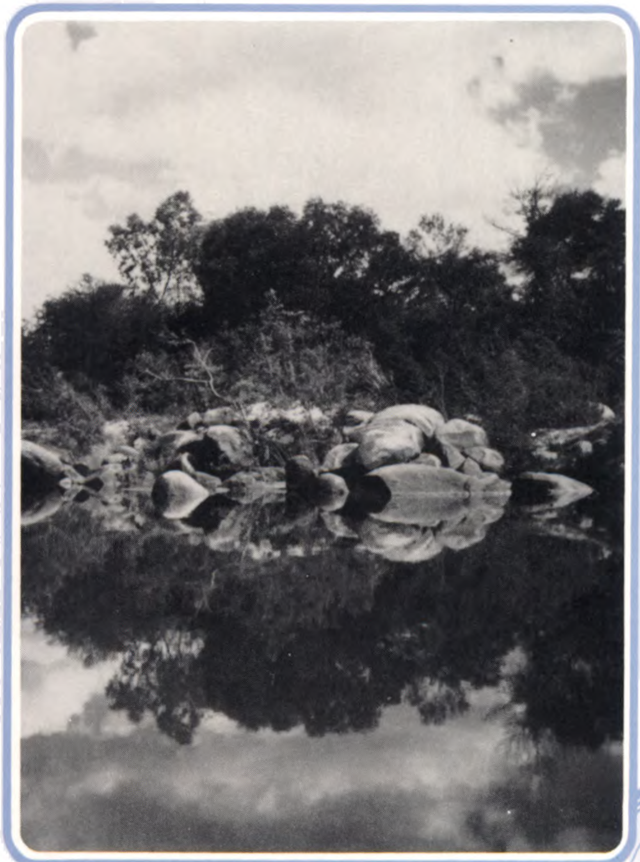
The IUCN Wetlands Programme

# Wetlands Ecology and Priorities for Conservation in Zimbabwe

## Proceedings of a Seminar on Wetlands of Zimbabwe

T. Matiza and S.A. Crafter



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The IUCN Wetlands Programme coordinates and reinforces activities of the Union concerned with the management of wetland ecosystems. The Programme focuses upon the conservation of ecological and hydrological processes, in particular by developing, testing, and promoting means of sustainable utilisation of wetlands. It does so in collaboration with IUCN members and partners, in particular those other international institutions with a specific wetland mandate, especially the Ramsar Convention Bureau, and the International Waterfowl and Wetlands Research Bureau (IWRB).

The core of the Programme is a series of field projects which develop the methodologies for wetland management, in particular in the countries of the developing world where wetlands are used intensively by local communities which depend upon these for their well-being. Related strategic and policy initiatives draw upon the results of these projects and present their conclusions in a form useful for government decision makers and planners.

The activities of the Programme are designed on the basis of the concerns and information provided by IUCN members. To facilitate this, the Programme works through IUCN's regional offices. The Programme also works closely with the major development assistance agencies to ensure that conservation considerations are adequately addressed in their projects.

The Wetlands Programme receives generous financial support from the World Wide Fund For Nature (WWF), the Swiss Directorate of Development Cooperation and Humanitarian Aid (DDA), the Finnish International Development Agency (FINNIDA) and the Government of the Netherlands. Project support has been received from the Swedish International Development Authority (SIDA), Norwegian Agency for Development Cooperation (NORAD), United States Agency for International Development (USAID), the Ford Foundation and a number of IUCN members including the Finnish Association for Nature Conservation (FANC), Institut Français pour le Développement en Coopération (ORSTOM), the Royal Society for the Protection of Birds (RSPB), the United States National Park Service (USNPS) and the World Wide Fund For Nature (WWF). It is coordinated from the IUCN Headquarters in Switzerland, with regional coordinators in Central America, South America, Brazil, southern Africa and Asia.

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**Editors**

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# Contents

# Foreword

Zimbabwe is perched on top of the Central Plateau of Southern Africa and her wetlands are small in size but very diverse and unique in nature. The wetlands include dambos, floodplains, riparian systems, pans and artificial impoundments. These systems constitute a very important natural resource for Zimbabwe, as evidenced by the growing importance now placed on wetlands at national level.

The concept of wetlands as a functioning natural ecosystem is relatively new in Zimbabwe. As a result, the components of the ecosystem have always been treated as independent entities in the planning and development of wetlands. More recently, the conservation and wise use of wetlands as ecosystems has been receiving increasing attention countrywide. This was perhaps spurred by the awareness aroused by the IUCN/SADCC Wetlands Conservation activities and the general realisation that wetlands are very productive ecosystems and therefore natural zones of wealth. Recurrent food shortages, water scarcity and general drought-induced desiccation has forced many societies, both urban and rural, to focus on wetland ecosystems as providers of food and water and as extremely valued natural resources.

Despite the long standing and important role of wetlands as providers of resources, these systems have, in the past, been neglected by research, policy and legislation. This can partly be attributed to the perception of wetlands as wastelands that should be drained. The lack of understanding and appreciation of wetlands values, functions and products by planners and decision makers has led to irreversible damage to the wetlands systems of Zimbabwe. It is now becoming increasingly apparent that wetlands are losing most of their functions, products and attributes. Dambos have progressively dried out to the extent that they have completely lost that which used to attract dozens of birds and various types of wildlife. Riparian wetlands and artificial impoundments throughout the country are suffering from siltation and general degradation due to the poverty-induced cultivation of stream banks and gold panning. Other issues and threats to Zimbabwe's wetlands systems are deforestation of watersheds, overgrazing, eutrophication, pollution, land tenure and dam developments. A number of these threats and issues stem from national problems of poverty, population pressure and uncoordinated sectoral developments. The nature of these problems clearly indicates that wetlands conservation in Zimbabwe cannot be fully achieved without addressing these issues.

These and many other issues were discussed by the seminar that concluded with a set of resolutions covering the structure of the Zimbabwe Wetlands Programme and the way forward. The seminar, whose proceedings are presented here, marked the beginning of the Zimbabwe Wetlands Conservation Programme.

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# Wetlands in Ziınbabwe: an overview

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## Introduction

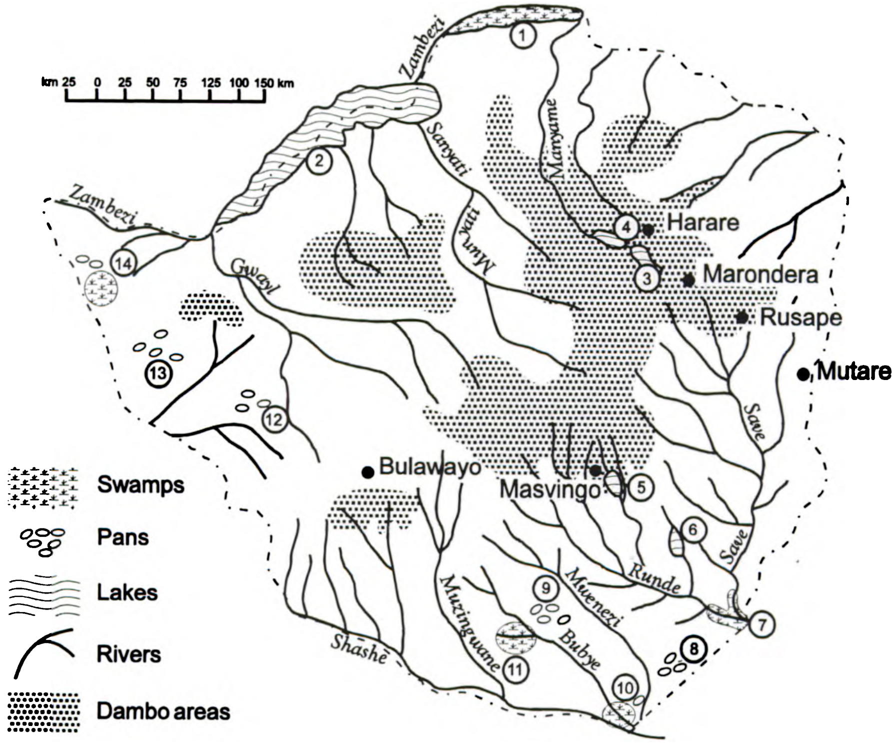
The wetlands in Zimbabwe have largely been neglected by research, policy and legislation. This neglect can be attributed to peoples' perception of wetlands as sources of disease and wastelands that should be drained. According to the Ramsar Convention (1971), the term 'wetland' refers to:

> "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres."

In addition to this definition, wetlands have been classified according to their geographical location. Larson and co-workers (1989) classified wetlands into marine, estuarine, riverine, lacustrine and palustrine systems. Dugan (1990) classified wetlands into salt water, freshwater and man-made wetlands. Considering these internationally accepted definitions and classifications, Zimbabwe is well endowed with wetlands representing riverine, lacustrine and palustrine, but not marine, systems.

The main wetlands in Zimbabwe include the floodplains, riverine systems, dambos, pans, swamps and artificial impoundments (see Figure 1). Due to its geographical location and the physiographic nature of its surface and drainage, Zimbabwe lacks large floodplains, extensive swamps and coastal wetlands.

Wetland ecosystems perform functions, provide products and possess attributes that are beneficial to almost all forms of life. They are linked to other systems through the cycles of energy, matter and water. Wetland ecosystems are dynamic and are influenced by environmental changes around them.




1 Mid Zambezi Valley - Mana Pools
2 Lake Kariba
3 Lake Chivero
4 Darwendale Dam/Manyame Lake
5 Lake Kyle/Mutirikwi
6 McDougal Dam
7 Save - Runde Confluence Floodplain
8 Gorhwana Pans
9 Bubye Pans
10 Majinji Pans
11 Kwaluzi Swamp
12 Mabomo - Joweni Pan Complex
13 Lememba - Shabashaba Complex
14 Tsamtsa

Figure 1 Wetlands of Zimbabwe (Source: Chabwela, 1991)

# Wetlands of Zimbabwe

The various types of wetlands in Zimbabwe are described below.

## Floodplains

Very small floodplain areas exist in Zimbabwe. These are confined to the Mid-Zambezi Valley (around the Mana Pools region) and around the Save-Runde River confluence in southeastern Zimbabwe (Chiredzi).

### Mid-Zambezi Valley and Mana Pools

The morphology of the Zambezi River from the Zambezi-Kafue confluence tends to broaden and becomes braided for about 130 km up to Mupata Gorge. The many fragmented streams produce low lying sand islands containing pans and pools, with more pans and pools along the riverbanks. Much of the flat valley floor and shallow river terraces along the river margins became inundated when the river was in high flood before the construction of the Kariba Dam. Today, the river only inundates its meander belt on a seasonal basis. Several streams (Chiruwa, Sapi, Rukomechi, Chirara and Nyakasanga) flow through the swampy floodplain to join the Zambezi. If floods from these rivers coincide with a major discharge from Kariba, substantial areas along the banks of the river may be inundated.

In this swampy land the major permanent pools are the Mana Pools, which consist of a series of varying sized pools lying in depressions of the former river channel. The Long and Chine Pools are the largest pools.

The current uses of the Mid-Zambezi floodplain are safari hunting and tourism. Threats to this wetland include: potential loss of habitat due to the river meandering, continued lack of floods due to the presence of Kariba Dam, persistent droughts, tsetse fly eradication programmes which may threaten aquatic life or increase population pressure on areas free of tsetse fly, and proposed dam development at Mupata Gorge which may permanently flood the area.

### Save-Runde confluence

At the confluence of the Save and Runde Rivers there is a small floodplain area containing a cluster of perennial pools. The pools are more numerous on the Runde River in the Gonarezhou National Park than on the Save River. A cluster of pools known as Chipinda, Chinguli, Nyahugwe and Mahove dominate the floodplain area located in the bed of the Runde River. Another cluster of pools (Majilondo, Masikondoro, Mavumalani, Masungani, Machiteti, Dambajewe and Mapalapi) are found upstream of the Pombadzi River, a tributary of the Runde River. Immediately north of the confluence are the Tamboharta Pools. These are a conglomeration of small pools which form where the flood waters of the two rivers mingle during the rainy season. The river now rarely overtops its banks which threatens those pools fed by flood water.

Much of the Save-Runde floodplain is located in the Gonarezhou National Park and is protected. In recent years the Save River system has suffered from excessive siltation caused by increasing population pressure and the associated problems of deforestation, overgrazing, stream bank cultivation and soil erosion induced by poor land management.

## Riparian wetlands

Notable riverine wetlands of national importance are the Save-Runde system, Manyame, Gwayi-Shangani, Mazowe and Sanyati systems. These riverine wetlands are usually characterised by riparian vegetation such as *Acacia albida*, *Azima tetracantha*, *Cordyla africana*, *Croton megalobotrys*, *Guibourtia conjugata*, *Pteleopsis myrtifolia*, *Salvadora angustifolia*, *Xanthocercis zambesiaca* and *Terminalia gazensis* (Hughes and Hughes, 1992).

The Save-Runde system drains 21 administrative districts with diverse population characteristics and land use. The Save is Zimbabwe's main inland river draining the central watershed. Once a very rich river with high annual flow, the Save has been gradually reduced to a heavily silted river, characterised by flash floods and trickle flow. Siltation characterises most rivers in Zimbabwe; some rivers suffer from physical destruction through gold panning, stream bank cultivation and other forms of human interference.

## Dambos

The dambo, a palustrine wetland, is widely distributed in Zimbabwe. With an estimated area of 1.28 million hectares, dambos are an important wetland resource in Zimbabwe. Dambos are sources of water, grazing and cultivation (wetland gardens) land in Zimbabwe's communal and commercial areas. The dambos, which used to contain *Typha* and attract dozens of Crowned Crane, Marsh Harrier, Stonechat and Red Bishop, have in recent years progressively dried out and now are badly eroded. The continued threats of extensive agriculture, overgrazing, gully erosion and fires are threatening the continued existence of dambo wetlands.

## Pans

Pans are not widespread in Zimbabwe. In the western districts, pans occur in the Tjolotjo Communal Land and Hwange National Park. In the southern districts, pans occur in Gonarezhou National Park and some parts of Mwenezi District. The pans in Tjolotjo Communal Land are used for cattle grazing while those in national parks are important habitats for waterfowl and are visited by a variety of game.

## Swamps

Due to its position on the Great Central Plateau of Southern Africa, Zimbabwe does not possess significant swamp areas. Notable swamps include the Tsamtsa and Kwaluzi Swamps, both located in low rainfall areas, while other small swamps are found scattered over the country. These swamps are also threatened by overgrazing and drying; the once permanent Binga Swamp in Goromonzi District was reported to have dried out during the 1991/92 drought.

### Artificial impoundments

Zimbabwe does not have natural lakes but has over 8,000 impoundments. The major artificial impoundments are the Kariba, Mutirikwi, Chivero, Manyame and Mazvikadei Dams. All the dams except for Kariba were constructed for domestic water and/or irrigation. Although Kariba Dam was constructed for hydroelectric power supply, the lake has assumed other functions of water supply, fisheries and tourism.

#### Lake Kariba

Lake Kariba is the largest dam in Zimbabwe and is shared with Zambia. The dam is over 30 years old and covers 536,130 ha, of which 294,930 ha belong to Zimbabwe. The lake has a maximum depth of 119 m and a mean depth of 29.2 m. A large area of Lake Kariba is protected by the National Parks and Wildlife Management Act as safari area and recreational park. Lake Kariba is threatened by overfishing, erosion of the escarpment which may cause siltation, future mining at Sengora, and pressure on the shoreline by private developers.

#### Manyame impoundments

The major impoundments of the Manyame River are the Chivero and Manyame Dams. When full, Lake Chivero has a surface area of 2,630 ha, a maximum depth of 27 m and a mean depth of 9.5 m. The lake and its environs were created as a recreational park. At present, the lake has a problem with the aquatic weed,water hyacinth (*Eichhornia crassipes*).

Lake Manyame is also a recreational park and is the larger impoundment on the Manyame River. Its surface area is 8,100 ha at capacity when maximum and mean depths are 23 m and 5.6 m respectively. The Manyame Lake has not been affected by *Eichhornia crassipes* but an oxygen weed (*Lagarosiphon ilicifolius*) infestation has been observed.

#### Other impoundments

Other large, artificial impoundments are Lakes Mutirikwi, Mazvikadei and McDougal. These, and other smaller impoundments, were constructed for domestic water use. Smaller impoundments are becoming progressively silted and some have dried up due to the current drought.

## Wetland values

Wetlands are very important ecosystems. They have served as centres of human population since ancient times. People, animals and plants need water for survival and this water is usually provided by wetlands. In addition to water, wetlands are involved in: provision of forage and agricultural land; regulation of groundwater recharge and discharge; control of floods and erosion; retention of sediments, nutrients and toxic substances; export of biomass; provision of fish habitat; action as windbreaks; stabilisation of microclimates and provision of water transport routes. Wetlands also support forest, wildlife and fish resources. They are centres of biological diversity and sources of unique culture and heritage.

It is undisputed that wetlands are very important ecosystems. In Zimbabwe, wetland ecosystems had and still have a strong link with the development of the society and a broad range of human activities. In the history of human settlement, adequate water supply is an important factor, thus most large settlements in Zimbabwe are located in or near wetlands. Harare, the capital city of Zimbabwe, is located on a network of streams (including the Marimba and Makabusi Streams) that drain into the Manyame River. Dambos are widespread within the boundaries of Harare city.

A loss of wetlands means a loss of fundamental resources and functions provided by wetlands. Civilisations and settlements have disappeared because of lost wetland ecosystems. In Zimbabwe, the progressive loss of wetland ecosystems has caused detrimental effects to society. Wetland loss, coupled with frequent droughts, has contributed to the general scarcity of water which is experienced in Zimbabwe today. The siltation of riverine wetlands and man-made wetlands has considerably reduced the availability of water for irrigation, livestock and domestic use. In 1992, 7,000 cattle died because of drought and lack of water in Masvingo Province (Anon., 1992a).

Zimbabwe has witnessed a progressive loss of wetlands during the past decades. The wet dambos that were widespread throughout the country are now difficult to find. River systems that used to flood for several months are now characterised by flash floods and high silt loads. These wetlands have been lost or degraded because of the disruption of the natural process by agricultural intensification, urbanisation, pollution, dam construction and other forms of intervention in the ecological and hydrological system. The over 8,000 dams constructed in Zimbabwe have affected wetland ecosystems. In Harare, it is common to see rubbish dumped in dambos and wetlands around urban areas are often polluted. The problems seen in the Manyame impoundments are classic examples of wetland pollution (Marshall, 1994). Agricultural activities have also had their share in destroying wetland ecosystems; irrigation schemes along the Save River are established on the floodplains and agricultural chemicals have contributed to the eutrophication of local wetlands.

## Causes of wetland loss and degradation in Zimbabwe

Various reasons have been put forward to explain the general loss and degradation of wetlands worldwide, including limited availability of information, inadequate planning, and imperfect policy and management. In Zimbabwe, these reasons also apply to wetland management. Wetlands have largely been neglected by research, policy and legislation and for a long time wetlands, apart from dams and river systems, were perceived as wastelands that should be drained.

Very few Zimbabweans fully understand the concept of wetlands. The responses to a questionnaire sent to various institutions and government departments showed that about 31% of the respondents defined a wetland as any land that is saturated to within 15 cm of the surface for the major part of the rainy season and is characterised by mottled and grassy vegetation; another 38% defined wetlands as a dambo; about 15.2% defined a wetland as a spring, dambo, sponge, marsh, swamp, river, lake and sea. The remaining 15.8% did not express their perception of wetlands. From this survey, it is apparent that Zimbabweans do not view wetlands as ecosystems.

This limited awareness of wetlands and their functions has possibly led to the poor public and national perception of wetlands. This perception is illustrated by the imprecision in the National policy on dambo utilisation and management. Although various Acts prohibit dambo cultivation, peasant farmers still cultivate these areas, despite being denied extension advice and financial support. Stream bank cultivation is an offence but the practice continues (Anon., 1992b). The contour ridges on most fields in the communal lands act to drain water and erode soil instead of conserving them. Widespread dam construction has adversely affected many rivers in Zimbabwe. These problems, combined with population pressure on wetland resources, have resulted in the loss of wetland ecosystems in Zimbabwe.

Imperfect policies and management have lead to inter-sectoral policy inconsistencies, institutional inefficiency and institutional jealousies. For example, the water in artificial impoundments is governed by the Water Act of the Ministry of Energy and Water Resources Development while the surrounding area is under the jurisdiction of the Department of National Parks and Wildlife Management. These institutions do not communicate or work together effectively in the management of these wetlands, to the detriment of the areas.

## Conclusion

It is clear that Zimbabwe has already lost numerous hectares of wetlands and that this trend in wetland loss and degradation is continuing. Dambos are drying, dams and rivers are suffering from siltation, and water is becoming more scarce. Despite the publicity of these problems, very little has been done to reduce or reverse this trend of wetlands destruction. The time has come for Zimbabwe to do something about these problems. The magnitude of the problem of wetlands loss and the impending threat to life clearly calls for a wetlands conservation and management programme. Such a programme would address issues such as information and research, wetland inventories, awareness, education and training, policy, legislation, organisation and institutional arrangements, and should suggest projects for Zimbabwe's wetlands conservation and management.

## References and bibliography

Anon. 1992a. *The Herald.* 3 January, 1992.

Anon. 1992b. *The Herald.* 5 January, 1992.

Chabwela, H.N. 1991. Southern African Wetlands Programme, draft report. IUCN, Harare, Zimbabwe. 687 pp.

Dugan, P.J. (Ed.). 1990. *Wetland Conservation: a review of current issues and required action.* IUCN, Gland, Switzerland. 96 pp.

Dambo Research Unit. 1987. The uses of dambos in rural development with reference to Zimbabwe. Final Report of ODA project R3869. Loughborough University of Technology, Loughborough, UK. 236 pp.

Hughes, R.H. and J.S. Hughes. 1992. *A Directory of African Wetlands.* IUCN, Gland, Switzerland and Cambridge, UK/UNEP, Nairobi, Kenya /WCMC, Cambridge, UK, xxxiv + 820 pp., 48 maps.

Larson, J.S., P.R. Adamus and E.J. Clairain. 1989. *Functional Assessment of Freshwater Wetlands: a manual and training outline.* Environmental Institute, University of Massachusetts, Amherst, USA. 62 pp.

Machena, C. 1987. Zonation of submerged macrophyte vegetation in Lake Kariba, Zimbabwe and its ecological interpretation. *Vegetatio* 73:111-119.

Marshall, B.E. 1994. Ecology and management of the Manyame Lakes. Pages 55-68. In: T. Matiza and S.A. Crafter (Eds). *Wetlands Ecology and Priorities for Conservation in Zimbabwe: Proceedings of a Seminar on Wetlands Ecology and Priorities for Conservation in Zimbabwe, Harare Kentucky Airport Hotel, 13-15 January, 1992.* IUCN, Gland, Switzerland. 170 pp.

Ramberg, L., S. Bjork-Ramberg, N. Kautsky and C. Machena. 1987. Development and biological status of Lake Kariba: a man made Tropical lake. *Ambio.* 16:314-321.

Ramsar Convention Bureau, 1990. *Directory of Wetlands of International Importance.* Ramsar, Gland, Switzerland. 782 pp.

# Integrated management of wetlands: a perspective from IUCN's global programme

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## Introduction

Over the course of the past ten years there has been a major increase in concern for wetlands worldwide. Several aid agencies now include wetland management amongst their environmental priorities. The US Treasury has adopted voting standards which instruct the US Executive Directors to the multilateral banks, and the Administrator of USAID, not to support projects which will destroy or degrade wetlands.

This concern for wetlands reflects a growing awareness of the importance of wetlands to human society and an improved appreciation of the impact of wetland loss upon people and wildlife. The growing importance of the Convention on Wetlands of International Importance (The Ramsar Convention) as a mechanism for inter-governmental consultation and cooperation is just one measure of this concern. There are today (January 1992) 65 signatories to the Convention, of which 17 are in Africa.

As concern for wetlands has grown, so the focus of wetland conservation efforts has moved beyond biological survey and identification of sites of national and international importance to centre upon the challenge of how to manage these areas. In doing so the complexity of wetlands, and the diversity of factors which affect them, emphasises the need for an effectively integrated approach to management at both site specific and national levels. As Zimbabwe considers how best to address this challenge, the present paper attempts to provide some guidance by reviewing the concept of integrated management of wetlands, examining a number of case studies which provide examples of efforts to pursue integrated management in other regions, and considering some lessons that these examples provide.

## Wetlands: managing complex ecosystems

Wetlands are complex ecosystems which result from the interaction of four biological and physical features: soils, water, plants and animals. The central principle of an integrated approach to wetland management is that it should recognise the inter-relationships between these biological and physical components and seek to maximise the benefits that can be obtained from sustainable multiple use. However, only rarely are these components managed in an effectively integrated manner, rather emphasis tends to be upon maximising benefit from a single product obtained from one resource. Today, there is growing recognition that much of this investment in single purpose use of wetlands has led to the destruction of these natural ecosystems and deprived the rural poor of natural resources. Such resources could have served a broad based development process, rather than one slanted for the use of urban centres. For example, dams to provide power for domestic needs and development of industry have often disrupted floodplain agriculture, reduced the area of floodplain pastures and devastated fisheries (Scudder, 1989). Similarly, intensive investment in coastal agriculture and aquaculture has in many areas destroyed the potential for low input agriculture, while reducing the catch of coastal fisheries (Burbridge *et al.*, 1988). Such development policies are now widely criticised as having neglected the millions of small farming and fishing families whose rising disposable incomes could drive development. To rectify this neglect, small scale development approaches, building on the productivity of natural ecosystems, are now being developed.

The critical need today is to recognise the inter-linkages and benefits to be obtained from integrated management of fish, trees, water and wildlife. This will, however, require integration of management institutions, such as departments of forestry, fisheries and agriculture, while developing a perspective which looks beyond individual wetland sites. The hydrological basin and coastal zone, within which the wetlands lie and which maintain the flow of nutrients and water upon which the wetlands depend for their productivity, must be taken into account. Such an approach should also consider the downstream benefits of wetland conservation, such as flood control and maintenance of water quality, thus emphasising further the central role that wetlands can play in regulating the hydrological cycle. While this requires major institutional change, it also needs to be accompanied by substantial policy change.

To add to this complexity, we need to recognise that management of these biological and physical systems also requires us to address the other factors whose interaction with the biological and physical resources governs the pressures upon wetlands and thus lie at the heart of successful long term management.

The first of these factors is economics. National economic and agricultural policies frequently determine the rate at which wetlands are converted. Thus in Europe, wetland drainage has been stimulated by the artificially high prices paid for a number of crops under the EEC's Common Agricultural Policy. For example EEC wheat prices were 40% to 60% above world market prices over the period 1978-80. As a result, the conversion of lowland wet grazing meadows for growing winter wheat became a very profitable financial investment for individual farmers. And in the USA, price supports for sugar, together with strategic economic considerations, have favoured agricultural conversion of the Everglades marsh in Florida.

A more complex example is provided by northern Nigeria where, despite efforts by the states of Borno, Kano, and Bauchi to conserve the natural floodplain of the Hadejia River system, agricultural and economic policies are spurring conversion. In response to falling oil prices and the need to save hard currency, the federal government banned all wheat imports as of January 1987. At the same time a 50% subsidy on inputs and equipment for wheat cultivation was made available while, as a result of the import ban, the producer price for domestic wheat rose by 1,000% between 1986 and 1989. By the 1988-89 growing season in Kano State alone, some 30,000 ha had been converted for wheat cultivation. While this wheat boom will generate a profit for individual farmers, the benefits will be short lived. The sandy soils are predicted to degrade rapidly under irrigated wheat cultivation, thus compromising long term options for rural development in the region (Kimmage, 1991).

In much of Southeast Asia, where in some countries economic growth has risen above 10% per annum in recent years, wetland loss is frequently the direct consequence of this rapidly expanding economy.

The rapid rise in demand for land for urban and industrial development generates an economic momentum which renders invalid many conservation arguments based upon the multiple values of these natural systems. Thus, even when it can be shown that development of aquaculture in coastal wetland systems will yield little long term economic value, private developers continue to invest in drainage and conversion in expectation that even if aquaculture fails the land is worth more as wasteland, on which houses can be built, than as wetland. While such calculations ignore the public benefits of these systems, economics is nevertheless a central force and one that needs to be addressed by any comprehensive wetland conservation programme. Specifically it argues for an aggressive conservation policy, based upon establishment of exclusive protected areas in priority sites, in those countries where the economic pressures have favoured the rise of a group of wealthy entrepreneurs who have no interest in sustainable use and are concerned only with short term, personal profit.

The second major system which determines how best to manage wetland resources is formed by the social, cultural, and institutional context within which wetland management is carried forward. As discussed previously, many traditional societies have developed complex systems to regulate access to resources. These can in many instances provide the basis for multiple use under today's conditions. Yet where control over all natural resources is vested in agencies of central governments, which are often based hundreds of kilometres away from the resources concerned, such locally based management of natural resources is severely hampered. In addition, many of the technical staff responsible for administering government policy have little knowledge of the ecosystems for which they are responsible. In designing and establishing planning and management frameworks for long term conservation and use of wetland resources, special care needs to be taken in order to ensure that these are pursued within an appropriate institutional arrangement. Such an arrangement would combine the central role of government and the necessary supporting legislation with the capacity to vest power in the local resource users and draw upon traditional knowledge as appropriate.

## Towards integrated management

The message of the preceding paragraphs is that the wetland conservation challenge is certainly complex. It requires action at many levels and delicate integration of a diversity of issues and institutions. However, while it is essential to avoid minimising the difficulties inherent in such an approach, it is equally important to examine the wetland conservation efforts of other countries and regions, and try to learn from their experiences. To assist in this process the following examples describe work in two countries in Central America and two in Africa, where the past five years have seen important achievements in the integrated management of wetland resources.

### Mangrove management in Central America

In both Nicaragua and Costa Rica, recognition of the importance of their countries' mangrove resources, and of the severity of the pressures upon these, has led to the development of a number of initiatives to manage these resources sustainably. Two of the most advanced are on the Pacific coast of Nicaragua near León, and the region of Terraba-Sierpe on the southern Pacific coast of Costa Rica. While the detailed approach in these two areas has been adjusted to the specific conditions and needs of each, they have both addressed four major issues.

The first step has been a diagnosis of the status of the mangrove resources in each project area and identification of the principal problems facing these. In Nicaragua, this has taken the form of a detailed survey of the mangrove forest and of the fish, shellfish and wildlife resources of the estuarine system, and has resulted in a detailed description of the condition of the mangroves which are under severe pressure from local people harvesting timber, bark and firewood. In Costa Rica, the initial survey focused upon the mangrove forest resource in order to lay the basis for a forest management plan. This needs to be followed up in due course with a more detailed survey of the other resources.

In conjunction with the biological survey, the Nicaraguan project has carried out a detailed socio-economic survey to assess the true extent of dependence by the local people on the mangrove resource, and to try and understand why these communities are currently exploiting mangroves at levels which are clearly not sustainable, even in the medium term. In Costa Rica the socio-economic study has been less detailed, and has focused in a first phase upon identifying the principal needs of the one village which has exclusive use of the forest area governed by the management plan. By doing so, the project has sought to improve management of one of the critical parts of the system before extending activities to other areas of the estuary.

The third stage in the management process has been to identify specific activities which can help relieve pressure upon the mangrove resources, both by assisting the local communities to manage resources more effectively and to diversify their household economies. In Costa Rica, this has consisted of providing guidance on improved sylviculture practices. These can reduce damage to the forest during harvesting and favour extraction of a diversity of products from each area, rather than, as in the past, allowing individuals to harvest bark while leaving the timber to rot, and *vice versa*. Complementing this work, trials are now underway in Costa Rica to improve the quality of charcoal produced from the mangroves through installation of improved kilns, and trials to improve extraction of tannins from the bark are being pursued in both countries. Finally, in Costa Rica the cooperative of mangrove workers, Coopemangle, has been provided with a revolving fund. This has allowed investment in transport designed to increase access to markets and thus cut out the costs imposed by middlemen who used to buy the charcoal direct from the village.

Complementing these efforts to improve management of the mangrove resource, attention in Nicaragua has begun to focus on improving fishing as a means of diversifying the economy of some communities. In Costa Rica there has been a gradual development of small scale tourism in the mangroves. Despite the limited nature of this tourism, it generates an important source of income for the families involved, helps relieve pressure upon the household economy and thus facilitates the adoption of a sustainable level of mangrove harvest.

The fourth step in these initiatives has been to identify and establish an appropriate institutional structure for long term management. In Costa Rica this has been facilitated by the approach of the Forestry Department which has given Coopemangle exclusive rights for exploitation of the mangrove area covered by the management plan. Thus while the Forest Department retains a supervisory role, the responsibility given to Coopemangle provides the cooperative with a substantial incentive to manage and protect this effectively. In Nicaragua this aspect is less well advanced but a number of similar solutions are being explored, in particular establishment of cooperatives which have the responsibility for exploitation of all resources within the mangrove ecosystem.

While this work in Costa Rica and Nicaragua only began in 1988 and is therefore still at an early stage of development, there are encouraging signs of progress. Above all there is substantial support for this work among the local communities who see this as providing them with a more secure future. At governmental level, support for this work is reflected in the creation of a wetlands directorate in Nicaragua; Costa Rica has joined the Ramsar Convention and Nicaragua is poised to follow suit.

## Coastal zone planning in Guinea-Bissau

The coastal zone of Guinea-Bissau covers approximately two-thirds of the country and supports one of Africa's most important complexes of tidal flats, estuaries and mangroves. In recognition of the importance of these resources, the Government of Guinea-Bissau in 1989 initiated a coastal zone management programme designed to lay the basis for sustainable long term use of coastal resources as the foundation for socio-economic development in the coastal zone. Reflecting the national importance of the coastal zone in Guinea-Bissau, and the wider land use planning goals of the project, the approach adopted was substantially more complex than that described for Central America.

The first stage in the planning process has been to survey the biological and physical resources of the coastal zone, by means of a blend of remote sensing and field survey. This has allowed detailed mapping of the critical coastal resources, in particular the mangroves and other coastal wetlands, forest cover and soil potential. Complementing this, an extensive village survey along the coastal zone has allowed quantification of resource use by the coastal communities and identification of critical problems as perceived by these communities.

