, and disrupted or mistimed reproductive patterns for wildlife species in the delta. The delta today is much drier at the end of the dry season than under natural conditions, with a reduction in wetland and open water areas, infestation of stagnant waterways with exotic vegetation, and intrusion of saltwater (Beilfuss *et al.* 2000¹⁹).

Wetland vegetation communities are being replaced by upland communities, and no longer support the web of floodplain life that previously existed. There is widespread encroachment of woody savanna species onto the open floodplain. The desiccation of the floodplain has opened the area to aggressive poaching of wildlife species, with a 95% or greater reduction in grazing species such as Cape buffalo, waterbuck, reedbuck, zebra, and hippopotamus between 1978 and 1992 (Tinley 1994). Grassland fires are widespread across the dry plains, degrading fire-sensitive communities (Beilfuss 2001²⁰). Globally endangered Wattled Cranes, an indicator species for many of the flood-dependent waterbird species of the Zambezi system, have ceased to breed across most of the delta (Bento 2002²¹). In October 2003, the Zambezi Delta was designated as the Mozambique's first Wetland of International Importance under the Ramsar Convention because of its immense value for wildlife and its national economic importance. The wetland is rapidly losing ground, however, and urgent action is needed.

The solution: Integrated Water Resource Management in the Zambezi Basin

Despite widespread degradation, there are good reasons to be optimistic about the future of the Zambezi system. For the past eight years close collaboration with scientists, historians, dam operators, government officials, and local communities to promote the sustainable management of the lower Zambezi River has taken place. Through a series of face-to-face meetings, including three international workshops, awareness was raised among local stakeholders and national decision-makers about the benefits of managed flow releases. Most notably, the Workshop on the Sustainable Use of Cahora Bassa Dam and the Zambezi Valley (October 1997) was hosted by the dam managers and attended by three national ministers, two governors, and other prominent decision-makers. During this meeting, participants reached consensus on an ecologically sustainable framework for managing the water resources of the lower Zambezi and improving the living standards of thousands of riverine households (Davies 1988²²). This project has featured in sundry journals and newspapers in Mozambique, and was acknowledged by the President of Mozambique, Joaquim Chissano, and members of his cabinet. A documentary on this work was featured on the BBC World Service and at the World Water Forum in Japan in 2003. This extensive dialogue has resulted in the political will and commitment necessary to now take advantage of this unique window of opportunity to implement a vision for the future of the Zambezi system.

The goal is to facilitate the “best” use of lower Zambezi waters by developing, implementing, and

18 Tinley, K. 1975. Marromeu wrecked by the big dam. *African Wildlife* 29: 22-25.

19 Beilfuss, R.D., P. Dutton and D. Moore. 2000. Land cover and land use changes in the Zambezi Delta, p. 31-106. In J. Timberlake (ed.) *Biodiversity of the Zambezi Basin wetlands. Volume III. Land Use Change and Human Impacts*. Consultancy report for IUCN ROSA. Biodiversity Foundation for Africa, Bulawayo; and The Zambezi Society, Harare, Zimbabwe.

20 Beilfuss, R. 2001. *Hydrological disturbance, ecological dynamics, and restoration potential: the story of an African floodplain*. University of Wisconsin-Madison. Ph.D. dissertation.

21 Bento, C.M. 2002. *The status and prospects of Wattled Cranes *Bugeranus carunculatus* in the Marromeu Complex of the Zambezi Delta*. University of Cape Town, South Africa. M.Sc. thesis.

22 Davies, B.R. (ed.) 1998. *Sustainable use of the Cahora Bassa Dam and the Zambezi Valley*. Final report. Arquivo do Património Cultural, Maputo, and Ford Foundation.

monitoring a clear, equitable, and practical plan for the management of flow releases from Cahora Bassa Dam (Beilfuss and Davies 1999²³). Through:

- Assessing in terms of the widest variety of users, the environmental, economic, and broader developmental advantages and disadvantages of different strategies for managing Cahora Bassa and the waters of the lower Zambezi.
- Evaluating flow requirements in the Zambezi system using a holistic methodology called DRIFT (an acronym for Downstream Response to Instream Flow Transformations) (King *et al.* 2002²⁴).
- Combining data and knowledge from relevant biophysical, social, and economic disciplines, to produce a range of objective, scientifically-based flow scenarios for consideration.
- Bringing together agency, stakeholder, and community representatives to reach consensus on the most appropriate water release scenario, based on an accepted hierarchy of clear, measurable objectives for water flows and water quality.
- Working with managing authorities to implement the selected release scenario through a set of operating rules for releases from Cahora Bassa.
- Monitoring releases.

- Providing adaptive feedback to decision-makers and dam operators who will make the necessary adjustments in water releases to meet the measurable objectives for flow management.

Through this process, the in-country capacity and common ground necessary to institutionalize the holistic management of Zambezi waters is established.

Workshop discussion following the presentation

The first comment following Mr. Bento's presentation was an acknowledgment that the impact downstream of the dams is very important and that often those working upstream do not fully appreciate the situation or impacts – particular note was made about the opening of the dam gates when floods occur and of the destruction and loss of lives that can occur as a result of this. Comment was made that with better information on weather, and in particular rainfall, it may be possible to manage the release of water at times of flooding in order to avoid a large release only when the dam is full.

A question was raised as to the relative importance of changes in flow regime in Kariba for Cahorra Bassa dam. It was noted that inflows from rivers on the middle Zambezi have a significant input that makes the in-flow into Cahorra Bassa reflect a normal flood cycle flow. Comment was made that studies on the Shire River show that this is the only river bringing a large amount of water into the delta.

23 Beilfuss, R.D. and B.R. Davies. 1999. Prescribed flooding and wetland rehabilitation in the Zambezi Delta, Mozambique, p. 143-158. *In* W. Streever (ed.) An international perspective on wetland rehabilitation. Kluwer Academic Publishers, Amsterdam, Netherlands.

24 King, J.M., C.A. Brown and H. Sabet. 2003. A scenario-based holistic approach to environmental flow assessments for regulated rivers. *River Research and Application* 19(5-6): 619-639.

7.5 INSHORE FISHERIES AND FISH POPULATION CHANGES IN LAKE KARIBA

Prepared by Dr Jeppe Kolding,
B. Musando and N. Songore

Background

This is a short synopsis of a fully referenced paper by Kolding *et al.* (2003²⁵). Man-made Lake Kariba equally shared between Zambia and Zimbabwe, has since its creation in 1958 seen substantial changes in both its fisheries and in the fish communities. Although probably one of the best studied fresh water systems in Africa, the sustainable exploitation levels of its fish communities are still largely unknown. Fear of overfishing, or at least indications of fully exploited resources, have repeatedly been expressed, whereas other studies have contested these views (see Kolding *et al.* 2003 for references).

Lake Kariba is not a stable system in line with most other small or medium sized lakes in Africa. The environment, in terms of the fluctuating hydrological regime, explains a large proportion of the variability in catch rates (CPUE). The question is therefore how much of the observed changes can be attributed to fishing activities and how much is due to natural environmental fluctuations. Another important management issue, particularly on the Zambian side, is the high fishing pressure and changing fishing pattern in terms of increased use of small mesh sizes and customary use of illegal fishing methods such as drive fishing. As the inshore fisheries of Zambia and Zimbabwe have evolved differently and have been subject to different types of management regimes the overall objective is therefore simply to compare the results after more than 40 years of continuous monitoring in order to evaluate the impacts on the inshore fish communities.

Management and regulations

From the very beginning the essential issue in the management of the fishery was the question “Who

was to fish”? On this question the Zambian and Zimbabwean authorities fundamentally disagreed, which eventually led to divergent policies that still mark the fisheries in the two countries today. The Zimbabwean side is highly regulated with demarcated fishing areas (Figure 16), effort and gear limitations, and strictly enforced mesh-size regulations with a minimum of 100 mm stretched mesh. The Zambian side is in principle an open access fishery, and up to 1986 there were no gear regulations. From then a minimum mesh size of 76 mm was set and beach seining was prohibited. In practice, however, there has been little enforcement due to lack of resources. As a result of the two management regimes there has been very little variation in the fishing pattern on the Zimbabwean side (Figure 17). On the Zambian side, however, the number of nets has increased over time (Figure 18) while the average mesh size has decreased almost linearly from around 140 mm to 90 mm over the same period.

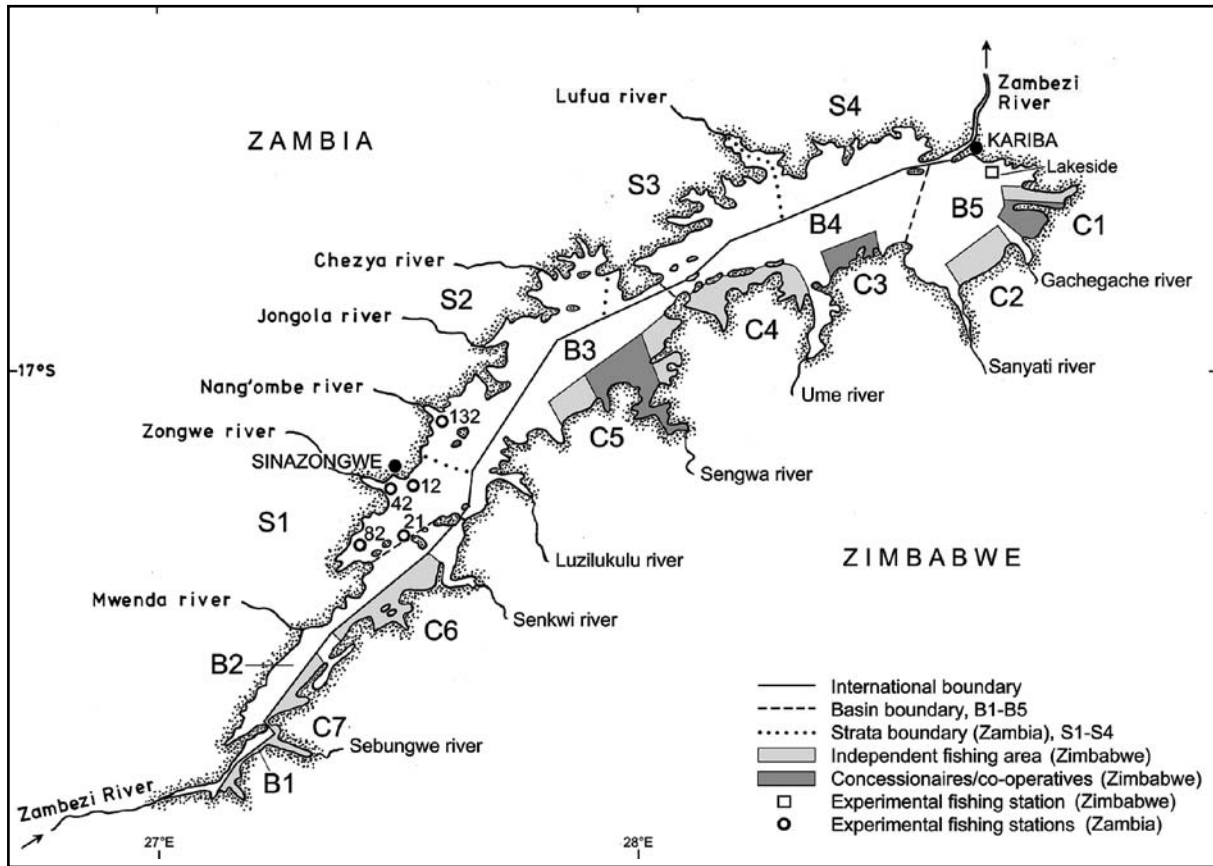
Results

The changing fishing pattern on the Zambian side in terms of increasing effort and decreasing mesh sizes is not reflected in the overall species composition of the catches, neither are there any major differences in the overall catch composition between the two countries. For both countries the relative species composition in the landings has changed remarkably little since 1980. On the other hand, the development of catch rates in the experimental fishing nets on the Zimbabwean side (at the unfished Lakeside station) and the Zambian side (Sinazongwe area) show clear differences (Figure 19). The average experimental catch rate in Zambia is about seven times lower compared to Lakeside from the mid-1980s.

Most of the observed changes in species composition of the experimental catches can be attributed to the natural species succession that Lake Kariba has undergone since its creation as a new pristine environment. On both sides of the lake the appearance of new species (both naturally and introduced) and the increasing relative abundance

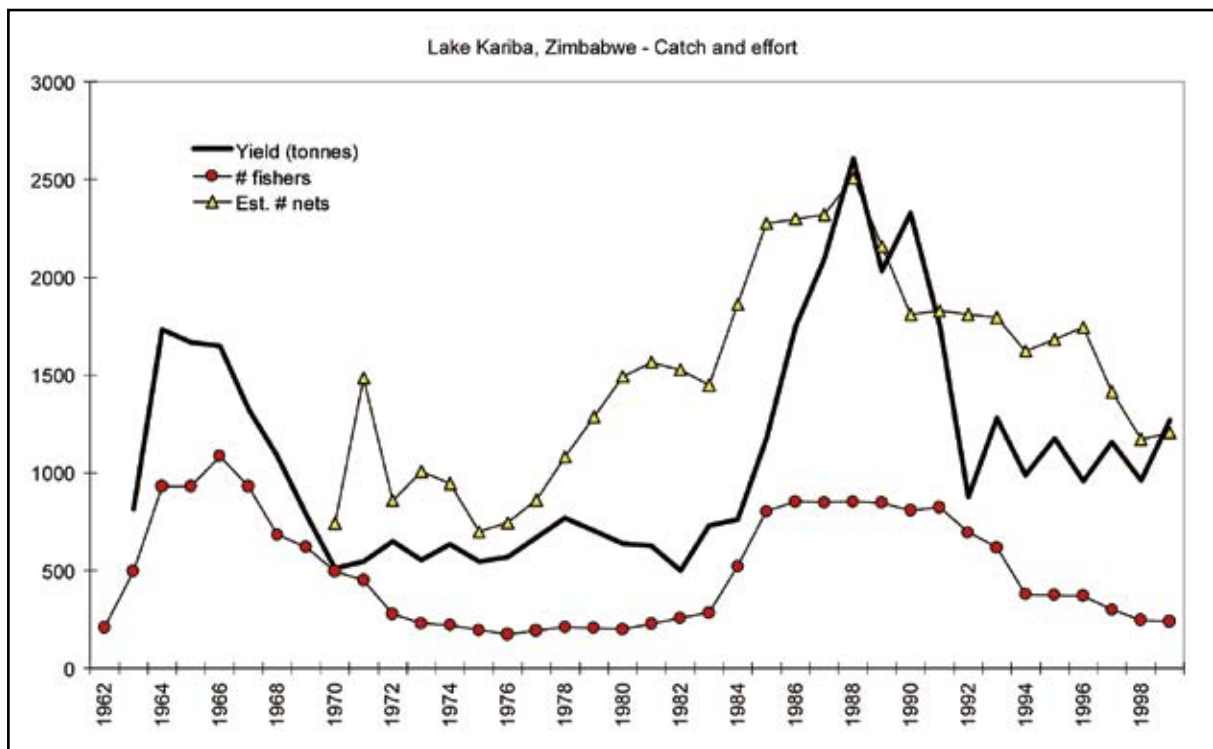
25 Kolding, J., B. Musando and N. Songore. 2003. Inshore fisheries and fish population changes in Lake Kariba, p. 66-100. In E. Jul-Larsen, J. Kolding, J.R. Nielsen, R. Overa and P.A.M. van Zwieten (eds.) 2003. Management, co-management or no management? Major dilemmas in southern African freshwater fisheries. Part 2: Case Studies. FAO Fisheries Technical Paper 426/2. FAO, Rome, Italy.

Figure 16: Map of Lake Kariba



Key: five natural basins (B1..B5), the designated inshore fishing grounds on the Zimbabwean side (C1..C7), the sampling strata in Zambia (S1..S4), the selected experimental fishing stations in Zambia around Sinazongwe (open circles), and the experimental fishing station (Lakeside) in Zimbabwe near Kariba town (open square).

Figure 17: Estimated total annual effort and annual yield from the Zimbabwean inshore fishery (1962 to 1999)

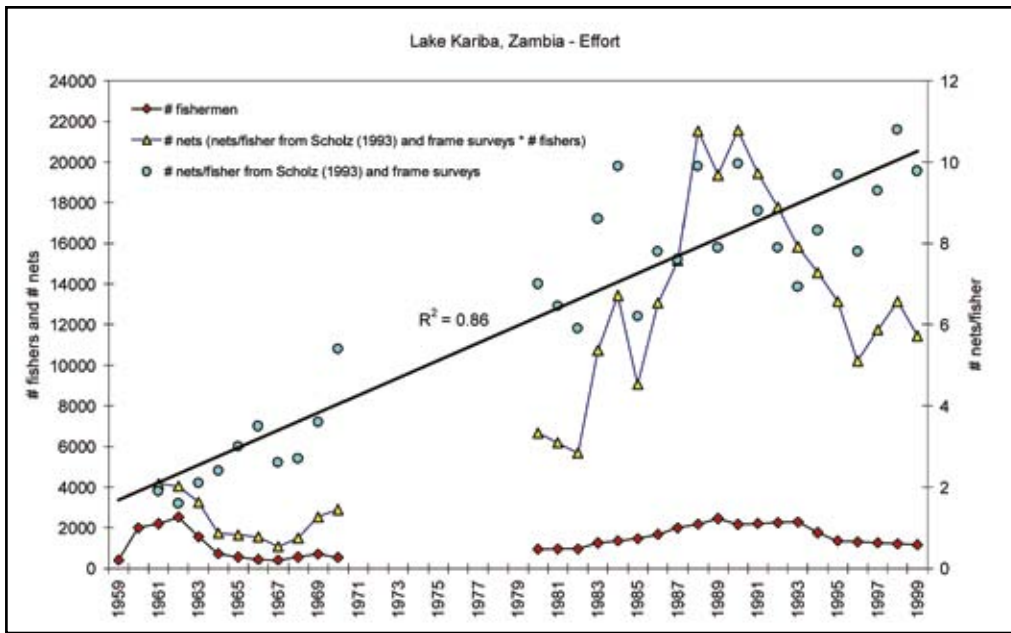


of other species have resulted in steadily increased fish species diversity (Figure 20), with no significant differences between the two sides of the lake.

Although the means of the biomass-size distributions (intercepts) are significantly different the slopes are not. This indicates that despite the differences in the absolute biomass (standing stock), the overall community size structure is relatively homogeneous. Taking the relatively stable inshore catch composition and the development in species diversity (Figure 20) into

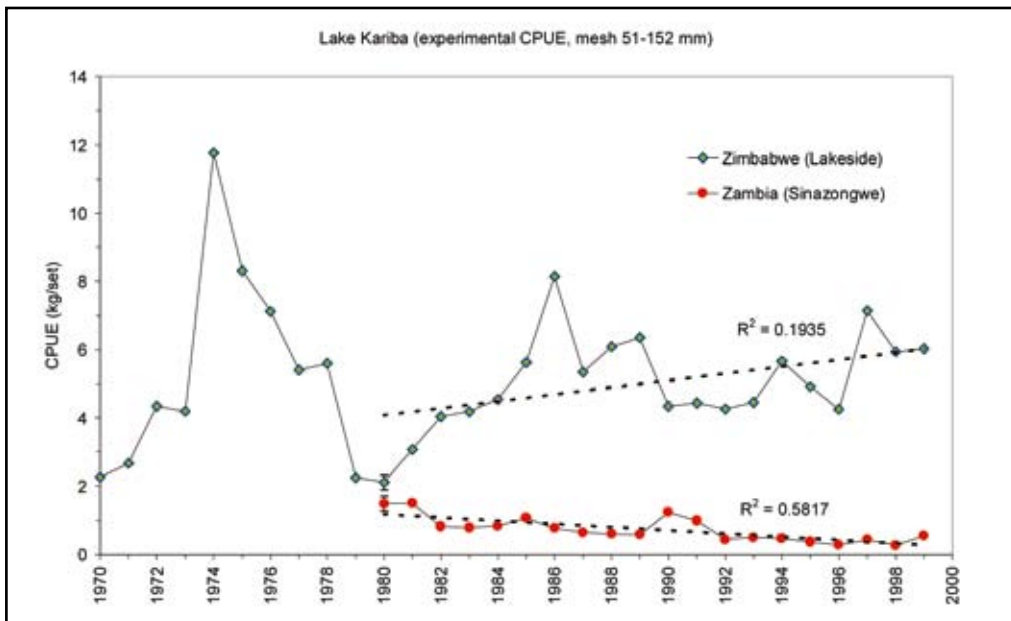
The strong difference in the mean experimental catch rates between Zimbabwe and Zambia (Figure 19), however, is reflected in the overall biomass-size distribution of the two areas (Figure 21).

Figure 18: Estimated effort development in the Zambia inshore fisheries



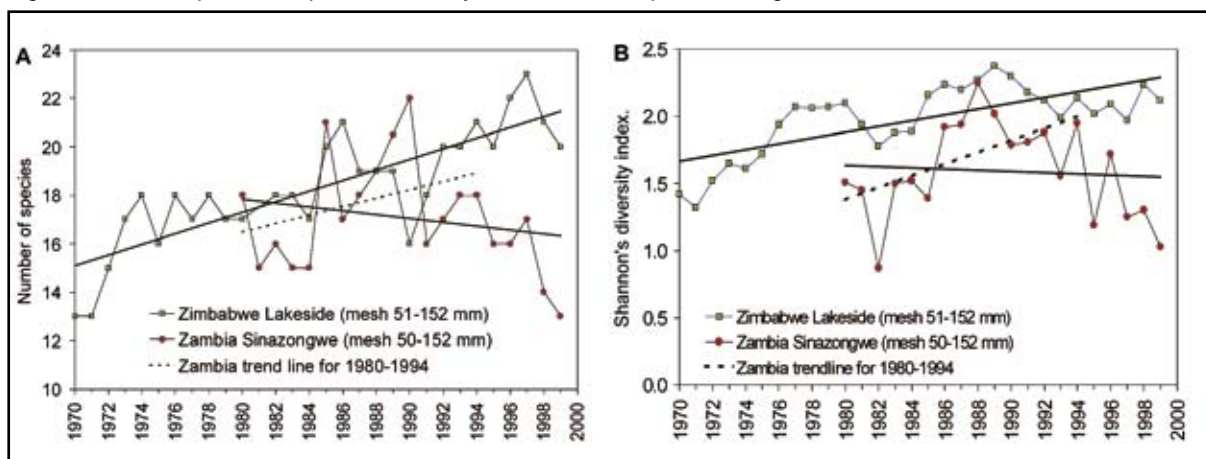
Note: Straight line is a linear regression on the nets/fishers.