This integrated survey of biological and physical resources, together with socio-economic analysis, has allowed a detailed land use plan for the coastal zone to be established. It synthesises information on resource use potential, and integrates this with information on the distribution of the various ethnic groups whose traditional forms of resource use are generally closely adapted to the characteristics of the ecosystem. In addition, those critical ecosystems which merit special protection have been identified and preliminary limits of appropriate core areas and buffer zones have been mapped.

In itself this land use planning process is of little value. Rather it needs to be taken up and used as the basis for future investment in the coastal zone by all Government departments with a mandate to support development in the coastal zone, and by the bilateral and multilateral aid community which purport to assist in this process. Accordingly, throughout the survey process, special attention has been given to maintaining a close dialogue with all government and non-governmental institutions involved, and with the aid community. This was marked by the convening of a round table to review the draft land use plan at which government institutions, NGOs, leaders of the coastal communities and representatives of the aid community came together to review and debate the plan. As a result the plan today has solid recognition within government; it has already played an important role in helping to focus tourism development in areas where this is environmentally sound, regulate fishing in coastal waters, and encourage the bilateral aid community to address the plan's priorities in their own support to development in the coastal zone.

This official recognition of the plan has been complemented by slow but steady recognition by rural communities that the plan is not a new mechanism designed by central government to impose unwanted controls upon their use of resources, but rather provides a mechanism for increased assistance in pursuit of their priorities. While the extensive consultation carried out in pursuit of the socio-economic survey laid the basis for this awareness, it has been complemented by a series of radio programmes which have explained the importance of the plan and the benefits which it can yield. Similarly, a coastal zone festival was held in one of the major coastal towns in order to present the final recommendations of the plan to the communities. Thus, while these are still very small steps, and the ultimate proof of the plan's benefits will be through action on the ground, this focus on community participation has been of critical importance to the long term success of the programme.

Field activities designed to translate the plan into change on the ground have to date focused on two of the critical areas recommended for protected area status. In each of these areas an approach based upon that described for Central America is now underway, with special emphasis being placed on the communities living within the buffer zone of the protected areas.

In view of the importance of the coastal zone in Guinea-Bissau, the activities described here have not only helped lay the basis for long term management of coastal resources, but have also played a major role in assisting the Government to pursue its National Conservation Strategy. By emphasising the complexity of the coastal management challenge and the role that a carefully integrated approach can play in addressing this, the coastal zone plan has provided a tangible example of the benefits to be obtained from a National Conservation Strategy. In turn the establishment of a National Environment Council in early 1992 provides a high level mechanism for debate of conservation issues and for further promoting the integrated approach required to implement the coastal zone plan on a long term basis.

## Uganda's national wetlands programme and policy

When President Museveni came to power in Uganda he brought with him an awareness of the importance of wetlands in Uganda, and in particular the growing concern over drainage and wetland loss amongst the people of the southwest, his stronghold during years of opposition. As a result, when the Ministry of Environment Protection (MEP) was created in 1986, its first action was to halt wetland drainage and seek the development of a national wetlands programme and policy which could govern the country's use of wetland resources.

In pursuit of this policy, the MEP first surveyed the distribution and status of the country's wetland resources, complementing this with a number of detailed studies of the economic value of their important functions. These included a study of the role of papyrus in removing pollutants from water and thus protecting Kampala's water supply, and the importance of swamp fisheries. They were complemented by similar studies of the use of wetlands by selected local communities in order to assess more systematically their perception of the resources and their importance to village economies.

The information generated by this work has been used to prepare a draft wetlands policy which, since 1989, has been undergoing an extensive process of review by all concerned government departments. To facilitate this consultative process, the

Government established in 1989 an Inter-ministerial Wetlands Committee on which all concerned government institutions are represented, together with the University of Makerere. By meeting regularly this Committee provides a mechanism for debating the concerns of the various ministries with an interest in wetland resources, and for reviewing major proposals for exploitation of wetlands, such as large irrigation schemes. Perhaps most important, the Committee provides an opportunity to formalise dialogue between the ministries and demonstrates that the MEP and the Wetlands Policy can assist other ministries by helping them avoid investment in activities such as large scale irrigated agriculture which, in most situations, are an inappropriate focus for development efforts.

In support of this wetlands work the MEP has established a Wetlands Unit which at the end of 1991 had three wetlands specialists employed as long term staff and another in training. These technical staff now play a critical role in providing support to the line ministries which increasingly seek guidance on the design of activities which concern wetlands. In turn this is being complemented by training on wetlands issues for the line ministries such that they can address these issues more effectively in their daily work.

Uganda's decentralised system of government gives great authority to the District Development Committees (DDCs) which assess priorities for local investment in development and regulate land use. It is to these committees that individual farmers come with requests for permission to drain or otherwise alter wetlands. As awareness of the problems of wetland drainage has grown, the DDCs have increasingly sought the support of MEP and the line ministries in determining whether permission should be accorded. In order to build long term capacity to respond to this need, MEP has increasingly focused on providing the district level staff of the line ministries and the DDCs with basic training in wetland management. With this grounding the Districts can more readily identify those projects which will have a significant impact on wetlands, and specify more precisely the form of assistance which they require from MEP and the line ministries in Kampala. In addition, the Wetlands Policy has been discussed in depth with representative DDCs in order to ensure that this not only has their support but is practical and implementable. Future efforts will continue to focus upon this decentralisation.

## Conclusion and recommendations

The message of the preceding sections is that integrated wetland management is a complex process which requires action at many levels. And, as the geographical scope of the programme concerned grows, the complexity of this work grows with it. Yet despite this complexity, a number of countries are making clear progress in translating these concepts into improved wetland management and conservation on the ground. As the present seminar considers the priorities for wetland conservation and management in Zimbabwe, the experience from other regions gives grounds for encouragement.

Of the many lessons which can be drawn from the examples presented here, three have particular significance for this seminar. First, effective conservation at site specific or national level requires collaboration amongst a wide range of disciplines in addressing a diverse array of ecological, social, economic and institutional issues. In turn, such collaboration will only be effective when pursued through a careful process of consultation. In short, the wetland conservation community, which today continues in many countries to be dominated by biologists, needs to reach out to other disciplines and win their support if real progress is to be made in addressing the problems facing wetlands. The present seminar can facilitate this not only by its success in bringing together a diverse group of disciplines in order to debate these issues, but by laying the basis for sustained interdisciplinary collaboration as appropriate follow-up is pursued in the months and years to come.

Second, in pursuing wetland conservation priorities there is a major need for improved information on the status of the resources, the functions which they provide, their use by human communities, and the pressures upon them. Research into these aspects of wetland conservation and management therefore needs to be encouraged. However, in order that this research can be most effective, be targeted at the highest priorities and, most important, lead to real change on the ground, it should be pursued as an integral component of a wetland management or planning initiative. Every effort should be made to encourage such applied research.

Finally, as is clear from the case studies from Guinea-Bissau and Uganda, major wetland planning initiatives address a wide range of land use planning and institutional issues which are central not only to wetland conservation, but are essential for effective long term integration of conservation and development at national level. By developing approaches through which to address these issues, wetlands conservation initiatives can serve a major role in translating the central concepts of national conservation strategies into tangible action on the ground. And while this might be argued for many other groups of ecosystems, the especially intense human use that is made of wetlands, and the high international profile which these currently receive, gives wetlands a particularly important role to play. Hopefully the present seminar can be the first major step towards realising this potential in Zimbabwe.

## Acknowledgements

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## References

Burbridge, P.R., Koesoebiono, H. Dirschl and B. Patton (Eds). 1988. *Coastal Zone Management in the Strait of Malacca. Proceedings of a Symposium on Environmental Research and Coastal Zone Management in the Strait of Malacca, 11-13 November, 1985. Medan, Indonesia.* Dalhousie University, Canada. 317 pp.

Kimmage, K. 1991. Small scale irrigation initiatives in Nigeria: the problems of equity and sustainability. *Applied Geography* 11:5-20.

Scudder, T. 1989. River Basin Projects in Africa. *Environment* 31(2):4-32.

# The environmental status of the Save Catchment

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(presented by H. Masundire)

## Introduction

The Save Catchment has received considerable attention from conservation and natural resource agencies. As it contains the major interior river of Zimbabwe, it is of considerable importance to large scale irrigation development.

This paper summarises the available data on the environmental situation in the Save Catchment, which is claimed to be in an advanced state of degradation.

### Background

The catchment of the Save extends over 4.2 million hectares, approximately 10% of Zimbabwe's land surface. The Save River runs for a distance of nearly 400 km from the central watershed to southeastern Zimbabwe. It encompasses about 20% of all the cultivated land in commercial lands of Zimbabwe and has 40% of the communal land population (Government of Zimbabwe, 1990).

The Save River is of national importance in Zimbabwe's agricultural development as it forms the basis of several of the major irrigation schemes in the country, notably those at middle Save and Chisumbanje (Williams, 1981). The southeast lowveld of Zimbabwe has the best potential for extensive irrigation development in the country.

Most of the land tenure systems found in Zimbabwe are represented in the catchment. The majority (60-70%) of the catchment is occupied by communal lands, with much of the remaining land shared between large scale commercial farmland and resettlement lands: there are also sizeable small scale commercial farming lands and state farms.

### Soils, climate and vegetation of the Catchment

Most of the Save Catchment has soils derived from gneissic granite which gives rise to sandy, well drained soils with low fertility status (Nyamapfene, 1991). The climate varies from a wet and dry tropical climate in the upper catchment to a dry tropical climate in the lower catchment (Muller, 1982). The potential natural vegetation of most of the catchment is 'miombo' woodland, largely dominated by *Brachystegia spiciformis* and *Julbernardia globiflora* (Wild and Barbosa, 1967). In the drier regions of the lower catchment, woodland dominated by *Colophospermum mopane* is widespread (Wild and Barbosa, 1967).

## Socio-economic characteristics

The communal lands in the Catchment are typical of those found throughout Zimbabwe, that is they are concentrated in the areas with less agricultural potential and have a long history of lack of investment. Communal farmers have suffered from lack of credit facilities, poor supply of agricultural inputs, inadequate marketing services, insufficient extension staff and poorly developed infrastructure (Campbell *et al.*, 1989). Population densities of 40 to 50 persons/km$^2$ are typical, with individual households having an average of 3 ha of cultivated land (Reh *et al.*, 1989).

Many of the constraints facing farmers in communal lands also apply to farmers in resettlement areas. In the latter areas the population-resource balance is not as adverse and most households cultivate 5 ha of land with sufficient grazing resources for a small herd of livestock (World Bank, 1991; Fergusson *et al.*, in press).

## Woodland cover status in the Save Catchment

In most of the communal lands in the Catchment, the woodland cover has been much reduced. In six randomly selected sampling clusters within the Save Communal Lands, all had less than 20% dense woodland and only one, in the south of Save Communal Land, had over 60% dense and open woodland (Figure 1A). The loss of woodland is related to land clearing for cultivation (Figures 1B).

In three adjacent tenure systems experiencing the same climate and on the same soil types, the different patterns of woodland cover can be clearly seen. In Chiweshe Ward, in the north of the Save Communal Land, there is very little dense and open woodland (Figure 2A). This is in contrast to the potential natural woodland where approximately 80% of the landscape is dense and open woodland, as seen in the Mutanda Resettlement Scheme in 1961 and 1981 (Figure 2B). This is a former commercial farming area where livestock production was practised (Fergusson *et al.*, in press). Zviyambe Small Scale Commercial Farming Area is

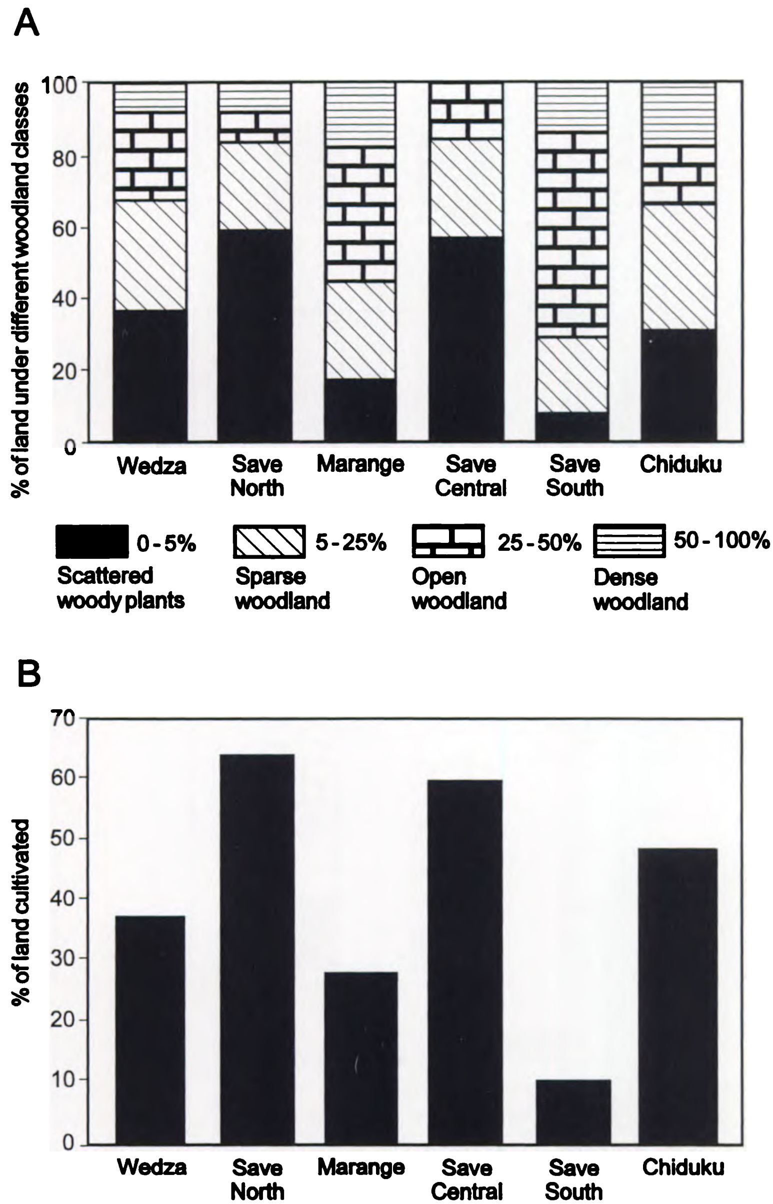


**Figure 1** Extent of cultivation and woodland cover characteristics in various communal lands of the Save Catchment (Source: du Toit *et al.*, 1984)

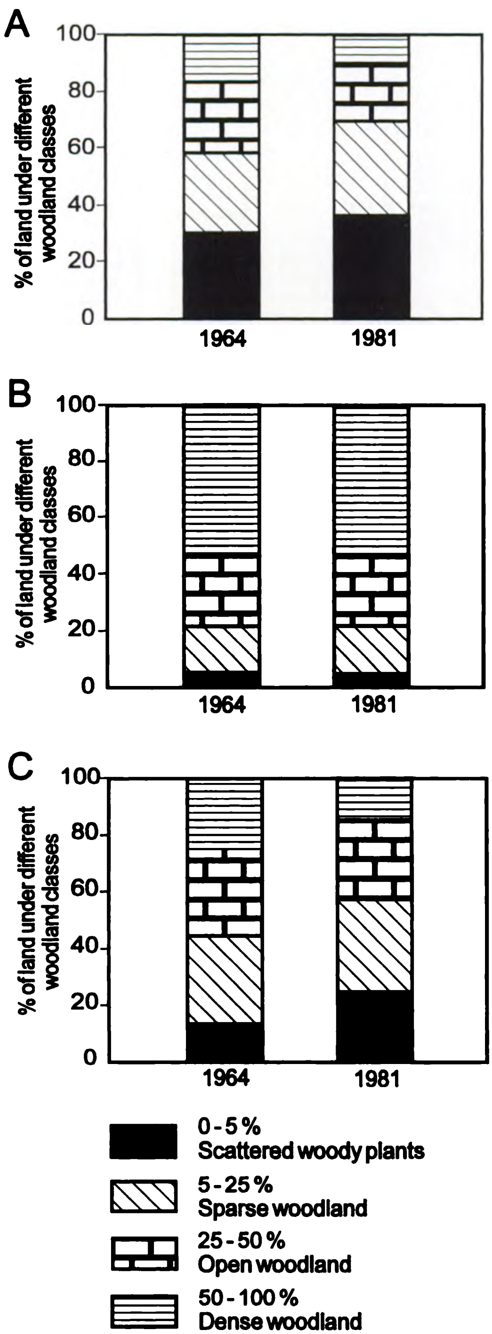


Figure 2 Woodland cover characteristics in 1964 and 1981
A Chiweshe Ward of Save Communal Land
B Mutanda Resettlement Area
C Zviyambe Small-Scale Commercial Farming Area
(Source: Campbell and du Toit, in press)

similar to Chiweshe but with slightly greater amounts of dense and open woodland and less cultivation (Figure 2C).

Evergreen riverine forest is found along the Save and probably plays an important role in stabilising the banks of the river (Campbell and du Toit, in press). Within the communal lands, about 40% of the riverine forest has been removed. In Chiweshe Ward of Save Communal Land, significant amounts of native forest disappeared between 1964 and 1981, while Mutanda and Zviyambe Wards have retained most of their forest.

Figure 3A displays the species diversity (measured by the Shannon-Wiener index, which takes into account the number of species and the relative importance of each species) and Figure 3B the species richness (numbers of species) of the woody plants in different community types in the upper catchment (Campbell and du Toit, in press). The first six communities are relatively undisturbed, whereas the last four communities are those found associated with abandoned fields or recently used fields. Heavy disturbance does not decrease species diversity because the diversity of undisturbed communities is relatively low, due to strong dominance by one or two species in climax vegetation. Disturbance usually removes the dominance, leaving the community with generally greater diversity. Nevertheless, disturbance generally reduces species richness.

## Factors controlling woodland cover status

The prime reason for woodland removal relates to clearing for cultivation (Figures 1A and 1B), where the amount of dense and open woodland remaining is in direct proportion to the amount of land that has been cultivated, either now or in the past. In a study carried out by du Toit and co-workers (1984), only one of the seven sampling areas in the Save, that in Save south, did not have a large percentage of the land devoted to cultivation. This was an area of 'mopane' woodland, whereas the other areas were formerly 'miombo' woodland. This pattern of greater cultivation and clearing of 'miombo' woodland is typical of the catchment (du Toit *et al.*, 1984). In the 'miombo' areas, the only relatively mature woodland remaining is that associated with hills and rivers (Campbell and du Toit, in press).

In Mutanda Resettlement Area, the influence on woodland structure of wood harvesting for fuel and construction was studied. After seven years of settlement it was found that the influence did not extend to 400 m from a village (Figure 4).

The relationship between woodland cover and cultivation can be dramatically seen in Mutanda Resettlement Area (Figure 5), with a dramatic reduction in dense woodland and a dramatic increase in area cultivated since the area was settled after independence. In new resettlement areas, large areas of well wooded country will be deforested (World Bank, 1991; Grundy *et al.*, in press). This rapid conversion of woodland to cultivated land is unlike the situation in the communal lands, where the level of deforestation and land clearance was already high in the 1960s and there have not been great changes in deforestation over the last two decades (Figure 2) or in the amount of land that is cultivated (Figure 6). However, in some

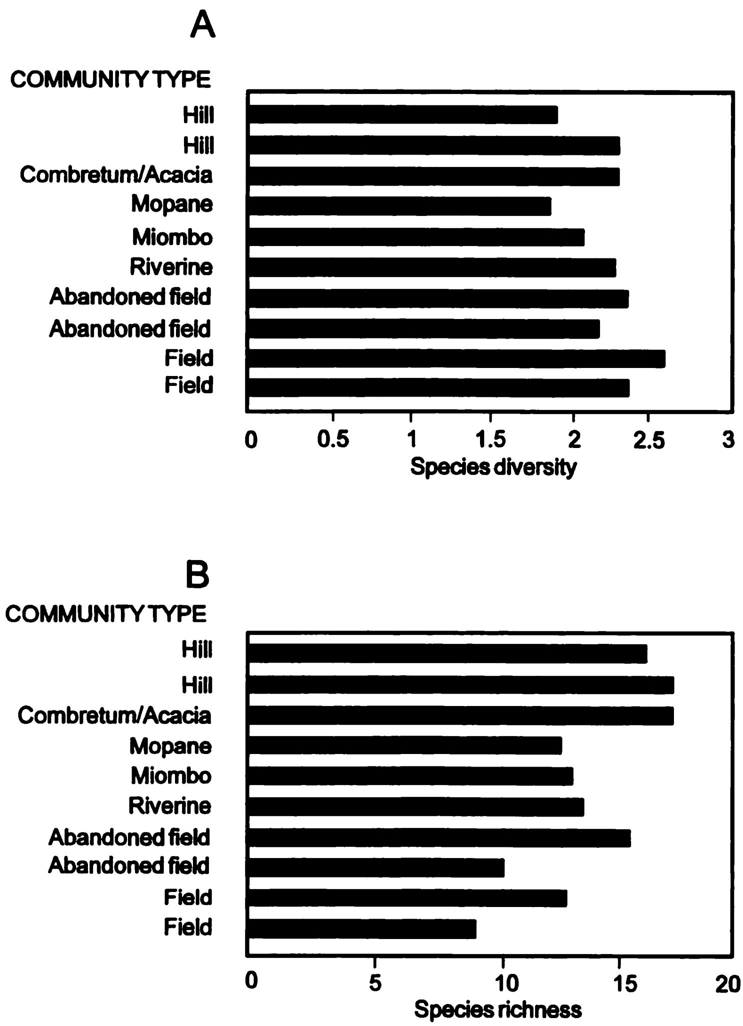


Figure 3 Species diversity and species richness of various community types in the Upper Save Catchment (Source: Campbell and du Toit, in press)

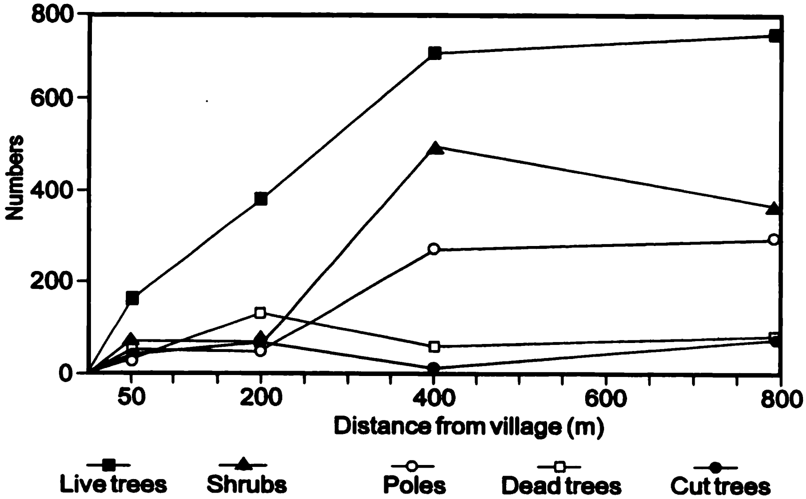


Figure 4 Changes in numbers of live trees, shrubs, potential building poles, dead trees and cut trees as a function of distance from a village in Mutanda Resettlement Area (Source: Grundy *et al.*, in press)

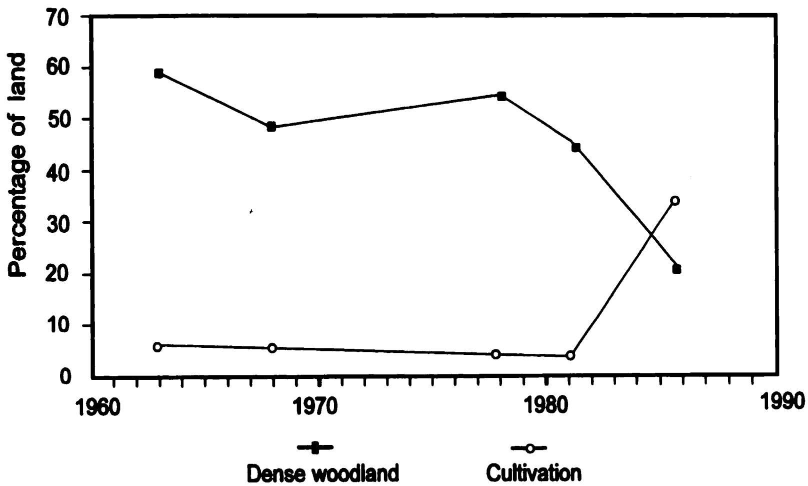


Figure 5 Changes over time of area cleared for cultivation and dense woodland in Mutanda Resettlement Area (Source: Grundy *et al.*, in press)

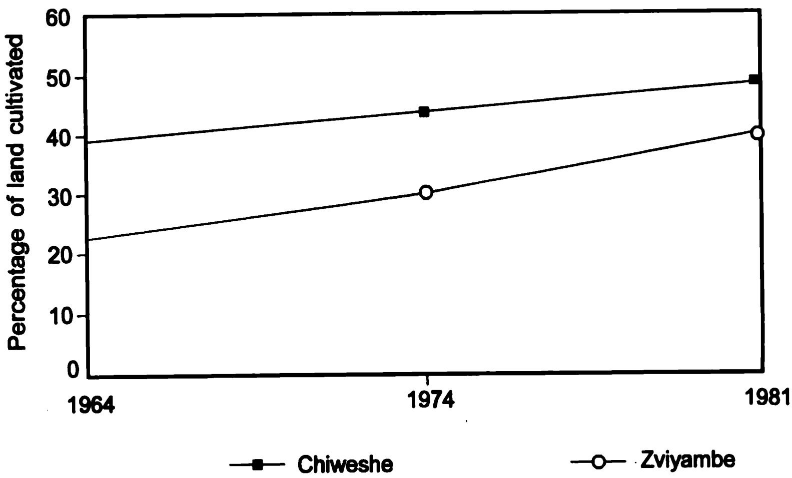


Figure 6 Changes in land use in Chiweshe Ward of Save Communal Land and Zviyambe Small-Scale Commercial Farming Area (Source: Reh *et al.*, 1989)

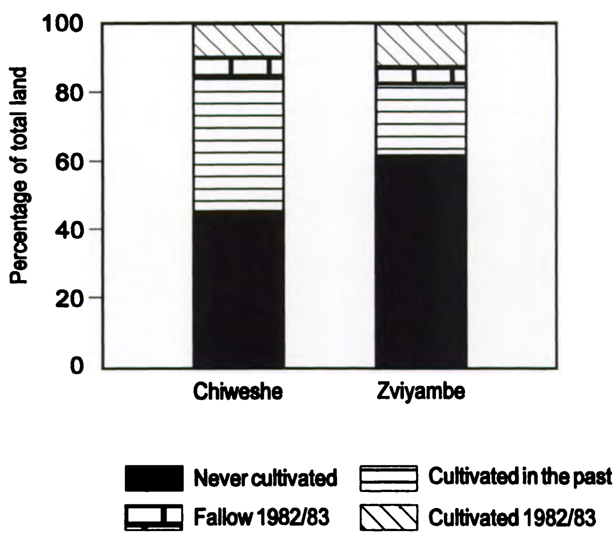


Figure 7 Extent of cultivated land in Chiweshe Ward of Save Communal Land and Zviyambe Small-Scale Commercial Farming Area (Source: Reh *et al.*, 1989)

of the more remote communal lands, where population densities were low prior to independence, there has been an influx of settlers with consequent deforestation.

In the communal lands, considerable loss of woodland occurred because of colonial land use policies whereby people were moved from one area to another (Wilson, 1990) with consequent clearing of new fields. This may explain why large areas of Chiweshe Ward were cultivated in the past but at the time of the survey by Reh and others (1989) only a small portion was cultivated (Figure 7). On the other hand, a good proportion of the land formerly cultivated was not cultivated in 1982/83 because of the devastating drought at the time and the abandonment of land because of nutrient depletion.

The presence of woody species in cultivated fields relates to the traditional practice of leaving trees, usually fruit trees, in fields (Campbell, 1987; Grundy *et al.*, in press). This practice continues, in spite of advice from the extension service to remove such trees (Wilson, 1990), as farmers place considerable value on these trees (Campbell, 1987; Wilson, 1990).

## Factors affecting soil fertility and hydrology

The work of Gambiza (1987) and de Jager (1988), as summarised and re-analysed by Campbell *et al.* (in prep.), shows the influence of cattle numbers on various soil properties. Using multivariate analysis techniques, the soils of the grazing areas (or simulated grazing areas) in communal lands are shown to have reduced nutrient status compared with the soils from areas with lower grazing pressure.

The value of tree cover for water conservation can be seen in the influence of litter (predominantly tree litter) on water infiltration (Figure 8A). With lower litter cover, water infiltration decreases significantly, this being more pronounced on basaltic than granitic soils. The influence of heavy grazing pressure can also be seen; for each litter cover class much lower infiltration occurs on the soils with the highest levels of utilisation (Figure 8B).

Dambos are widespread in Mutanda Resettlement Area and Zviyambe Small-Scale Commercial Farming Area but are not easily identified in the adjacent communal land, probably because they have been denuded of grass by the high density of livestock and have dried out (du Toit and Campbell, 1989). On a larger scale, changes in water flow in the Save River (Figure 9) show a higher runoff relative to rainfall in the 1970s as compared to the 1950s. The increased flow is probably due to much reduced evapotranspiration because of deforestation (du Toit, 1985). Although there is increased flow relative to rainfall, there is probably greater within-year variation between months, with more prevalence of flooding in the wet season and less water flow in the dry season. Further analysis of hydrological records would be valuable, but the perception of the local people is that the Save River, springs and pools are drying up (du Toit and Campbell, 1989) even though analysis of long term meteorological records indicates no reduction of rainfall (du Toit, 1985).

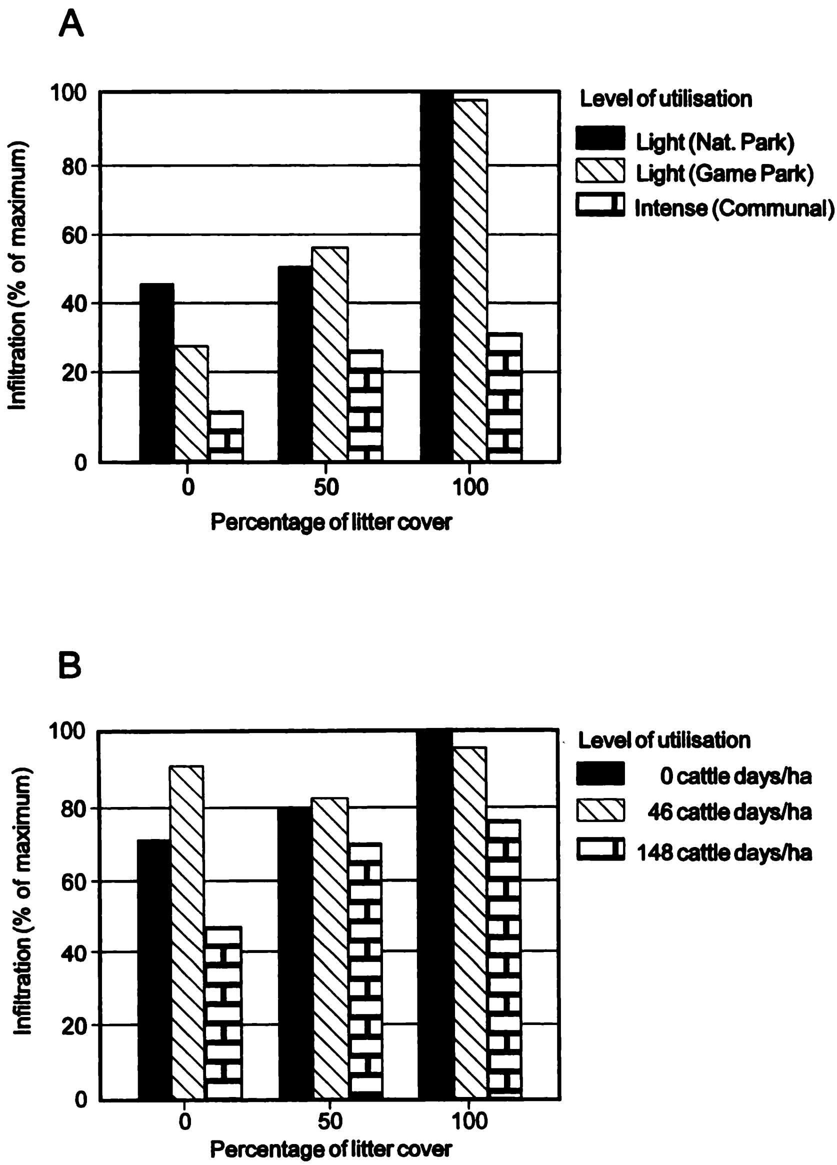


Figure 8 Influence of litter cover and land use on water infiltration
A Basaltic soils in the Chiredzi area
B Granitic soils in the Masvingo area
(Sources: Gambiza, 1987; de Jager, 1988; Campbell *et al.*, in prep.)

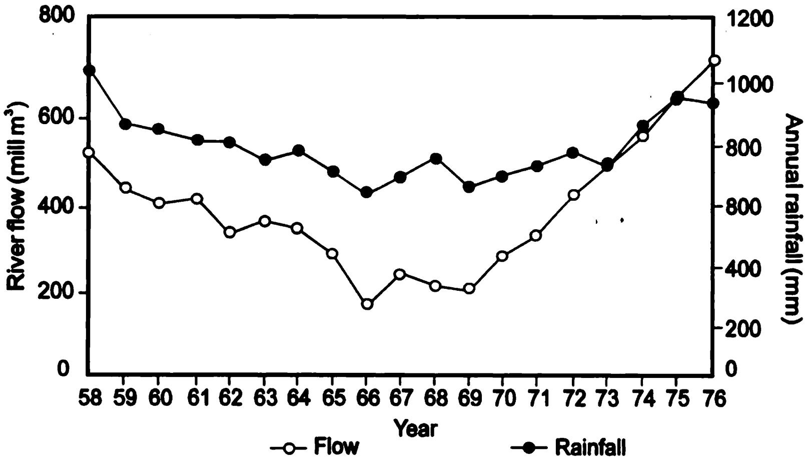


Figure 9 Annual river flow of the Upper Save River and annual rainfall of Wedza (five year running means) (Source: du Toit, 1985)

# Conclusions

This paper indicates that the woodland cover in the Save Catchment has been much reduced in the communal lands, but further reduction is taking place relatively slowly. In contrast, the resettlement areas are showing a dramatic decrease in woodland cover. The most important reason for reduced woodland cover is clearing for cultivation, rather than for harvesting of wood for fuel or construction. It is difficult to demonstrate the environmental influences of this deforestation because of the lack of data but some preliminary studies indicate the importance of tree litter for water infiltration. The high stocking rates in the communal grazing areas probably influence erosion rates, but once again there are no empirical data on the relationships. However, studies have demonstrated decreased water infiltration and reduced soil fertility with high stocking rates.

The end result of these processes is apparently the drying of the dambos, springs and even the Save River itself. It is abundantly clear that the environment is changing, and that the changes are, by and large, negative. People's perceptions support this theory (du Toit, 1985; de Jager, 1988).

People understand the processes operative in the degradation trend (du Toit, 1985) but are trapped within an environment, both socio-economic and physical, not well suited to crop production. Population densities in communal lands already exceed carrying capacities under current technologies (Attwell, 1989). The resourcefulness of the local people can be seen in the wide array of local practices that are used to make the most out of the environment; the best example of intense resource management by small scale farmers is seen in the conservation and management of soil fertility (Campbell *et al.*, in press).

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## References

Attwell, C.A.M. 1989. Population-resource interactions. Pages 84-98. In: B.M. Campbell, R.F. du Toit and C.A.M. Attwell (Eds). *The Save Study: Relationships between the environment and basic needs satisfaction in the Save catchment, Zimbabwe.* Supplement to *Zambezia*, University of Zimbabwe Press.

Campbell, B.M. 1987. Use of wild fruits in Zimbabwe. *Econ. Bot.* 41:375-385.

Campbell, B.M., M. Bowler, G. Chanda and C. Makuku. (in prep.). Degradation in Zimbabwe's communal areas.

Campbell, B.M. and R.F. du Toit. (in press). Vegetation patterns in a semi-arid savanna area in Zimbabwe, with special reference to the influence of peasant agricultural systems. *Kirkia.*

Campbell, B.M., R.F. du Toit and C.A.M. Attwell (Eds). 1989. *The Save Study: Relationships between the environment and basic needs satisfaction in the Save catchment, Zimbabwe.* Supplement to *Zambezia*, University of Zimbabwe Press. 119 pp.

Campbell, B.M., I. Grundy and F. Matose. (in press). Tree and woodland resources - the technical practices of small-scale farmers in Zimbabwe. In: P. Bradley and K. McNamara (Eds). *Living with trees: A future for social forestry in Zimbabwe.* World Bank, Washington.

de Jager, P. 1988. Environmental degradation in communal land. M.Sc. thesis, Department of Biological Sciences, University of Zimbabwe.

du Toit, R.F. 1985. Soil loss, hydrological changes and conservation attitudes in the Sabi Catchment of Zimbabwe. *Environmental Conservation* 12:157-166.

du Toit, R.F. and B.M. Campbell. 1989. Environmental degradation. In: B.M. Campbell, R.F. du Toit and C.A.M. Attwell (Eds). *The Save Study: Relationships between the environment and basic needs satisfaction in the Save catchment, Zimbabwe.* Supplement to *Zambezia*, University of Zimbabwe Press.

du Toit, R.F., B.M. Campbell, R.A. Haney and D. Dore. 1984. Wood usage and tree planting in Zimbabwe's Communal Lands. Report produced for the Forestry Commission of Zimbabwe and the World Bank. 187 pp.

Fergusson, R., D. Parry, S. Balebereho, B. Campbell, R. Cunliffe, I. Grundy and C. Rafangenysha. (in press). The agricultural systems in Mutanda Resettlement Area, Zimbabwe. *Zimb. J. Agric. Res.*

Gambiza, J. 1987. Some effects of different stocking intensities on the physical and chemical properties of the soil in a marginal rainfall area of southern Zimbabwe. M.Sc. thesis, Department of Biological Sciences, University of Zimbabwe.

Government of Zimbabwe. 1990. Project proposal for funding by the EEC. The Save Rehabilitation Programme: Environmental Monitoring in the Catchment. Department of Natural Resources. Unpublished report. 7 pp.

Grundy, I., B.M. Campbell, S. Balebereho, R. Cunliffe, C. Tafangenyesha, R. Fergusson and D. Parry. (in press). Availability and use of tress in Mutanda Resettlement Scheme, Zimbabwe. *Forest Ecology and Management.*

Muller, M.J. 1982. *Selected climatic data for a global set of standard stations for vegetation science.* Junk, The Hague. 253 pp.

Nyamapfene, K. 1991. *Soils of Zimbabwe.* Nehanda Publishers, Harare, Zimbabwe.

Reh, I., S.A.M. Van Oosterhout, B.M. Campbell and R.F. du Toit. 1989. Resource use and agricultural production. Pages 15-33. In: B.M. Campbell, R.F. du Toit and C.A.M. Attwell (Eds). *The Save Study: Relationships between the environment and basic needs satisfaction in the Save catchment, Zimbabwe.* Supplement to *Zambezia*, University of Zimbabwe Press.

Wild, H. and L.A.G. Barbosa. 1967. *Supplement to vegetation map of the Flora Zambesiaca Area.* Collins, Salisbury.

Williams, O. 1981. Irrigation farming in the south-east lowveld of Zimbabwe: Retrospect and prospect. *Geography* 66:228-232.

Wilson, K.B. 1990. Ecological dynamics and human welfare: a case study of population, health and nutrition in Southern Zimbabwe. Ph.D. thesis, University of London.

World Bank, 1991. Zimbabwe agricultural sector memorandum. Volume II: Main report. World Bank, Southern Africa Department, Agricultural Operations Division, Washington.

# Mid-Zambezi and Mana Pools: ecology and conservation status

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## Introduction

This paper is concerned with those land units of the Mid-Zambezi River system, which are particularly influenced by periodic or permanent inundation or saturation. While the term 'Upper Zambezi' is generally taken to refer to the section of river upstream of Victoria Falls, and 'Lower Zambezi' is taken to refer to the river below Cabora Bassa Dam, the term 'Mid-Zambezi' is not used consistently. The term is sometimes applied to the entire section between Victoria Falls and Cabora Bassa, while Zimbabwean usage of the term often refers only to the section between Kariba and Cabora Bassa. I adopt the broader, more widely used definition and briefly discuss the lake shore environment of Lake Kariba as well as the sandbank environment of the river and its flanking alluvial terraces downstream. I also describe the inland seasonal pans which occur on flat, sedimentary terrain in the region.

## Physical characteristics of the Mid-Zambezi Valley

Significant wetlands have not developed along the river between Victoria Falls and the upper reaches of Lake Kariba owing to the rapid fall of the river (over 280 m) through gorges in rocky terrain.

Lake Kariba, with a retention level of about 480 m above sea level, extends 300 km between Devil's Gorge and Kariba Gorge. Wave action along the convoluted shoreline has created either gently sloping sandy beaches, mud banks and platforms, or steep rocky banks, depending on local topography and geology. Wetland habitats form a smaller total area on the Zimbabwean side of the lake than on the Zambian side as the regional dip of the sedimentary rock strata is towards the southeast. The Zambian lake shore, therefore, consists mainly of gentle dip slopes while the Zimbabwean lake shore has a higher proportion of steep scarp slopes.

With the low rainfall (400-800 mm per annum) and high temperatures (17°C mean minimum and 35°C mean maximum), wetlands (apart from pans) are confined to a narrow, discontinuous strip along the shoreline zone, within which hydrological conditions are directly influenced by the lake.

Below Kariba Gorge, the Zambezi enters a down faulted trough, which is an extension of the Great African Rift system. Ancient rocks of the Basement Complex form escarpments which are up to 50 km apart and rise some 1,000 m above the valley floor. Younger Triassic sedimentary rocks (Karoo formation) comprise the valley floor, which is gently undulating between 350 m and 640 m above sea level. The Zambezi has deposited recent alluvial material throughout the valley floor while continually changing its course and is now moving closer to the Zambian escarpment. Block faulted outliers of the Basement rocks form the Chewore Hills at the eastern end of the trough, where the Zambezi has eroded Mupata Gorge through a process of superimposition.

Between Mupata Gorge and Kariba Gorge (which also consists of Basement rocks cut in the same manner), the Zambezi is broad (up to 3.5 km wide) and flows between numerous sandbanks and shifting islands. The alluvial deposits along this section of the river vary greatly in age, depth, texture and colour, and reflect past alterations in the river's channel as well as changes in the amount and type of sediments imported from the catchment. A 60 $km^2$ area of alluvium within the Mana Pools National Park is the most extensive on the southern side of the Zambezi. Large deposits have also accumulated at the mouths of the Sapi and Chewore Rivers. The Kafue River joins the Zambezi along this section as its major tributary.

## Hydrology of the Mid-Zambezi

The hydrological regime of the Zambezi is characterised by high variability in river flow within and between years. For instance, the maximum total annual inflow to Lake Kariba has been almost 100 $km^3$, with the minimum total annual inflow being about a quarter of this and mean inflow being about a half (the coefficient of variation is over 30%). Extreme recorded monthly flows show a ratio of 62:1 between maximum and minimum.

Of the river flow leaving the Mid-Zambezi section (generally 50-60 $km^3$ per annum, after evaporative losses from Lake Kariba), about 75% is contributed by the upper catchment and the remainder is contributed approximately equally by the Kafue River and by the rest of the tributaries below Victoria Falls.

Before Kariba Dam was built, the Mid-Zambezi had two flow peaks each year (du Toit, 1982 and 1983). The first (known to local people as 'gumbura') came around February; this was the lesser of the two, was characterised by dirty floodwater and came from rainfall in the local region (i.e. the catchment below Victoria Falls). The second, higher flood (known as 'murorwe') came around April, with clear water from the Upper Zambezi catchment and the Kafue catchment, and apparently lasted approximately two weeks.

# The wetland systems

## The lake shore habitats of Lake Kariba

The crucial influences on the lake shore habitats of Lake Kariba are the rate, timing andextent of seasonal drawdown and lake rise. These factors vary in accordance with the natural pattern of inflows and with the hydroelectric power management regime.

Much of the shoreline zone is covered with a sward of the grass *Panicum repens*, which developed within a decade of impoundment despite retardation of its rate of colonisation by considerable fluctuations in lake level. This species mingles with other inland grasses on dry soil, occupies most of the soak zone and thrives in water up to 1 m deep (Donnelly, 1969). Other common plants of the Kariba shoreline community (e.g. *Polygonum* spp., *Cyperus* spp., and *Ludwigia stolonifera*) have evolved means to cope with the great seasonal variation in water availability. But *P. repens* is exceptional in being able to survive for a year or more underwater (Kenmuir, 1978) as well as growing through the dry season, by virtue of its subsurface stolons which enable it to resist desiccation.

The normal annual pattern of rise and fall of the lake is characterised by increasing lake levels over the December to January period, coinciding with local precipitation. The rate at which the lake rises increases rapidly during February-May, with the delayed floodwater contribution of the Upper Zambezi. From mid-year, the lake falls steadily through the dry season.

As the lake falls, terrestrial or semi-aquatic vegetation grows on the soak zone, forming a green fringe at a time when the inland plant communities are dehydrated and unproductive. This plant growth is encouraged by high soil moisture, warm conditions, nitrogen flushing (release of plant-available nitrates through aerobic decomposition) and release of other nutrients from oxidising organic matter. The shoreline vegetation constitutes a crucial dry season food resource for herbivorous animals (buffalo, impala, elephant, hippopotamus and other wild mammals on the Zimbabwean shores, and livestock on the Zambian shores). Taylor (1989) described the seasonal utilisation of *Panicum* pastures by buffalo in Matusadona National Park in the late dry season. The concentration of large mammals around the shoreline provides a major attraction for the expanding tourist industry.

Because *Panicum* is quick growing and can tolerate considerable variation in soil moisture, the grassland is remarkably resilient to fluctuations in lake level. However, beds of submerged hydrophytes are far more sensitive to the rate of flooding or drawdown. Light penetration is insufficient to support plant growth below 10-12 m underwater. If the lake rises too quickly, the major hydrophytes (*Lagarosiphon ilicifolius*, *Ceratophyllum demersum*, *Najas pectinata* and *Potamogeton* spp.) are reduced through photo-extinction, while too rapid a drop may exceed the rate at which these plants can spread to deeper water.

Maintenance of dense beds of submerged hydrophytes is vital to fisheries production; these beds play a major role in nutrient cycling through primary production, the provision of a substrate for primary and secondary production, and the provision of cover to enable juvenile fish to evade predators (Bowmaker, 1975). Cichlids, mormyrids, labeos and other inshore fish species up to a length of about 18 cm are susceptible to predation by the tigerfish, *Hydrocynus forskalli* (previously known as *H. vittatus*) (Donnelly, 1969) and therefore need the shelter of weed beds.

While a fairly constant lake level may be conducive to the maintenance of these hydrophyte beds, moderate seasonal fluctuations in lake level are beneficial to the overall productivity of the lake, particularly to fisheries, because they promote nutrient cycling. When the lake falls, the hydrophytes growing in shallow water are stranded and decompose, together with vast quantities of invertebrates (particularly mussels), thus enriching the drawdown substrate. Storks, ibises, waders and other birds benefit from the seasonal food resource provided by freshly exposed invertebrates. The terrestrial vegetation which spreads over the drawdown zone attracts mammals whose excretory products accumulate in this area. When the lake rises, nutrients released from the flooded organic matter promote primary production, as well as explosive growth of the zooplankton population, and fisheries production is thereby enhanced. The herbivorous cichlid, *Tilapia rendalli*, which is of considerable commercial value, is able to feed directly on *P. repens* when it is flooded.

Nutrient cycling along the shoreline is of particular importance because the nutrient level of Lake Kariba is constrained by two major factors. Firstly, despite contributing over three quarters of the annual inflow to the lake, the Zambezi River brings in a relatively low load of nutrients owing to the large proportion of insoluble and mineral poor rocks and soils in the Upper Zambezi catchment (Balon, 1974) as well as to the filtering action of the Barotse and Chobe Swamps (Mitchell, 1973). Secondly, the lake has a very high annual throughflow relative to its volume (a ratio of 1:3) and thus there is a major loss of nutrients via turbine discharges. This loss is intensified by the fact that the turbines draw nutrient-rich bottom waters during much of the year when the lake is stratified.

To provide the beneficial effects of nutrient cycling while not constraining the growth of hydrophyte beds, it appears desirable that the pattern of rise and fall in lake level approximates the natural hydrological regime, with the lake rising from December to mid-year and falling thereafter. Bowmaker (1973) suggested that a fully developed, multi-species community of littoral vegetation is only possible provided the half cycle amplitudes of lake level fluctuation do not exceed 3.5 m and provided that the rate of fluctuations does not exceed 0.6 m rise or fall per month. The experience of recent changes in the level of Lake Kariba during a series of drought years suggests that the littoral plant communities are now somewhat more resilient to the extent and rate of fluctuation than was suggested by Bowmaker, but the timing of recession and flooding is crucial. The dynamics of the wetland system of the Kariba lake shore clearly warrant further research.

## The river and alluvial terraces below Kariba

The river has a braided form through much of its course between Kariba Gorge and its confluence with the Chewore River. Prior to the construction of Kariba

Dam, rooted macrophytes were scarce apart from flood resistant species such as *Phragmites mauritianus* (Jackson, 1961), but the more regular river flow in recent years has induced a considerable increase in *Lagarosiphon ilicifolius* and *Ludwigia stolonifera*. Floating macrophytes collect in small inlets, side channels and cut off meanders; these macrophytes include Water Hyacinth (*Eichhornia crassipes*), Kariba weed (*Salvinia molesta*) and *Azolla* spp. This braided river section also includes expanses of grassland with *Panicum repens*, *P. coloratum*, *Cynodon dactylon*, *Paspalum scrobiculatum* and *Echinochloa colona* constituting major food resources throughout the year for concentrations of wild grazing animals (notably buffalo, hippopotamus and elephant). The sandbanks are one of Zimbabwe's major crocodile breeding areas and are also the habitat of water birds such as the Whitefronted Plover, Whitecrowned Plover, Water Dikkop and African Skimmer. Within this system of braided channels, sandbanks and islands of consolidated alluvium, the complex web of ecological relationships is typical of other wetland systems along major African rivers.

The vegetation communities on alluvial terraces flanking the river are dominated by *Faidherbia albida* (previously known as *Acacia albida*) trees, which form extensive woodlands on lower, sandier alluvial deposits and which mix with a variety of other tree species (such as *Trichilia emetica*, *Kigelia africana*, *Lonchocarpus capassa* and *Combretum imberbe*) on higher, more consolidated sediments. These alluvial woodlands constitute a dry season concentration zone for large mammals (such as elephant, buffalo and impala). This is because plant productivity is greater and more prolonged, and shade and water are more abundantly available in this area in the late dry season than on the rest of the valley floor and escarpments (Jarman, 1972). Within the woodland are a series of elongated pools, lying along cut off river channels which contain numerous hippopotamuses and crocodiles. The riverine habitats are an important staging area for migratory waterbirds and provide refuges for several rare species (such as Nicator, Livingstone's Flycatcher and Rufousbellied Heron).

The extent to which these alluvial woodlands constitute a wetland or floodplain system is contentious. It has been stated that the establishment and regeneration of the woodlands was dependent upon regular flooding of the Zambezi. The present absence of significant regeneration has thus been ascribed to the cessation of flooding after the construction of Lake Kariba (Attwell, 1970; Magadza, 1981), since inundation and silt deposition were thought to be required for the growth of seedlings. However, analysis of information on river flows prior to the damming of the river suggests that flooding was not a regular annual event and only occurred infrequently, probably when late local catchment floods were superimposed upon early floods from the upper catchment (du Toit, 1983). Regeneration of *F. albida* and other alluvial trees is occurring on islands and on other patches of alluvium where the browsing pressure of animals is reduced, suggesting that such pressure is a major influence on regeneration. The situation is complicated by an increase in termite activity resulting in consumption of a considerable proportion of the herbaceous layer; this may be partly due to reduced flooding allowing termites to colonise new areas (Dunham, 1989).

Apart from the lack of woodland regeneration, which is a common situation in African floodplain forests (Hughes, 1988), another aspect of concern is the rate of river bank erosion below Kariba. From the analysis of aerial photographs, Guy (1981) demonstrated a major loss of alluvium along the frontage of the Mana Pools National Park, and Nugent (1983) confirmed a doubling in the width of the river in several sections of alluvium after the construction of the dam and prior to 1981. This erosion is ascribed to several features of the discharge regime at Kariba Dam, including heavy floodgate spillage during the dry season when river bank vegetation affords little protection against erosion, and sudden drops in river level caused by closure of floodgates. Since Kariba and Kafue Dams now act as silt traps, and eroded alluvium is therefore not fully replaced by fresh sediment, it is to be expected that the river bank erosion will continue until the river reaches a new equilibrium profile, as appears to have now happened along several sections of the river (Nugent, 1983).

### Inland pans

Between the Zambezi River, or Lake Kariba, and the escarpments are extensive woodlands of *Colophospermum mopane*, occurring on fine to medium grained sands which overlie compacted, almost impervious, sodic horizons. During the rainy season, small depressions on flatter parts of the valley floor become inundated to form numerous seasonal pans. For much of the year, such pans provide feeding and breeding sites for invertebrates, amphibians and birds, as well as satisfying the watering and wallowing requirements of large animals within the wildlife reserves. The majority of pans are no more than a hectare in extent and are ephemeral but some larger ones may retain water throughout the year, depending on rainfall. The lungfish (*Protopterus amphibius*) is adapted to survive in these pans. Thorough investigation of the ecology of these pans would be rewarding.

## Conservation status and management of the Mid-Zambezi system

On the Zimbabwean side of the Mid-Zambezi, the land is almost entirely designated as either Safari Area or National Park; there are wildlife reserves to the south of Lake Kariba, in addition to the Recreational Park extending around the shoreline of the lake. This land use designation obviously affords considerable protection to the wetland ecosystems but significant conservation problems still exist.

The major issue associated with conservation of these wetlands is hydroelectric development. Soon after Zimbabwe's independence, considerable attention was paid to the possibility of an additional hydroelectric scheme at Mupata Gorge, which would have involved the inundation of the entire Mid-Zambezi alluvial system. While hydroelectric development led to the creation of valuable wetland habitats around the shoreline of Lake Kariba, the Mupata Gorge scheme threatened to eradicate the remaining large-river habitats and alluvial woodlands, which are poorly represented elsewhere in Zimbabwe. The potential loss of environmental diversity was described in an environmental impact assessment of the Mupata Gorge scheme (du Toit, 1982); this report suggested that the alternative Batoka Gorge scheme, between Victoria Falls and Lake Kariba, would be less costly in environmental terms. For engineering reasons, the Mupata Gorge scheme has in fact been shelved in favour of the Batoka Gorge scheme, which is currently the subject of renewed feasibility studies.

Whether the Batoka Gorge scheme is built or whether the Kariba scheme remains as the only control on the Mid-Zambezi, considerable attention must be paid to the integration of ecological and engineering concerns to ensure an optimum regime of lake level fluctuations and downstream discharges. I have previously outlined the need for a moderate drawdown of Lake Kariba during the hot, dry season in order to stimulate primary and secondary production around the lake shore. However, excessive discharge from Lake Kariba during this period is not desirable since the increased river flow would be out of phase with the seasonal adaptations of many of the downstream biota and would accelerate river bank erosion.

As a consequence of a series of drought years and the need to make efficient year round use of available water in meeting Zimbabwe's growing electricity demand, there have been no floodgate discharges from Kariba Dam during the past decade; all discharge has been via the turbines. The trend towards greater and more constant turbine discharge has been reflected in an increasingly regulated downstream river flow. It can be anticipated that the monthly river flow will change to an even less natural pattern when the Batoka Gorge scheme comes into operation. This is because Batoka Gorge has minimal storage capacity and will be operated as a 'run-of-river' scheme, generating a considerable proportion of Zimbabwe's electricity during the period of high river flow (February-June). Water stored in Lake Kariba during this period will then be released via the Kariba turbines in order to maintain the combined output of the two schemes through the hot, dry season. This will entail a much more rapid drop in the level of Lake Kariba than presently occurs, along with greater downstream river flow during this period, which is undesirable. These effects will constitute some of the major environmental impacts of the Batoka Gorge scheme and require detailed investigation as feasibility planning of this scheme proceeds.

Apart from the effects of hydroelectric power generation, the major conservation problems affecting the Mid-Zambezi wetlands are pollution and uncontrolled exploitation of lake shore resources and inshore fisheries along the settled areas of Lake Kariba. A land use plan for the Kariba shoreline is presently being elaborated and, if forcefully implemented, will hopefully reduce these problems through appropriate zonation of human activities. However, the equally contentious and more insidious problem of pollution (due particularly to spraying of pesticides during agricultural and tsetse control operations) has not abated despite occasional outbursts of public concern.

## References

Attwell, R.I.G. 1970. Some effects of Lake Kariba on the ecology of a floodplain of the mid-Zambezi Valley of Rhodesia. *Biological Conservation* 2:189-196.

Balon, E.K. 1974. Fish production of a tropical ecosystem. Pages 249-573. In: E.K. Balon and A.G. Coche (Eds). *Lake Kariba: A Man-Made Ecosystem in Central Africa.* Dr. W. Junk, The Hague.

Bowmaker, A.P. 1973. Hydrophyte dynamics in Mwenda Bay, Lake Kariba. *Kariba Studies* No. 3:42-59.

Bowmaker, A.P. 1975. Fisheries productivity of Lake Kariba. *Tobacco Forum* 2:17-25.

Donnelly, B.G. 1969. A preliminary survey of *Tilapia* nurseries on Lake Kariba during 1967/68. *Hydrobiologia* 34:195-206.

Dunham, K.M. 1989. Long-term changes in Zambezi riparian woodlands, as revealed by photopanoramas. *Afr. J. Ecology* 27:263-275.

du Toit, R.F. 1982. A preliminary assessment of the environmental implications of the proposed Mupata and Batoka Hydro-Electric Schemes: Zambezi River, Zimbabwe. Natural Resources Board, Harare, Zimbabwe.

du Toit, R.F. 1983. Hydrological changes in the Middle-Zambezi system. *Zimbabwe Science News* 17:121-126.

Guy, P.R. 1981. River bank erosion in the Mid-Zambezi Valley, downstream of Lake Kariba. *Biological Conservation* 19:199-212.

Hughes, F.M.R. 1988. The ecology of African floodplain forests in semi-arid and arid zones: a review. *J. Biogeography* 15:127-140.

Jackson, P.B.N. 1961. Ichthyology, the fish of the middle Zambezi. *Kariba Studies* No. 1:1-36.

Jarman, P.J. 1972. Seasonal distribution of large mammal populations in the unflooded Middle Zambezi Valley. *J. Applied Ecology* 9:283-299.

Kenmuir, D. 1978. *A Wilderness Called Kariba.* Mardon Printers, Harare. 140 pp.

Magadza, C.H.D. 1981. Editorial - Mana Pools. *Zimbabwe Science News* 15:110.

Mitchell, D.S. 1973. Supply of plant nutrient chemicals in Lake Kariba. Pages 165-169. In: W.C. Ackermann, G.E. White and E.B. Worthington (Eds). *Man-Made Lakes: Their problems and Environmental Effects.* American Geophysical Union, Washington.

Nugent, C. 1983. Channel changes in the Middle Zambezi. *Zimbabwe Science News* 17:127-129.

Taylor, R.D. 1989. Buffalo and their food resources: the exploitation of Kariba lakeshore pastures. *Symposiums of the Zoological Society of London* 61: 51-71.

# The ecology and conservation status of the Save-Runde floodplain

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## Introduction

The Save-Runde floodplain covers approximately 4,000 ha and is one of the two major floodplains in Zimbabwe, the other being the Mana Pools floodplain. It is located in the southeast of the country at the confluence of the Save and Runde Rivers.

Although the floodplain is important in many aspects, unfortunately very little is known about its ecology. Reviews by Hughes and Hughes (1992) and Chabwela (1991) provide the basic information for this paper. A number of issues are related to the conservation of the floodplain and suggestions are made on which measures should be considered for its management.

## Location and features

The Save-Runde floodplain is located between 32°15'-32°30'S and 21°15'-21°20'E. The elevation ranges from 350 m to 450 m, making it the lowest point in Zimbabwe. Much of the floodplain lies within the Gonarezhou National Park while the eastern boundary is inhabited by communal people.

The Save-Runde wetland is characteristic of small floodplains belonging to the middle aged rivers and has the following characteristics:

- The floodplain has been built up by deposition of eroded material, which is laid down when the velocity of the river falls as it leaves the escarpment and enters the plain. Its size is limited by the surrounding hills.
- Abandoned river channels are numerous in the floodplain.
- The river is seasonal with significant variation in water levels between years.
- The wetland is highly vulnerable and likely to be short lived.

Wetlands in the area include the Tamboharta, Masikindolo, Chinguli, Masungani, Chipinda, Mapalapi, Mavumalani, Malindo and Machiteti Pools and the Rupembi swamp (Mozambique).

## Ecology

As the floodplain occurs in the lowland area, the surrounding vegetation is of the dry 'mopane' type. This is usually characterised by drought resistant species such as *Acacia* spp., *Adansonia digitata*, *Boscia* spp., *Cadaba* spp., *Capparis* spp., *Commiphora* spp., *Colophospermum mopane*, *Sterculia africana*, *Tamarindus indica*, *Salvadora* sp. and *Ximenia americana.* A further botanical list is given in Hughes and Hughes (1992).

In some cases 'mopane' is complemented by a number of river valley species such as *Combretum imberbe*, *C. fragrans*, *C. obovatum*, *Ostryoderris stuhlmannii*, *Lannea stuhlmannii*, *Sclerocarya caffra* and *Piliostigma thonningii.* In situations where the riparian vegetation is reasonably developed, the vegetative cover may include species such as *Diospyros mespliformis*, *Mimosa* sp., *Oncoba spinosa*, *Borassus aethiopum* and *Hyphaene ventricosa*, *Ficus* sp. and *Acacia albida.* Species composition is determined by the type of the alluvium, moisture, frequency of the flooding, topography and disturbance.

In areas where macrophytes are not well developed, *Phragmites* and *Echinochloa* may be present; in some areas *Pennisetum*, *Panicum* and *Digitaria* are common on river banks. Most plant species are those that are successfully adapted to the erratic behaviour of the river.

Common mammals, as listed by Hughes and Hughes (1992), include *Aonyx capensis*, *Atilax paludinosus*, *Dasymys incomtus* and *Galago senegalensis*. Large mammals occur in areas of minimal disturbance and include African Elephant (*Loxodonta africana*), Black Rhinoceros (*Diceros bicornis*), Cape Buffalo (*Syncerus caffer*) and various carnivores (IUCN/UNEP, 1987).

Most bird species occurring in the floodplain are woodland species but water fowl visit the ponds (see Hughes and Hughes, 1992, for more detail).

Fish species recorded in the area include Tilapines, *Hydrocyon vittatus*, *Nothobranchius* sp. and *Protopterus annectens* (Hughes and Hughes, 1992).

## The importance of the floodplain

Wetland functions, products and attributes have been discussed by a number of authors (Sather and Smith, 1984; Dugan, 1990; Chabwela, 1991). While very little is known about this floodplain, significant wetland values include biodiversity, wildlife habitat and the potential for fisheries development, water supply to communities, and tourism.

Wetlands are important in Zimbabwe from a number of considerations (Chabwela, 1991):

1. Water is relatively scarce in Zimbabwe and wetlands serve as reservoirs for dry season supply.
2. Wetland sites are generally small in size, and are consequently highly vulnerable, but they are widely distributed in Zimbabwe. If conserved, their potential for diversified utilisation would be great.
3. The government has encouraged the expansion of cash crop production which would need reliable sources of water for irrigated agriculture.
4. Zimbabwe is deficient in fish protein and wetlands are major areas where fish can be produced.
5. Although Zimbabwe usually receives sufficient rainfall, it nevertheless has a high risk of drought. The water stored in wetlands helps to minimise these risks.

The Save-Runde floodplain is an important wetland for utilisation by wildlife as it is largely located within the Gonarezhou National Park, an important wildlife habitat. The community inhabiting the Save River on the eastern bank is in many ways directly benefitting from this floodplain.

## Threats to the floodplain

Potential threats to global wetlands have been discussed by Dugan (1990) and threats to Zimbabwe's wetlands by Chabwela (1991).

Although the National Park affords some protection to the floodplain it is nevertheless under considerable threat. The damming of both rivers and their tributaries in the catchment area, for both irrigation and domestic uses, has significantly reduced the channel flow of both rivers. Reduction of vegetation cover in the catchment area, due to large scale deforestation, may cause severe erosion in the highlands and siltation in the lowland areas. There is pressure on land from the growing population; this is most apparent in the eastern Save and in the watershed area. Drought is a major problem in the lowland area. A combination of drought and damming has a considerable effect on the structure and function of the floodplain.

## Future plans

The management of the floodplain should not be concentrated at the site but should involve the entire catchment. For the most part, management plans should emphasise the importance of wetlands to the National Park and to the immediate community. Since much of the hydrological system has been severely disturbed, it is necessary to rehabilitate the system and to explore ways to reduce the effects of the current activities in the catchment.

## References

Chabwela, H.N. 1991. *Southern Africa wetlands conservation programme.* Report document. IUCN, Harare, Zimbabwe. 687 pp.

Dugan, P.J. (Ed.). 1990. *Wetland conservation: a review of current issues and required action.* IUCN, Gland, Switzerland. 96 pp.

Hughes, R.H. and J.S. Hughes. 1992. *A Directory of African Wetlands.* IUCN, Gland, Switzerland and Cambridge, UK /UNEP, Nairobi, Kenya /WCMC, Cambridge, UK. xxxiv + 820 pp., 48 maps.

IUCN/UNEP. 1987. *The Directory of Afrotropical Protected Areas.* IUCN, Switzerland and Cambridge, UK. xix + 1034 pp.

Sather, J.H. and R.D. Smith. 1984. *An overview of major wetland functions and values.* U.S. Fish and Wildlife Service, Washington DC, USA.

# A review of the hydrology of dambos in Zimbabwe

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## Introduction

A 'wetland' is defined as an area that is permanently or temporarily covered with water that may or may not be flowing; it may be of natural or artificial origin. Examples of wetlands are marshes, fens, peatlands, swamps, rivers and natural or artificial lakes. This definition includes almost all surface water bodies and therefore covers some of the major global water resources.

In Zimbabwe, riverine wetlands, artificial water reservoirs and dambos are found. While the hydrological processes of most wetlands occurring in Zimbabwe are reasonably understood, the hydrological processes within dambos have not been properly researched. This is partly the result of legislation that prevents the utilisation of dambos and the pre-occupation of hydrologists with problems of assessing the other water resources. Recently there have been several studies aimed at understanding the hydrological functions of dambos (Balek and Perry, 1973; Dambo Research Unit, 1987; Bullock, 1988). The results of these studies are reviewed in this paper.