Figure 19: Mean catch rates in the experimental fishery on the Zimbabwean and the Zambian side of Lake Kariba



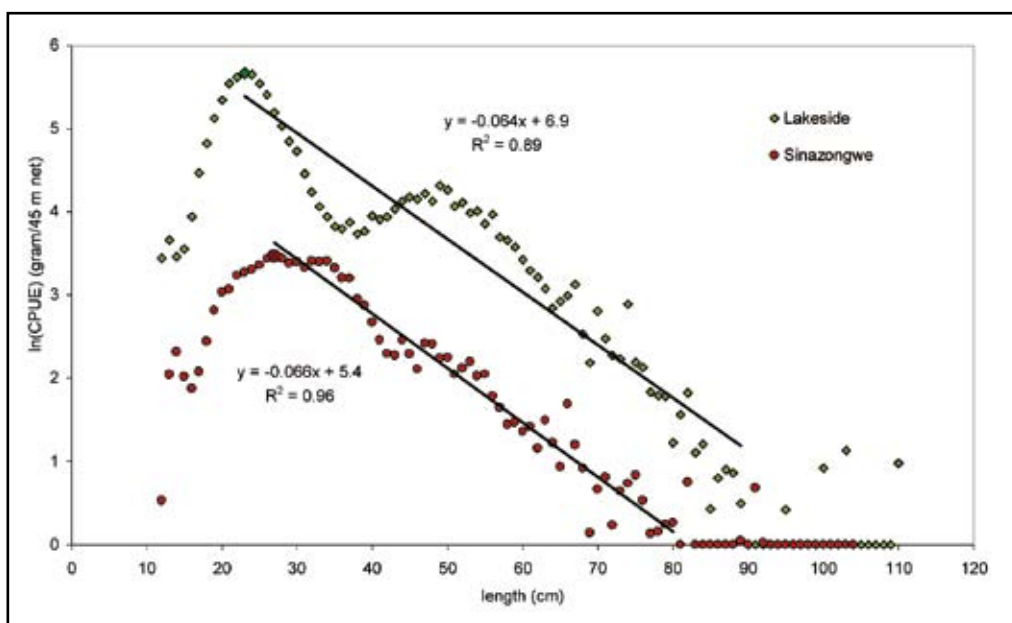
Mean catch rates (kg/set) in the experimental fishery (mesh size range 52-152mm) on the Zimbabwean and the Zambian side of Lake Kariba. 95% confidence intervals are indicated for 1980 when the Zambian inshore fishery reopened and the trend lines (both significantly different from 0) represent the period 1980 to 1999.

Figure 20: Development in species diversity in the Kariba experimental gillnets



Development in species diversity in the Kariba experimental gillnets (mesh sizes 50-152 mm) represented by A: annual mean number of species caught and B: Shannon's diversity index (H'). Continuous trendlines are for the whole period of observations. Broken trendlines are from the period 1980-1994 in Zambia after which the data are not fully representative (Kolding et al. 2003). The broken trendlines for Zambia are statistically not significantly different at 95% confidence intervals

Figure 21: Relative biomass-size distribution from Zimbabwe and Zambia experimental fisheries (1980-1994)



Relative biomass-size distribution with linear regression from Zimbabwe (Lakeside) and Zambia (Sinazongwe) experimental fisheries during the period 1980-1994 for all fish caught in mesh sizes 50-152 mm. Linear regressions on ln-transformed standardised mean catch rates (gram/45 m net set) were made from length range 23-89 cm (Zimbabwe) and 25-78 cm (Zambia) (from the highest value to first 0-observation). The SE of the slopes are 0.0028 and 0.0019 for Zimbabwe and Zambia respectively which means the slopes are not significantly different at 95% confidence level.

account, it appears that the higher fishing intensity in Zambia with smaller mesh sizes only are affecting the overall biomass of the stocks, but not the community structure and species composition. There are therefore no indications that the present fishing level and fishing pattern in the Zambian inshore fishery show any potential threat to the biodiversity of the lake. Furthermore, as the overall yields have not declined, the lower catch rates are not a sign of overfishing in a biological sense, but simply a sign of fishing. Hence, by decreasing the mesh sizes, and thereby increasingly exploiting the smaller species/sizes in the biomass-size spectrum, the Zambian fishers are not only able to largely maintain their individual returns (CPUE) despite overall increasing effort, but also maintain the same relative size spectrum in the community which ecologically speaking only makes sense (see Jul-Larsen *et al.* 2003²⁶, Chapter 5).

Conclusions

The inshore fisheries on the Zimbabwean and Zambian side of Lake Kariba have experienced fundamentally different management regimes since the beginning. The Zimbabwean side is highly regulated and enforced resulting in a fishing pressure and fishing pattern which has not changed much over time and where the fish stocks are only moderately exploited. In contrast, the Zambian inshore fishery, with open access and virtually no enforcement of regulations, has developed a much higher fishing intensity and a changed fishing pattern towards increasingly smaller mesh sizes resulting in a higher exploitation level and reduced stock sizes. While effort in both countries has been fluctuating over time, the general trend in Zimbabwe is a decrease with corresponding increase in catch rates. In Zambia effort generally has increased with a corresponding decreasing trend in CPUE. At present, the overall fishing effort, in terms of number of nets, is about seven times higher in Zambia than in Zimbabwe, while the average experimental catch rates are seven times lower. Still, the artisanal catch rates are not very different on both sides of the lake (on average 1.8 and 2.8 kg/net for a fisher in Zambia and Zimbabwe

respectively). This would indicate the Zambian fishers somehow are able to maintain the catch efficiency by decreasing the mesh sizes and, probably through increased use of fish driving.

Nevertheless, there are no indications of biological overexploitation in the Zambian inshore fishery in terms of reduced total yields or changed fish communities. This leads to the conclusion that the Zimbabwean inshore fishery is under-utilised while the Zambian fishery is more optimised in terms of yield. Lake Kariba is slowly but constantly changing in terms of biological species succession indicating that it has not yet reached its final maturity stage 40 years after its creation. Both sides of the lake appear to undergo the same trends in diversity development, irrespective of fishing pressure and fishing pattern. The equal slopes of the biomass-size distributions indicates that the relatively high fishing pressure on the Zambian side does not have any negative impact on the community structure, only that the stock sizes are reduced (lower intercepts) presumably due to fishing. These results from different management regimes strongly suggest that, contrary to traditional beliefs, fisheries management is much more of a socio-economic than a biological issue. Furthermore, the strong contemporary emphasis on gear and mesh-size regulations should be critically questioned as valid stock protection measures.

Workshop discussion following the presentation

The first comment following Dr. Koldings' presentation was in relation to the issue of how to decide between managing for a balanced outcome or to optimise the outcome in one area, such as an ecological or economical optimum. In response there was general agreement that the choices related to the management objectives at a policy level. Note was also made that analysis of management success should not be restricted only to the water body itself (such as Lake Kariba), but also consider the impacts downstream. Concern was raised about the extrapolation of data from one part of the lake specified for experimental

26 Jul-Larsen, E., J. Kolding, J.R. Nielsen, R. Overa and P.A.M. van Zwieten (eds.) 2003. Management, co-management or no management? Major dilemmas in southern African freshwater fisheries. Part 1: Synthesis Report. FAO Fisheries Technical Paper 426/1. FAO, Rome, Italy.

fishing into a lake wide scenario. Dr. Kolding confirmed that due care had been taken in extrapolation.

Note was made that regardless of the pros or cons of management verses non-management the long term fisheries data presented in the talk indicated that the links between livelihoods and the flow regime of rivers are becoming more, rather than less, pronounced. The reasons for this indicated by the data were: firstly that high fishing pressure means that biomass carryover of fish from year-to-year is low, and catches are mostly dependent on that year's recruitment, which in turn is dependent on whether it is a wet or dry year in the basin. It

was noted that absolute dam level is not the driving hydrological variable, but rather the extent of the variation of that water level over time that explains most of the decline in abundance: and secondly that during times when formal employment opportunities are low or when population growth outstrips those opportunities, the natural resources offered by aquatic ecosystems in the region are the 'social security' for the people.

Final discussion focused on the controversial side of the presentation and the inference it made that optimisation could be achieved without management – concern was expressed that a manager could not accept optimisation through no management.



Lake Fishing (C Béné)

7.6 RESEARCH ON FISH BIOLOGY

Telemetry as an important management tool to study fishery species.

Prepared by Dr. Tor Naesje, C. Hay, E. Thorstad, F. Økland, B Chanda and N Nickanor

The successful management of freshwater fisheries depends on good understanding of fish migrations and habitat preferences in often complex and variable ecosystems. Management tasks, however, are complicated when rivers form borders between states. Large rivers also often flow through several countries, illustrated by the Zambezi River that flows through Zambia, Angola, Namibia, Botswana, Zimbabwe, Mozambique, Malawi, and Tanzania. As a consequence, the fish resources move freely between the states and, hence, are shared between countries.

To promote sustainable fisheries in the Zambezi River the Namibian Ministry of Fisheries and Marine Resources (MFMR) has in collaboration with the Norwegian Institute for Nature Research (NINA) studied the status of the fish resources, the fish exploitation (subsistence, recreational and semi-commercial fisheries), and the availability and presence of fisheries species including small and large fish movements in the river. In addition, baseline socioeconomic studies have been performed in riparian communities. The studies have been financed by Norwegian Agency for Development Cooperation (NORAD), MFMR, NINA, and World Wildlife Fund (WWF) which are all acknowledged for their significant contributions.

As a part of the studies of the availability of fisheries resources, movements and habitat utilization of tigerfish (*Hydrocynus vittatus*), nembwe (*Serranochromis robustus*) and threespot tilapia (*Oreochromis andersonii*) were studied in 2000 and 2001 and reported here, while studies of African pike (*Hepsetus odoe*), greenhead tilapia (*Oreochromis macrochir*) and pink happy (*Sargochromis giardi*) were initiated in 2003 and are still going on.

Telemetry background

Telemetry is the use of telecommunication for wireless transfer of information. In biological sciences, the term *biotelemetry* usually refer to the

use of electronic tags transferring information about an individual to a remotely placed observer, either by radio or acoustic signals.

Fish movements have traditionally been studied using techniques that involve marking (tagging) and releasing of fish, and then recapturing at a later date. Such methods, however, only provide two data points: where the fish was initially caught and where it was recaptured. The use of telemetry



Nembwe with tag attached (T Naesje)

technology provides a means to collect continuous data about movements, behavior and activity patterns of individual fish for extended periods, up to years, and investigate the lives of fishes in their natural habitats. The type of aquatic telemetry system used depends on the environmental conditions. For example, radio signals are usually best transmitted in freshwater, while acoustic (sound) signals are required for studies in sea water and estuarine environments.

Radio telemetry systems commonly make use of antennas to establish "listening" zones for signal detection, whereas acoustic systems use hydrophones. Researchers can either manually track the movement of the tagged fish, and/or use

a network of receivers moored in the water to automatically monitor the data transmitted from the tags. The transmitters can either be attached externally or implanted into the fish (internal tag). Internal tags are either surgically implanted into the abdomen after capturing and anaesthetizing the fish, or fed to the fish with food. With the rapid advances in telemetry a wide range of transmitter types are now available. For example, tags can be equipped with various sensors that allow the recording of external and physical parameters like temperature, salinity and depth. Other sensors can measure internal and physiological parameters like muscle activity and heart rate.

The application of telemetry research in aquatic environments is extremely diverse. This research tool has been successfully applied to investigate the human impacts of aquatic environments, such as the effects of pollution, fish-ways, weirs and hydroelectric power stations. As a tool for biodiversity research, telemetry studies have investigated the interactions between alien and native species, and assisted with the planning and evaluation of conservation measures. Telemetry research has also been applied within the aquaculture industry to optimise commercial production, assess fish welfare (health) and the environmental effects of aquaculture. And not at least, the management and sustainable utilisation of fishery resources have benefited from telemetry research.

The Zambezi River Study

Telemetry studies in the Upper Zambezi River aimed to investigate the movement behavior and habitat utilization of important fish species, and the implications for the management of subsistence and recreational fisheries.

The tigerfish, which has a reputation as one of the world's most spectacular freshwater game fishes, is also important in the subsistence and semi-commercial fisheries in the Zambezi River. Although widespread in Africa and still common in certain areas, tigerfish have declined in many rivers among others due to pollution, water extraction and migration barriers, such as weirs and dams.

The nembwe, one of the largemouth predatory cichlids, is a popular recreational angling species and an important species in the floodplain subsistence and commercial fisheries. The threespot tilapia is, like nembwe, an important cichlid species in the commercial and subsistence fisheries, and a valuable recreational angling species. Unlike the predatory habits of tigerfish and nembwe, threespot tilapia feed on diatoms, algae and detritus, and large individuals may take insects and other invertebrates.

To obtain the information on their movement behavior 15 tigerfish (body length 30 to 54 cm), 13 nembwe (32 to 40 cm), and 6 threespot tilapia (25 to 50 cm) were tagged in the Upper Zambezi River, 25 to 60 km south of Katima Mulilo in Namibia. The study lasted for 6-7 months before and during the flood in the summer of 2000/2001. The fish equipped with radio tags were manually tracked and on average positioned every 4th day. The radio tags used were attached externally below the dorsal fin of the fish.

The movement patterns of the three species differed considerably. The nembwe was the most stationary species, while tigerfish displayed extensive movements and the threespot tilapia revealed intermediate movements. Average distance moved between tracking surveys was 16 times longer for tigerfish (1447 m) than for nembwe (93 m), and 4 times longer for threespot tilapia (391 m) than for nembwe. Mean length of the river stretch used by the fish was 14 times longer for tigerfish (18.8 km) than for nembwe (1.3 km), and 4 times longer for threespot tilapia (5.4 km) than for nembwe.

Most riverine cichlid species are regarded as having a highly resident life style. Although systematic migratory patterns were not demonstrated in this study, the cichlids displayed considerably movements, especially the threespot tilapia. Thus, the large riverine cichlids may not be as highly resident as previously suggested. The results also indicate that adults of all three species were more associated with vegetation than previously assumed, although tigerfish to a lesser extent than threespot tilapia and nembwe.

This study provided fisheries managers with important information on their fish resources. Co-ordination of local and regional management regulations is recognized as being important to sustain fisheries and protect the fish resources. In rivers that flow through or border on several countries such as the Upper Zambezi River, multilateral management regulations are needed; especially for management of migratory species such as the tigerfish, and for other fish species that frequently cross the river into neighboring countries, as all the three species studied. However, tigerfish may be less vulnerable to high exploitation in a specific area than the more resident species nembwe and threespot tilapia, as it is more likely that a locally depleted population can be re-colonized by fish from other areas.

Management regulations are often implemented with the use of gear and fishing effort restrictions, and introduction of sanctuaries and no fishing periods. In the Upper Zambezi River, local stocks of nembwe and threespot tilapia will be depleted if the fishing mortality exceeds their local carrying capacity. In addition to gear and effort restrictions, sanctuaries within areas with high fishing pressure will protect resident fish such as nembwe. Threespot tilapia may require larger sanctuaries for protection, since they seem to utilize larger river stretches. Small sanctuaries, however, will not protect the long-distance moving tigerfish.

The most important results from the radio telemetry research in the Zambezi River is that tigerfish, nembwe and threespot tilapia are international resources, and management regimes needs to be harmonized to secure a fair distribution among stakeholders and sustainable utilization of the fish resources. This is today a prioritized task among fish managers and researches in the countries bordering the Upper Zambezi River²⁷.

Workshop discussion following the presentation

It was noted that the electronically tagged fish had not been as mobile as had been expected and the relationship between this finding and the implications for regional resource management of fish was noted. In response to another question it was confirmed that the experimental gill net fishing was performed both in the mornings and evenings.



Experimental fishing on the Upper Zambezi (T Naesje)

27 Information Sources:

Thorstad et al. 2003. Space use and habitat utilisation of tigerfish and two cichlid species nembwe and threespot tilapia in the Upper Zambezi River. Implications for fisheries management. NINA Project Report 24. (email: eva.thorstad@nina.no)
Biotelemetry- a versatile tool for aquatic management and research. Booklet published by Norwegian Institute for Nature research. (email: tor.naesje@nina.no)

7.7 FISHERIES RESEARCH IN THE UPPER ZAMBEZI

Experiences in working towards the improved management of shared aquatic resources in the Zambezi Basin – cases from African Wildlife Foundation's Four Corners and Zambezi Heartlands
Prepared by Mr. Jimmiel Mandima

Introduction

African Wildlife Foundation (AWF) has over the past 41 years made a significant contribution to the conservation of some of Africa's charismatic wildlife species in Eastern and Southern Africa. In Southern Africa, two of AWF's project sites – the Four Corners and Zambezi Heartlands, are spread over 6 of the 8 countries that share the Zambezi River Basin. Waters of the Zambezi, Chobe, Kwando-Linyati system, Kafue, Okavango Delta, the Luangwa and numerous other small tributaries and the reservoirs along the Zambezi support thriving commercial, subsistence and recreational fisheries.

This paper gives a brief background on AWF's sites within the Zambezi Basin and describes how, as an organization with a direct interest in the conservation of Africa's landscapes, and working with local partners, it has set up systems aimed at addressing challenges to the management of shared aquatic resources in Southern Africa.

Background to the Four Corners and Zambezi Heartlands

The Four Corners and Zambezi Heartlands are both centered on the Zambezi River, a major driver for both aquatic and terrestrial wildlife biodiversity in Southern African. The Four Corners TBNRM Initiative is focused at an area of approximately 220,000 km² including eastern Caprivi Strip in Namibia, Ngamiland in Botswana, Hwange District in Zimbabwe and parts of Southern and Western Provinces in Zambia (Figure 22).

The Zambezi Heartland on the other hand, is a three country, trans-boundary landscape that includes a range of extremely bio-diverse landholdings along the middle stretch of the Zambezi River. Geographically, it covers an area of approximately 39,120.86 km², consisting of 6,495 km² National Parks, 4,885 km² Game Management Areas (GMAs), 11,244 km² Safari Areas, and the rest are open communal areas (Figure 23). In this site, the Zambezi River and its tributaries are an important habitat for freshwater fish resources that include the tigerfish (*Hydrocynus vittatus*), lungfish (*Protopterus annectens brienii*), and a wide variety of cichlid (tilapias) and cyprinid species, some of which are local endemics and rare species.

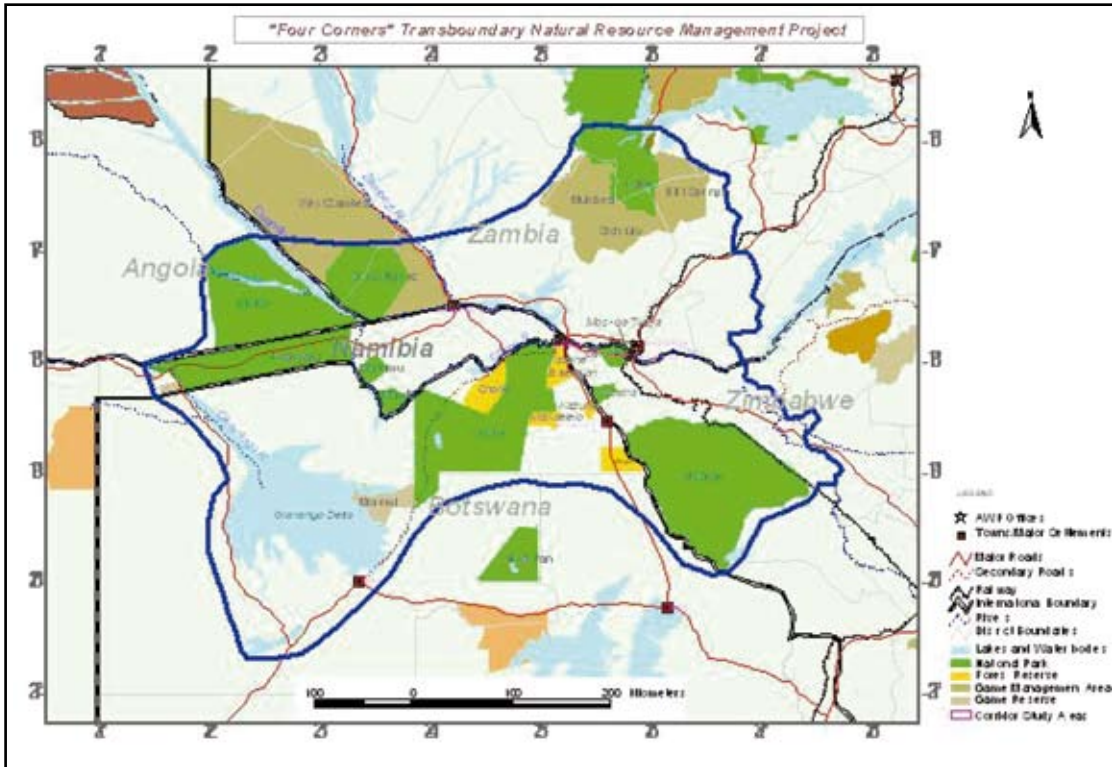
It is noteworthy that more than 20% of all freshwater fish species are now threatened or endangered because of dams and water withdrawals that have destroyed the free-flowing river ecosystems where they thrived (Ricciardi & Rasmussen, 1999)²⁸. The mighty Zambezi River is no exception to this threat as two of Southern Africa's large hydro schemes are on this river – Kariba and Cahora Bassa. Further threats to fisheries resources include poor land husbandry, erosion and deposition of silt in rivers and streams that destroy breeding grounds. Chemical pollution from agricultural activities and urban settlements cause eutrophication resulting in proliferation of invasive weeds, hence de-oxygenation of bottom waters.