## Dambo characteristics

The literature suggests several definitions of dambos, some which are contradictory. Whitlow (1984) defined a dambo as a valley grassland that is seasonally waterlogged, is characterised by a distinctive grass and sedge flora and is without trees. Other authors have emphasised that a true dambo has no trees, while some are of the view that dambos have no streams. The differences in these definitions are due to the authors' emphasies on features that may be local to the dambos they studied. After reviewing several definitions and the characteristics of dambos in Zimbabwe, Bullock (1988) suggested the following definition for dambos in Zimbabwe:

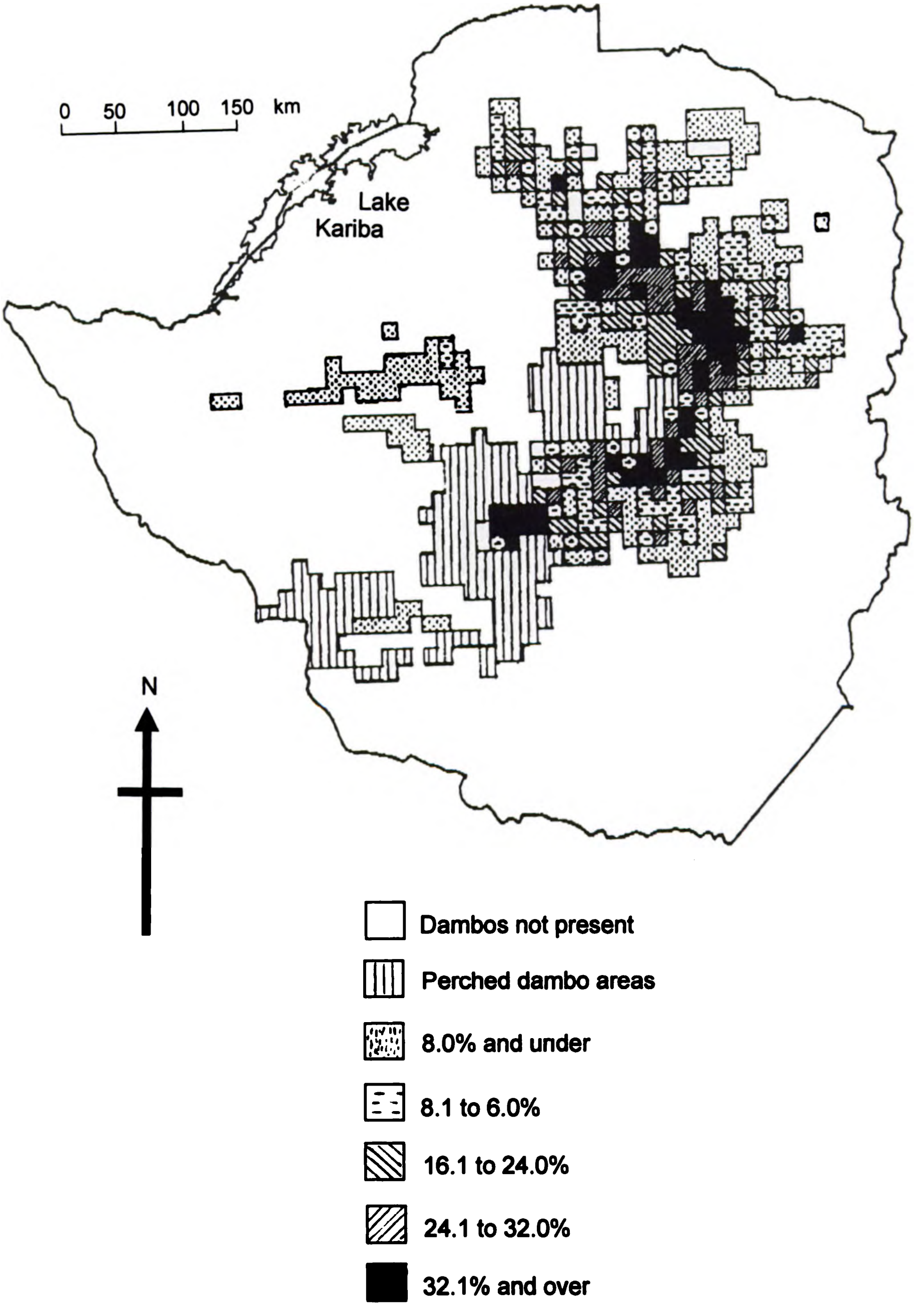


Figure 1 Distribution of dambos in Zimbabwe (Adapted from: Whitlow, 1984)

> "a grass-covered, generally treeless, periodically inundated valley bottom of hydromorphic soil containing a poorly defined stream channel, which is associated with the wooded, gently undulating plains of the post-African planation surfaces."

This definition is regarded as being representative of the variations in dambo features within Zimbabwe. In addition, the definition takes cognisance of the fact that dambos are dynamic, and thus can change their features.

It has been observed that dambos are not internally homogenous but that three zones can be identified within a dambo. These are the interfluve, dambo periphery, and the dambo itself which occupies the bottom of the valley. The interfluve is characterised by sandy soils which are covered by 'miombo' woodland. The dambo periphery is a seepage zone with moist soils that are often vegetated by species of *Andropogon* and *Eragrostis*. At the centre is the dambo which may be dry and without a stream.

Figure 1 shows the distribution of dambos based on provisional mapping undertaken by Whitlow (1984). Dambos cover 3.6% of Zimbabwe and 84% of them occur on gneiss and intrusive granitic rocks. Most dambos are found in areas with an altitude above 1,200 m on the central watershed and are associated with a mean annual rainfall greater that 800 mm.

## Hydrological functions of dambos

Various models have been proposed to explain the hydrological functions of dambos. The most commonly held belief is that a dambo behaves like a sponge that stores large quantities of water during the rainy season and then releases this water during the dry season. Dambos are therefore believed to maintain dry season flows. This model is based on the assumption that since dambos are often waterlogged, even during the dry season, they must store water for subsequent release and that catchments with dambos have aquifers with both high storage and transmissivity.

Dambos have also been assumed to increase the catchment yield. This assumption is based on the fact that since dambos become saturated during the rainy season they promote the formation of runoff. Dambos are supposed to ameliorate river flows during floods by overbank storage, and the resistance of grass to water movement. It has also been suggested that the time to peak of flood flows is reduced.

The validity of the above statements, which have in most cases been intuitively derived, has not been questioned and legislation controlling the utilisation of dambos in Zimbabwe has been based on these beliefs. Legislation restricts the cultivation of dambos as it is thought that this will lead to reduction in the catchment yield and, most importantly, of the dry season flows of rivers draining dambos. Obviously this would have adverse effects on the downstream water users. The validity of these assumptions is examined below in the light of recent studies undertaken on dambo catchments. This is not only important for theoretical reasons but will enable rational utilisation of the dambos.

## Effect of dambos on catchment yield

The effect of dambos on catchment yield was examined on four experimental Luano catchments in Zambia. From the analysis of the data collected, Balek and Perry (1973) concluded that the proportion of the catchment covered by dambos had no effect on the annual volume of runoff. The variability of the annual runoff was explained by rainfall. Evapotranspiration losses within the seepage zone and from the 'miombo' woodland were also found to reduce the catchment yield. The importance of the evapotranspiration losses in the water balance of dambo catchments was observed by the Dambo Research Unit (1987).

In Malawi, Hill and Kidd (1980) undertook a regional analysis of flows, and concluded that dambos reduced the catchment yield. According to their data, for every 1% increase in the area of the catchment under dambo, the yield decreased by 6.4 mm due to the evapotranspiration losses.

Bullock (1988) used 108 catchments in Zimbabwe to examine the effect of dambos on yields. Within these catchments, the area covered by the dambo varied from 0.3% to 62.9% with a mean of 14%. Dambos were found to have no significant effect on catchment yield in Zimbabwe. These findings contrast with the conventional wisdom that dambos increase the catchment yield.

## Effect of dambos on dry season flows

The studies on the Luano catchments by Balek and Perry (1973) led to the conclusion that dambos had no effect on both the magnitude and duration of the dry season flows. The depletion of the groundwater storage was not due to reduced base flows but to evapotranspiration losses. Studies on the rooting depth of trees within these catchments revealed that for the 'miombo' woodland, the rooting depth was 7 m or greater, enabling trees to extract water from the aquifers. According to Balek and Perry, the relative importance of the evaporative losses will determine if streams draining the dambos will be perennial or intermittent. They observed that the groundwater storage of dambo catchments was minimal.

Drayton and co-workers (1980) examined the relative importance of base flows on 52 catchments containing dambos in Malawi and concluded that dambos had no effect on the magnitude and duration of dry season flows. Similar findings were made by Meigh (1988) using 27 catchments in Zimbabwe and Malawi.

In Zimbabwe, Bullock used the base flow index (BFI) to determine the relative importance of base flows from catchments with dambos. The BFI is the ratio of the annual volume of base flows to that of the total runoff. On the 49 catchments studied, BFI was found to vary from 0.09 to 0.60 with a mean of 0.34. Thus on average 34% of the total flow on these catchments originated from stored sources, such as soil moisture and groundwater. The BFI was found not to be related to dambo density. Soil type seemed to be the only factor that could explain the variations in BFI, which tended to be high on catchments with a deep regolith.

Bullock (1988) found that a dambo density of less than 15% had no effect on low flow characteristics. Above this threshold, an increase in the dambo density tended to decrease the low flows. For example, a 5% increase in dambo density would result in about a 10% increase in the duration of zero flows. Similarly an increase in dambo density above this threshold decreased the mean six-monthly minimum flows. Other low flow measures, such as mean annual minimum flows, were not affected by the dambo density.

The above findings clearly show that the simple, sponge model of the dambo is invalid. Dambos in fact decrease both the magnitude and duration of the dry season flows. The clayey soils within dambos inhibit any upward movement of water from below into the dambo. Any lateral subsurface flow from the interfluve towards the dambo will be discharged into the seepage zone and this water will be lost by evapotranspiration.

## Effect of dambos on storm flows

On the basis of their studies on the Luano catchments in Zambia, Balek and Perry (1973) concluded that dambos delayed the formation of storm flows due to soil moisture deficit. However, once the soils within a dambo catchment have become saturated, the dambo then promotes the formation of storm flow. According to these observations, an increase in dambo density within a catchment should cause an increase in the proportion of precipitation which becomes storm runoff. Due to the high rainfall in the region studied in Zambia, about 1,270 mm/year, saturation occurs every year resulting in storm flow generation.

In Malawi, Drayton and co-workers (1980) concluded that dambos reduced and damped peak flows due to overbank storage within the dambo catchment. This conclusion, which contradicts that of Balek and Perry (1973) was based on a regional flow analysis.

Bullock examined the effects of dambos on the relative importance of storm flow contributions and the characteristics of flood flows in central Zimbabwe. Storm flow index (SFI) was derived for 39 catchments with daily flow data (SFI=1-BFI). The SFI revealed that stream flows in Zimbabwe are dominated by storm flows and that 87% of the catchments analysed had SFI values greater than 0.5. There was no relationship between SFI and the proportion of the catchment under dambo; on permeable soils, there was a tendency for the SFI to decrease. Flood characteristics, such as mean annual peak flows, were studied for 79 catchments. The proportion of dambos within a catchment did not explain the variability of the flood characteristics which rather reflected the annual rainfall and catchment area. There was no evidence of damping of peak flows.

The above observations contradict the conclusion of Balek and Perry (1973) that dambos increase the proportion of storm flows and imply that the partial contributing area concept of storm flow formation is not valid for dambo catchments. In addition, dambos in Zimbabwe do not reduce storm flows due to overbank storage as proposed by Drayton and others (1980).

## Runoff formation

The above discussion has revealed that the simple sponge model of a dambo is not valid. It is therefore necessary to gain an understanding of the formation of runoff on dambos to enable their optimum utilisation without endangering the environment. The relevance of four widely accepted models of runoff formation to the situation in Zimbabwe is discussed below.

### Hortonian overland flow

The absence of micro-drainage features on dambos indicates that the Hortonian overland flow model is not applicable to dambos in Zimbabwe. Infiltration rates measured by the Dambo Research Unit on some dambos were greater than 80 mm/hr, which implies that for the formation of overland flow, storms with intensities greater than this value would be required. Such storms do not occur frequently in Zimbabwe.

### Partial contributing area

According to the partial contributing area concept, the rainfall intensity exceeds the infiltration capacity in specific parts of the drainage basin resulting in the formation of runoff. But as already pointed out, this is not possible for most storms that occur within Zimbabwe.

### Variable source area

The variable source area concept proposes that direct precipitation on soil saturated from below will result in the formation of runoff. This model has been found to be valid in humid regions and may be valid for dambos in areas with heavy rainfall such as in Zambia. In Zimbabwe the water table of dambos fluctuates during the rainy season, implying that dambos are not always saturated during this period. Runoff formation, according to the variable source area concept, is not possible without saturation.

### Through flow

An examination of the soil profiles on dambos in Malawi and Zimbabwe revealed that the upper sandy colluvium is underlain by a relatively impermeable clayey horizon. The high infiltration capacities of the interfluve cause most of the rainfall to be absorbed into the soil and then form inter-flow. Within the dambo periphery, sandy soils give way to clayey soils which impede lateral through flow and cause the flow to move to the surface. Within the valley bottom, the dambo proper, the soils become impermeable as they expand, resulting in the formation of runoff. Thus while the dambo is important in runoff formation, it also receives inputs from the interfluve. The lack of a relationship between the dambo density and the proportion of runoff that is storm flow suggests that the interfluve and the dambo are equally important in runoff formation.

During the dry season, there is sub-surface flow from the interfluve towards the dambo. This water will be discharged in the dambo periphery due to the relatively impermeable clayey soils. It does not make any significant contribution to the dry season flows since most of it is lost through evapotranspiration. Satellite imagery studies of the distribution of actual evapotranspiration within dambo catchments (British Geological Survey, 1989) showed that the actual rate of evapotranspiration compared with the potential evapotranspiration in the dambo periphery or seepage zone was 80%, while within the dry dambo the rate was 64%. Any deep sub-surface flows from the interfluve towards the dambo are unlikely to be discharged within the dambo, due to the impermeable clayey soils covering the dambo, and will be discharged outside the dambo.

## Conclusion

This review of recent studies on dambos has shown that the sponge model of the dambo is incorrect in Zimbabwe. Dambos have no effect on catchment yields or characteristics of both dry season flows and storm flows. High evapotranspiration losses within the seepage zone suggest that dambos are important in returning water to the atmosphere, rather than contributing to river flows. Although process oriented studies on dambos have still to be undertaken, it seems that through flow is important in the formation of runoff within dambos.

## References

Balek, J. and J.E. Perry. 1973. Hydrology of seasonally inundated African headwater swamps. *J. Hydrol.* 19:227-249.

British Geological Survey. 1989. The basement aquifer research project 1984-89. Final report to the Overseas Development Administration.

Bullock, A. 1988. Dambos and discharge in central Zimbabwe. Ph.D. thesis, University of Southampton, United Kingdom.

Dambo Research Unit. 1978. The use of dambos in rural development with reference to Zimbabwe. Loughborough University and University of Zimbabwe.

Drayton, R.S., C.H.R. Kidd, A.N. Mandeville and J.B. Miller. 1980. A regional analysis of river floods and low flows in Malawi. Institute of Hydrology, Wallingford, United Kingdom.

Hill, J.L. and C.H.R. Kidd. 1980. Rainfall-runoff relationships for 47 Malawi catchments. Report No. 47, Water Resource Branch, Government of Malawi.

Meigh, J.R. 1988. Low flow analysis of elected catchments in Malawi and Zimbabwe. Preliminary report on the Basement Aquifer Project. Institute of Hydrology, Wallingford, UK.

Whitlow, J.R. 1984. A survey of dambos in Zimbabwe. *Zim. Agric. J.* 814:129-138.

# Ecology and management of the Manyame lakes

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## Introduction

The Manyame lakes are a group of four man-made reservoirs on the upper Manyame River and one on the Mukuvisi River which is a tributary of the Manyame. They were all built to provide water for the City of Harare, as well as Chitungwiza and Norton, and they vary considerably in size and age (Table 1). The most important factor in their ecology is eutrophication, resulting from the presence of large urban areas within their catchments (Figure 1), and its effects on water quality. Lake Chivero is the most eutrophic because it receives sewage effluent from Harare and Chitungwiza and, consequently, its ecology has been studied in some detail (Thornton, 1982). Much less is known about the others

Table 1 Morphometric characteristics, at full supply level, of the Manyame lakes

| | Date of construction | Area (ha) | Volume ($m^3 \times 10^6$) | Max. depth $Z_{max}$ (m) | Mean depth $\bar{Z}$ (m) |
|---|---|---|---|---|---|
| Cleveland | 1913 | 30 | 1.00 | – | 3.3 |
| Seke (Prince Edward) | 1929 | 109 | 3.64 | 10.0 | 3.3 |
| Harava (Henry Hallam) | 1973 | 215 | 9.25 | 17.5 | 4.3 |
| Chivero (McIlwaine) | 1952 | 2,630 | 250.04 | 27.4 | 9.5 |
| Manyame (Robertson) | 1976 | 8,100 | 490.00 | 22.6 | 6.0 |

Note: The pre-1990 names of these lakes are inserted in parentheses because they are used in most of the literature

Sources: Thornton (1980); Ministry of Energy and Water Resources Development

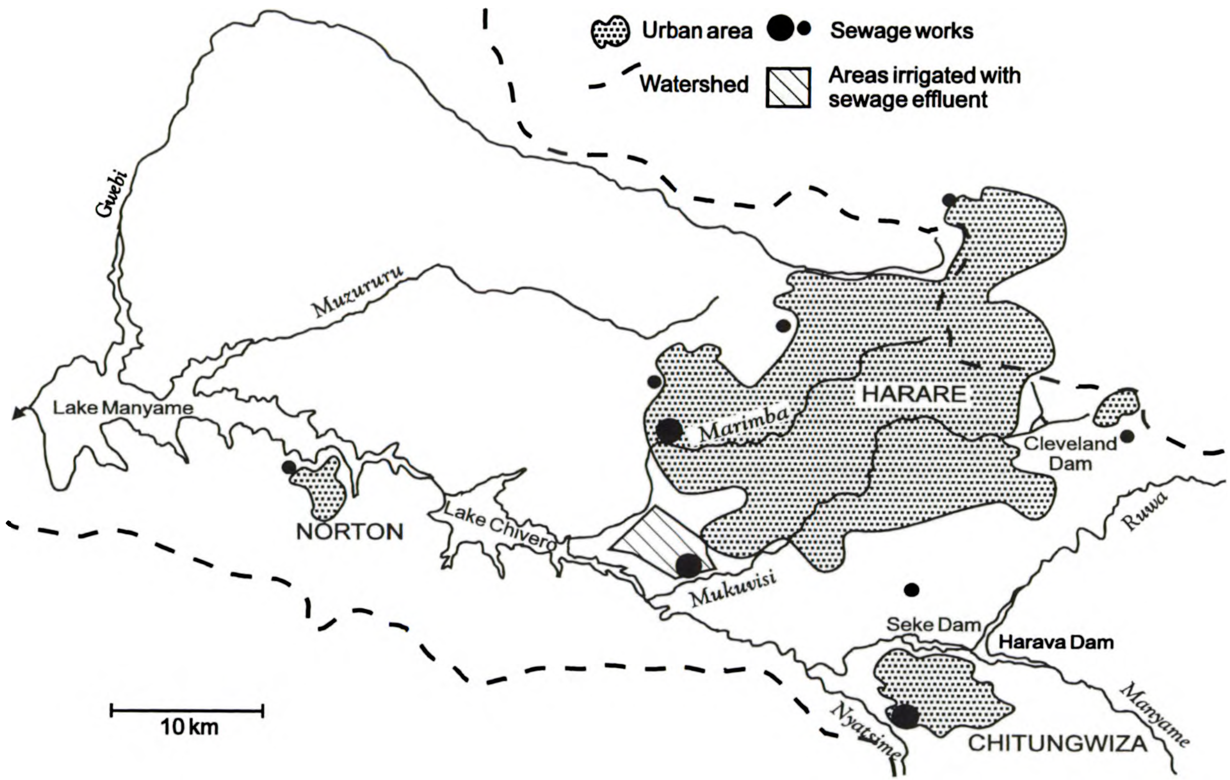


Figure 1 The location of the Manyame lakes in relation to urban centres. The northern (Manyame/Mazowe) and southern (Manyame/Mupfure) watersheds mark the limits of the catchments

although, with the exception of Cleveland Dam which has an undeveloped catchment area, they are becoming increasingly vulnerable as urban growth continues.

## The problem of sewage effluent

At present over 1.25 million people, or more than 13% of the population of Zimbabwe, live in the three urban centres located in the catchment area of the Manyame lakes (Table 2). By the year 2010, the population in the catchment will have grown to around 4 million or 18% of the total. This means, of course, that the quantity of sewage effluent will rise as rapidly and its disposal will become increasingly problematical. Most of the effluent finds its way, via the Mukuvisi and Marimba Rivers, into Lake Chivero which has been subjected to the problems of eutrophication for the last thirty years. The first major blooms of blue-green algae appeared in the winter of 1960 when the dry season flow of sewage effluent was around 30,000 $m^3$/day (McKendrick and Williams, 1968). By 1964 the flow had risen to around 40,000 $m^3$/day and algal blooms had become a permanent feature of the lake, causing serious difficulties in water purification and may have been responsible for seasonal outbreaks of gastroenteritis amongst children in the city (Zilberg, 1966).

Nitrogen and phosphorus are the most important limiting nutrients in Zimbabwean waters (Thornton, 1980) and high levels of these nutrients are present in sewage effluent. Irrigation of crops or pastures is an effective way of reducing their concentration (Table 3) and in 1970 the City of Harare embarked on a major

Table 2 The present and projected population of the three main urban centres in the Manyame lakes catchment area

| | 1969 | 1982 | 1989 | 2000 | 2010 |
|---|---|---|---|---|---|
| Harare | 386,000 | 658,000 | 970,000 | 1,700,000 | 3,000,000 |
| Chitungwiza | – | 172,000 | 243,000 | 442,000 | 806,000 |
| Norton | 3,400 | 12,400 | 23,000 | 66,000 | 180 000 |
| Total | 389,400 | 842,400 | 1,236,000 | 2,208,000 | 3,986,000 |
| % of national population | 7.6 | 11.2 | 13.2 | 15.1 | 18.1 |

Source: L. Zanawe (pers. comm., 1991)

programme of nutrient reduction by using its effluents for irrigation (Williams, 1970). This was successful and the quality of the water in Lake Chivero improved throughout the 1970s even though the flow of sewage effluent increased. However, the situation is worsening again, partly because the effluent discharge has risen to some 160,000 $m^3$/day and partly because of poorly treated sewage from Chitungwiza which flows into the Nyatsime River and is responsible for an increase in the concentration of nitrogen and phosphorus in the Manyame River (Table 4).

Table 3 The reduction of nutrients in sewage effluent before and after its use as irrigation water. All values are expressed as mg/l

| | Bulawayo | | Harare | |
|---|---|---|---|---|
| | Before | After | Before | After |
| SRP | 20.6 | 0.9 | 9.0 | 0.9 |
| $NO_3$-N | 0.1 | 2.5 | 14.0 | 2.1 |
| $NH_3$-N | 52.9 | 0.1 | 12.0 | 0.5 |
| Chloride | – | – | 180.0 | 45.4 |

Note: SRP = Soluble reactive phosphorus
$NO_3$-N = Nitrate nitrogen
$NH_3$-N = Ammonia nitrogen

Sources: Bulawayo data, Thompson (1968); Harare data, McKendrick (1982)

Table 4 The mean concentrations (mg/l) of nutrients in the Manyame, Mukuvisi and Marimba Rivers

| | year | SRP | $NO_3$-N | $NH_3$-N |
|---|---|---|---|---|
| Manyame | 1967 | 0.04 | 0.45 | 0.001 |
| | 1977 | 0.09 | 0.27 | 0.02 |
| | 1990 | 0.64 | 0.10 | 1.60 |
| Mukuvisi | 1967 | 6.20 | 4.10 | 4.70 |
| | 1977 | 0.38 | 1.07 | 0.05 |
| | 1990 | 2.26 | trace | 2.85 |
| Marimba | 1967 | 13.70 | 4.50 | 2.41 |
| | 1977 | 0.81 | 0.96 | 0.03 |
| | 1990 | 0.34 | 0.01 | 0.30 |

Note: The data for 1990 are based on one sample only

Sources: Thornton (1982); J. McKendrick (pers. comm., 1991)

## The eutrophication of Lake Chivero

The chemical history of Lake Chivero can be reconstructed from various sources (Munro, 1966; McKendrick and Williams, 1968; Marshall and Falconer, 1973; Thornton, 1982; J. McKendrick, pers. comm., 1991). It became increasingly eutrophic until 1970 when sewage effluent began to be used for irrigation (Figure 2) and most chemical variables, especially those associated with eutrophication (pH, chloride, ammonia and soluble reactive phosphorus) increased sharply until irrigation began. Dense blooms of blue-green algae were common during this period (Falconer, 1973) and were considered to be the most serious problem on the lake.

Once the lake began to change to a mesotrophic condition, from 1970 onwards, there was a decrease in the concentration of most chemical variables, with the exception of nitrate-nitrogen, which reached a peak in 1975. The reason for this is unclear but it may be connected to a release of ammonia from the bottom waters and sediments or the available nitrogen could not be used because algae populations were being limited by the decreased levels of phosphorus.

The situation seemed to change again during the 1980s but there is little direct chemical evidence to show what was happening. A massive outbreak of Water Hyacinth followed the droughts of 1982-84 and by 1990 the plant covered over 20% of the lake surface (Marshall, 1989 and 1991). Water Hyacinth evidently retained large quantities of nutrients, as did *Salvinia molesta* on Lake Kariba (Mitchell, 1973), and the water quality in the lake was very good. The algal bloom was not in evidence and water transparency had increased to such an extent that extensive beds of the oxygen weed (*Lagarosiphon ilicifolius*) developed. This plant was abundant in the lake in 1962 (Munro, 1966) but had disappeared by 1966 (Marshall, 1971), probably because it had been shaded out by the dense blue-green algae population. The Water Hyacinth mats were, however, a serious problem in a number of ways, notably by causing deoxygenation in the water, which affected water purification, and by interfering with fishing and boating. Mechanical removal failed completely and the mats were brought under control with herbicides in 1991. The destruction and sinking of the infestation released nutrients and a dense bloom of blue-green algae has consequently appeared on the lake. It is now reverting to its eutrophic state and problems resulting from this can be expected in the future.

Sewage effluents and agricultural runoff can carry a variety of pollutants including plant nutrients and pesticides. Pollution problems are likely to become more severe as the cities become increasingly industrialised. Evidence suggests that the levels of DDT and dieldrin in fish from the lake have decreased. This is to be expected since their use in the catchment area has been reduced in recent years. However, their concentration has apparently increased in the water and sediments (Table 5); the reasons for this are unknown. Heavy metals were present in low concentrations in 1976 (Greichus *et al.*, 1978) but no analysis has been made since then.

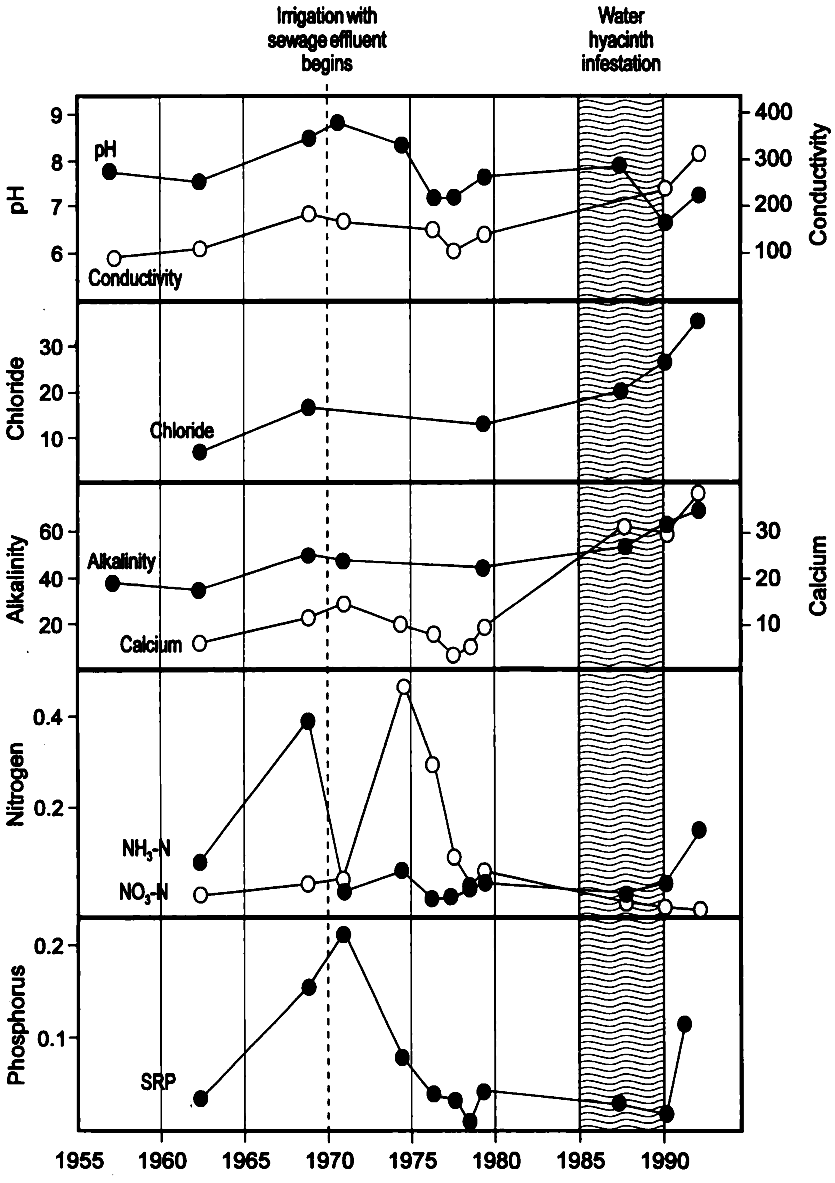


Figure 2 Changes in some chemical variables (mg/l) in the surface waters of Lake Chivero, 1957-1991 (Sources: Thornton, 1982; J. McKendrick, pers. comm., 1991)

Table 5 The concentration (μg/kg dry weight) of some pesticides in Lake Chivero

| | | 1974 | 1979 | 1987-88 |
|---|---|---|---|---|
| DDT | | | | |
| | Water | <0.1 | – | 0.4 |
| | Sediments | 57 | – | 76 |
| | *O. macrochir* >500 g | 450 | 1,270 | 210 |
| | *C. gariepinus* | – | 1,510 | 180 |
| Dieldrin | | | | |
| | Water | <0.01 | – | 0.2 |
| | Sediments | 4 | – | 5 |
| | *O. macrochir* >500 g | 120 | 25 | – |
| | *C. gariepinus* | – | 990 | – |

Note: *Oreochromis macrochir* (green-headed tilapia) is herbivorous whilst *Clarias gariepinus* (African catfish) is omnivorous

Sources: Greichus *et al.* (1978); Greichus (1982); Mhlanga and Madziva (1990)

## Current status of the Manyame lakes

None of the other lakes are as eutrophic as Lake Chivero (Table 6) but they are all at risk as urban development continues. This is illustrated by Seke Dam which receives runoff from the Harare airport and military base complex and from part of Chitungwiza. It is apparently eutrophic and the levels of phosphorus and ammonia have risen considerably (Table 7).

Little data are available for Harava Dam which appears to have a rather lower nutrient content than Seke (Table 6). However, sewage effluent from the Mabvuku-Tafara area drains into it via the Ruwa River and nutrient levels are likely to rise as the population increases.

Lake Manyame is also at risk from two sources: the nutrient-rich water which comes from Lake Chivero and the growth of industry and population in Norton. The earliest work on this lake dates from 1976 (Cotterill and Thornton, 1985) when it was still in the relatively eutrophic, post-filling phase which is characteristic of new reservoirs on the Zimbabwean highveld. The levels of nitrogen and phosphorus were relatively high but by 1979 they had fallen considerably and the lake was considered to be mesotrophic (Watts, 1982). However, by 1991 the levels of phosphorus and nitrogen (especially ammonia) had risen markedly and it is clear that the process of eutrophication in this lake has already begun.

Table 6 The mean concentration (mg/l except for pH) of some chemical variables in the surface waters of the Manyame lakes, 1991

| | Harava | Seke | Chivero | Manyame |
|---|---|---|---|---|
| pH | 7.8 | 7.5 | 7.9 | 7.6 |
| Alkalinity ($CaCO_3$) | 43.6 | 30.0 | 87.2 | 82.8 |
| Albuminoid $NH_4$ | 0.27 | 0.80 | 0.71 | 0.17 |
| $NH_3$-N | 0.06 | 0.20 | 0.15 | 0.07 |
| $NO_2$-N | 0.003 | 0.003 | 0.005 | 0.003 |
| $NO_3$-N | 0.005 | 0.002 | 0.005 | 0.003 |
| Total Nitrogen | 0.336 | 1.008 | 0.870 | 0.249 |
| SRP | 0.07 | 0.04 | 0.11 | 0.25 |
| Calcium | 17.8 | 16.3 | 42.8 | 30.4 |
| Iron | 0.72 | 0.34 | 0.19 | 0.12 |
| Chloride | 10.6 | 7.0 | 37.2 | 23.6 |

Source: J. McKendrick (pers. comm., 1991)

Table 7 Changes over time in the chemical composition of Seke Dam (mean values in mg/l except for pH)

| | 1954 | 1966 | 1979 | 1991 |
|---|---|---|---|---|
| pH | 6.8 | 7.0 | 6.8 | 7.5 |
| Alkalinity ($CaCO_3$) | 21.4 | 27.1 | 25.3 | 30.0 |
| $NO_3$-N | – | – | 0.05 | 0.002 |
| $NH_3$-N | – | trace | 0.017 | 0.200 |
| SRP | – | 0.003 | 0.004 | 0.040 |
| Fe | – | 0.80 | 0.10 | 0.34 |
| Ca | – | – | 1.5 | 16.3 |

Sources: McKendrick and Williams (1968); Marshall (1971); Watts (1982); J. McKendrick (pers. comm., 1991)

## Ecological consequence of eutrophication

The most obvious consequence of eutrophication in lakes is the accelerated growth of plants. In Lake Chivero these are primarily blue-green algae and Water Hyacinth but in Lake Manyame extensive beds of *Lagarosiphon ilicifolius* have become a major problem.

The dominant blue-green algae in the lake are *Microcystis aeruginosa* and *Anabaena flos-aquae*, both cosmopolitan species in eutrophic waters. They can occur in dense blooms with up to several million colonies per litre (Falconer, 1973) which cause problems in water purification, leave unpleasant tastes and odours in the water and secrete toxins which cannot be removed by normal water purification methods. Circumstantial evidence suggests that these toxins may be responsible for outbreaks of gastroenteritis among children in Harare (Zilberg, 1966; Marshall, in press). On the other hand, these algae are responsible for very high levels of primary productivity which, in turn, promotes secondary production.

Lake Chivero supports productive commercial and sport fisheries (Marshall, 1978) and fish yields are related to the trophic status of the lake (Figure 3). Although the Green-Headed Tilapia (*Oreochromis macrochir*) is able to feed on the blue-green algae (Minshull, 1978) there is little doubt that they do not utilise this resource fully. Converting blue-green algae into fish protein is a desirable way of utilising the excess nutrients in the lake and there is a need to investigate other species which may be able to utilise the blue-green algae more fully. The fisheries have recently been affected by Water Hyacinth which interferes with nets, but this problem is being brought under control.