AWF's Intervention Strategy

- **Establishment of the Aquatic Resources Working Group in Four Corners:** As part of the process of implementing the Four Corners TBNRM Initiative, AWF organized a meeting in January 2002 to identify partners and the mechanism for supporting initiatives aimed at joint and improved management of shared fisheries resources. The meeting was also intended to complement efforts made in addressing the issue of co-management of shared fresh water resources. The meeting culminated in the establishment of the Aquatic Resources Working Group (ARWG). Membership to the working group consists of

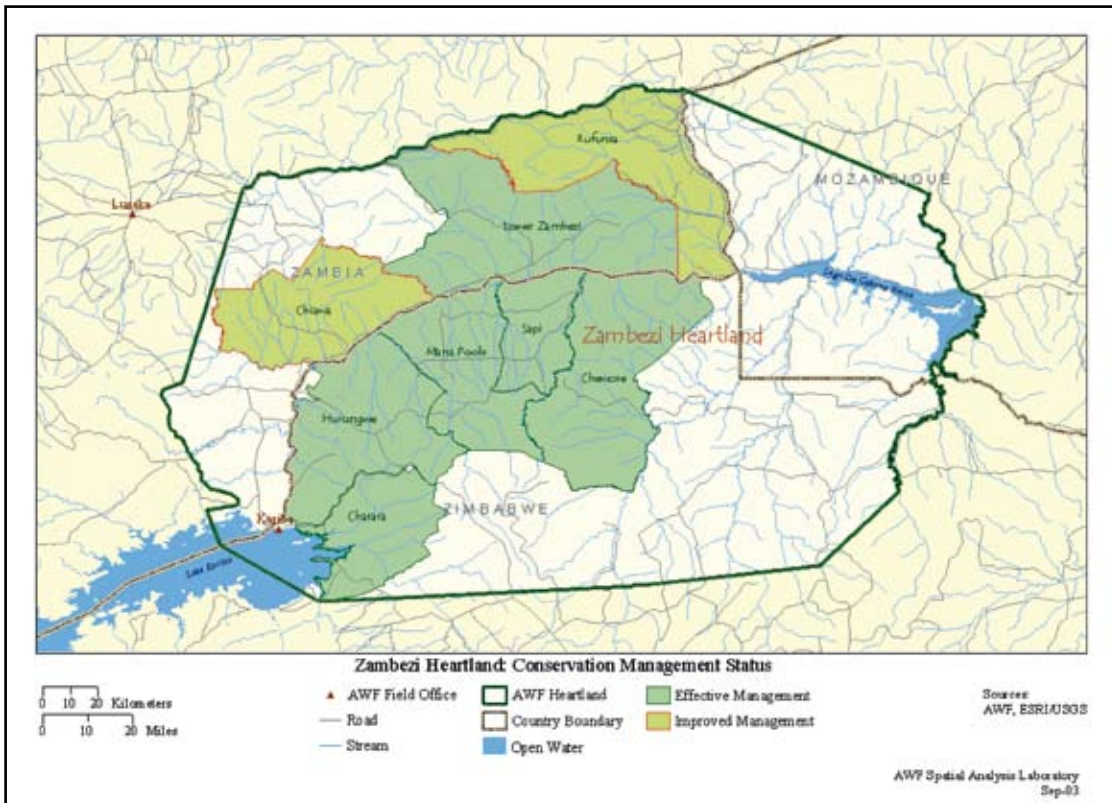
28 Ricciardi, A. and J. B. Rasmussen. 1999. Extinction rates of North American freshwater fauna. *Conservation Biology*, p. 1220-1222.

Figure 22: The Four Corners Heartland



(Source: Four Corners GIS lab, 2003)

Figure 23: Zambezi Heartland Conservation Management Status



(Source: AWF SAL, 2003)

representatives of the respective Fisheries Departments/Units in the four countries, as well as a representative of SADC and South African Institute of Aquatic Biodiversity (SAIAB). The group's core values are to implement the provisions of the SADC Fisheries Protocol whose underlying values are to promote collaboration in the management of shared fisheries resources and information exchange in the region.

- **Other partnerships in Zambezi Heartland:** AWF has further established a multi-national and multi-institutional technical team to implement its work on monitoring water resources in Zambezi Heartland. Key partners include the University of Zimbabwe's Lake Kariba Research Station (ULKRS), the Zimbabwe Parks and Wildlife Management Authority's Lake Kariba Fisheries Research Institute (LKFRRI), Zambia's DoF, the Environmental Council of Zambia (ECZ), Zambezi River Authority (ZRA), Tchuema Tchato CBNRM Programme in Mozambique. Plans are at an advanced stage to co-opt Mozambique's Provincial Services for Fisheries and National Institute of Fish Research (IIP). Representatives from each one of these organizations take part in field activities under the leadership of an AWF project officer. This strategy has facilitated trans-boundary collaboration among institutions.

Activities implemented to date

In the Four Corners TBNRMA, AWF implemented two sub-projects through field activities carried out by the ARWG and these are outlined below.

- **Standardization of aquatic resources ecological monitoring methodologies:** The sub-project was initiated in order to establish a fisheries resource monitoring team for the Four Corners TBNRMA that would develop a suite of ecological monitoring methods that would become an integral component of a more broadly based ecological monitoring team for the Four Corners Area. The specific objective was to formulate and test standardized methods of monitoring the fishery resources with the long-term aim to have a joint system of fisheries

management among the four nations. Key activities under this component included a workshop to formulate pilot standardized methods that incorporate socio-economic issues. During the first expedition in April/May 2003, multi-mesh gillnets with mesh sizes ranging from 12mm to 150mm were used. Twelve sites, representing different floodplain microhabitats, were surveyed and a total of thirty fish species were caught during the survey, dominated by *Schilbe intermedius*, followed by the tigerfish, *Hydrocynus vittatus* and *Synodontis spp.* This survey was carried out at a time when the flood regime of the floodplain was at a record high for the decade so a limited variety of habitats could be accessed. Catch Assessment Surveys (CAS) and Frame Surveys that collected socio-economic information on floodplain fishing activities and recorded catches from fisher folk were conducted at the same time.

A second expedition was conducted during the low water flood regime in September/October 2003. The same complement of gillnets was used but this time supplemented by electro-fishing, seine netting and a fyke net. The additional gears allowed for sampling in shallow sites and backwaters. A total of 41 fish species was caught in experimental fishing but the species dominance pattern remained the same with *Schilbe intermedius*, the butter catfish, dominating contributing 55% to the total catch.

- **Fish biodiversity surveys in Upper and Lower/Middle Zambezi:** The main activities under this component were in the Four Corners Heartland, where three field expeditions aimed at investigating the fish biodiversity of the Upper Zambezi in Zambia. The objective of the baseline fish survey was to produce a database that will be a valuable tool for the co-management of aquatic natural resources by the management parties concerned. The survey started from the low water period of 2002 (August-September) through to the low water period of 2003.
- **Inventory of aquatic plants in Upper Zambezi:** To complement the fish biodiversity survey and standardization of ecological monitoring methodology sub-projects, an inventory of

aquatic plants present at the different sites where experimental fishing was carried out. This work provided baseline information for fish habitat characterization that will be useful in correlating fish species distribution, diversity and abundance to habitat type.

The overall goal for the plant survey was to demonstrate the importance of water plants in the productivity of aquatic systems so that they would be included in future fisheries research with management implications.

- **Basic water quality assessments:** AWF sought to make basic limnological assessments to complement the fish and aquatic plants surveys. The work included measurements of the basic physical and chemical parameters in order to get a feel of the water quality as well as assessments of planktonic communities in the different sites (phytoplankton, zooplankton and zoobenthos). All water quality measurements were done using standards methods as described by Golterman *et al* (1974)²⁹.

Highlights of results from work done to date

Standardization of aquatic resources monitoring methods

- A total of 67 aquatic plants were collected and identified from the floodplain at Senanga.
- More than fifty (50) species of fish were collected during the test surveys
- A suite of ecological monitoring methods has been tested and will be adopted for use by the fisheries departments/units of the Four Corners countries.
- The utility of different monitoring methods during different seasons has been established and relevant recommendations will be developed.
- An aquatic resources database is being developed in Microsoft Access and an interface with Arc View GIS software will be established to allow for spatial presentation of information and data.

Aquatic biodiversity surveys in Four Corners

- Excellent collections have been made of fish from the majority of habitats in the Upper Zambezi River system.
- An excellent understanding of the distribution, habitat preferences and responses to flooding cycle of the great majority of the species found in the Upper Zambezi River system.
- Good series of specimens for the taxonomic description of new species known to occur in the samples.
- Taxonomic problems that need to be addressed have been identified.

Lessons learnt

The activities carried out by AWF in Southern Africa's largest freshwater system were aimed at contributing to the improvement of the management of shared water and aquatic resources in SADC. The Zambezi River is certainly a major aquatic system that transcends borders and different landscapes from its source to the mouth. It passes countries with different policies and regulations that govern the utilization of water and the resources therein, especially fish yet whatever any one of these countries does has a direct or indirect impact on all others within the catchment. It is evident from fisheries observations made in Zambezi Heartland that fish is a 'common good' in the sense of being utilized by citizens of the trans-boundary region regardless of nationality. Yet it is also clear that fishing practices in use now cannot allow for the sustainable use of the resource, hence the need for intervention on the basis of baseline data gathered by AWF.

By getting a multinational team of aquatic resources experts to work together in inventorying what fishes are available in the Zambezi and its tributaries, and agreeing on a suite of ecological monitoring methods, AWF has facilitated the management of the shared resource at a landscape scale which does not recognize political borders. The documentation of fish species that exist in different habitats along the longitudinal transect of the Zambezi will assist in resource allocation between

29 Golterman, H. L., R.S. Clymo and M.A.M. Ohnstad (eds.) 1974. Methods for physical and chemical analysis of fresh water. IBP Handbook No. 8, 211p. Blackwell Scientific.

different user communities who depend on fishing as a livelihood strategy. This baseline information allows for informed decision-making by both resource managers and users, and will result in the equitable use of the fish resource and sustainable use. This approach essentially captures the key tenets of the ecosystem approach, defined by IUCN as ‘a strategy for management of land, water and living resources that promotes conservation and sustainable use in an equitable way’ (Smith & Maltby, 2003)³⁰.

AWF acknowledges that what it has achieved to date is a starting point which needs to be built on by local institutions, other partner international organizations and governments in order for the ‘landscape level approach’ to conservation and resource management to become a reality. As an organization we note that our experience in southern Africa clearly demonstrates that working with local partners with the requisite knowledge of the area, including local communities – who are often considered to be both threats to and

beneficiaries from the resource, is a key strategy to achieve trans-boundary, landscape level conservation. It also assists in building regional capacity that will aid the sustainability of such initiatives once an external organization leaves.

Acknowledgements

The USAID Regional Center for Southern Africa (RCSA), the Netherlands Directorate-General for International Cooperation (DGIS) and the Ford Foundation are acknowledged for the financial support to this activity. Professor Paul Skelton, Ms Ronelle Kemp – our botanist, and Messrs Wilson Mhlanga and Denis Tweddle and all members of the ARWG and the SAIAB team are specially thanked for their inputs.

Workshop discussion following the presentation

There was no major discussion on this paper.

30 Smith, R.D. and E. Maltby. 2003. Using the ecosystem approach to implement the Convention on Biological Diversity: key issues and case studies, x+118 pp. IUCN, Gland, Switzerland and Cambridge, UK.