The deeper waters of most large Zimbabwean reservoirs become deoxygenated to some extent during the summer but the period is more prolonged in eutrophic systems. Deoxygenation in the bottom waters of Lake Chivero was more pronounced in 1969, when the lake was still highly eutrophic, than in 1979 when its nutrient levels had declined (Thornton and Nduku, 1982a). The current rise in nutrient levels could lead to a variety of problems including periodic fish kills which can be caused by seiche movements that bring anaerobic bottom water to the surface (Marshall, 1981).

Higher plants, such as Water Hyacinth and oxygen weed, obstruct fishing and boating; mats of Water Hyacinth also cause deoxygenation of the water (J. McKendrick, pers. comm., 1991). The Water Hyacinth in Lake Chivero also caused structural damage to the dam and threatened downstream structures when thousands of plants were swept over the spillway in 1990 (Marshall, 1991).

## Corrective measures

Eutrophication has caused major problems in Lake Chivero and the process seems to have commenced in the others. The most important management priority for the Manyame Lakes is to preserve and improve the quality of their water because their main purpose is to supply water to urban areas. This can only be done by reducing the quantity of nutrients flowing into them.

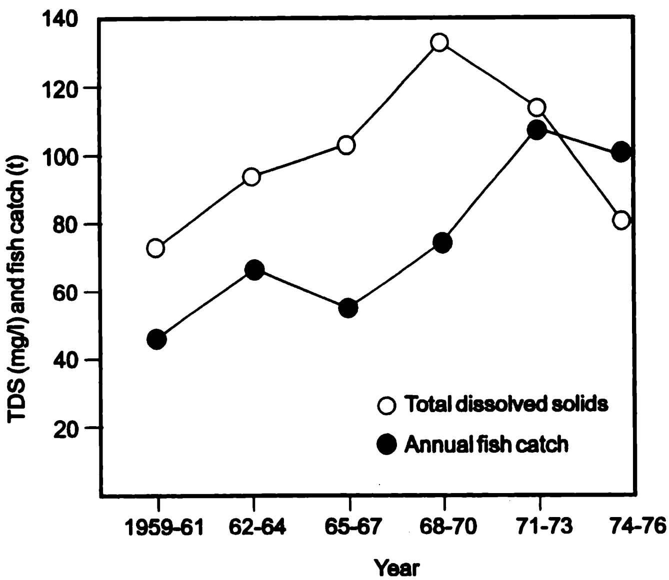


Figure 3 Commercial fish catches in Lake Chivero in relation to total dissolved solids. The data are shown as means for three-year periods (Source: Marshall, 1978)

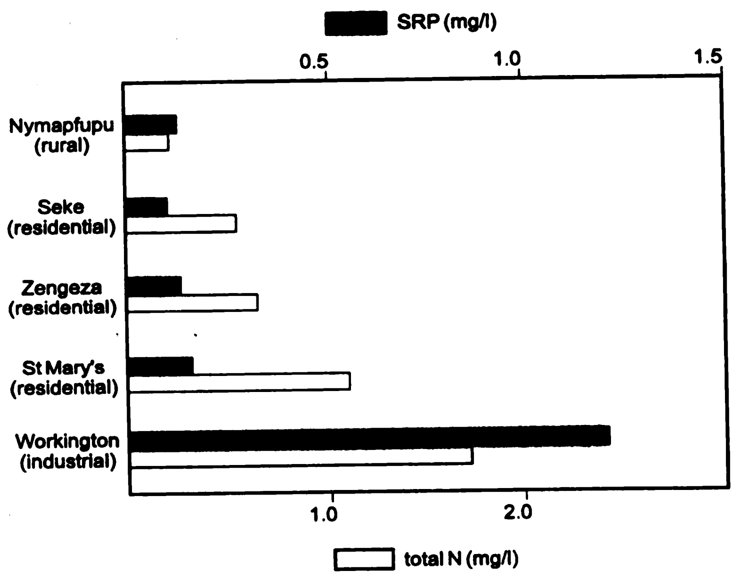


Figure 4 The mean levels of nitrogen and soluble reactive phosphorus in water draining one rural, three high-density residential and one industrial area into Lake Chivero (Redrawn from Thornton and Nduku, 1982b)

Table 8 Changes in the chemical composition of Lake Manyame (means in mg/l except for pH)

| | 1976-77 | 1979 | 1991 |
|---|---|---|---|
| pH | 7.5 | 7.2 | 7.6 |
| Alkalinity ($CaCO_3$) | 86.0 | 61.3 | 82.6 |
| $NO_3$-N | 0.1 | 0.03 | 0.006 |
| $NH_3$-N | 0.02 | 0.01 | 0.07 |
| SRP | 0.01 | 0.001 | 0.25 |
| Fe | 0.76 | 0.07 | 0.12 |
| Ca | 10.0 | 4.0 | 30.4 |

Sources: Watts (1982); Cotterill and Thornton (1985); J. McKendrick (pers. comm., 1991)

The irrigation system, established by the Harare City Council, has worked well and led to a great improvement in the situation during the 1970s. It has no doubt slowed down the rate of eutrophication but, unfortunately, the amount of available land between the city and the lake is limited and no longer adequate. One possibility is to divert effluent into other catchments, such as the Mupfure to the south, where much larger areas of land are available. This proposal has been incorporated in the Harare Master Plan (J. McKendrick, pers. comm., 1991) and should be carried out as a matter of urgency because the lake water is likely to deteriorate further in the near future.

However, control of sewage effluent is not all that is needed since Thornton and Nduku (1982b) have shown that significant quantities of nutrients are contained in runoff from urban centres, especially industrialised areas (Figure 4). Non point-source runoff is extremely difficult to control and will become more so as urban sprawl continues over ever increasing areas of land. Storm water runoff could potentially supply enough nutrients to maintain eutrophic conditions in the lakes, thus there is need to reconsider the future development of urban areas (Thornton and Nduku, 1982b).

If nutrients can be controlled other problems will inevitably diminish. The growth of Water Hyacinth, for example, would be greatly reduced and it could be managed through biological control agents. The costs of providing potable water to the residents of Harare and Chitungwiza would be greatly reduced whilst the potential of the lakes themselves for recreation, fishing and conservation could be fully realised.

## Acknowledgment

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## References

Cotterill, N.G. and J.A. Thornton. 1985. Hydroclimate development following impoundment in a tropical African man-made lake (Lake Robertson, Zimbabwe). *J. Limnological Society of Southern Africa* 11:54-61.

Falconer, A.C. 1973. The Phytoplankton ecology of Lake McIlwaine, Rhodesia. M.Phil. thesis, University of London.

Greichus, Y.A. 1982. Insecticides in Lake McIlwaine, Zimbabwe. Pages 94-99. In: J.A. Thornton (Ed). *Lake McIlwaine: the Eutrophication and Recovery of a Tropical African Lake.* Dr W. Junk, The Hague.

Greichus, Y.A., A. Greichus, H.A. Draayer and B.E. Marshall. 1978. Insecticides, polychlorinated biphenyls and metals in African lake ecosystems. II. Lake McIlwaine, Rhodesia. *Bulletin of Environmental Contamination and Toxicology* 19:444-453.

Marshall, B.E. 1971. The ecology of the bottom fauna of Lake McIlwaine (Rhodesia). M.Phil. thesis, University of London.

Marshall, B.E. 1978. An assessment of fish production in an African man-made lake (Lake McIlwaine, Rhodesia). *Transactions of the Rhodesia Scientific Association* 59:12-21.

Marshall, B.E. 1981. Fish and eutrophication in Lake McIlwaine. *Zimbabwe Science News* 15:100-102.

Marshall, B.E. 1989. The water hyacinth problem in Lake McIlwaine. *Zimbabwe Science News* 23:91-94.

Marshall, B.E. 1991. The problem of water hyacinth in Lake Chivero. *Mining and Engineering* 56(4):31-36.

Marshall, B.E. (in press). Toxic cyanobacteria in Lake Chivero: a possible health hazard? *Transactions of the Zimbabwe Scientific Association* 65.

Marshall, B.E. and A.C. Falconer. 1973. Eutrophication of a tropical African impoundment (Lake McIlwaine, Rhodesia). *Hydrobiologia* 42:109-123.

McKendrick, J. and R.K. Williams. 1968. The effects of urban drainage on Lake McIlwaine, Rhodesia, and subsequent water purification difficulties. Paper presented to the Conference of the Institute of Water Pollution Control, East London. 18 pp.

McKendrick, J. 1982. Water supply and sewage treatment in relation to water quality in Lake McIlwaine. Pages 202-217. In: J.A. Thornton (Ed.). *Lake McIlwaine: the Eutrophication and Recovery of a Tropical Lake.* Dr. W. Junk, The Hague.

Mhlanga, A.T. and T.J. Madziva. 1990. Pesticide residues in Lake McIlwaine, Zimbabwe. *Ambio* 19:366-372.

Minshull, J.L. 1978. A preliminary investigation of the ecology of juvenile *Sarotherodon macrochir* (Boulenger) on a shallow shoreline in Lake McIlwaine, Rhodesia. M.Sc. thesis, University of Rhodesia.

Mitchell, D.S. 1973. Supply of plant nutrient chemicals in Lake Kariba. Pages 165-169. In: W.C. Ackermann, G.F. White and E.B. Worthington (Eds). *Man-made Lakes: Their Problems and Environmental Effects.* American Geophysical Union, Washington D.C.

Munro, J.L. 1966. A limnological survey of Lake McIlwaine, Rhodesia. *Hydrobiologica* 28:281-308.

Thornton, J.A. 1980. A review of limnology in Zimbabwe: 1959-1979. National Water Quality Survey Report. Series No. 1. Ministry of Water Development and Department of National Parks and Wildlife Management, Harare. 86 pp.

Thornton, J.A. (Ed.). 1982. *Lake McIlwaine: the Eutrophication and Recovery of a Tropical African lake.* Dr. W. Junk, The Hague.

Thornton, J.A. and W.K. Nduku. (1982a). Water chemistry and nutrient budgets. Pages 43-59. In: J.A. Thornton (Ed.). *Lake McIlwaine: the Eutrophication and Recovery of a Tropical African Lake.* Dr. W. Junk, The Hague.

Thornton, J.A. and W.K. Nduku. (1982b). Nutrients in run-off from small catchments with varying land usage in Zimbabwe. *Transactions of the Zimbabwe Scientific Association* 61:14-26.

Thompson, J.G. 1968. Report on the use of municipal sewage effluents for irrigation on Aisleby and Good Hope, Bulawayo. Symposium on the Re-use of Sewage Effluent. Department of Conservation and Extension, Salisbury.

Watts, C.J. 1982. An examination of phytoplankton nutrient limitation in Lake McIlwaine and the Hunyani River system. Pages 117-133. In: J.A. Thornton (Ed.). *Lake McIlwaine: the Eutrophication and Recovery of a Tropical African Lake.* Dr. W. Junk, The Hague.

Williams, R.K. 1970. Practical methods to reduce the intensity and occurrence of algal blooms at Lake McIlwaine. *Rhodesia Science News* 4:54.

Zilberg, B. 1966. Gastroenteritis in Salisbury European children. *Central African Journal of Medicine* 12:164-166.

# The Mazowe River impoundments: ecology, utilisation and management status

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## Introduction

River impoundments on the Mazowe River can be divided into two main types, the planned and the unplanned, haphazard impoundments.

The planned impoundments are the dams and the weirs which are found mainly in the areas where the Mazowe River flows through the commercial farming areas. The only major dam is the Mazowe Dam. The proposed Bindura Dam, to be constructed in the Matepatepa commercial farming area, will be the second major dam. The unplanned, haphazard river impoundments are associated with gold panning activities and are widespread and seasonal. They are obvious during the dry season while in the wet season they are flooded by the increased water volume of the river. Gold panning activities are on-going and the impoundments are dynamic; their positions change as panning activities shift to new areas of the river.

This paper focuses mainly on the unplanned, haphazard river impoundments because they are more widespread, and therefore have more implications for the ecology, utilisation and management status of the Mazowe River, than those that have been planned.

## The planned river impoundments

The planned impoundments in the Mazowe River exhibit the general ecological, utilisation and management status observed in the other planned river impoundments in Zimbabwe. They are generally mesotrophic with the limnetic zone as the largest and most productive zone. The topography of the dam or weir bottoms and surrounding land determines the overall depth of the impoundments. While the geology and vegetation in the catchment area have a major influence on the water chemistry and debris in the impoundments, fertilizers applied in the commercial farming areas also influence water chemistry when they are leached and washed out by the heavy rains.

Because of the variation in water level (drawdown) throughout the year, the primary producers are represented by less marginal, rooted vegetation than in stable water bodies. A variety of herbivores, which includes representatives of most animal groups from microorganisms to fish, are found in the secondary producers. The physical nature of water acts as a buffer to large and rapid changes of temperature and so organisms living in water experience less temperature extremes than those found on land (Mills, 1975, cited in McLusky, 1981).

The management status of the planned impoundments is reasonable as they are located in areas where the management of the environment is sound. The impoundments are used as a source of domestic water supply and for irrigation purposes. Recreational activities such as fishing and boating are carried out in the larger impoundments, such as the Mazowe Dam. These activities have not reached a stage where they can be said to be detrimental to the management of the impoundments. It should be noted that the impoundments have a limited life expectancy since they are slowly silting up with debris and eroded materials washed down by the river (Mills, 1975, cited in McLusky, 1981). As the natural silt load of the river is not very high, the process is expected to take hundreds of years. However, those impoundments situated downstream of the unplanned impoundments are subjected to high silt loads and will have a shorter useful life.

## The unplanned, haphazard river impoundments associated with gold panning activities

The unplanned impoundments are created by excavation of the river bank and bed for gold panning. The two broad groups of river impoundments associated with gold panning activities are the moderate and large scale impoundments (Gondo and Mkwanda, 1987). The moderate impoundments associated with gold panning activities are characterised by small excavation pits ranging from 2 to 15 m in depth. They tend to be widespread over areas of up to one kilometre long by 10 to 30 m wide. The excavation pits tend to be separated by small ridges although coalescence is common. The large impoundments are associated with gold panning activities which combine large excavation pits (15-25 m in length, over 4 m in width and usually 6 m in depth) with tunnels into the river banks. In some cases, the activities have become so intensive and specialised that they have assumed the proportion of commercial mining (Gondo and Mkwanda, 1987).

### Ecology

The ecology of the impoundments is highly disturbed. As the creation of such impoundments is economically driven, and most of the panning activities are illegal, no ecological issues are taken into consideration. According to the results of a survey carried out by Gondo and Mkwanda (1987), the activities have resulted in destruction of the riverine vegetation, ranging from simple aquatic flora to water loving (hydrophylic) trees within the river bed. Tree species being destroyed include *Salix mucronata, Vernonia glabra, Muxia oppositifolia, Rhus quartiniana* and *Syzygium cordatum*. Abandoned impoundment sites are often colonised by the weed *Argemone mexicana.*

A more detailed survey is needed to determine whether the riverine fauna has been destroyed to the same level as the flora. Given the fact that gold panning activities require the use of an implement called a 'zamba', which makes the water turbulent during use, the conditions are not favourable for the fauna to settle in or colonise the impoundment. It is also likely that flora and fauna are depopulated in areas where James water is drawn from the impoundments for the James Tables which extract gold from the sediments dug from the river bed.

The fact that the impoundments are shallow means that the temperature is variable. Coupled with the fact that the impoundments are dynamic and often turbulent, the conditions found in the impoundments do not encourage colonisation and only those flora and fauna that can adapt to these conditions will survive.

## Utilisation

The impoundments are mainly used as a source of water for panning activities. Field surveys have not shown evidence that the impoundments are a source of water supply for domestic purposes. However, the settlements that have arisen in association with gold panning activities do not have domestic water facilities and they may rely on the water in the impoundments for domestic use.

## Management

The management status of the impoundments is a function of a number of factors, including the manner in which the impoundments are created by the panning activities, the settlements associated with gold panning, information available to the people who construct the impoundments, and the absence of an integrated resource management policy for gold panning activities. The impact of human activities associated with the impoundment ecosystems varies from the trivial to the dramatic (McLusky, 1981).

Siltation management of unplanned impoundments is poor. When impoundments are created by excavation of the river bank, the stability of the bank is reduced making it susceptible to erosion. The eroded material then silts up the impoundments downstream, thereby reducing their lifespan.

The settlements that have been attracted by the mining activities contribute indirectly to the poor management of the impoundments. The clearance of vegetation increases erosion, especially sheet wash erosion, which contributes to the siltation problems mentioned above. A crude quantitative survey at a site in Shamva was carried out to determine the extent of deforestation in a 100 m transect beginning at the edge of the settled area. It was found that 62.5% of the trees had been cut, the inter-tree and the inter-stump distances were 10.4 m and 8.9 m respectively, and the basal cover was 20% (Mkwanda, 1989).

The general lack of appreciation of the full economic value fór conserved and/or sustainably managed riverine ecosystems by the people involved in the construction of the impoundments, has led to ecological degradation caused by the panning and over-exploitation. The illegal impoundments are being constructed because of the open access to the Mazowe River, which is a national asset and not privately owned. This is further exacerbated by the absence of an integrated resource management policy on gold panning activities *vis-a-vis* the river impoundments. This has led to inconsistency of inter-sectoral policy among the institutions involved with the management of the river system and they have failed to intervene in the management of the impoundments.

## Conclusion

The unplanned, haphazard impoundments on the Mazowe River require careful analysis of their functions and services, their capacity to support extensive and intensive management, and their economic value. This information should be used to ensure that the area is maintained in a manner that will safeguard the river's ecology.

## References and bibliography

Gondo, P.C. and R. Mkwanda. 1987. Report on the survey of Gold Panning Activities. Department of Natural Resources. Unpublished report.

McLusky, D.S. 1981. *Estuarine Ecology*. Oxford University Press, UK.

Mkwanda, R. 1989. Gold Panning and the Environment in Mashonaland Central. Department of Natural Resources. Unpublished report.

Mkwanda, R. 1990. Report on the visits to the Confluence of Mazowe and Nyaguwe Rivers and the Shamva Alluvial Gold Mining Site. Department of Natural Resources. Unpublished report.

# The Binga Swamp Forest

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## Introduction

The Binga Swamp Forest was gazetted a Protected Area through the Rhodesian (now Zimbabwean) Government Statutory Instrument No. 197 of 1971, issued in terms of Section 81(1)(A) of the Natural Resources Act (Chapter 150) as amended from Section 82 of the Natural Resources Act (Chapter 264). The Binga Swamp Forest covers an area of approximately 17 ha and is situated in Mr Tselentis' farm, 35 km northeast of Harare along the Harare-Arcturus Road.

An area of forest, unique to the general flora of the area and covering 3.2 ha (8 acres) is protected. The flora of the hills surrounding the Binga Swamp Forest may be broadly described as 'miombo' woodland, largely characterised by *Julbernardia globiflora* and *Brachystegia spiciformis*; other common species include *Uapaca kirkiana*, *Parinari curatelifolia* and many *Acacia* species. The valley in which the Binga Swamp Forest occurs contains cracking black soils. Much of the valley area is open grassland with a few isolated trees of *Acacia* while the permanently wet parts of this valley are occupied by the unique flora of the Binga Swamp Forest.

## Present conditions of the forest

The present state of Binga Swamp Forest is appalling as the swamp has completely dried up; no part of the protected area was wet when the area was visited in January 1992.

The forest is presently undergoing a notable change in floral composition. The large trees, particularly *Syzygium cordatum* and *Ficus sur*, are dying at an alarming rate. A total of 134 dead trees was recorded in the forest, mostly in the area which was previously the centre of the Swamp. The cause of the deaths is not known but may be related to the drying up of the swamp, caused by a lowering of the water table. Thus the original forest, which was characterised by water loving plants, is jeopardised by a change in the soil hydrology. The death of *Syzygium* and *Ficus*

Table 1 A checklist of plants in Binga Swamp Forest.The scientific names of all plants are given; English common names (according to Coates Palgrave, 1977), Shona and Ndebele names are given where possible. The checklist is not an exhaustive list of everything that occurs in Binga Swamp Forest but a guide on what to expect and, hopefully, an inspiration to other botanists to improve on it and to carry out more work on the forest

C = climber
G = <0.5 m in height (undergrowth within the forest floor)
OG = <0.5 m in height (undergrowth occurring in the open part of the forest)
S = 0.5-3 m in height (shrub)
T = 3-10 m in height (tree)
TT = 10 m in height (tall tree)
NT = present in the forest but not identified
* = not indigenous

| Scientific name | English name | Shona name | Ndebele name | Code |
|---|---|---|---|---|
| *Acacia sieberana* | Paper bark acacia | mubay-amhondoro | umhladwayi | T,S |
| *Achyranthes aspera* | Devil's horsewhip | kasita | umdombe | G |
| *Albizia amara* | Bitter albizia | mugarahanga | umbola | T |
| *Bequaertiodendron magalismontanum* | Stem-fruit | musaswa | unhlautshwa | TT,T,S |
| *Caesalpinia decapetala* | Mauritius thom | – | – | S,G* |
| *Catha edulis* | Bushman's tea | mutsvahari | inandinandi | NT |
| *Celtis africana* | White stinkwood | muguru | umdlautu | TT,T,S |
| *Cussonia arborea* | Octopus cabbage tree | mufenge | umelemele | T |
| *Cyperus* spp. | Sedges | – | – | G |
| *Desmodium repandum* | – | – | – | G |
| *Desmodium salicifolium* | – | – | – | G |
| *Dicliptera spinulosa* | – | – | – | G |
| *Diospyros lycioides* | Red star-apple | mupumhazruvu | umgathuva | T,S |
| *Dolichos kilimandscharicus* | – | – | – | S |
| *Dovyalis zeyheri* | Oval kei apple | mutsvoritsvoto | umgokolo | S |
| *Doryopteris inaequalis* | Fern | – | – | G |

Table 1 (continued)

| Scientific name | English name | Shona name | Ndebele name | Code |
|---|---|---|---|---|
| *Ekebergia capensis* | Dogplum | munyimonyimo | – | TT |
| *Erythrina abyssinica* | Red-hot-poker tree | mutiti | umggoggoggo | TT,T,S |
| *Erythroxylum emarginatum* | Common cocoa tree | rutsitu | – | S,G |
| *Euclea crispa* | Blue guarri bush | mudziyire | umtshekesane | S |
| *Ficus sur* | Cape fig | mukuyu | umkhiwa | TT,T,S |
| *Flemingia grahamiana* | – | – | – | S |
| *Gloriosa superba* | Flame lily | – | – | OG |
| *Ilex mitis* | African holly | – | – | TT,T,S |
| *Jacaranda mimosifolia* | Jacaranda | – | – | NT* |
| *Lantana camara* | Lantana | mbarapati | ubuhobe | S* |
| *Loranthus* spp. | – | – | – | P |
| *Maesa lanceolata* | Maesa | musungwa | – | TT,T,S |
| *Maytenus heterophylla* | Common spine thorn | mugaranjiva | isihlangu | S |
| *Maytenus senegalensis* | Confetti tree | – | – | T,S |
| *Malia azedarach* | Persian lilac | musiringa | isiringa | T,S* |
| *Mondia whitei* | – | – | – | C |
| *Mussaenda arcuata* | – | murudzameo | – | T |
| *Myrica serrata* | – | musha-mbangwena | – | G |
| *Myrsiphyllum asparagoides* | – | – | – | G |
| *Ophioglossum reticulatum* | – | – | – | G |
| *Oplismenus* sp. | Forest grass | – | – | G |
| *Orthosiphon rubicundus* | – | – | – | OG |

Table 1 (continued)

| Scientific name | English name | Shona name | Ndebele name | Code |
|---|---|---|---|---|
| *Pavetta gardeniifolia* | Common pavetta | – | – | T,S |
| *Pavonia columella* | – | – | – | G |
| *Phragmites mauritianus* | – | – | – | G |
| *Physalis peruviana* | – | mubheri | – | G |
| *Pittosporum viridiflorum* | Pittosporum | muchemedzambuya | – | T,S |
| *Protasparagus aspergillus* | Asparagus | rukato | umjibila | S,G |
| *Pteris cretica* | Pteris | – | – | G |
| *Pterolobium stellatum* | – | rukato | uthothawu | NT |
| *Rauvolfia caffra* | Rauvolfia | – | mukamamasanhi | TT,T,S |
| *Rhamnus prinoides* | Shiny leaf | muberere | – | TT,T,S |
| *Rhoicissus tridentata* | Bitter grape | musukavakadzi | – | C,S |
| *Rhus longipes* | Large leafed rhus | mudzambuya | – | T,S,G |
| *Rubus* spp. | Bramble | – | – | C,S |
| *Scabiosa columbaria* | – | – | – | OG |
| *Securinega virosa* | Snowberry | mudyabudi | umnagawuwe | S |
| *Senecio latifolius* | – | – | – | OG |
| *Sesbania macrantha* | – | – | – | S |
| *Sesbania* sp. | – | – | – | G |
| *Setaria sphacelata* | Golden timothy | – | – | OG |
| *Spilanthes mauritiana* | – | – | – | G |
| *Syzygium cordatum* | Waterberry | mukute | umdoni | TT,T,S,G |
| *Thelypteris* sp. | Fern | – | – | G |
| *Themeda triandra* | Red grass | – | – | OG |
| *Toona ciliata* | Toon tree | – | – | T,S* |
| *Verbena bonariensis* | Verbena | – | – | OG |
| *Vernonia amygdalina* | Tree vernonia | dembezeko | inyathelo | T |
| *Vernonia subligora* | Vernonia | – | – | T,S |

The forest is presently undergoing a notable change in floral composition. The large trees, particularly *Syzygium cordatum* and *Ficus sur*, are dying at an alarming rate. A total of 134 dead trees was recorded in the forest, mostly in the area which was previously the centre of the Swamp. The cause of the deaths is not known but may be related to the drying up of the swamp, caused by a lowering of the water table. Thus the original forest, which was characterised by water loving plants, is jeopardised by a change in the soil hydrology. The death of *Syzygium* and *Ficus* trees, both particularly water loving species, indicates that soil moisture has significantly reduced.

Many factors may be responsible for the lowering of the water table. Excessive disturbance by cattle around the fenced area has caused trampling and defoliation of the grasses, which may affect the mechanisms of groundwater recharge. There seems to be a general trend in climatic conditions in the whole Southern African Region towards drier savanna. Drought will influence the hydrology of all areas of Zimbabwe, including the Binga Forest.

Because of changes in soil moisture, there is a noticeable vigorous invasion of the swamp forest by new species which are replacing the original forest. Whereas a few of the species of the original forest have not shown signs of dying back, e.g. *Celtis africana*, the majority of the dominant species (*Syzygium cordatum* and *Ficus sur*) are dying. These are being replaced by either other swamp forest species or by alien species such as *Lantana camara, Caesalpinia decapetala*, *Meliah azedarack*, *Toona ciliata* and *Citrus sinensis.*

The indications are that the present forest cover is quickly degrading through death of the major forest species. In the next few years, if the hydrology of the swamp does not improve, the forest cover may change from the water loving species, which were supported by the swamp to a vegetation cover characteristic of drier conditions, probably similar to that in the valley outside the swamp.

A checklist of some of the species found in the Binga Swamp Forest is found in Table 1.

## Utilisation

Presently the swamp is not being used for any economic purposes. However, it has value in botanical and ecological research and for maintenance of genetic diversity of the flora.

Myself and Mr Mupare of the National Botanical Gardens are engaged in a continuous monitoring exercise to monitor the florisitic changes taking place in the area and to determine the major environmental factors which influence these patterns.

## Bibliography

Coates Palgrave, K. 1977. *Trees of Southern Africa.* C. Struik Publishers, Johannesburg. 959 pp.

Drummond, R.B. 1981. *Common Trees of the Central Watershed Woodlands of Zimbabwe.* NRB Publications, Salisbury, Zimbabwe.

Wild, H., H.M. Biegel and S. Mavi. 1972. *A Rhodesian Botanical Dictionary of African and English Plant Names*. Government Printer, Salisbury, Harare.

# Tourism and wetlands management in Zimbabwe: with special reference to the Zambezi River System

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## Introduction

The central plateau of Zimbabwe drains to the north into the Zambezi River System and to the south into the Limpopo River System. Other important rivers are the Pungwe, which drains the northeastern highlands, and the Lundi-Save system which drains the southern part of the country. As well as the major drainage systems, wetlands are represented by dambos, pans, and 8,000 impoundments. All of Zimbabwe's lakes are man-made and Lake Kariba is the largest.

Zimbabwe's wetlands offer a variety of uses including tourism. In general, most outdoor recreation is centred around bodies of water (Stroud, 1987), with fishing being the most important form of water based recreation. Based on figures of 1980, the main reasons for visiting Zimbabwe were, in order of priority, game viewing, angling, canoeing and bush walks (Pangeti, 1990). Tourist activities in wetlands include boating, fishing, canoeing and kayaking, game viewing, swimming, white water rafting and sight seeing. The income generated from tourism is significant. Therefore sustainable utilisation and maintenance of quality of the wetlands is important.

The past decade has witnessed a growing realisation that economic development and environmental awareness are not contradictory goals. Economic development is dependent upon the environment and natural resources to provide the goods and services which directly generate income.

This paper gives an outline of wetland based tourism in Zimbabwe, focusing on the Zimbabwe River System and including Lake Kariba.

## The Zambezi River wetland system

The wetland areas of the Zambezi River System within Zimbabwe include the river above the Victoria Falls and the Mid-Zambezi, from the falls to Kanyemba on the Zimbabwe-Mozambique border. This area draws more than 80% of the country's tourists. Zimbabwe has approximately 70 tour operators registered with the Department of National Parks and Wildlife Management, 50 of which operate in the Zambezi Valley (Pangeti, 1990).

The spectacular Victoria Falls is the largest tourist attraction within this wetland system. Two hundred kilometres downstream Lake Kariba, the largest of Zimbabwe's reservoirs at 5,700 $km^2$, was constructed in 1958 for hydroelectric power generation. Although the creation of the lake destroyed the fertile floodplain, it created development prospects in an otherwise unproductive area. The 250 km section downstream from the dam wall to Kanyemba offers a magnificent wilderness, including the Mana Pools National Park which is famous for its wildlife.

## Recreation and related activities

### Lake Kariba

Unique in its wide range of tourist and recreational activities, Lake Kariba forms one of the major tourist attractions in Zimbabwe. Water related activities include: angling, canoeing, sailing, water skiing, power boating, SCUBA diving, spear fishing and swimming. For those interested in terrestrial pursuits there is game viewing, back-packing, photographic safaris, bird watching and hunting. This wide variety of interests is possible because three extensive wildlife areas, Charara and Chete Safari Areas and Matusadona National Park, border the Zimbabwean shore of the lake. Furthermore, the communal lands between the wildlife areas have such a sparse human population that these areas have recreational use as well.

Kariba town has the only commercial airport servicing the area from Mlibizi to Kanyemba. Most of the safari activities in the area are organised from the town, which caters for an average of 200 tourists a day and up to 500 a day during peak holidays (Kariba Town Publicity Association Secretary, pers. comm., 1991).

#### Accommodation

Considerable developments cater for and promote tourist activities. Elaborate accommodation facilities exist for tourists; the five luxury hotels in the Kariba area have a total capacity of 150 bed nights and the Department of National Parks and Wildlife Management at Matusadona, and private safari lodges, offer 200 accommodation units. There are several clubs which also offer accommodation.

There is high demand for both public and private accommodation related to recreation on the lake. The Kariba Town Council controls limited land and material resources and cannot meet the demand for serviced stands. This factor alone has increased the value of properties in the town to the level beyond that in Harare. The high demand is related to the boom in the tourist industry both from within Zimbabwe and overseas. Existing hotels are responding to the demand and many have plans for expansion.

### Sport Fishing

Angling is one of the most popular recreational activities on the lake but insufficient attention has been paid to the enumeration of anglers and evaluation of the economic aspects of the sport. Angling on Kariba peaks during public holidays, long weekends and at angling tournaments. The tigerfish (*Hydrocynus vittatus*), famous for its spirited fight, is the most sought after by anglers (Kenmuir, 1984; Bell-Cross and Minshull, 1988).

The annual Kariba International Tiger Fish Tournament (KITFAT) is the largest of Zimbabwe's angling tournaments and attracts participants from outside the country. It was estimated that the total cost of one tonne of fish taken at KITFAT in 1981 was Z$40,000 and that 42 kg/ha/yr of fish were taken from angling alone (Langerman, 1981); in the 1989 KITFAT tournament, Z$1 million was spent to catch one tonne of tigerfish (C. Machena, pers. comm., 1991). Compared to the commercially important 'kapenta' (*Limnothrissa miodon*), which cost Z$4,000/t to land, tigerfish is an expensive commodity. Another tigerfish tournament (Tiger Fishermen of the Zambezi) takes place annually at Msuma upstream of the Devil's Gorge.

The whole lake, including rivers, is open to angling all year round except for those rivers that are closed during the crocodile breeding season. The most heavily utilised area is the Sanyati Basin, with most angling taking place in the Nyaodza and Sanyati Rivers and the Charara shoreline. In fact, this shoreline was closed to commercial fishing in 1972 to facilitate boating and angling as it is in close proximity to Kariba town and tourist facilities. Elsewhere along the lake angling is carried out around holiday resorts such as Bumi Hills Lodge, Binga Rest Camp and Mlibizi Hotel.

Despite the presence of crocodiles, and because of the clear waters, spear fishing is a popular pursuit.

### Boating

Kariba has a number of marinas of varying capacity with storage sheds for small boats and mooring facilities for the larger boats. The bulk of the boats are stored for owners who live away from Kariba. There are also limited houseboat and motor boat hiring facilities.

There are 2,080 boats on the Zambezi River, with the bulk on Kariba, and many people tow their own boats when they visit the lake. There is currently a restriction limiting the number of large boats (greater than nine metres long) mooring around the major holiday resorts in Kariba. Peak periods of boat traffic are during public and school holidays. There are proposals to introduce paddle boats and wind surfing in Kariba to provide low cost, aquatic entertainment.

### Canoeing and wilderness safaris

Canoeing is a popular sport on the Zambezi and Ume Rivers and on Lake Kariba. Canoe tourists experience peace and quiet in a refreshing, scenic and relaxing setting with the opportunity for solitude. The isolation and scenic beauty of the Zambezi make bird watching and game viewing along the river a unique experience. Canoeing safaris are arranged to preserve the feeling of solitude so that few participants are on the river at any one time.