ANNEXES

A. List of participants

Surname	First Name	Title	Position	Institute and Address	Contact Details
Banda	Moses	Dr.	Chief Research Officer	Fisheries Research Unit P.O. Box 27, Monkey Bay, Malawi	Tel: + 265 1587440 / 1587360 Fax: + 265 1587249 E-mail: mafri@sdpn.org.mw
Béné	Christophe	Dr.	Research Scientist Water and Fisheries Management	WorldFish Center P.O. Box 1261, Maadi 11728 Cairo, Egypt	Tel: + 202 736 4114 Fax: + 202 736 4112 E-mail: c.bene@cgiar.org
Bento	Carlos	Mr.	Biologist	Museum of Natural History, 104, Praca Travessia do Zambezi Maputo, Mozambique P.O. Box 257, Eduardo Mondlane University	Tel: + 258 82853055 E-mail: bento1968@hotmail.com
Brown	Cate	Dr.	Managing Partner	Southern Waters, Cape Town P.O. Box 13280 Mowbray, 7925, Cape Town South Africa	Tel: + 27 21 4653135 Fax: + 27 21 4653901 E-mail: cbrown@southernwaters.co.za
Brown	Jerry	Mr.	IEHA Advisor	USAID/RCSA Plot 14818 Lebatlane Rd PO Box 2427, Gaborone, Botswana	Tel: + 267 3924449 Fax: + 267 3924404 E-mail: jebrown@usaid.gov
Chirwa	Amon	Mr.	Deputy Director of Water Resources	Ministry of Water Development P/Bag 390, Lilongwe 3, Malawi	Tel: + 265 1770344/1773369 Fax: + 265 1773737 E-mail: hydrology@Malawi.net / abchirwa@yahoo.com
Cunhete	Maria	Ms.	Head, Provincial Service for Fisheries, Tete	Head, Provincial Service for Fisheries, Tete, P.O. Box 65, Mozambique	Fax: + 258 5223166 Cell: + 258 82850362
Daka	Angel	Dr.	Deputy Director	CLUSA, Lusaka, Zambia	Tel: + 260 1 235746 Cell: + 260 97793536 E-mail: clushemp@zamnet.zm

Surname	First Name	Title	Position	Institute and Address	Contact Details
Davies	Sandy	Ms.	Fisheries Management Consultant	NFDS Ltd Private Bag BR 351 no 145 Postnet Kgale, Gaborone, Botswana	Tel: + 267 3926298 Fax: + 267 3926290 Cell: + 267 71559766 E-mail: bigfish@info.bw
Dugan	Patrick	Dr.	Deputy Director General – Africa and West Asia	WorldFish Center 3, Abu El Fedaa stl, Zamalek 11211 Cairo, Egypt, Mail: P.O. Box 1261 Maadi 11728, Cairo, Egypt	Tel: + 202 736 4114 Fax: + 202 736 4112 E-mail: p.dugan@cgjar.org
Hay	Clinton	Dr.	Chief Fisheries Biologist	Ministry of Fisheries and Marine Resources P/Bag 2116, Mariental, Namibia	Tel: + 264 63 242642 Fax: + 264 63 242643 E-mail: cijhay@mweb.com.na
Hitula	Alushe	Ms.	Fisheries Biologist	Freshwater Fish Farming Project Ministry of Fisheries and Marine Resources P.O. Box 2137 Rundu, Namibia	Tel: + 264 66 256813 Fax: + 264 66 256844 E-mail: versacon@iway.na
Jamu	Daniel	Dr.	Project Leader	WorldFish Center P.O. Box 229, Zomba, Malawi	Tel: + 265 15 36298 Fax: + 265 15 36274 Cell: + 265 8821701; 26097 418603 (in Zambia) E-mail: dmjambu@sdp.org.mw
Kalonga	Killian	Mr.	Senior Fisheries Officer (Western Province)	Department of Fisheries P.O. Box 910243, Mongu, Zambia	Tel: + 260 7 221519 Fax: + 260 7 221893 Cell: + 260 97 427935 E-mail: dofwp@zamtel.zm
Kapasa	Cyprian	Mr.	Deputy Director (Research)	Department of Fisheries Fisheries Research Branch P.O. Box 350100, Chilanga, Zambia	Tel: + 260 1 278597 Fax: + 260 1 278418 E-mail: psicator@zamnet.zm
King	Jackie	Dr.	Principal Research Officer	Freshwater Research Unit University of Cape Town Rondebosch 7701, South Africa	Tel: + 27 21 6503626 Fax: + 27 21 6503301 E-mail: jking@botzoo.uct.ac.za
Kolding	Jeppe	Dr.	Associate Professor	University of Bergen, Dept. of Fisheries and Marine Biology, Bergen, Norway	Tel: + 47 555 84407/00 Fax: + 47 555 84450 E-mail: jeppe.kolding@ifm.uib.no

Surname	First Name	Title	Position	Institute and Address	Contact Details
Mafuca	Jorge	Mr.	Head Provincial Officer of IIP	National Institute of Fishing Research (IIP), Songo, Tete, Mozambique	Tel: + 258 05282650 Fax: + 258 05282650 E-mail: jorge@mozilp.org
Mandima	Jimmie	Mr.	Acting Co-ordinator	Africa Wildlife Foundation P.O. Box 179, Kariba, Zimbabwe	Tel: + 263 61 2475 Fax: + 263 61 3507 Cell: + 263 91 283401 E-mail: jmandima@mweb.co.zw
Mbewe	Mbamwai	Mr.	Senior Fisheries Research Officer (Lake Kariba)	Department of Fisheries, Zambia P. O. Box 9, Sinazongwe, Zambia	Tel: + 260-1-483146 Fax: + 260-1-483085 E-mail: mbamwai@yahoo.com
Mhlanga	Wilson	Mr.	Senior Ecologist	Lake Kariba Fisheries Research Institute P.O. Box 75, Kariba, Zimbabwe	Tel: + 263 61 29367 Fax: + 263 61 2938/9 Cell: + 263 91 236104 E-mail: wmhlanga@africaonline.co.zw
Mhlanga	Lindah	Ms.	Research Fellow	University Lake Kariba Research Station University of Zimbabwe P.O. Box, Kariba, Zimbabwe	Tel: + 263 61 3035/2981 E-mail: wmhlanga@africaonline.co.zw
Milindi	Godfrey	Mr.	Acting Deputy Director (Extension)	Department of Fisheries Fisheries Extension Branch P.O. Box 350100, Chilanga, Zambia	Tel: + 260 1 278418 Fax: + 260 1 278618 E-mail: piscator@zamnet.zm
Mubanga	Chisata	Mr.	Senior Fisheries Officer	Department of Fisheries, Zambia P. O. Box 630450 Choma, Zambia	Tel: + 260 32 20460 Fax: + 260 32 20460
Munthali	Wizaso	Ms.	EIA - Officer	Environmental Council of Zambia Bldg Plot 6975 Ridgeway P. O. Box 35131, Lusaka, Zambia	Tel: + 260 1 254130/254023/59 Fax: + 260 1 254164 E-mail: wmunthali@necz.org.zm
Musando	Bumango	Mr.	Senior Fisheries Research Officer (Itzhi-Tezhi)	Department of Fisheries, Zambia P. O. Box 64 Itzhi-Tezhi, Zambia	Tel: + 260 32 63118/63031
Muwowo	Don	Mr.	Principal Fisheries Technical Officer	Department of Fisheries, Zambia P. O. Box 360079 Kafue, Zambia	Cell: +260 97 862451

Surname	First Name	Title	Position	Institute and Address	Contact Details
Mwango	John	Mr.	Chief Aquaculture Research Officer	Department of Fisheries Fisheries Research Branch P.O. Box 350100, Chilanga, Zambia	Tel: + 260 1 278250 Fax: + 260 1 278418 Cell: + 260 95 817924 E-mail: piscator@zamnet.zm
Mwelwa	Elenestina	Mrs.	Principal Environmental Scientist	ZESCO Head Office, Environmental Unit P.O. Box 33304, Lusaka, Zambia	Tel: + 260 1 237811 Fax: + 260 1 237811 E-mail: emmwelwa@zesco.co.zm
Naesje	Tor	Dr.	Chief Research Biologist	Norwegian Institute for Nature Research Tungasletta 2, NO-7485 Trondheim, Norway (in RSA in 2004)	Tel: + 4773801400 Fax: + 47 73801401 Cell: Norway +4793466778 / RSA: +27727365817 E-mail: tor.naesje@nina.no
Ndhllovu	Medrina	Ms.	Secretary	Department of Fisheries P.O. Box 350100 Chilanga, Zambia	Tel: + 260 1 278597 Fax: + 260 1 278618 E-mail: piscator@zamnet.zm
Ngalande	Patrick	Mr.	Chief Fisheries Research Officer	Department of Fisheries Fisheries Research Branch P.O. Box 350100, Chilanga, Zambia	Tel: + 260 1 278597 Fax: + 260 1 278618 Cell: + 260 97 887300 E-mail: pngalande@yahoo.co.uk
Nsongela	Shadreck	Mr.		World Wide Fund for Nature WWF Zambia Coordination Office Plot 4978 Los Angeles Blvd Long acres Box 50551 Ridgeway Lusaka, Zambia	Tel: + 260 1250404 E-mail: snsongela@zamtel.zm
Rashidi	Brian	Mr.	Consultant	Freshwater Fishing Farming Project Ministry of Fisheries and Marine Resources P.O. Box 2137, Rundu, Namibia	Tel: + 264 66 256860 Fax: + 264 66 256860 Cell: + 264811293456 E-mail: brashidi@iway.na
Sandlund	Odd Terje	Dr.	Senior Scientist, Co-ordinator development co-operation	Norwegian Institute for Nature Research (NINA) Tungasletta 2 NO-7485 Trondheim, Norway	Tel: + 47 73801548 Fax: + 47 73801401 Cell: + 4792606683 E-mail: odd.t.sandlund@nina.no

Surname	First Name	Title	Position	Institute and Address	Contact Details
Turpie	Jane	Dr.	Senior Lecturer	Percy FitzPatrick Institute, University of Cape Town, Rondebosch 7701, South Africa Anchor Environmental Consulting, University of Cape Town, Rondeback, 7701, South Africa	Tel: + 27 21 650 3302 Fax: + 27 21 650 3295 Cell: + 27 82 4595960 E-mail: jturpie@botzoo.uct.ac.za
Zulu	Timothy	Mr.	Chief Training Officer	Department of Fisheries Fisheries Research Branch P.O. Box 350100, Chilanga, Zambia	Tel: + 260 1 278418 Fax: + 260 1 278618 Cell: + 260 95 950551 E-mail: piscator@zamnet.zm

B. Workshop agenda

Monday 31 May 2004

- 0800 - 0900 **Registration**
- 0900 - 1000 **Inaugural Session**
Introductory Remarks - Mr. Cyprian Kapasa, Department of Fisheries Zambia
Introductory remarks - Dr. Patrick Dugan, WorldFish Center
Official Opening - Mr. Sylvester Mphishi, Permanent Secretary of the Southern Province
- 1000 - 1030 Coffee/Tea
- 1030 - 1300 **Technical Session 1: Country reviews**
Chair: Mr. Jimmiel Mandima
Rapporteur: Dr. Cate Brown
- **Mozambique** by Mr. George Mufuka
 - **Malawi** by Dr. Moses Banda
 - **Zambia** by Mr. Patrick Ngalande
 - **Zimbabwe** by Mr. Wilson Mhlanga
 - **Namibia** by Dr. Clinton Hay
- 1300 - 1430 Lunch
- 1430 - 1600 **Working Group: Review of priority issues and critical gaps**
- 1600 - 1630 Coffee
- 1630 - 1730 Plenary
- 1800 Reception