As the canoes on Lake Kariba keep close to the shore, participants have the opportunity for angling, bird watching and game viewing from the water.

### Game viewing, back-packing and photographic safaris

The Matusadona National Park and the Charara Safari Area are rich in wildlife. Large populations of game concentrate along the lake shore during the dry season when water is scarce in other parts of the park. These animals disperse into the hinterland during the rainy season when there is sufficient water and green vegetation.

There are two companies which specialise in game drives and together they cater for 5,000 people per year. Game drives are often combined with other activities such as canoeing, wilderness safaris, photographic safaris, back-packing and boating. A few companies offer back-packing facilities and utilise Nyanyana and Matusadona camp sites as bases. These safaris, usually of four days' duration, cater for four to ten people.

### Other attractions

The casino in Kariba attracts a large number of tourists, mostly from Zimbabwe. Hotels also offer conference facilities.

The lake shore area has a number of hot springs but only those near Binga Rest Camp have been developed to attract tourists.

## The Victoria Falls

Victoria Falls, the world's largest waterfall, is the upstream boundary of the Mid-Zambezi. In addition to the spectacle of the Victoria Falls, the area offers tourist activities such as game viewing, photographic safaris, river cruises above the falls and water related sports. White water rafting is a new sport which is growing in popularity (du Toit, 1982) as the Zambezi offers one of the best experiences in the world. Two companies are currently licensed to carry out white water rafting; they are allotted different days for launching and the number of participants is limited.

There is a casino at Victoria Falls and a second one is being built at the Elephant Hills Hotel. Victoria Falls has accommodation for 940 hotel bed nights (excluding Elephant Hills) and 200 bed units in lodges and campsites. The majority of the patrons are regional and local tourists. The four conference facilities in Victoria Falls are busy all year round.

### Mana Pools and the Zambezi below Kariba Dam wall

The area below the dam wall includes Hurungwe, Sapi and Chewore Safari Areas and the Mana Pools National Park. In 1985 there were five companies operating in the Mana Pools National Park and by 1991 there were 20 tour operators. The occupancy rate in the overnight tourist facilities in this popular park has been 100% for the past four years (Moore, 1991). In 1986, controls were introduced to limit the use of the river and preserve the wilderness quality of the experience; during 1990, 10,653 visitors were accommodated overnight in campsites and lodges.

From the Kariba Dam wall to Kanyemba, canoeing and fishing are the important activities. A significant use of the river is 'long-haul' canoeing which started in 1982 and now earns Z$2 million annually (Moore, 1991). Canoeing on the Zambezi is increasing in popularity: from 1987 to 1990, total permits have increased from 504 to 879. Commercial operators and private persons were issued with 749 and 130 canoe permits respectively in 1990. There is a limit of one canoe safari per day per section of the river in order to preserve the feeling of isolation.

Campsites for canoeing trips are designated by the Department of National Parks and Wildlife Management at suitable intervals along the river. These old sites are currently being changed for new ones to avoid fouling and degradation of the area.

### Artificial impoundments used for recreation

Lake Kariba has been discussed in a previous section; other large lakes, including Mutirikwi, Mazvikadei, Manyame and Chivero, were constructed for irrigation and domestic water supply. However, after each impoundment was established recreational uses developed.

Lake Chivero was built to supply water for Harare; as a fishery developed on the lake, so did recreation. Until recently the lake has suffered from a Water Hyacinth (*Eichhornia crassipes*) infestation which has affected tourism (Masundire, 1991). Lake Mazvikadei, the third largest dam in Zimbabwe, was built to provide irrigation water. The lake has no public access (Masundire, 1991) and there is no managing authority. The other large dams, Mutirikwi, Manyame and Chivero belong to National Parks.

## Constraints to recreation

Recreation in the Zambezi Valley System faces a number of constraints which are discussed below:

### Accessibility

Except for the Kariba Basin, the other lake basins have poor access roads and other facilities. As a result, they are under-utilised while the Kariba Basin tends to be over-utilised, especially during holidays.

### Conflicts between water related activities

There is a conflict between 'kapenta' fishing rigs and hoteliers. The fishing rigs are noisy because of the generators and, if fishing is conducted close to the hotels, it is often difficult for guests to sleep. Fishing permits stipulate that all fishing rigs should have silencers but this is not always enforced. Fishermen are asked to fish 3 km from the shore but they argue that they are being prejudiced against in favour of hoteliers. There is also conflict between speed boats and yachts.

Limited harbour space sometimes forces boats to moor in the developed areas. The privatisation of lake frontages, right down to the lake level, has caused conflicts. Action from responsible authorities is needed to resolve the conflict between recreation and other uses of water as well as among recreation activities themselves; activity zoning could do much to resolve these problems.

The movement of game between the hinterland and the lake shore may be popular with tourists but it is not necessarily so with Kariba communities. In high density areas, there is conflict between people and game and in such circumstances the people scare the game away. Elephants often become aggressive and destroy valuable gardens, thus some locals would like to see the elephants shot.

### Water pollution

The number of boats on Lake Kariba is too high and oil and fuel pollution are caused by accidental leakages or spillage from engines and/or deliberate waste oil dumping into the lake. Oil is hazardous to animals and people and it reduces the water quality. Enforcement of regulations against pollution is difficult as no one polices the lake and the onus lies on the users.

### Poaching

Mana Pools and the rest of the Zambezi Valley have serious poaching problems, especially of rhinoceros. Lake Kariba also faces serious fish poaching problems, the most endangered species being the tigerfish. Elimination of key species from tourism areas will reduce the value of the area as a tourist amenity. With the increase of poaching in the Zambezi Valley there is also an element of instability and tourist numbers are significantly affected by the internal security situation.

## Challenges ahead

There is no doubt that Zimbabwe's wetlands are of great value to the tourist industry and contribute to economic development. However, it is encouraging that there is a growing awareness that most wetlands are valuable in their natural or semi-natural state. Inefficiency in utilisation occurs because all uses are not properly evaluated, enumerated or controlled. A balanced approach should be found between development and conservation.

Planners need to be aware of the interaction between multi-functional resource users and the effects of heavy utilisation. Lake shore development studies seek to collate all lake shore development plans and arrive at an integrated lake shore plan. The studies also seek to transfer responsibility for management of wildlife and fishery resources in the area to the local communities. These schemes will, in the long run, lead to the community benefiting from the resource. Support of local authorities and NGOs is essential to effect success of these measures. It is also imperative that conservation programmes are included in all development activities.

## References and bibliography

Bell-Cross, G. and J.H. Minshull. 1988. *The Fishes of Zimbabwe*. Trustees of the National Museums and Monuments of Zimbabwe, Harare. 294 pp.

du Toit, R.F. 1982. A preliminary assessment of the environmental implications of the proposed Mupata and Batoka Hydro-Electric Schemes: Zambezi River, Zimbabwe. Compiled for the Committee to Advise on the Environmental Impacts of Major Projects. Natural Resources Board of Zimbabwe.

Kenmuir, D.H.S. 1984. Fish population changes in the Sanyati Basin, Lake Kariba, Zimbabwe. *S. Africa J. Zool.* 19:194-209.

Langerman, J.D. 1981. Report on the 1980/81 Angling Census in Sanyati Gorge, Lake Kariba. L.K.F.R.I. Unpublished report 41.

Machena, C. 1991. Dam developments and their environmental effect: the Kariba experience. Pages 27-42. In: T. Matiza and H.N. Chabwela (Eds). *Wetlands Conservation Conference for Southern Africa. Proceedings of the Southern African Development Coordination Conference held in Gaborone, Botswana, 3-5 June, 1991.* IUCN, Gland, Switzerland. x + 224 pp.

Masundire, H.M. 1991. Proposals for an ecosystem management policy for Mazvikadei Reservoir. *Zimbabwe Science News* 25(4/6):42-44.

Moore, A. 1991. The growth of tourism in Lower Zambezi Valley-Kanyemba. Paper presented at Workshop on Man and Biosphere, Kariba 21-27 July 1991.

Pangeti, G.N. 1990. The policy, management and administration of national park tourism in SADCC; with special reference to Zimbabwe. Paper presented to the SADDC Workshop on Wildlife-Based Tourism, Luangwa, Zambia, 17-24 August, 1990.

Pangeti G.N. 1991. Options for tropical wildlife management. Paper presented to the 10th World Forestry Congress, Paris. 26 September 1991.

Stroud, R.H. 1987. An American experience in recreational use of artificial waters. In: R.H. Lowe-McConnell (Ed.), *Man-Made Lakes*. Institute of Biology Symposia No 15. Academic Press, London.

Turner, K. 1991. Economics and wetlands management. *Ambio* 20(2):59-63.

# Effects of dam building on riverine wetlands

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## Introduction

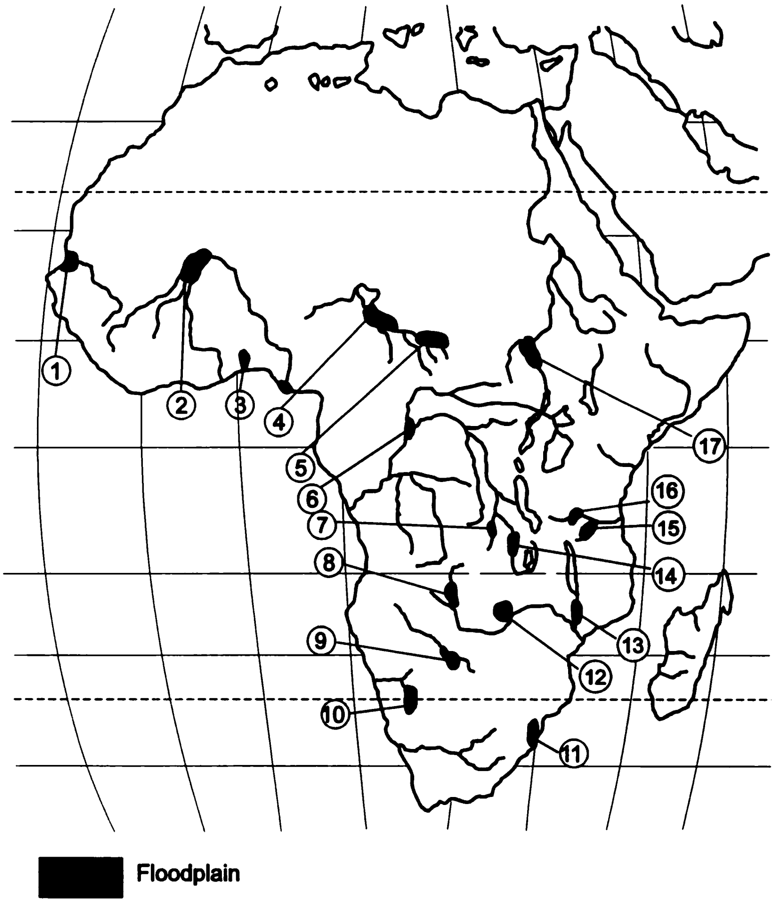
The construction of dams has varied effects on the hydrology, ecology, economy, community health and sociology of riverine wetlands: the subject has been investigated by several authors (Ackerman *et al.*, 1973; Scudder, 1975; Lowe-McConnell, 1977; Brooker, 1981; Bernacsek, 1984; Alabaster, 1985; Crisp, 1985; Ebel, 1985; Edwards and Howell, 1989; Magadza, 1991).

Riverine wetlands are unique ecosystems characterised by distinctive assemblages of flora and fauna. The riverine wetland ecosystem includes not only the flora and fauna within the river itself but also the fringing area, the floral and faunal composition of which are influenced by the river. Riverine biota are especially adapted in morphology, behaviour and physiology to the moving, aquatic environment (Hynes, 1970; Quigley, 1977).

Many riverine wetlands are associated with human populations which depend on the wetland in a variety of ways including water supply, navigation, fishing and agriculture. The early civilisations of Egypt and Mesopotamia were associated with riverine wetlands.

Africa's rivers are associated with a complex network of riverine wetlands and some rivers are associated with expansive floodplains (Figure 1). The flow of water in the rivers is very seasonal and is dictated by rainfall; this seasonality of flow becomes more pronounced with distance from the equator. Zimbabwe lies in those latitudes which have one rainy season and one long dry season each year. Availability of water throughout the year is, therefore, dependent upon the quantity and distribution of rain during the dry season.

In order to ensure uninterrupted water supply for domestic, industrial and, in some cases, agricultural use, dams have been built on many of Africa's rivers (Figure 2). These dams have created reservoirs of varying sizes; in general, the largest of these were built for hydroelectric power generation. Zimbabwe has over 150 dams of over one hectare in area, some of which are shown in Figure 3.




1. Senegal
2. Niger, Central delta
3. Oueme
4. Logone, Yaeres
5. Chari
6. Zaire, Mbandaka
7. Lualaba
8. Barotse
9. Okavango
10. Cunene/Ovambo
11. Pongolo
12. Kafue
13. Shire
14. Luapula
15. Rufiji
16. Ruaha
17. Nile, Sudd

Figure 1 Location of the major rivers and floodplains of Africa (Source: Welcomme, 1985)

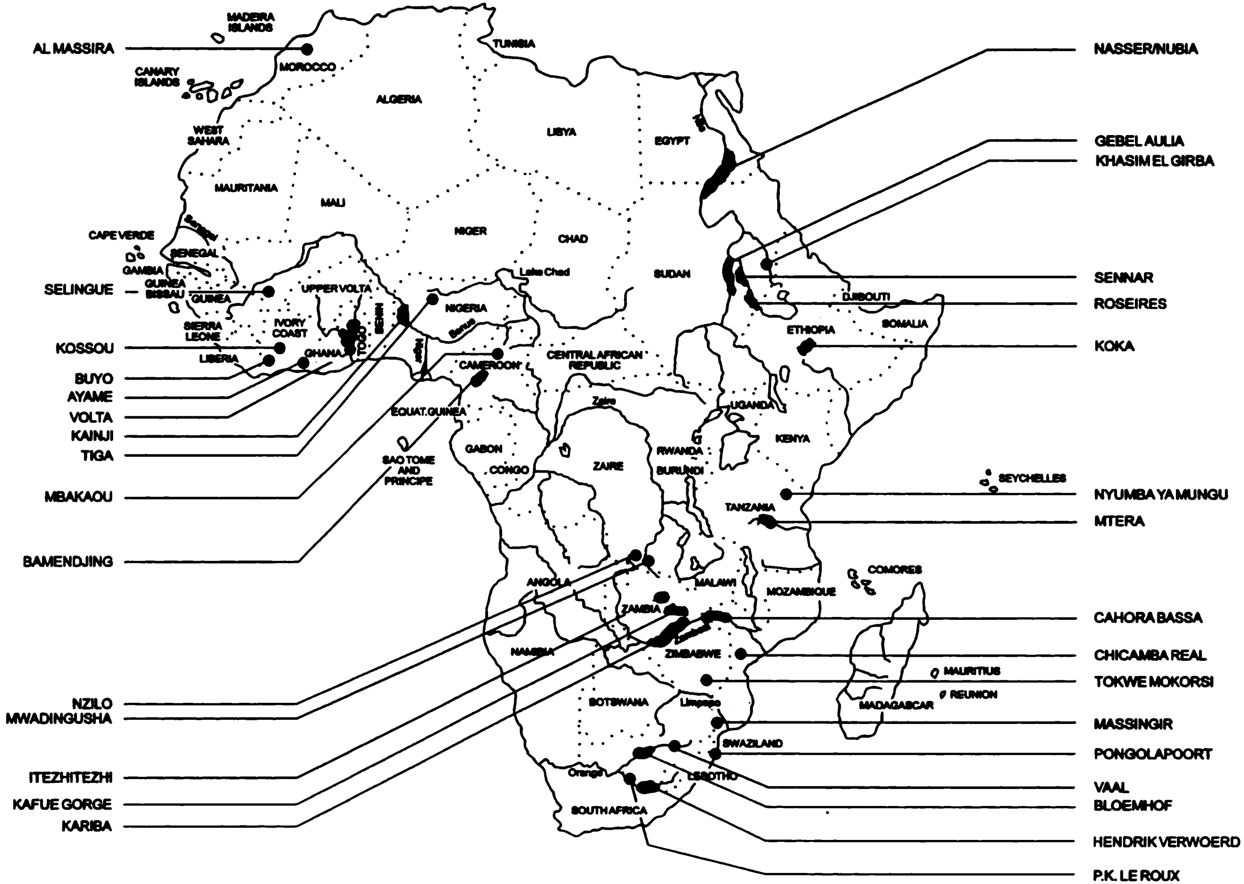
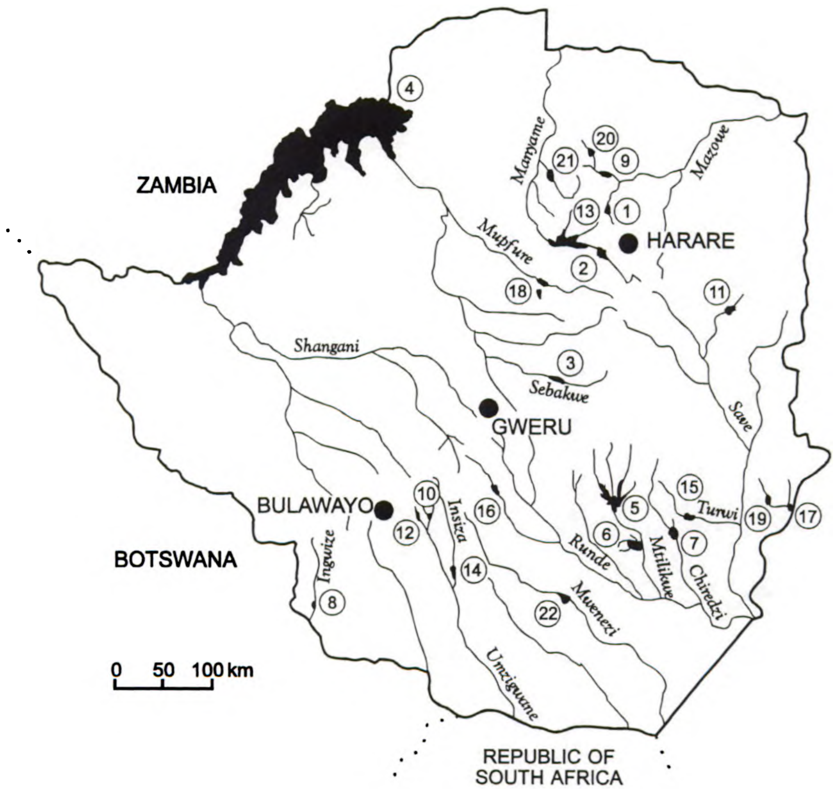



Figure 2 Geographical location of 32 major African impoundments (Source: Bernacsek, 1984)




| | |
|---|---|
| 1. Mazowe | 12. Upper Ncema |
| 2. Manyame Poort | 13. Darwendale |
| 3. Sebakwe | 14. Mayfair |
| 4. Kariba | 15. Siya |
| 5. Kyle | 16. Palawan |
| 6. Bangala | 17. Ratelshoek |
| 7. Manjirenji | 18. Clifton |
| 8. Ingwezi | 19. Bangazaan |
| 9. Mwenje | 20. Vureneme |
| 10. Inyankuni | 21. Mazwikadei |
| 11. Lesapi | 22. Manyuchi |

**Figure 3** Geographical locations of 22 major Zimbabwean impoundments

Where dams have been constructed they have had varying effects on the associated riverine wetlands. This paper reviews some ecological and socio-economic effects of dam building on riverine wetlands with specific reference to Zimbabwe's riverine wetlands.

## Downstream effects of dams

Closure of rivers by the construction of dams leads to controlled flooding of the downstream reaches. River flow becomes more regulated and less variable and floods no longer spill over the banks, resulting in drier river banks (Bernacsek, 1984). This phenomenon has been observed on most dams (Moxon, 1969; Entz, 1976). The flood magnitude of the Zambezi River was reduced by about 24% by the construction of the Kariba Dam (SWECO/SWED Power, 1981) resulting in reduction of flooding of the Mana Pools floodplain (Begg, 1973).

### Effects on the flora and fauna

Riverine vegetation is reduced in extent by damming, being replaced by dry land vegetation in those areas normally kept wet during flooding. The regulated flow may create favourable conditions for the establishment of both rooted and floating macrophyte communities. Macrophyte growth downstream increased after construction of the Akosombo Dam (Obeng-Asamoa, 1979), the Aswan High Dam (Latif, 1984), the Kariba Dam (Attwell, 1970; Begg, 1973) and elsewhere (Hilsenhoff, 1971; Ward, 1974). The periphyton associated with macrophytes increases with the macrophyte populations; phytoplankton may develop downstream of dams due to reduced flow velocities. However, few studies have reported a reduction of aquatic vegetation downstream of dams due to desiccation (Kroger, 1973). The situation of most Zimbabwean riverine wetlands associated with impounded rivers remains largely unknown.

Populations of some macroinvertebrates, such as gastropods and chironomids, are higher in rivers that have rooted submerged, rooted emergent or floating macrophytes (Hynes, 1961; Borhan, 1981). Downstream macroinvertebrate populations tend to increase following dam construction (Brooker, 1981). Undammed rivers with highly variable natural flows usually have reduced benthic populations because of habitat instability. Stabilisation of flow following impoundment, coupled with reduced velocity, leads to increases in populations of some macroinvertebrates (Badcock, 1953).

#### Fish populations

Fish production is significantly reduced downstream of dams, due either to failure by some fish species to make reproductive migrations or to loss of habitat where downstream floodplains are no longer flooded (Lelek and El Zarka, 1971; Davies, 1975; Chude, 1979; Obeng-Asamoa, 1979; Welcomme, 1985). Some of the most extreme downstream effects of dams occur during the filling phase of reservoirs,

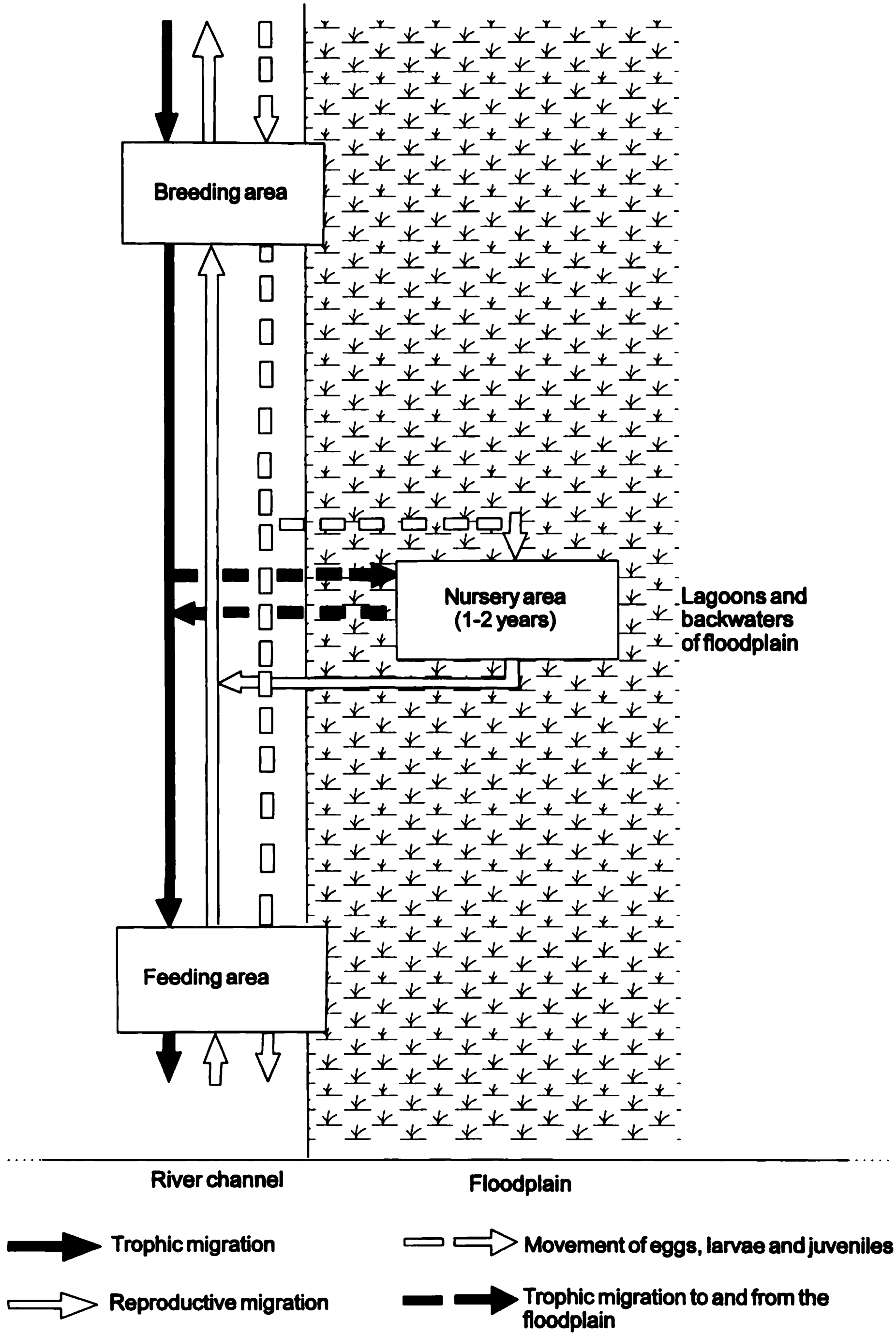



Figure 4 Summary diagram of principal movements of fish (Basedon and Bonetto, 1981)

immediately following closure of rivers (Bernacsek, 1984). Downstream flow is either cut off completely (Petr, 1981) or is reduced to a small fraction of normal (Davies, 1975). This occurred at Mtera reservoir in Tanzania and at Cabora Bassa in Mozambique and resulted in massive fish kills downstream and stranding of reproductively active fish (Davies, 1975; Petr, 1981; Bernacsek, 1984).

For many fish species, the optimal breeding habitat is usually different from the optimal feeding habitat, thus such fish species must migrate periodically between the two habitats (Welcomme, 1985). Many riverine fish species of economic importance such as characins, siluroids and cryprinids make various potamodromous migrations (Welcomme, 1985). The migrations may be longitudinal, along the main river channel, or lateral between the main river channel and associated floodplains (Figure 4) (Kenmuir, 1978; Welcomme, 1985). One of the most drastic downstream effects of dams is that they act as barriers to fish migrations along the main river channel (Brooker, 1981; Ebel, 1985). The author observed some cyprinid fish species unsuccessfully attempting to climb up a low dam wall on the Manyame River near Ske-Doma Township when the reservoir was spilling.

Adults of the four species of eels (*Anguilla bengalensis labiata, A. bicolor, A. marmorata* and *A. mossambica*) known to occur in Zimbabwe migrate to the sea for breeding (Jubb, 1961; Bell-Cross and Minshull, 1988). The elvers migrate into rivers where they spend the next 10-20 years before returning to the Indian Ocean for breeding. It was argued that Kariba dam was an impenetrable barrier for eel migrations but evidence suggests that eels are still able to move upstream across the dam wall because eels younger than the dam were observed in Lake Kariba and further upstream (Balon, 1974; Kenmuir, 1978, Bell-Cross and Minshull, 1988). It is not known whether the African mottled eel (*A. bengalensis labiata*) manages to cross Cabora Bassa Dam in its migrations. The effect of Zimbabwe's other dams on eel migrations is uncertain.

In other countries, fish ladders and by-pass canals have been constructed to aid the longitudinal migrations of fishes along dammed rivers (Bernacsek, 1984; Ebel, 1985) but this phenomenon has received very little attention in Africa in general and Zimbabwe in particular. The structure of all Zimbabwe's dams is completely obstructive to fish movements and it is unlikely that even those few with drop inlet and tunnel spillways, such as Mazvikadei, Bangazaan, Ratelshoek and Siya, will allow longitudinal fish migrations.

Damming results in desiccation of downstream floodplains, the consequence of which may be loss of habitat for some floodplain fishes. Species that would normally migrate laterally (Figure 4) from the main river channel to the floodplain (Welcomme, 1985) suffer from this loss of habitat.

## Effects on water quality

Dams alter water quality downstream because reservoirs function as nutrient and silt traps. In deep, thermally stratifying reservoirs where discharge is drawn from the hypolimnion, the discharged water is cool, rich in dissolved solids and clear, but has little dissolved oxygen and may contain hydrogen sulphide (Begg, 1973;

Coche, 1974; El Moghraby, 1979; Obeng-Asamoa, 1979). Such discharges cause the death of fish and other biota downstream due to low oxygen and/or high concentrations of hydrogen sulphide. This has been observed in Roseires, Akosombo and Kainji Dams (Henderson, 1973; El Moghraby, 1979; Obeng-Asamoa, 1979). Masundire (1991, in press) observed the discharge of anoxic water, rich in hydrogen sulphide and ferrous compounds, at Mazvikadei Dam.

Unless they are spilling, most of Zimbabwe's dams discharge water from depths likely to be anoxic from time to time. Studies of downstream effects of water discharge from reservoirs need to be carried out in order to assess the extent of this problem. However, re-oxygenation of the water occurs naturally some distance from the point of discharge.

### Social impacts

Human settlements downstream of dams may also be affected by dam construction due to the chance of the dam wall collapsing and flooding the river basin. The collapse of dam walls and consequent flooding has led to significant loss of human life; the failure of Malpasset Dam in France in 1964 (James, 1988), the Vaiont reservoir disaster in Italy in 1963 (Kiersch, 1988) and the Machhu-II Dam disaster in India in 1979 (Serafim and Coutinho-Rodriguez, 1989) are some examples. In 1989, the International Committee on Large Dams (IICOLD) published a non-exhaustive list of 142 dam failures over the last three centuries (Serafim and Coutinho-Rodriguez, 1989). To ensure their safety, communities downstream of major dam projects have to be relocated to safer environs. Inhabitants of the Zambezi valley below Kariba Dam had to be resettled above the Zambezi escarpment in Hurungwe District. The area they vacated was reserved for wildlife management as the Charara, Hurungwe, Mana Pools, Sapi and Chiwore safari areas and national parks.

## Upstream effects of damming

Riverine wetlands upstream of dams are modified from a lotic (running water) to a lentic (standing water) habitat; the river channel and part of its basin are inundated to form man-made lakes and a new ecosystem is created.

### Effects on flora and fauna

Impoundment of riverine wetlands results in the loss of riverine vegetation and the whole ecosystem associated with it. A new water-land interface is created where dryland vegetation abuts the shore of the reservoir. Ultimately, as the reservoir grows older, riverine vegetation may colonise the shores of the reservoirs.

New vegetation develops around most reservoirs. Phytoplankton, previously unable to flourish in the fast-flowing river channel, find favourable conditions in still waters. In the shallow fringes of reservoirs, three types of higher plant forms develop:

1. A mixture of dry land grasses, sedges and semi-aquatic plants, capable of withstanding some desiccation, occupy the drawdown zone.
2. Submerged macrophytes, which are truly aquatic plants, usually establish once the reservoir level stabilises (Beadle, 1981; Masundire, in press). The distribution of these plants is limited by the depth of light extinction.
3. Floating macrophytes may invade the still water of newly formed reservoirs.

Floating macrophytes may proliferate in reservoirs to the extent that they create management problems, such as *Salvinia molesta* on Lake Kariba (Mitchell, 1969, 1970), *Eichhornia crassipes* on Lake Chivero and in irrigation canals in Zimbabwe's southern lowveld. Submerged macrophyte populations may also become problems as is the case of *Lagarosiphon* sp. in Lake Manyame.

Microinvertebrates develop and increase in diversity from a poor, riverine, planktonic fauna to a much richer, truly planktonic, lacustrine fauna. The establishment of zooplankton communities occurs quite rapidly after reservoir creation (Masundire, 1991, in press). In Lake Kariba, Thomasson (1965, 1980) listed 58 littoral and 31 pelagic zooplankton species while Masundire (1989, in press) listed 65 species from the pelagic zone only.

Macroinvertebrates tend to increase in both species diversity and abundance in reservoirs (McLachlan, 1969; Paperna, 1970; Scott *et al.*, 1982; Hunter *et al.*, 1982; Backiel, 1985) due to the expanded littoral habitat. In older reservoirs, where sediment has formed, profundal benthos develops which is excluded from natural river channels because of the scouring effect of the flowing water. Bivalves have been observed both to increase in reservoirs (Halstead, 1971; Bernacsek, 1984; Kenmuir, 1980) and to decrease following river impoundment (Hammerton, 1976; Entz, 1976).

The flooding of terrestrial riverine vegetation results in loss of habitat for riverine bird species which are forced to find more suitable habitat on either side of the impoundment. Thus the composition of bird species within the impounded basin changes. Populations of fish-eating birds tend to increase; large populations of *Phalacrocorax carbo lucidus* (Whitebreasted Cormorant), *P. africanus* (Reed Cormorant), *Anhinga rufa* (Darter), *Ardea cinerea* (Grey Heron) and *Haliaeetus vocifer* (Fish Eagle) established on Mazvikadei Reservoir in its first year of filling (Masundire, 1991).

### Fish

Impoundment of rivers often results in reduction of diversity of fish species (Lowe-McConnell, 1977, 1987) as well as changes in species composition, as the fish naturally occurring in the area are essentially riverine. *Barilius zambezensis* and small *Barbus* species, which are characteristic of fast flowing rivers, disappeared from Cabora Bassa following impoundment (Beadle, 1981). Similar disappearances were observed with regard to mormyrids and some *Alestes* spp.

in Volta (Petr, 1968, 1974; Lelek, 1973; Lowe-McConnell, 1987). Reduction of fish species diversity following impoundment has also been recorded in Kainji (Beadle, 1981; Lowe-McConnell, 1987). However, in Lake Kariba, excluding introduced species, impoundment increased fish species diversity; 31 species were recorded in the Middle Zambezi before Kariba Dam was built (Harding, 1966) and 40 species were recorded after impoundment (Balon, 1974).

Species changes may involve the appearance of new species from either natural colonisation or from deliberate introduction. With inundation of the river channel, new food sources, such as phytoplankton, zooplankton, macrophytes, and macroinvertebrates, increase. In large reservoirs, a true open-water pelagic zone is created which may be invaded by planktophagic species or may remain uncolonised where riverine species fail to adapt to this new habitat.

Populations of planktophagic species, and those feeding on attached algae, macrophytes or macroinvertebrates, tend to increase in reservoirs. Three tilapiine species, *Sarotherodon galilaeus*, *Tilapia zillii* and *Oreochromis niloticus*, previously scarce in the Volta River, become more abundant in the reservoir after closure of Akosombo Dam (Lowe-McConnell, 1987). *Pellonula afzeliusi* and *Cynothrissa mento*, indigenous clupeids of the Volta River, prospered in the reservoir (Reynolds, 1974) and expanded to colonise the pelagic zone where they perform diurnal vertical migrations similar to those performed by the endemic Lake Tanganyika sardines (Lowe-McConnell, 1987).

Similar observations were made in Kainji where populations of planktophagic species *Alestes baremose,* and two clupeids, *Sierrathrissa leonensis* and *P. afzeliusi,* expanded in the new lacustrine environment as did the populations of their predators, especially *Hydrocynus forskalli* (Otobo, 1974; Lewis, 1974; Beadle, 1981).

It is not always the case that some indigenous species will adapt to colonise the pelagial of newly created, man-made lakes. In Lake Kariba, the open waters remained devoid of fish until the successful introduction of a planktivorous clupeid, *Limnothrissa miodon*, from Lake Tanganyika (Bell-Cross and Bell-Cross, 1971; Begg, 1976). The existence of *L. miodon* in the pelagial caused the predator, *Hydrocynus vitattus*, to move into pelagic waters in search of prey. The pelagic zone of the Itezhi-tezhi Reservoir in Zambia has remained uncolonised by fish and efforts are in progress to introduce *Limnothrissa miodon* into the reservoir. There are other large and fairly deep reservoirs in Zimbabwe whose pelagic zone might be devoid of fish as *L. miodon* is the only truly pelagic species.

In general, reservoir creation may lead to lower diversity of fish species but also results in increased fish biomass and therefore higher fish yields (Holcik, 1966; Backiel, 1985; Fernando and Holcik, 1991).

## Disease

Creation of man-made lakes has increased the incidence of diseases caused by parasites whose vectors or intermediate hosts live in water. Bilharzia, caused by *Schistosoma* spp. and requiring aquatic snails for transmission, and malaria, caused by *Plasmodium* spp. and requiring anopheline mosquitoes as vectors, have increased in riparian communities (Hira, 1970; McLachlan and McLachlan, 1971; Entz, 1976; Hunter *et al.*, 1982).

Incidence of malaria in Zimbabwe is related to low altitude and availability of water. Reservoirs in low altitude areas such as Kariba, Mutirikwe, Bangala, Manjirenji, Manyuchi and Siya represent focal points for malaria infections. All Zimbabwe's reservoirs have effectively increased the availability of suitable breeding sites of the bilharzia snail. This phenomenon is true in all countries where schistosomiasis is endemic (Hira, 1970; Malek, 1972; Hunter *et al.*, 1982).

### Social effects of damming

One of the most traumatic effects of dam building on human populations is the displacement of riverine communities. The most documented example is that of 86,000 Tonga people who inhabited the Zambezi Valley and were dislocated by the construction of the Kariba Dam (Scudder, 1975). The socio-economic life of the Tonga was intimately linked to the Zambezi Valley. They produced two crops per year in gardens watered by rainwater or by flood water of the Zambezi River. In order to make way for Lake Kariba they had to be moved to higher ground with extremely poor soils (Bond, 1956) and terrain which was unsuitable for agriculture (Scudder, 1975; Magadza, 1991).

Not all of Zimbabwe's dam construction has necessitated translocation of people but when this occurred it caused significant hardships to the people concerned. Recent examples are the displacement of people prior to construction of Manyuchi Dam in Mwenezi District, Masvingo Province, and currently the movement of people from the Osborne Dam area in Makoni District, Manicaland Province.

Problems of relocation include inadequate compensation, loss of family heritage and shrines, which are very important in traditional African cultures, and having to resettle in new areas often lacking in basic infrastructure such as schools and health and communication facilities.

## Conclusions

In the majority of cases in Zimbabwe, the ecological and sociological implications of dam building appear to have received little attention in the planning of dam sites. Maximum benefits could be derived from Zimbabwe's reservoirs if ecological concerns are included at the planning stage so that the impoundments will serve multiple purposes by design and not by accident; fish production, recreation and other water related activities seem to be incidental to most major reservoirs.

This paper highlighted both positive and negative aspects of dam developments on riverine wetlands. In the reservoirs, fish species diversity is usually reduced but fish yields tend to increase, however, fish production usually decreases downstream of dams. Species diversity of aquatic plants, microinvertebrates and macroinvertebrates increases upstream of dams. Downstream water flow becomes reduced and more regulated, reducing the wetland areas. The chemical attributes of discharge water may be deleterious to downstream ecologies. Discharge waters normally contain less suspended solids, making discharge waters more erosive.

Where there is threat to human lives due to dam construction, there are problems of translocation and resettlement of people who are usually unwilling to move. It is not clear whether these people ultimately benefit from these engineering feats. It could be argued that Kariba Dam left the Tonga people worse off and that, 30 years later, they are still suffering the ill-effects of displacement.

Perhaps a dam project is successful for as long as it satisfies the purpose for which it was initiated; hydroelectric power generation, irrigation, domestic or industrial water supply.

## References

Ackermann, W.C., G.F. White and E.B. Worthington (Eds). 1973. Man-made lakes: their problems and environmental effects. *Amer. Geo. Union Monogr.* 17. 847 pp.

Alabaster, J.S. (Ed.). 1985. Habitat modification and freshwater fisheries: *Proceedings of a symposium of the European Inland Fisheries Advisory Commission.* Butterworths. 278 pp.

Attwell, R.I.G. 1970. Some effects of Lake Kariba on the ecology of a floodplain of the mid-Zambezi Valley of Rhodesia. *Biol. Conserv.* 2:189-196.

Backiel, T. 1985. Fall of migratory fish populations and changes in commercial fisheries in impounded rivers in Poland. Pages 25-41. In: J.S. Alabaster (Ed.). *Habitat modification and freshwater fisheries. Proceedings of a symposium of the European Inland Fisheries Advisory Commission.* Butterworths.

Badcock, R.M. 1953. Comparative studies in populations of streams. *Rep. Inst. Freshwater Res. Drottingholm* 35:38-50.

Balon, E.K. 1974. Fish production of a tropical ecosystem. Pages 249-573. In: E.K. Balon and A.G. Coche (Eds). *Lake Kariba: a man-made tropical ecosystem in Central Africa.* Monogr. Biol. 24. Junk, The Hague.

Beadle, L.C. 1981. *Inland waters of tropical Africa: an introduction to tropical limnology.* 2nd ed. Longman, London. 475 pp.

Begg, G.W. 1973. The biological consequences of discharge above and below Kariba dam. *Proceedings of the 11th Congress of the International Commission for Large Dams, Madrid* 11:421-430.

Begg, G.W. 1976. The relationship between the diurnal movements of some of the zooplankton and the sardine, *Limnothrissa miodon*, in Lake Kariba. *Limnol. Oceanogr.* 21:529-539.

Bell-Cross, G. and B. Bell-Cross. 1971. Introduction of *Limnothrissa miodon* and *Limnocaridina tanganicae* from Lake Tanganyika into Lake Kariba. *Fish Res. Bull. Zamb.* 5:207-214.

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

Bernacsek, G.M. 1984. Guidelines for dam design and operation to optimize fish production in impounded river basins. CIFA Technical Paper 11. FAO, Rome. 98 pp.

Bond, G. 1956. Geology report. Rhodesia School of Exploration Society Report: Upper Kariba Expedition.

Bonetto, C.A. 1981. Contribution al conocimiento limnologico del Rio Paraguay en su tramo Inferior. *Ecosur* 8(5):55-58.

Borhan, M.A. 1981. The River Nile fish and fisheries 1980. Progress Report of the Institute of Oceanography Fish Inland Waters Fish Culture Branch, Alexandria. 5.

Brooker, M.P. 1981. The impact of impoundment of the downstream fisheries and general ecology of rivers. *Applied Biology* 6:91-152.

Chude, L.A. 1979. Fish and fisheries of Lake Ndakolowu - A floodplain downstream of Kainji Dam. Annual Report of the Kainji Lake Research Institute (1978-1979).

Coche, A.G. 1974. Limnological study of a tropical reservoir. Pages 1-26. In: E.K. Balon and A.G. Coche (Eds). *Lake Kariba: a man-made tropical ecosystem in Central Africa.* Monogr. Biol. 24. Junk, The Hague.

Crisp, D.T. 1985. Effects of impoundment and regulation of the river Tees at Cow Green (Northern Pennines, UK) upon fish populations in the affected tributaries and in the river immediately downstream of the dam. Pages 421-51. In: J.S. Alabaster (Ed.). *Habitat Modification and Freshwater Fisheries: Proceedings of a symposium of the European Inland Fisheries Advisory Commission.*

Davies, B.R. 1975. Cabora Bassa hazards. *Nature, Lond.* 254:477-478.

Ebel, W.J. 1985. Review of effects of environmental degradation on the freshwater stages of anadromous fishes. Pages 62-79. In: J.S. Alabaster (Ed). *Habitat Modification and Freshwater Fisheries: Proceedings of a symposium of the European Inland Fisheries Advisory Commission.*

Edwards, R. and R. Howell. 1989. Welsh rivers and reservoirs: management for wildlife conservation. *Regulated rivers: research and management* 4:213-223.

El Moghraby, A.I. 1979. Some aspects of the impact of Roseires reservoir on the hydrobiology of the Blue Nile. *Proceedings of the International Conference on Kainji Lake and River Basin development in Africa.* Ibadan, Kainji Research Institute. 1:158-169.

Entz, B. 1976. Lake Nasser and Nubia. Pages 271-298. In: J. Rzoska (Ed). *The Nile, Biology of an Ancient River.* Monogr. Biol. 29. Junk, The Hague.

Fernando, C.H. and J. Holcik. 1991. Fish in reservoirs. *Int. Revue. ges. Hydrobiol.* 76:149-167.

Halstead, L.B. 1971. Freshwater bivalves on the shores of Lake Kainji. *Nigeria Field* 36:135-139.

Hammerton, D. 1976. The Blue Nile in the plains. *Monogr. Biol.* 28:243-256.

Harding, D. 1966. Lake Kariba. The hydrology and fisheries of Kariba. Pages 7-19. In: R.H. Lowe-McConnell (Ed). *Man Made Lakes. Institute of Biology Symposia No. 15.* Academic Press, London.

Henderson, H.F. 1973. Stratification and circulation in Kainji Lake. *Geophys. Monogr.* 17:489-494.

Hilsenhoff, W.L. 1971. Changes in the downstream insect and amphipod fauna caused by an impoundment with hypolimnion drain. *Ann. ent. Soc. Am.* 64:743-746.

Hira, P.R. 1970. Schistosomiasis at Lake Kariba, Zambia. I. Prevalence and potential intermediate snail hosts at Siavonga. *Trop. Geogr. Med.* 22:323-334.

Holcik, J. 1966. The development and formation of fish fauna in the Orava reservoir. *Biol. Prace. Bratisl.* 12:5-75.

Hunter, J.M., L. Rey and D. Scott. 1982. Man-made lakes and man-made diseases: towards a policy resolution. *Soc. Sci. Med.* 16:1127-1145.

Hynes, H.B.N. 1961. The invertebrate fauna of a Welsh mountain stream. *Arch. Hydrobiol.* 57:344-388.

Hynes, H.B.N. 1970. *The ecology of running waters.* Liverpool University Press.

James, L.B. 1988. The failure of Malpasset Dam. Page 17. In: R.B. Jansen (Ed.). *Advanced Dam Engineering for Design, Construction and Rehabilitation.* Van Nostrand Reinhold.

Jubb, R.A. 1961. *An illustrated guide of freshwater fishes of the Zambezi River, Lake Kariba, Pungwe, Sabi, Lundi and Limpopo Rivers.* Stuart Manning, Bulawayo. 171 pp.

Kenmuir, D.H.S. 1978. *A Wilderness Called Kariba.* Wilderness Publications, Harare. 140 pp.

Kenmuir, D.H.S. 1980. Aspects of the biology and population dynamics of freshwater mussels in Lake Kariba and Lake McIlwaine. Lake Kariba Fish Research Institute, Zimbabwe. Project report 36. 381 pp.

Kiersch, G.A. 1988. Vaiont reservoir disaster. Page 41. In: R.B. Jansen (Ed.). *Advanced Dam Engineering for Design, Construction and Rehabilitation.* Van Nostrand Reinhold.

Kroger, R.L. 1973. Biological effects of fluctuating water levels in the Snake River, Grand Teton National Park, Wyoming. *Am. Midl. Nat.* 89:478-481.

Latif, F.A. 1984. Lake Nasser (Egypt). Pages 193-259. In: J.M. Kapetsky and T. Petr (Eds). *Status of African Reservoir Fisheries.* CIFA Tech. Pap. 10. FAO, Rome. 362 pp.

Lelek, A. 1973. Sequence of changes in fish populations of the new tropical man-made lake, Kainji, Nigeria, West Africa. *Arch. Hydrobiol.* 71:381-420.

Lelek, A. and S. El Zarka. 1971. Preliminary observations on the effect of Kainji Dam on the downstream fisheries. *J. West Afr. Sci. Assoc.* 16:171-178.

Lewis, D.F.C. 1974. The effects of the formation of Lake Kainji (Nigeria) upon the indigenous fish population. *Hydrobiologia* 45:281-301.

Lowe-McConnell, R.H. 1977. Ecology of fishes of tropical waters. Institute of Biology, *Studies in Biology No. 76.* 64 pp.

Lowe-McConnell, R.H. 1987. *Ecological studies in tropical fish communities.* Cambridge University Press. 382 pp.

Magadza, C.H.D. 1991. The social impacts of the creation of Lake Kariba. Pages 156-158. In: M. Hashimoto and B.D.F. Barrett (Eds). *Guidelines of Lake Management. Volume 2: Socio-economic Aspects of Lake Reservoir Management.* ILEC/UNEP.

Malek, E.A. 1972. Snail ecology and man-made habitats. Pages 57-60. In: *Schistosomiasis. Proceedings of a symposium on the future of Schistosomiasis control.* Dept Trop. Med. and Parasitology. Tulane University, Louisiana.

Masundire, H. 1989. Zooplankton composition and abundance in relation to water transparency and predation in Lake Kariba, Zimbabwe. *Arch. Hydrobiol. Ergeb. Limnol.* 33:513-520.

Masundire, H. 1991. Proposals for a management policy for Mazvikadei reservoir. *Zimbabwe Science News* 25:42-44.

Masundire, H. (in press). The filling phase of Mazvikadei reservoir, Zimbabwe. *Hydrobiologia.*

McLachlan, A.J. 1969. The effects of aquatic macrophytes on the variety and abundance of benthic fauna in a newly created lake in the tropics (Lake Kariba). *Arch. Hydrobiol.* 66:212-216.

McLachlan, A.J. and S.M. McLachlan. 1971. Benthic fauna and sediments in the newly created Lake Kariba (Central Africa). *Ecology* 52:800-809.

Mitchell, D.S. 1969. The ecology of vascular hydrophytes on Lake Kariba. *Hydrobiologia* 34:448-464.

Mitchell, D.S. 1970. Autecological studies of *Salvinia auriculata* Aubl. Ph.D. thesis. University of London. 669 pp.

Moxon, J. 1969. *Volta, man's greatest lake.* Andre Deutsch Ltd. London. 256 pp.

Obeng-Asamoa, E.K. 1979. The effects of Akosombo dam on the oxygen regime of the Volta waters below the dam. *Proceedings of the International Conference on Kainji Lake and River Basin Development in Africa.* Kainji Research Institute, Ibadan. 1:170-177.

Otobo, F.O. 1974. The potential for the clupeid fishery in Lake Kainji, Nigeria. *Afr. J. Hydrobiol. Fish* 3:123-134.

Paperna, I. 1970. Study of an outbreak of schistosomiasis in the newly formed Volta Lake, Ghana. *Zeitschr. Tropenmed. Parasitol.* 221:411-425.

Petr, T. 1968. The establishment of the lacustrine fish fauna in Volta Lake in Ghana during 1964-65. *Bull. IFAN* 30:259-269.

Petr, T. 1974. Environmental aspects of the Kpong power development on the lower Volta river (Ghana, West Africa). Unpublished report.

Petr, T. 1981. Technical report on mission to assess the future fish production and fisheries potential of the Mtera impoundment, Tanzania (6-16 January 1981). FAO,Fisheries Dept. D 9/1 URT/78/025. FAO, Rome. 15 pp.

Quigley, M. 1977. *Invertebrates of stream and rivers: a key to identification.* Edward Arnold. 84 pp.

Reynolds, J.D. 1974. Biology of small pelagic fishes in the new Volta Lake in Ghana. Pt III. Sex and reproduction. *Hydrobiologia* 45:489-508.

Scott, D., K. Senker and A.C. England. 1982. Epidemiology of human *Schistosoma haematobium* infection around Volta Lake, Ghana, 1973 - 75. *Bull. WHO* 60:89-100.

Scudder, T. 1975. *The ecology of the Gwembe Tonga.* Kariba Studies II. Manchester University Press. 274 pp.

Serafim, J.L. and J.M. Coutinho-Rodriguez. 1989. Statistics of dam failures: a preliminary report. Water power and dam construction, April, 1989. Unpublished report.

SWECO/SWED Power. 1981. Cahora Bassa hydroelectric power scheme. Stage II. Preliminary report on ecology. SWECO, Stockholm. Unpublished report.

Thomasson, K. 1965. Notes on the algal vegetation of Lake Kariba. *Nova Acta R. Soc. Sci. Uppsal.* 19:1-34.

Thomasson, K. 1980. Plankton of Lake Kariba re-examined. *Acta phytogeogr. suecia* 68:157-162.

Ward, J.V. 1974. A temperature-stressed ecosystem below a hypolimnial release mountain reservoir. *Arch. Hydrobiol.* 74:247-275.

Welcomme, R.L. 1985. River fisheries. FAO Fisheries Technical Paper No. 262. 330 pp.

# Irrigation and cultivation in dambo wetlands in Zimbabwe

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## Introduction

Conservation progammes, by definition, seek to preserve or conserve ėcosystems or particular species. In areas such as whaling, ozone layer depletion, deforestation and pollution, man is seen as the guilty party. Man has overcome the constraints of nature but has not learned how to conserve nature or to regulate his power, thus endangering the environment. For a conservation programme to be successful, it must identify systems for turning men into willing participants in the conservation of the environment. Such systems clearly require an understanding of both the ecosystem to be conserved and the nature of man. Man is, for the most part, a logical creature; he will do what he perceives to be in his own immediate interest and may sometimes be persuaded to act for his medium or long term benefit. Alternatively, he can be persuaded from acting to his own detriment. Such a positive view of mankind is necessary if he is to participate in conservation programmes.

A classic example of a successful conservation strategy is Zimbabwe's Communal Area Management Programme for Indigenous Resources (CAMPFIRE). The motivational factors in this programme are relevant to wetlands conservation. CAMPFIRE deals with the conservation of wildlife in the communal lands and recognises the following factors:

1. People living in the communal lands cannot afford to be sentimental about wildlife or the environment in general. Concepts about the beauty of nature and the right of existence of all species do not strike a responsive chord in people struggling to survive. Wildlife conservation in the communal lands cannot be based on appeals to the people's magnanimity or by threats of penalties for poaching.

2. Wildlife in the communal areas is seen by the people as a food resource, to be realised by snaring and hunting. It has a very real value to a population group with few other assets.
3. Conservation strategies maintain or enhance the value of the resource for the community while concurrently conserving the resource. Such systems are based on sustainable utilisation of the resource.
4. The poorer the user or conservor community, the more immediate must the returns be from the conservation efforts.
5. The community must be a willing participant in the programme and the costs of the programme must not be beyond their means.

In practice, CAMPFIRE encourages communal peasants to conserve their wildlife so that it may be sold to safari operators for their wealthy, northern clients. For each animal shot, the value is paid out as cash to each member of the conservor community.

## Wetland conservation

Conservationists concerned with wetlands may use an approach similar to CAMPFIRE, as the difference between wetland and wildlife conservation in the communal lands is not as great as may seem to the casual observer. Wetlands do provide a resource to communal area farmers for water supply, cropping and grazing. The community cannot be persuaded to conserve the wetlands either by threats (i.e. legislation prohibiting stream bank cultivation) or by appeals to magnanimity. Systems can be devised which both conserve wetlands and simultaneously allow utilisation of their water, vegetation and soil resources for the benefit of the community. Any benefits accruing to the user community can be quickly and cheaply realised. A prerequisite to success of a programme like CAMPFIRE is the education of and willing participation by the user community.

The key to this programme is to allow user communities to derive immediate economic benefit from wetlands as this motivates them to ensure that the resource is conserved. This type of approach can be successful with wetlands because of their perceived productivity for irrigated agriculture. Indeed, dambos have been used for many decades by Shona farmers (Whitlow, 1983).

The major perceived dangers to wetlands are erosion and desiccation. These two hazards relate not only to direct degradation of the wetlands but also to downstream effects, such as loss of dry season flow and siltation of rivers. This paper identifies the hazards associated with wetland cropping and discusses the underlying mechanisms controlling the wetland environment of dambos, one of the major types of wetland located in Zimbabwe, Malawi and Zambia. In addition, methods of sustainable use of wetlands are suggested.

## Types of wetlands in Zimbabwe

One of the difficulties in dealing with wetlands conservation is the wide range of wetland types encountered, each with its own mode of formation, hydrology and erosion risks. Given such diversity, it is difficult to prescribe a blanket methodology for the development of wetland irrigation.

The two major types of wetlands in Zimbabwe are dambos and alluvial plains. These have different origins, hydrology and morphology, and, therefore, require different systems of safe usage. Within each class of wetlands there are subdivisions based on modes of origin and further subdivisions based on bedrock geology.

Dambos in Zimbabwe cover approximately 1.2 million ha (Whitlow, 1985), representing an irrigation potential of approximately 200,000 ha (Bell *et al.*, 1987). Alluvial aquifers in the communal lands of Zimbabwe are estimated to be capable of irrigating 12,000 ha (Owen, 1989). The nationwide potential of alluvial aquifers is probably twice this figure, which is still significantly less than the dambo potential. Thus dambos are a more significant irrigation resource. Alluvial aquifers derive, in a large measure, their importance from the fact that they occur in the more arid areas of Zimbabwe.

As it is impossible in a short paper to discuss the conservation of all these different types of wetlands, this paper will concentrate on the most common form of wetlands in Zimbabwe, the dambo. Further, only dambos on granitic rocks will be considered as the vast majority (89%) of all dambos are located on granites and granitic gneisses, 4% are on Kalahari sands and 7% on other geologies (Whitlow, 1985).

## The history of dambo wetland use in Zimbabwe

It is useful at this point to consider the history of wetlands use in Zimbabwe. Before the advent of white settlers, African farmers used wetlands for flood recession irrigation. Whitlow (1983) reports very extensive, remnant ridge and furrow patterns in several dambos between Marondera and Nyanga. Other reports from early European explorers and settlers (Selous, 1920; Brooke, 1965) confirm that dambo cultivation was a well established and highly productive form of traditional agriculture among the indigenous farmers. This form of cultivation appears to have been successful in the past and continues to be so today. The reduction of dambo farming, and the abandonment of many ridged dambos, appears not to have been due to environmental reasons but to displacement by settlers and prohibitive legislation (Whitlow, 1983).

Despite the extensive use of dambos by African farmers, the State enacted two pieces of legislation to prohibit the cultivation of these wetlands. The first was the Water Resources Act of 1927 which aimed to control any activities which could interfere with stream banks or with wetlands in stream source areas. The second was the Natural Resources Act of 1952 which sought to prevent the destruction of vegetation in wetlands and along steam banks. The legislation was enacted in order to ensure sustained base flow during the dry season and to reduce downstream siltation of river systems. The effect of these two acts was to make it illegal to cultivate wetlands. Precisely how this legislation was intended to protect wetlands is not clear but the overall effect was to promote grazing on wetlands and cropping, with attendant deforestation, on the interfluves. It now appears that the legislation may have had the effect of increasing wetland erosion.

As population increased, so wetlands utilisation, both for cropping and grazing, also increased despite the legislation. Some wetlands, particularly those in the lower rainfall areas, began to show signs of deterioration, including gully and sheet erosion and desiccation. There is some evidence that intensive grazing is more destructive of wetlands than the original ridge and furrow cultivation system (McFarlane and Whitlow, 1991). Whether this was due to the methods of wetland use, or to the low intensity of cultivation, is not known. However, certain wetlands show very extensive ancient ridge and furrow systems without any concomitant signs of erosion.

There was a belief that wetlands were sponges which stored water and then released it slowly through the dry season, thus maintaining base flow. The Water Resources Act was designed to protect this base flow so that the water could be utilised downstream, but it completely ignored the vital role that this water was already playing in food production. Moreover, in 1927 there were few rainfall recording stations and no gauging weirs to record stream flow, thus no hard hydrological information was available. Some 60 years later, the exact role of wetlands in streamflow is still unresolved, in spite of the additional available data.

## Hydrology of dambo wetlands

The 1927 Water Act was intended to stop dambo cultivation in order to preserve dry season base flow from the dambo 'sponge'. In the intervening years, hydrological data has been gathered and analysed, allowing the role of dambos in the maintenance of base flow to be critically assessed.

In qualitative terms, the occurrence of dambos on granitic rocks is related to the following factors:

- the sandy nature of the regolith which facilitates infiltration;
- shallow slopes which facilitate infiltration and reduce surface runoff;
- the presence of heavy subsoils which affect drainage and promote lateral groundwater flow;
- massive impermeable bedrock which impedes deep vertical drainage;
- variations in the relative depth to bedrock which influences groundwater movement and promotes discharge into the dambo seepage zones.

Table 1 The effects of increased dambo area on flow characteristics

| Flow characteristic | Increase | Decrease | No effect |
|---|---|---|---|
| Catchment yield | – | 1 | 2, 3 |
| Base flow volume | 4 | 3* | 5, 3 |
| Base flow duration | 4, 2, 6 | 3* | 3, 5 |
| Storm flow volume | 2, 3*, 7 | 4, 6 | 3, 5 |
| Storm flow peak | minor: 3* | minor: 2, 4, 6, 7 | – |

Key to authors:

1. Hill and Kidd (1980) in Malawi
2. Balek and Perry (1973) in Zambia
3. Bullock (1988) in Zimbabwe; * denotes effects on deep, permeable soils only
4. Kanthack (1945) in Central Africa
5. Drayton *et al.* (1980) in Malawi
6. Schulze (1979) in South Africa
7. Muneka and Mwassile (1986) in Zambia

The effect of dambos on stream flow response may be considered for catchment yield, base flow volume and duration, storm flow volume and storm flow peak, as shown in Table 1. These results suggest that the effect of dambo occurrence in Zimbabwean catchments on overall stream flow response is equivocal. However, where dambos are associated with deep, permeable, upper-catchment regoliths there is evidence that dambos reduce base flow volume and duration, increase storm flow volumes and enhance maximum flood peaks (Bullock, 1988). These findings can be readily explained. The decrease in base flow indices results from the increased water losses due to high dambo evapotranspiration rates. The increase in storm flow indices results from reduced infiltration into the already saturated dambo surfaces.

## The effects of dambo cultivation on hydrology

As has been demonstrated in the previous section, dambos *per se* have no significant effect on catchment hydrology. Cultivation of dambos and their upland catchments will have an effect on the evapotranspiration regime and it is this factor which may effect downstream catchment yields. It has been argued by Balek and Perry (1973) and by Bell and others (1987) for Zambia and Zimbabwe respectively, that evapotranspiration loss is the most significant factor influencing water balance in dambo catchments. Changes in natural dambo vegetation due to cropping must be analysed with respect to changes in evapotranspiration. Bell and others

(1987) have stressed that changes in the vegetation in the uplands, particularly the removal of trees, may have a more important influence on evapotranspiration losses than cultivation on dambos.

Dambos remain moist much of the year due to lateral seepage from the upper catchment into the dambo zone (Bell *et al.*, 1987). Therefore the water levels in the dambo are maintained at the expense of the water levels in the upper catchment. These natural losses must be replaced by annual precipitation if the dambo system is to remain wet. If it is assumed that the natural system is in equilibrium, then the effects of cultivation must be calculated in terms of additional losses.

Dambo cultivation without irrigation is unlikely to alter significantly the evaporative loss of water compared with the natural or grazed dambo. Residual moisture and groundwater seepage may keep some dambos perennially wet, especially in high rainfall regions (over 1,000 mm/year) and where associated with deeply weathered regoliths. Such conditions are more common in Malawi than in Zimbabwe (McFarlane and Whitlow, 1991) and, under such conditions, no irrigation will be required. Cultivated crops are likely to have similar rooting depths and water requirements to natural dambo grasslands. Bell and others (1987) calculate that if 10% of the dambo area is planted to crops with high water requirements (K crop coefficient increased by 60%), the increase in water demand can be met by 20 mm of precipitation. Therefore, dambo cultivation based on residual soil moisture use is unlikely to affect the water balance significantly, and should not be prohibited on these grounds.

Dambo cultivation with irrigation is likely to take place in the latter part of the dry season once soil moisture has been depleted by crop evapotranspiration. The application of irrigation water will affect the aquifers, both in the dambo and in the upper catchment, causing a drop in water table levels. If this water is applied to areas from which evapotranspiration has ceased, or has been much reduced due to lowered water levels, then the additional crop water will come from aquifer storage. Such water requirements may be significant and can be estimated as 5 mm/day for the late dry season in central Zimbabwe.

Wet dambo areas should be cultivated but where a dry dambo is irrigated, a maximum of 10% of the catchment area should be irrigated (Bell *et al.*, 1987). In fact, dambo irrigation may be a self regulating system in that excessive use will lead to desiccation of the dambo and reduced productivity of crops relying on residual moisture. If communities are given the responsibility for and the benefits of dambo management and use, they may well regulate excess pumping of water, just as CAMPFIRE participants regulate poaching. The effects of excess pumping will be seen in the following season as lowered water tables.

A further factor affecting water balance of dambos is the vegetation cover on the upper catchment. It appears that the upper catchment was naturally covered by 'miombo' woodlands. These deep rooted trees have perennial access to the groundwater. If the woodland is removed and replaced by cultivated crops, then the evapotranspiration from the upper catchment will be much reduced in the dry season, allowing greater seepage into the dambo area. This has happened in many areas of Zimbabwe.

It is therefore argued that dambo cultivation has little effect on stream flow and should be allowed. Dambo irrigation should be practised with care on a relatively small area (10%) of the catchment. The upper catchment area is an integral part of the dambo system and deep rooted, high water demand plants, such as *Eucalyptus* trees, should be restricted in these areas.

## Erosion of dambos

The Natural Resources Act, 1951, was enacted, in part, to protect dambos from the gullying and erosion which had resulted from the mechanised ploughing of whole dambos on commercial farms. Gullying was seen both as a mechanism of soil loss, with concurrent downstream siltation, and a cause of dambo desiccation by accelerated drainage. The legislation curtailed all dambo cultivation, both in the commercial farming areas and the communal lands, but erosion had not been a feature of dambo cultivation in the latter areas. The traditional African methods of cultivation, with a small scale patchwork of basins, ridges and furrows, and with very shallow disturbance of the soil profile, had not resulted in dambo gullying.

In the communal lands, a result of the legislation was the transfer of dambo cultivation to the interfluve areas with livestock grazing being correspondingly moved to the dambos. A time series study of aerial photography since the enactment of the legislation shows that this particular agricultural regimen has initiated and accelerated gullying in the communal areas (McFarlane and Whitlow, 1991). The reasons for gully development were sought in land use practices on the dambo itself and causes within the wider catchment were not sought.

Recent work on dambos (McFarlane, 1987; McFarlane and Whitlow, 1991) has identified more clearly the processes of dambo formation, dambo insetting and the mechanism likely to promote gully development. Dambos are now understood to be the low points in a topographic surface lowered by subsurface leaching and suffusion as a result of groundwater movement. The groundwater circulation takes place below an impermeable surface layer of dambo clay and discharges dissolved material downstream and in areas where the dambo clay has been breached. As the dambos become progressively inset, they become narrower and their fluviatile configuration becomes more pronounced. With progressive natural development, the dambos are replaced by stream systems. Dambos in Zimbabwe are already considerably narrower and more inset than dambos of Malawi due to their geographic position on the remnant watershed of the African erosion surface.

Wetland conservationists, in addition to their legitimate concern about surface runoff, must be aware of the potential for groundwater flow to cause gullying by increased leaching and suffusion. This hastening of the dambo system's natural progression towards a true fluviatile system, will effectively drain these wetlands. The strength of the groundwater circulatory system appears to be the critical component in this process which is driven by the hydraulic gradient between the interfluve water table and the dambo floor. A high interfluve water table will increase the hydrostatic pressure below the clay in the dambo bottom and thus initiate breaching where the clay is weaker and thinner. This breaching of the clay causes slumping, surface water discharge and initiates gully formation.

The unfortunate effect of the Zimbabwean legislation has been to increase grazing on the dambos, increase cultivation on the interfluves and to cause deforestation of the interfluves in order to provide space for cultivation. This has resulted in the following effects:

1. Livestock tracks have provided channels for concentration of surface runoff and promoted gullying.
2. Removal of interfluve woodland has increased interfluve water levels, thus increasing hydrostatic pressure below the dambo and promoting beaching of the clay and gullying.
3. Replacement of cultivated crops with grazing on the dambos has reduced the evapotranspiration from the dambos resulting in higher subsurface water pressures and promoting breaching of the dambo clay and gullying.
4. Reliance on rain fed agriculture alone has reduced land productivity, yields and food security and has led to extended cultivation and deforestation.

## Systems for wetland cultivation and conservation

The preceding analysis shows that the existing legislation for the preservation of dambo wetlands is badly misdirected and in fact is likely to cause more damage to dambos. Clearly such legislation must be amended.

The task of wetland conservation will be difficult; the dambo systems on the central watershed are fragile and will require care if they are not to be destroyed. They occur within a geomorphologically marginal setting and low rainfall (Whitlow, 1984). Gully erosion, stream invasion and desiccation are all ever present dangers, both from human activity and from processes of natural landscape evolution.