Tuesday 1 June 2004

- 0900 – 1300 **Technical Session 2: Development Challenges**
Chair: Dr. Patrick Dugan
Rapporteur: Dr. Clinton Hay
- Hydropower development & water management requirements (Ms. Elenestina Mwelwa, ZESCO)
 - Resource-use pressures & conflicts (Ms. Linda Mhlanga, University of Zimbabwe)
 - Urban impacts on rivers (Ms. Wizado Munthali, Environment Council of Zambia)
 - Opportunities and constraints for private sector investment in the fisheries of the Zambezi (Dr. Angel Daka, CLUSA)
 - WWF initiatives in the Zambia (Mr. Shadreck Nsongela, WWF)
- 1300 - 1430 Lunch
- 1430 – 1600 **Working Group: Review of major development challenges and implications for fisheries**
- 1600 - 1630 Coffee
- 1630 - 1730 Plenary

Wednesday 2 June 2004

0900 – 1230 **Technical Session 3: Research Priorities**

Chair: Dr. Jeppe Kolding

Rapporteur: Ms. Sandy Davies

- Water and Fisheries Governance: implications for the Zambezi (Dr. Christophe Béné, WorldFish Center)
- Valuation of river fisheries in the Zambezi basin (Dr. Jane Turpie, University of Cape Town)
- Assessing Environmental Flows: prospects for the Zambezi basin (Dr. Jackie King, University of Cape Town)
- Flow requirements in the Zambezi delta (Mr. Carlos Bento, Museum of Natural History, Mozambique)
- Inshore fisheries and fish population changes in Lake Kariba (Dr. Jeppe Kolding, University of Bergen)
- Research on fish biology in the Zambezi River (Dr. Tor Naesje, NINA)
- Fisheries research in the upper Zambezi (Mr. Jimmiel Mandima, AWF)

1230 - 1400 Lunch

1400 - 1630 **Working Group: Setting research priorities**

1630 - 1700 Coffee

1700 - 1800 Plenary

1800 - 1830 Closing

1830 Reception

C. Opening speech by the Permanent Secretary of the Southern Province

The Mayor of Livingstone,
The Deputy Director General of the WorldFish Center,
The Directors of Fisheries within the regions,
Distinguished Guests,
Ladies and Gentlemen

It is my privilege and pleasure to extend a warm welcome to you all to this very important workshop on the fisheries of the Zambezi basin. On behalf of the Ministry of Agriculture and Co-operatives in which the department for fisheries falls, I want to extend a particularly warm welcome to the participants from beyond Zambia's frontiers. For the few days you will spend with us, make our country your home. We wish you a pleasant stay. Zambia feels honoured to be hosting this very important gathering.

On behalf of the Ministry of Agriculture and Co-operatives and indeed on my own behalf, I wish to express my profound gratitude to the WorldFish Center for support to hold this workshop. The regional and international cooperation in the management of Fisheries in the Zambezi basin you are initiating is a welcome positive step in the Southern African Development Community (SADC) towards sustainable development. I believe that all the countries represented here will support this new initiative.

The Zambezi basin system is the largest in Southern Africa and one of the most important on the African continent. It provides multiple benefits ranging from water for domestic irrigation and hydropower uses, fishers and a wide diversity of wildlife products. The river basin plays a central role in the livelihoods of millions of people in the surrounding (riparian) states. As the countries of the basin place increasing attention on how best to harness these multiple benefits sustainably, it is increasingly important that the potential and constraints of different resource use are understood and factored into decision-making process.

Amongst the many wild natural resources that the basin provides, the fisheries are especially important. Not only are these generally the most available wild resource, but they also play a crucial role in providing

high quality nutrition for the people of the basin while also sustaining a diversity of livelihood strategies ranging from those who catch fish to those who process and trade the catch. Mr. Chairman; let me divert a bit and talk about the water resources in the Zambezi basin that is a major factor in the development of fisheries. It is finite, scarce and vulnerable. Therefore, it sets limits for the amount of fisheries and its development. The water sector in the Zambezi basin faces many problems which are characterised by:

- Extreme temporal and spatial rainfall variability, often triggering severe drought and occasional flooding;
- Rapidly growing and urban populations, leading to increasing water scarcity and water pollution.
- Minimal coverage of water and sanitation services among the urban and rural poor, and thus a high incidence of water-borne diseases and other illnesses related to inadequate sanitation.
- Heavy dependence on extensive agriculture, with generally very low water use efficiency. About 70% of the region's water consumption is used in agriculture.
- Degraded watershed and deteriorating water quality.
- Numerous trans-boundary river basins with complex international rights issues.
- Growing importance of hydropower with equally significant trans-boundary implications.

In addition the development of the water sector in the region is contrasted by:

- **THE LEGAL AND REGULATORY FRAMEWORK** – the region needs an effective legal and regulatory framework. In most riparian countries, national water legislation is inadequate and weakly enforced.
- **INSTITUTIONAL STRENGTHENING** – lack of integrated plans has recognised as one of the major constraints in promoting sustainable development and equitable sharing of water resources.
- **LINKAGES WITH SUSTAINABLE DEVELOPMENT POLICIES** – Economic instruments seldom provide monetary incentives to encourage the conservation and sustainable use of water resources. Economic instruments can encourage cost effectiveness; increase investments in water infrastructure, and act as incentives for efficient use of water, and pollution control.

- DATA COLLECTION, MANAGEMENT AND DISSEMINATION – Zambezi basin countries need to improve their knowledge about management of water resources. Therefore, it is dependent on acquiring information, managing information and making it available to end-users.
- AWARENESS BUILDING, EDUCATION AND TRAINING – there is a lack of awareness about the state of water resources as well as the economic, social, environmental and management issues among the public. Water is no longer a free commodity. It is a finite resource with supply constraints; it has scarcity value, and there is a cost to using it. Similarly, people must know that water quality should not be degraded; water contamination leads to water-borne diseases, affecting human health and productivity.
- STAKEHOLDER PARTICIPATION – government ministries, municipalities or water companies are usually responsible for water supply. It is a top-down approach, which has many disadvantages. For example the beneficiaries are not involved in project design, & implementation
- INFRASTRUCTURE – most riparian countries' water infrastructure, regardless of purpose (domestic water supply, sanitation, hydropower generation, irrigation, flood control and drainage) is inadequate.

Mr. Chairman; having looked at the problems, characteristics and constraints to the development of water sector let me come back to the fisheries resources. The fisheries sector in Zambia faces a number of challenges. The main ones being that of low fish supply consumption per capita which stands at 7kg per person per year as opposed to world health organisation's recommended 17kg per person per year. The other major challenge facing the sector is that of exploiting and utilising the fisheries resources sustainably. The Zambezi basin has considerable potential to increase fish production and consumption. The new initiative of fish cage culture is a good example. I am quite aware that the department of Fisheries has introduced the concept of co-management of the fisheries with surrounding fisheries communities and other related stakeholders. I encourage them to forge ahead as it encourages the stakeholders' participation in planning and development of the fishery for the benefit of all. The problems of over-fishing and environmental

degradation can only be overcome if communities and all stakeholders participate in the management of the aquatic resources.

Mr. Chairman: a flow of information with regards to the resource base is therefore vital before increasing fish production and improving exploitation, handling, processing and marketing of aquatic resources. This workshop should address information gathering and related networking among the institutes and individuals that produce and use aquatic information. I would ask this gathering to address: the needs to encourage research on sustainable use and management of aquatic resources and: the need to establish linkages between all involved institutions - currently information related to fisheries and other aquatic resources are collected and stored by various ministries and non-government organisations.

Mr. Chairman: my government gives priority to orderly documentation of information gathered by various institutions and encourages information exchange between institutions collecting similar information. The government is happy with your initiative in strengthening networking. Mr. Chairman: in recognition of the challenges faces by the fisheries the workshop should have the following objectives;

1. To review current understanding of the current status of fisheries in the Zambezi basin.
2. To identify current and future issues being faced by these resources and the communities who are dependent upon them.
3. To identify activities currently underway to address these issues.
4. To identify future priorities for research and training in support of strengthened management and policy measures that will enhance livelihood benefits from aquatic resources and fisheries within the basin.
5. To develop a network of scientists and practitioners concerned with aquatic fishery management within the basin.

Mr. Chairman; I wish you all success in your deliberations. You must know that so much depends on your efforts in reviewing and sharing of aquatic information and knowledge among yourselves, users and producers. It is now my pleasure to declare this workshop officially open. God Bless – I thank you.

D. Summary of the key points in country review presentations

Country	Status of fisheries	Policy and Management strategies	Challenges and Threats	Past and Current Programmes	Gaps and Research Issues	Key Institutions
Malawi	Data from 1976 indicates that fish production has fluctuated between 2,000 and 11,000 tonnes per annum, with total catches dropping to c. 2000 tonnes in 1992, after which they have remained relatively constant	<ul style="list-style-type: none"> Conventionally by mesh-size regulations and banning of gears Co-management adopted because of non-compliance. In pilot phase 10 year on L Malombe = some problems but appears to be the correct system 	<ul style="list-style-type: none"> Exploitation Pollution industry and agriculture Suspended soils from deforested areas – most river basins degraded. Lack of compliance to, and enforcement of, regulations Urbanisation Invasive weeds – hyacinth 	<ul style="list-style-type: none"> Inventory of flora and fauna Biological and Ecological studies Stock assessment & monitoring Water quality assessment & monitoring Social, Cultural & Economic studies Harmonization of policies 	<ul style="list-style-type: none"> Integrated approach to river basin management 	<ul style="list-style-type: none"> WWF
Mozambique	Estimates of sustainable yield are 8,000 to 10,000 tons for kapenta and 6,400 tons for table fish The status of fisheries on the Lower Zambezi is unknown For the sport fishery there is no CPUE data	<ul style="list-style-type: none"> To improve fish protein supply in order to cover part of the food shortage Increase net foreign exchange earning to the national income produced by the fishery sector Improve life standards of the fishing communities (alleviate absolute poverty) The kapenta fisheries in Cahorra Bassa are regulated but there is essentially no fishery policy for other inland waters. 	<ul style="list-style-type: none"> Uncontrolled access to fishery resources No control over illegal gears Lack of data for management Conflict between sustainability of socio-economic and resources needs Conflicts and disputes between resource users Achieving co-ordination and co-operation between institutions Lack of a management strategy for fishery in the lake, affluent rivers and the river below the lake 	<ul style="list-style-type: none"> Licensing of Kapenta and Artisanal fisheries Kapenta catch and effort monitoring Kapenta biology studies Environmental monitoring Catch & effort assessment- artisanal fishery Limnological assessment Kapenta stock assessment using echo-sounding for the entire lake Frame survey in Cahorra Bassa Stock and biological assessment of species accessible to artisanal fisheries Management plan for the lake 	<ul style="list-style-type: none"> Regulation and policy for inland waters Enforcement of control Artisanal data collection Establish correlations between suitable catches with environmental factors; Establish biology and reproduction seasonality some species Fishing yields and CPUE data Determine reasons behind the limitation of kapenta fishing to only 3 of 7 basins Establish the unfishable areas of each basin Establish the importance of the different river mouths for growth and recruitment of fish 	<ul style="list-style-type: none"> FAO ZIMOZA

Country	Status of fisheries	Policy and Management strategies	Challenges and Threats	Past and Current Programmes	Gaps and Research Issues	Key Institutions
Namibia		<p>White Paper, Act and Regulations in place. Strategy aims for:</p> <ul style="list-style-type: none"> sustainable utilization protect biodiversity different management approaches (River Systems) subsistence over commercialization protection through gear restrictions stakeholder involvement in control measures regional co-operation 	<ul style="list-style-type: none"> The management of shared resources Implementation and harmonization of legislation Continued monitoring of the fisheries Improved understanding of biology of important fish species Respond to the needs of the people Continued availability of funds and human resources (scientific) 	<ul style="list-style-type: none"> Monitoring of stocks Baseline biological study of fish resource Biodiversity Recruitment Fish movement Resource exploitation Recreational/subsistence/semi-commercial Annual fish surveys Recreational/subsistence/semi-commercial exploitation Baseline socio-economic studies Fish market studies Post harvest activities Information available on subsistence fishery, Households, Fish Market, Fishing Villages, existing fishery management systems 	<ul style="list-style-type: none"> Lack of harmonized policies Lack of standardized research methodologies Lack of baseline data for region Monitoring of resources & fisheries Knowledge of traditional management systems Implementation of Legislation 	<ul style="list-style-type: none"> MFMR MET Regional & Local Authorities Traditional Authorities MAWRD NINA Neighbour Fisheries Departments AWF WWF FAO NORAD
Zambia	CPUE is on the decline in almost all fisheries and fish communities are becoming poorer	<ul style="list-style-type: none"> Co-management at Kariba Dam - fairly well established but others are less developed Most of upper Zambezi catchment is under tradition management Upper Zambezi main river managed by government 	<ul style="list-style-type: none"> Introduction of alien fish through fish farming Industrial pollution and mine effluent in Kafue Severe droughts Dam construction Inadequate resources to enforce fish regulations 	<ul style="list-style-type: none"> Kafue Fisheries FAO 1968 multipurpose studies on Kafue Pre-impoundment studies on fisheries of the Kafue Flats (FAO 1971) Kafue Basin Study University of Zambia (1980+) Fishery development in the Upper Zambezi Basin (FAO 1968) Zambia/Zimbabwe SADC Kariba Fisheries Project 1989 to 1998 	<ul style="list-style-type: none"> Capacity to collect basic statistical data Domestication of indigenous species to promote aquaculture using indigenous species Provide legal support to co-management initiatives 	<ul style="list-style-type: none"> Department of Fisheries Department of Water Affairs Department of Environment Environmental Council of Zambia Cooperating partners

Country	Status of fisheries	Policy and Management strategies	Challenges and Threats	Past and Current Programmes	Gaps and Research Issues	Key Institutions
Zimbabwe	Catches of kapenta have decreased from 15,288 to 9,827 tonnes from 1998 to 2001 while the inshore (artisanal) fishery has increased from 1,083 tonnes in 1998 to 3,400 in 2001	<ul style="list-style-type: none"> Act governing fisheries research and management Fisheries management is at national level under ZPWMA Joint management is not yet operational although the agreement (Protocol) between Zimbabwe and Zambia has been signed by the two governments. 	<ul style="list-style-type: none"> Implementation of joint fisheries plans Development of an artisanal fishery on the Zambezi and Limpopo Rivers Poor understanding of co-management by the fishers Lack of a detailed fisheries policy Need to enhance fish production in Small Water Bodies Management structures for fisheries outside the Parks Estate 	<ul style="list-style-type: none"> Short-term studies in the artisanal fishery Long-term monitoring studies in the artisanal fishery Stock Assessment for selected inshore fish Data storage and annual statistical report production Short-term studies in the kapenta fishery Long-term monitoring programme of Kapenta CPUE Limnological data Hydrological data Ecosystem modelling 	<ul style="list-style-type: none"> Surveys on fish distribution Review of fisheries management strategies - incorporate socio-economic factors Review fisheries research Impact of exotics on fish species diversity Assessment of fish production potential Develop joint fisheries research strategy and implement Strengthen monitoring Review co-management Estimates of illegal off take Update Fisheries Policy Restructuring of management structures 	<ul style="list-style-type: none"> ZPWMA University of Zimbabwe (ULKRS and CASS) Natural History Museum AWF FAO (Sub-regional office for Eastern and Southern Africa)

E. Outputs A, B, and C – priority issues and critical gaps

A. Management and policy challenges	B. Status of research investment to address these	C. How this research contributes to management and policy processes (mechanisms)
<p>1. Implementation of Legislation e.g. Non-compliance to fisheries regulations (use of illegal gears) and inability to enforce existing legislation often exasperated by civil unrest/conflict in the region</p>	<p>1a. Policy development in progress (Zam/Zim/Bot). 1b. Legislation in place (Nam) (note that little research undertaken on effectiveness of co-management CASS,LKN)</p>	<p>1a. Protocol signed Zambia/Zimbabwe on fisheries resources on fisheries resources of Kariba & transboundary water of Zambezi River 1b. Malawi beginning to implement co-management on lakes (not yet rivers)</p>
<p>2. Inland Fisheries Policy development e.g. revision and updating of policies</p>	<p>2a. Policy development in progress (Zam/Zim/Bot). 2b. Legislation in place (Nam)</p>	
<p>3. Inadequate regulations e.g. regulations outdated</p>	<p>3a. Policy development in progress (Zam/Zim/Bot). 3b. Legislation in place (Nam)</p>	
<p>4. Harmonization of policies e.g. on a central, local and regional scale and also between line Ministries within countries. A lack of integrated approaches to river basin resource utilization/management</p>	<p>4a. Kariba Lakeshore Combination Masterplan (Zam/Zim) 4b. Integrated water resources management for the Kafue system (Zam) 4c. Consultation with all line Ministries (Nam) 4d. Lake Kariba Joint Fisheries Protocol (Zam/Zim) 4e. ZAMCOM 4f. SADC Fisheries Protocol 4g. Review of policies GOPA 4h. Some work is done to harmonise resource management issues</p>	<p>4a. Increase effectiveness of legislation implementation and control 4b. Course in coastal zone management developed at University of Zimbabwe after research harmonizing policy on resource utilization and management</p>
<p>5. Complexity of resources users e.g. sustaining the production while an increase in population/ demand and high poverty levels, challenges of co-management between users, multi species fishery, gear technology and the use thereof</p>	<p>5a. Consultation meetings with stakeholders (Lake Kariba) (Zam/Zim), Caprivi (Nam) 5b. Appropriate gear technology studies (Zam) 5c. Stakeholder studies (Namibia) 5d. Fisheries studies done (Namibia)</p>	<p>5a. Assist with co-operation/complexity of resource users 5b. Facilitates communication/advocacy 5c. Optimize utilization of the resource</p>
<p>6. Knowledge of the resource base</p>	<p>6a. Some biological/socio-economic surveys at selected water bodies (Zam, Zim, Nam) 6b. Social, economic surveys done 6-8 years ago (Mal & Zam), 3 years (Moz)</p>	<p>6a. Must know what you manage (to manage) /precautionary approach 6b. Social, economic research has contributed to information related to revision of Fisheries Act (Zam) will lead to consolidated concept (Moz)</p>
<p>7. Evaluation of the real economic value of the fisheries</p>	<p>7a. Limited information available on economic value of resource at selected areas (Zam/Nam/Mal)</p>	<p>7a. To find trade-off between development and resource protection</p>

<p>8. Inadequate resource allocations i.e. HR and economic typified by inadequate institutional capacity in government organizations (skilled HR and equipment and inadequate structure)</p>	<p>8a Restructuring (Zam/Zim/Nam)</p>	<p>8a. Increase efficiency/devolution of management responsibilities to local level</p>
<p>9. Lack of up to date management objectives That are able to reflect the complexity of the issues and system – e.g. the open access state of fisheries resources in the basin concerned, HIV/AIDS prevalence, Lack of civic education in relation to sustainable use of resources, inability to adequately disseminate extension concepts/ ideas to communities</p>	<p>9a. Policy development in progress (Zam/Zim/Bot). 9b. Policy in place (Nam) 9c. No HIV/AIDS impact studies on fishing communities 9d. Some work (Mal) on organization and structure of fisheries management 9e. No research done related to user/property rights in fisheries exploitation</p>	<p>9a. Clear guidelines for management approaches</p>

Key: Bot – Botswana, Mal – Malawi, Moz – Mozambique, Nam – Namibia, Zam – Zambia, Zim – Zimbabwe

F. Outputs D, E and F – development challenges

D. Development processes, pressures and constraints	E. Impact of these on fisheries	F. What investments are being made to address these and the gaps
<p>Dams (high impact) both Hydropower and storage</p> <p>E.g. Hydropower Dams</p> <ul style="list-style-type: none"> • Batoka gorge • Develils gorge • Mupata gorge • Malawi 4 • Mozambique 1 • Zambia 3 • Zimbabwe 1+ 	<ul style="list-style-type: none"> • Obstruction of fish migration • Changes in fish production (increase in lake Kariba) • Changes in species composition / diversity 9biodiversity loss and reduced quality) • Changes in downstream flow regimes • Reduce recruitment and productive and production of fish (e.g. Zambezi delta) • Increased agricultural land 	<ul style="list-style-type: none"> • Increased integrated approach to resource management by resource users e.g. ZESCO and Kafue flats • Increased awareness interest to address environmental issues • Education • Aquaculture development to alleviate pressures • Promotion of impact assessment before projects • ZAMCOM • Zambezi delta as Ramsar site • Fisheries regional collaboration (e.g. upper Zambezi)
<p>Roads (medium impact)</p>	<ul style="list-style-type: none"> • Increased access / communication to fish markets and immigration (in and out) • Environmental damage • Minor flood changes 	<ul style="list-style-type: none"> • Creation of fisheries supply chain thereby improving management
<p>Agriculture (high impact)</p> <p>Including irrigation schemes deforestation, and overgrazing</p>	<ul style="list-style-type: none"> • Encroachment into wetlands and destruction of breeding areas • Siltation due to soil erosion leading to destruction of breeding sites • Pesticides • Nutrient resulting in weed proliferation 	<ul style="list-style-type: none"> • Improved monitoring schemes feeding into decision making
<p>Aquaculture (high impact)</p>	<ul style="list-style-type: none"> • Introduction of alien species and impact on diversity • Hybridisation • Increased production • Fish disease 	<p>GAPS</p> <ul style="list-style-type: none"> • Inability to attract private sector investment in the sector • Lack of ownership of policy
<p>Population increase (high impact)</p>	<ul style="list-style-type: none"> • Increasing pressures on fisheries • Increasing demand for fish • Change in fish patterns • Increase conflict (e.g. among fishing communities) 	<ul style="list-style-type: none"> • Not enough ownership in the management process by stakeholders – often consultative but not participatory
<p>HIV/AIDS (high impact)</p>	<ul style="list-style-type: none"> • Increasing fishing pressure • Disruption of organisational structure and operations • Loss of expertise • Destruction of social structures and control mechanisms • Loss of investment 	<ul style="list-style-type: none"> • Inadequate investment towards management of resources • Lack of knowledge of integrated water management • Inadequate institutions for tourism in the Zambezi basin
<p>Urbanisation (medium impact)</p>	<ul style="list-style-type: none"> • Increased demand for fish • Pollution resulting in habitat degradation 	<ul style="list-style-type: none"> • Need more visionary and comprehensive development process
<p>Tourism (medium impact)</p>	<ul style="list-style-type: none"> • Lack of sustainable development 	<ul style="list-style-type: none"> • Inadequate collaboration regionally and nationally
<p>Mining Industry (medium impact)</p>		



For further information on The WorldFish Center publications please contact:

Business Development and Communications Division

The WorldFish Center

PO Box 500 GPO, 10670 Penang, Malaysia

Tel : (+60-4) 626 1606

Fax : (+60-4) 626 5530

Email : worldfishcenter@cgiar.org



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