The following techniques are recommended for the conservation of dambos:

1. Dambo catchments must be managed as integrated systems, and each catchment requires a utilisation plan. Such a plan could be produced by the users and then modified with technical assistance.
2. Dambo cultivation should be allowed, provided systems of a patchwork of ridges, furrows and basins, separated by grassed strips, are used to reduce runoff and soil loss.
3. Dambo grazing should be severely reduced or prohibited.
4. Dambo burning should be prohibited.
5. Interfluve areas must be managed as these areas provide most of the water for the dambo system. However, management may vary considerably; in marginal rainfall areas deforestation of the interfluve may be appropriate, while in high rainfall areas afforestation may be more appropriate.

6. Gullying should be reclaimed and runoff channels within dambos should be rehabilitated.
7. Water pumping or lifting for irrigation should be limited, based on the rainfall and individual dambo hydrology.
8. Water levels should be monitored.
9. Gully development should be monitored.

## Conclusions

Dambo cultivation could provide 200,000 ha of informal irrigation to the communal farming sector (Bell *et al.*, 1987) compared with approximately 5,000 ha provided by the Agritex irrigation schemes for the same sector. Clearly the value and productivity of this wetland resource warrants considerable effort and energy to maintain and enhance its productivity. Agritex and the Natural Resources Board should be asked to mobilise resources and amend the legislation so that this resource can be safely and sustainably utilised and conserved.

## References

Balek, J. and J.E. Perry. 1973. Hydrology of seasonally inundated African headwater swamps. *Journal of Hydrology* 19:227-249.

Bell, M., R. Faulkner, P. Holbkiss, R. Lambert, N. Roberts and A. Windrau. 1987. The use of dambos in rural development with reference to Zimbabwe. ODA Project Report R3896.

Brooke, R.K. 1965. Shifts in the avifauna of the Salisbury District of Southern Rhodesia during the historical period. Pages 297-307. In: G.J. Snowball (Ed.). *Science and Medicine in Central Africa.* Pergamon Press.

Bullock, A. 1988. Dambos and discharge in Central Zimbabwe. Ph.D. thesis, University of Southampton, UK.

Drayton, R.S., C.H.R. Kidd, A.N. Mandeville and J.B. Miller. 1980. A regional analysis of river floods and low flows in Malawi. Institute of Hydrology, Wallingford. Report No. 72.

Hill, J.L. and C.H.R. Kidd. 1980. Rainfall-runoff relationships for 47 Malawi catchments. Malawi Water Resources Department. Report TP7.

Kanthack, F. 1945. Relationship between rainfall and runoff in Central Africa. *Proc. Sth. Afr. Soc. Civil. Eng.* 43:29-48.

McFarlane, M.J. 1987. Dambos: Their characteristics and geomorphological evolution in parts of Malawi and Zimbabwe with particular reference to their role in the hydrogeological regime of surviving areas of African surface. Pages 254-302. In: *Groundwater Exploration and Development in Crystalline Basement Aquifers. Proceedings of a seminar held in Zimbabwe, June 1987.* Commonwealth Secretariat Publications, London.

McFarlane, M.J. and R. Whitlow. 1991. Key factors influencing the initiation and progress of gullying within dambos in parts of Zimbabwe and Malawi. *Land Degradation and Rehabilitation* 2:215-235.

Muneka, A. and N. Mwassile. 1986. Some aspects of the hydrology of dambos in Zambia. *Proceedings of the National Workshop on Dambos*. Nanga, April 1986. Ministry of Agriculture and Water Development, Zambia and FAO. 111-127.

Owen, R. 1989. Shallow alluvial aquifers for small scale irrigation. ODA Project Report R4239.

Schulze, R.E. 1979. Hydrology and water resource of the Drakensberg. Natal Town and Regional Planning Reports Vol. 42:122-123.

Selous, F.C. 1920. *A Hunter's Wanderings in Africa*. McMillan, London.

Whitlow, R. 1983. Vlei cultivation in Zimbabwe. *Zim. Agr. J.* 80(3):123-135.

Whitlow, R. 1984. A survey of dambos in Zimbabwe. *Zim. Agric. J.* 81(4):129-138.

Whitlow, R. 1985. Dambos in Zimbabwe: a review. *Zeitschrift für Geomorphologie, N.F. Suppl.* 52:115-146.

# Wetlands conservation under common property management regimes in Zimbabwe

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## Introduction

I am more inclined to consider the issue of wetlands in Zimbabwe as a problem of the sustainable utilisation of wetlands than a conservation problem. To look at the wetlands problem through purely conservational lenses usually implies preservation and ignores or condemns the multiplicity of uses which currently apply to wetlands in the communal lands (grazing, agriculture, fishing, recreation, gold panning). Moreover, conservation or preservation, as an analytical construct, is rather narrow in that it usually does not include sustainable utilisation as part of the conservation dynamic.

Sustainable utilisation is itself a contested paradigm. I use it here to refer to resource use that does not necessarily result in resource depletion or ecological degradation. Sustainable utilisation in this paper thus implies some form of management and regulation of resource use. As Murphree (1991) states:

> "Resources use without resource management is non-sustainable. But equally, any attempt to establish resource management without resource use is likely to be futile".

Bromley and Cernea (1989) remind us that the recent interest in the nature and status of common property was triggered not by pure academic concerns but rather by the practical problems faced in development interventions. Scholars and development practitioners alike have come to realise that successful intervention to reverse degradation of resources at the local level is predicated upon the understanding by policy makers of the nature of property and authority systems over natural resources. Based on greater understanding of property and resources management regimes, the debate on common property management has gradually distanced itself from the "tragedy of the commons" paradigm proposed by Hardin (1968). The current position is that regimens for the management of the common property resource offer viable solutions to some of the most pressing problems of resource degradation at the local level.

Perhaps one of the greatest problems facing the management of common property resources in Zimbabwe's communal lands is based on the fact that the state and the people have different constructions of land holding and land use. Extant state constructions are apparently a continuation of the colonial ideologisation of the land issue (Cheater, 1989). Evidence now exists to suggest that these are not true representations of the tenure system that is operating in the communal lands today. Cheater (1989) gives further discussions on the *de facto* tenure systems operating in communal lands. The management of common property resource in Zimbabwe's communal lands has suffered as a result of colonial legislation which was based on a deliberate misrepresentation of the structure of the communal tenure system, with a view to legitimising the expropriation of land and centralised control.

Of interest in this paper is not the history, both colonial and post-colonial, of land holding practices *per se*, but rather how state interpretations of the same have led to the apparently inexorable trend of degradation of the common property resource in the communal lands. The degradation of resources is not a feature exclusive to the communal lands, it occurs under all other property regimes in varying and perhaps even greater degrees. The major difference to note here is that resources degradation in communal lands results from state assumption of control over communal lands and the resultant demise of local management institutions, with their clearly defined rules, regulations and obligations.

## The nature of property and resource management regimes

'Property' refers to an enforceable right of a person or persons to some use or benefit of some thing and it is, therefore, a political relationship between persons. Property is not the thing to which the right refers, the right simply specifies the relationship. Moreover, property is a dynamic institution, constantly changing as the relationships between persons change (MacPherson, 1978).

In the Marxist view, property institutions are the result of class relationships of production and refer to the ownership of the means of production. Thus, since ownership of the means of production is determined by the mode of production in each epoch, property relations are indications of the dominant mode of production of that epoch. Since property rights define the relations between persons with respect to a particular thing, they define the behaviour of persons regarding that particular thing. Property rights thus refer to both rules of access and exclusion as well as rules regulating the use of that thing. Property relations are also property regimes.

According to Bromley and Cernea (1989):

> "A resource is a structure of rights and duties characterising the relationship of individuals to one another with respect to that particular resource".

A property regime over resources is regulated by a set of dynamic institutional arrangements which define the rules of access to, and exclusive from, that resource and how the resource may be used. There are four possible resource regimes over the various natural resources: state property, private property, common property, and non-property (open access).

**State property**

State property refers to state ownership and control over the use of a particular resource. It is essentially a state right to exclude groups or individuals from the use of that resource; national parks, national forests, rivers and dams are examples of state property regimes.

**Private property regimes**

Private property regimes refer to the right of the individual (or corporate body) to exclude other individuals or groups from the use or benefit of something.

**Common property regimes**

Common property regimes refer to private property for the group. It is created by the guarantee to each individual member of a group that he will not be excluded from the use or benefit or something. The group also has the right to exclude non-members from use or benefit of that thing. Individuals within the group have rights and duties to the resource in question. Both common property and private property are individual rights because they are guarantees to the individual (MacPherson, 1978). States as well as local institutions can manage common property. State management would involve the administration, by a local authority or other constituted body, of rules and regulations. Thus, for instance, the biological resources of a country are 'national common property' managed by the state, ostensibly for the benefit of all citizens.

**Open access or non-property regimes**

Open access or non-property regimes refer to situations in which there is no property. There are no property rights and hence no institutional arrangements to regulate access and use. In the words of Bromley and Cernea (1989):

> "In a situation of open access each potential user has complete autonomy with respect to use of the resource since no one has the legal ability to keep others out; the natural resource is subject to the rule of capture and belongs to no one until it is someone's physical possession. There are no property rights in this regime, there is only possession".

Scholars and development practitioners frequently confuse common property regimes with non-property regimes. Common property is frequently alleged to lead inevitably to resource degradation in a "tragedy of the commons" scenario (Hardin, 1968). However, scholars are now challenging Hardin's thesis on the basis that Hardin failed to distinguish open access from a common property regime. Thus the evidence suggests that because of its failure to account for the institutional arrangements in common property regimes, the resource degradation more accurately refers to a tragedy of open access than to a tragedy of common property regimes (Ciriacy-Wantrup and Bishop, 1975; Bromley and Cernea, 1989).

## Environmental legislation and wetlands in Zimbabwe

Research into agricultural practices used in dryland farming in the communal lands of Zimbabwe demonstrates that wetlands are key resources to all systems and that a complex pattern of interaction and trade-offs exists in wetland-dryland farming systems. Access to wetlands allows diversification into crops that cannot be grown in nearby dryland areas (Scoones, 1991). Wetlands in semi-arid environments are crucial to livestock management. That wetlands are key grazing resources is demonstrated in a study of a grazing scheme in one communal area of Zimbabwe (Scoones and Cousins, 1991). Local communities practice reserved grazing in dambos with regulation and enforcement by traditional leaders (Scoones, 1991).

Institutional arrangements are designed to regulate use of resources and management is not limited to the regulation of access to the resource but also involves maintaining the condition of the resource. Such institutional arrangements imply the existence of an authority structure with a capacity to enforce the regulations. Thus, in spite of state regulation, local processes of resource utilisation and regulation imply that there is a process of defining a common property regime regarding the utilisation of dambo resources. This suggests that there exists local recognition of the importance of wetlands to the whole production system of the communal areas. Because of this central role, local political processes are aimed at maintaining those resources as part of the common property regime and thus guarantee access by recognised group members.

While wetlands are obviously crucial to the communal farming system, and have been maintained as part of the common property regime because of the need to ensure access, legislation and official land use policy has failed to recognise this. Indeed, legislation and land use policy in both pre- and post-colonial eras have had the effect of taking out of production the key wetlands in both the European areas and the reserves. The rationale behind this was the need for conservation and environmental protection, based on unsubstantiated fears that use of wetlands would inevitably result in their ecological collapse.

## Legislation regarding dambo use

Using dambos as a example, Scoones and Cousins (1991) argue that the colonial state pursued a highly interventionist strategy towards natural resources management. State intervention in dambo use is traced from the Water Act of 1927 (amended 1976) which prevents unauthorised persons from interfering with "the bed, banks or course of a public stream or any swamps or marshes forming the source of a public stream or found along its course". In this act, the technical information concerning dambo and stream bank cultivation contained inaccuracies (Scoones and Cousins, 1991).

The Natural Resources Act of 1942, which introduced regulations prohibiting stream bank cultivation within 100 feet of a stream bank and on a wetland, continues to be enforced. Scoones and Cousins (1991) maintain that these regulations were enforced by the Natural Resources Board (NRB) whose official stance regarding wetlands use has remained unchanged to this day.

Technical evidence demonstrated the profitability of maize production in dambos, with the result that it was legalised in European areas in the 1960s. Despite the questioning of the technical rationale of the regulation, peasant farmers have remained bound to this legislation. Thus the state still effectively controls access to and use of dambos in the communal lands and this is strongly resented by the farmers who have observed successful, productive and (apparently) sustainable agriculture in the dambos over the years. Many technical specialists would support the communal land farmers on this stand (Scoones and Cousins, 1991).

This example of legislation that has a weak technical basis shows how state control needs to be decentralised to allow for greater autonomy of user groups. In spite of the existence of statute regulations and enforcement by NRB, use of wetlands has continued. However, because of the difficulties of state regulation from a distance, the development of appropriate common property regimes and regulatory institutions have been constrained. In some cases, use has taken on forms approximating open access because of the limited capacity of local authority structures to regulate use. As state control has recognised the use of wetlands in European areas but continues to proscribe it in the communal areas, this is a clear manifestation of the state's lack of understanding of the *de facto* tenure system operating in the communal lands.

The technical and bureaucratic nature of land use policy in Zimbabwe, together with inhibitive legislative structures, have resulted in common property arrangements being generally excluded from policy framework as viable options for resource management.

To argue that state control alone accounts for the disintegration of local capacity to regulate use, however, ignores the effect of local political and economic processes and responses to integration into the economy (Lawry, 1989). The opportunity to earn income from non-agricultural sectors means that individuals have alternative income earning opportunities to declining common property resources. Moreover, there is a trend of differentiation and class formation among the rural population which suggests that decision making also becomes increasingly based on differential and perhaps even competing interests of the rural people. Differentiation also implies different strategies regarding common property and as such wealthier peasants have progressively privatised the commons and put them under sometimes unsustainable land uses. This has been possible because of the breakdown of institutional regulations and arrangements as a result of state control.

Scoones and Cousins (1991) note that the struggle for control over dambo resources in Zimbabwe occurs between both the state and local communities as well as within the local communities themselves. Local contestation over dambo resources are very much a result of different interests regarding the use of the resource.

Policy making on land use, environmental issues and the economy in Zimbabwe has historically been fragmented and disjunctive. Ecological issues have often been used to rationalise short term political or economic dictates (Murphree and Cumming, 1991). Policy has also ignored local capacity for resource management and rarely makes use of local ecological knowledge. Local knowledge is based on intimate interaction with the environment and on observation, and is frequently more accurate on local conditions than the information available to planners. Policy and legislation have however made this knowledge redundant (Murphree, 1991).

## The common property debate

State appropriation of the communal lands has essentially limited local capacity to manage resources previously utilised under communal management regimes. It is not possible to reconstruct how common property resources were managed in pre-colonial times but evidence suggests that while land might have been individually owned, contrary to state ideological constructions, there were certain key resources to which access was crucial for the success of the prevailing land use systems. Such resources included grazing land, wildlife, timber and other forestry products, water and wetlands. Access to these resources was regulated by common property regimes.

State assumption of control over resources results in local institutions losing their legal rights to control the utilisation of the access to those resources. The state, however, because of logistical limitations of staff and funding, and also because it operates removed from the users of the resource, is unable to put effective management institutions in place. It has also been observed that the state's principal objective in centralising control over resources is to assert political authority over local interests and not to create new or more effective resource management regimes. States have also concentrated their regulatory efforts on individual users rather than on user groups (Lawry, 1989), leading to the dissolution of local institutional arrangements for regulation of resource use.

Murphree (1991) argues that the ability of traditional authority structures to manage common properties during the colonial era was seriously eroded by their coaptation into the colonial administration as part of the strategy of indirect rule. These authority systems could not function effectively in land and resource management when the tenure status of the land effectively changed to state land. As stated by Murphree (1991):

> "They and their constituencies were on state land with usufructural rights only, they had no powers of exclusion and access to certain natural resources (e.g. wildlife) were denied to them. Thus the conditions for a genuine communal property - rights regime were removed. Under these conditions, and with the state effectively unable to manage resources, resources use tended to acquire the characteristics of an 'open access' system. It is not surprising therefore that the communal lands have been the scene of the greatest environmental degradation in the country".

Local political processes, however, exist which attempt to define and maintain common property regimes for key resources in the production systems of the communal lands. The failure by the state to recognise these processes or to encourage the development of systems of group rights has slowed the development of appropriate management regimes for the key resources. It is thus urgent for policy solutions to take account of these processes before all institutional arrangements atrophy and a system of open access ensues.

The collapse of local level, institutional arrangements occurs when common property regimes are converted into systems of open access, in which the rule of capture drives each to get as much as possible as quickly as possible (Bromley and Cernea, 1989). The decline of these indigenous institutions is a result of the imposition of state control and changes occurring in the village economy (Lawry, 1989). Thus as opportunities to earn income from other than common property resources arise, and as communities become differentiated, differential interests in the common property resources are likely to emerge and the enervation of local institutional arrangements is expedited.

A fundamental result of open access has been resource degradation. What is required, therefore, is a system that can institutionalise common property resources management by creating new systems of group ownership of such resources. This has been attempted with wildlife management under the Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) and although initial results of CAMPFIRE are encouraging, it is still too early to give a conclusive prognosis.

## Conclusions and policy recommendations: the need for appropriate local institutions for common property resources management

For the sustainable management of wetlands in Zimbabwe's communal lands, policy needs to reconsider the whole land tenure issue in the communal lands to facilitate the sustainable utilisation of common property resources. Since the main constraint to sustain utilisation of common property resources in Zimbabwe today is the limited regulatory capacity of local authority structures, policy solutions should seek to encourage the development of communal tenure regimes. In the absence of such a development, open access will be unsustainable.

The problem facing communal resources in Zimbabwe today is largely a result of the inability of state control to replace local level management. State property can not be advocated as a viable option given the constraints of state management. On the other hand, privatisation as a solution in Zimbabwe's communal lands is just as unlikely to succeed given the questions of scale that would arise, the mixed cropping and livestock production systems and the grazing commonage. Moreover, privatisation would run contrary to government's ideological preference for egalitarian socialist development (Murphree and Cumming, 1991).

It has also been observed that the legislative environment under which common properties are currently utilised is unnecessarily restrictive and outdated. For policy changes to occur there have to be complementary changes in legislation to facilitate the new policy initiatives. There is a need for changes in legislation to make it possible for local communities to utilise the natural resources at their disposal. Murphree and Cumming (1991) state this point thus:

> "Current constraints to the development of (these) diverse resources include outdated legal and bureaucratic structures... Zimbabwean policy should vigorously encourage exploitation of these resources through initiative research and marketing and revise legal and bureaucratic constraints where necessary".

If a common property regime is instituted for the management of wetlands in the communal lands of Zimbabwe, then a process of institutional development should be set in motion and the CAMPFIRE experience would be valuable in this regard. Such institutional development would need to be informed of the nature of the resources in question and the particular uses to which they will be put by the user groups, the nature and structure of the user groups and the current dynamics of control and regulation. As Scoones (1991) states:

> "In order for development strategies for wetlands in drylands to be more effective and to avoid unsustainable intervention, appropriate economic assessments of the value of wetlands for local livelihoods are essential".

In urban and peri-urban areas, some system of group rights and/or regulation of wetlands is also desirable. For example, profitable market gardening based in wetlands has been observed in peri-urban areas in some African countries (Scoones, 1991). If such systems were individually based, then the water rights would have to be vested in a user group, given the nature of the resource.

Thus the need for an appropriate tenure regime for the communal lands today is urgent. The success of all rural resource management programmes is predicated upon the existence of an acceptable resource management regime in which all users are involved in decision making and stand to benefit from management. Moreover, the transaction costs involved in the management regime should be kept to a minimum. Policy should thus be based on a recognition of current use and attempts at local regulation and should aim at strengthening these local processes.

## References

Bromley, D.W. and M.M. Cernea. 1989. The management of common property natural resources: some conceptual and operational fallacies. World Bank Discussion Papers No. 57. 66 pp.

Cheater, A.P. 1989. *The ideology of communal land tenure in Zimbabwe: mythogenesis enacted.* Africa No 60. pp. 188-206. Department of Sociology, University of Zimbabwe, Harare.

Ciriacy-Wantrup, S.V. and R.C. Bishop . 1975. "Common property" as a concept in natural resources policy. *Natural Resources Journal* 15:713-727.

Hardin, G. 1968. The tragedy of the commons. *Science* CLXII:1243-8.

Lawry, S.W. 1989. Tenure policy toward common property natural resources. Paper prepared for the conference on Incentives and Constraints: Macroeconomic Policy Impacts on Natural Resources Utilisation. Smithsonian Institution, Washington, D.C.

MacPherson, C.B. (Ed.). 1978. *Property: Mainstream and Critical Positions.* University of Toronto Press, Toronto.

Murphree, M.W. 1991. Communities as institutions for resource management. Paper presented at the National Conference on Environment and Development, Maputo, Mozambique, 7-11 October, 1991.

Murphree, M.W. and D.H.M. Cumming. 1991. Savanna land use: policy and practice in Zimbabwe. CASS/WWF Paper No.1. Harare.

Scoones, I. 1991. Wetlands in Drylands: Key Resources for Agricultural and Pastoral Production in Africa. *Ambio* 20(8):366-371.

Scoones, I. and B. Cousins. 1991. Wetlands in Drylands: The agroecology of savanna systems in Africa. Part 3f: Key resources for agriculture and grazing: the struggle for control over dambo resources in Zimbabwe. IIED, London, U.K. 29 pp.

# Legislation and wetlands in Zimbabwe

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## Introduction

Wetlands have traditionally been understood to be land that is subject to permanent or seasonal flooding or areas of subsurface water accumulation through seepage such as in vleis or dambos. Thus the traditional definition of wetlands in Zimbabwe is very limited compared to the wider definition of wetlands used by the Ramsar Convention in 1971. Wetlands, in particular dambos, have been valued and conserved for the production of rice, yams and other popular tubers like 'tsenza'. Many dambos have dried up, due mainly to unsustainable agricultural practices. Valuable as these areas are, their protection has never been considered a national issue since most of the crops grown within wetlands have little commercial importance. Therefore, very little has been done to protect wetlands through Government policies and many people have been deprived of valuable and nutritious crops due to the drying up of dambos.

Wetlands have also been an important source of water for the residents of communal lands and their livestock, especially in the dry season. Their destruction contributes to the acute water problems being faced by many rural households.

This paper deals with current legislation which protects wetlands in Zimbabwe. Consequently, the term 'wetlands' in this paper includes floodplains, riverine wetlands, dambos, pans, swamps and artificial impoundments.

## Current legislation involving wetlands

The extent of legislative mechanisms in place to protect wetlands is clearly influenced by the attitude towards wetlands in Zimbabwe; the importance of wetlands in enhancing food security, water security and maintaining balance in the ecosystem is not well understood. Many wetlands are regarded as wastelands which must be drained to allow meaningful development to take place. An analysis of legislation relating to wetlands protection in Zimbabwe follows.

## The Water Act

The Water Act of 1976 attempts to ensure sustainable use of water through issuance of rights and permits as well as protection of water from pollution. It contributes towards the protection of wetlands but more stringent controls would be useful. The Water Act provides for the planning of optimum development and utilisation of water resources of Zimbabwe and the establishment of water development advisory councils for the establishment, jurisdiction and composition of Water Courts. Powers relating to the granting of applications for the use of public water, the control of groundwater, the prevention and control of water pollution, the approval of irrigation schemes and the safety of dams are vested in the Water Act. An outline of the Act is given below.

The administration of the Water Act rests with the Minister of Energy, Water Resources and Development (MEWRD), who can delegate the administration of the Act to the Secretary of MEWRD, who in turn can delegate powers to officers. Section 6 of the Act devolves much supervisory function to the state, which makes it difficult to implement. The Minister, under Section 9, may establish river boards for the purpose of regulating and supervising the operations of rights for the use of public water. This ensures that no one uses water to the exclusion of others.

The Secretary of MEWRD is responsible for drawing up Outline Water Development Plans (OWDP) for each river system in the country. The OWDPs should include major water uses and estimate the extent to which actual volumes, relative proportions of potential yields or total run off of any catchment area can be utilised. They specify potential areas for dam sites and determine storage for future use as well as all sources of land based pollution. The Minister may also establish a water development advisory council for any river system whose purpose is to advise the Minister on any OWDP and make recommendations on the operation of the OWDP. Any development in any catchment area should be in accordance with the OWDP. Final approval for the OWDP rests with the President.

The Water Court, established in terms of Section 22 of the Act, has jurisdiction over the use of public water and disputes concerning the abstraction, appropriation, control, diversion or use of public water. 'Casual uses' of public water, i.e. cooking, drinking, washing or watering stock, does not require a permit. Any person who requires a right to use public water for agricultural, electrical, institutional, local authority or township, railways or roads uses, must lodge an application with the Registrar of the Water Court; applications to use public water for mining purposes must be lodged with the Mining Commissioner.

Although the Act emphasises the conservation of water for utilisation purposes, in the process it ensures the conservation of some very important wetlands. The charging of tariffs for water usage also encourages optimum use for water and controls water usage.

Section 60 provides for the return of any water used for electrical, mining or miscellaneous purposes to the public stream from which it was abstracted or any other public stream specified by the Water Court.

Section 65 authorises the Minister to reserve any potential dam basin or dam site against construction or interference, except against mining operations. The Minister can also reserve the use of public water or declare public water control or a public water shortage area.

The Act also controls pollution of private, public and underground water. It is an offence, in terms of Section 102, to allow any organic or inorganic matter, effluent or waste matter to be discharged into a public stream, private water, public water or underground water except if it conforms with certain quality standards. The Minister may grant exemptions after consulting the Minister of Health.

Water pollution control in the Act is very weak as each case is considered on its own merit. The Act also fails to prevent pollution but prescribes measures to stop pollution *post facto*.

## The Natural Resources Act

Zimbabwe is innovative in having legislation that specifically mentions wetlands. The Natural Resources Act, enacted in 1941 and amended in 1975 and 1981, defines wetlands as land which is saturated by 150 mm or less of water for the major part of a rainfall season or exhibits in the soil profile one or more of the following features:

- mottles or rust like stains in root channels 150 mm or less from the surface of the land;
- black topsoil horizons, very rich in organic matter, overlying pale sands;
- dark grey or black heavy clay showing considerable surface cracking when dry and without marked evidence of self mulching.

This definition excludes dams and public streams not as wetlands but as natural resources.

According to the Act natural resources include: the soil, waters, minerals, springs, vleis, sponges, reed beds, marshes, swamps and public streams of Zimbabwe. Whenever the Act refers to the conservation of natural resources it also refers to conservation of all the wetland types mentioned in the Act. Reference to public water includes some of these wetlands. A summary of the Natural Resources Act is given below.

Section 3 establishes a Natural Resources Board to ensure the conservation of all natural resources including wetlands. Board members are appointed by the President and the Board's functions are:

1. to exercise general supervision over natural resources;
2. to stimulate, by dissemination of information and other means, a public interest in the conservation and improvement of natural resources; and
3. to recommend to the State the nature of legislation or other measures necessary for the proper conservation, use and improvement of natural resources.

Under Section 14, the Board shall, at the request of the Minister, report upon State and other soil and water conservation projects. Sub-section (2) of the same section ensures that the catchment area, or any dam, is managed to reduce silting of the dam.

In order to enforce its authority, the Board can issue an order, under Section 46, requiring the owner, occupier or user of the land to: undertake or adopt prescribed measures, construct prescribed works, carry out activities necessary for the conservation of natural resources, or refrain from carrying out acts which may lead to the injury of natural resources.

The Act allows for the formation of Intensive Conservation Areas, to be managed by a Conservation Committee composed of local landholders. These voluntary committees form grassroots conservation movements which assist the Board to carry out its functions.

In communal lands the Board may, with the approval of the Communal Land Board, direct that an area of land be reserved against human occupation, cultivation, grazing of stock and the cutting down of trees or other vegetation. These areas must be clearly demarcated and fenced. Thus the Board may reserve any wetlands in communal lands for the purposes of conservation.

The Minister is empowered, under Section 67, to construct any works desirable for the conservation of natural resources, including the control of water tables and disposal of irrigation drainage water.

The Act provides for the appointment of inspectors to enforce its provisions. Inspectors can make orders for conservation of natural resources whenever necessary. The order may relate to the prohibition or restriction of cultivation of any land, control of water, prevention of soil erosion or removal of vegetation.

Of importance is Section 81 (d) where the Minister is empowered to make regulations to prohibit or restrict the cultivation of wetlands, the banks of public streams or land adjacent to artificially conserved water. This gives the Minister wide ranging powers to protect wetlands in Zimbabwe.

## Natural Resources (Protection) Regulations

Section 3 of the Natural Resource (Protection ) regulations of 1976 provides that no person shall, without the written approval of the Board, cultivate or destroy any natural vegetation, or dig up, break up, remove or alter in any way the soil or surface of:

- a wetland;
- land within 30 metres of the naturally defined banks of a public stream;
- land within 30 metres of the high flood level of any body of water conserved in an artificially constructed water storage work on a public stream.

## Parks and Wildlife Act

The Parks and Wildlife Act, 1975, provides for the creation, conservation and utilisation of national parks, recreational parks, safari areas, sanctuaries, botanical gardens and botanical reserves. National parks may be constituted under this Act to preserve and protect the natural landscape and scenery, or to preserve and protect wildlife, plants and the natural, ecological stability of wildlife and plants. This ensures the conservation and protection of wetlands within national parks.

## Communal Land Forests Produce Act

Section 13 of the Communal Land Forests Produce Act, 1987, prohibits exploitation of forest produce within 100 m of the bank of any public stream unless the Minister has given written permission for such exploitation to take place. This is meant to control soil erosion on stream banks and is a source of legislative protection for wetlands.

## Conclusion

The legal machinery to protect Zimbabwe's wetlands is present in existing legislation. What, perhaps, is lacking is awareness of the importance of wetlands to Zimbabwe's socio-economic development.

# Policy, institutional framework and wetlands management in Zimbabwe

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## Introduction

Wetlands may be permanent or temporary wet areas or land-water interfaces. The water may be fresh, brackish or saline, and wetlands are characterised, in their natural state, by plants and animals which are adapted to living in wet conditions. In Zimbabwe, a commonly found wetland type is referred to as a 'dambo' (for a full description of a dambo see the paper by Mazvimavi in this volume).

Wetlands mean different things to different people and their management has often been neglected. Of late there is growing concern within government that there is need to develop a policy that will ensure sustainable and rational utilisation of the wetlands.

## Utilisation of wetlands

In the conservation of natural resources, protection of large mammals is often of major importance while other resources, such as rare birds, are often neglected. Hippopotamus (*Hippopotamus amphibius*), Waterbuck (*Kobus ellipsiprymnus*), Clawless Otter (*Aonyx capensis*), Nile Crocodile (*Crocodylus niloticus*), fish and migratory birds are associated with wetlands. Zimbabwe's wetlands provide cover and food as well as refuge from predators for indigenous fauna and migratory birds. These are some of the reasons advanced for the conservation and management of dambos.

It has been estimated that 15% of Zimbabwe's drainage basins are occupied by wetlands. Drainage of dambos provides rich agricultural soils and many of these systems have been transformed into agricultural land. Cultivation of dambos produces more reliable crop yields than rain fed farming and represents a form of insurance against years of drought and food shortage (Whitlow, 1989). Dambo land is used for vegetable and rice production and grazing pastures for livestock.

## Historical background to environmental legislation

Dambo cultivation has been practised in Zimbabwe since the Iron Age. During road construction in the Kapula Dambo near Masuma Dam, a section of dambo soil revealed the presence of pot shards indicating previous cultivation (Whitlow, 1983). Since Europeans settled in Zimbabwe over half of the dambos have disappeared because they were viewed as sources of malaria and bilharzia or were reclaimed for housing and industrial sites and tourist development. Dambo reclamation is being practised by the City of Harare due to a shortage of housing sites and dambos are used as dumps for rubbish, effluent and toxic waste. In Lake Chivero, levels of toxins and pathogens are extremely high and waterways have become choked with aquatic weeds that thrive in the nutrient rich environment.

Dambos can be very fragile; they are especially susceptible to grazing which degrades vegetation, thereby affecting dambo hydrology and encouraging soil erosion. In areas of low rainfall, below 1,000 mm/year, the reliance on dambo agriculture is significant (Whitlow, 1983). In Zimbabwe gully erosion is caused by dambo degradation.

## Summary of environmental legislation in Zimbabwe

The state has enacted several laws which protect wetlands and dambos; these are described below.

### The Water Act

The prohibition of dambo cultivation is enforced through the Water Act (Cap. 160). Section 22 (1) prohibits unauthorised operations which interfere with the bed, banks or course of a public stream or any swamps or marshes forming the source of the public stream or found along its course. Sections 41 and 45 are equally important in that effluent water can be disposed of and allowed to return at the nearest convenient point to the bed of the public stream from which it was taken. Part X deals with water pollution control and regulatory powers are in the hands of the Minister of Health and Child Welfare and the Minister of Energy and Water Resources Development, in consultation with the Standards Association of Zimbabwe. Section 160 provides for the appointment of River Boards to supervise the regulation, storage, distribution and use of water from any public stream, within an area to be fixed by the Minister.

### The Natural Resources Act

Another important legislation is the Natural Resources Act (Cap. 150) which was enacted to prevent destruction of the vegetation in dambos or in the vicinity of stream banks. Section 81(i)(d) and (e) provides that the President may make regulations in relation to prohibiting or restricting the cultivation and drainage of public streams including dambos, sponges, marshes, swamps and reed beds.

### Other relevant legislation

The Sabi-Limpopo Authority (Cap. 156) and the Parks and Wildlife Act No.14 of 1975 govern, with the approval of the Minister of Energy and Water Resources Development, the construction, establishment, acquisition, maintenance and operation of dams, canals and hydroelectric power stations.

Land use around Lake Kariba is governed by three legislative enactments. These are the Parks and Wildlife Act, the Water Act and the Zambezi River Authority (ZRA). The ZRA is exempted from having to obtain a water right. The release of water from Lake Kariba for hydroelectric purposes is under the ZRA while the extraction for other uses is controlled by the Water Act. Lake Kariba is a designated Recreational Park, administered under the Parks and Wildlife Act.

The Minister of Environment and Tourism has authority over all water bodies and rivers in Zimbabwe. Thus tourism, fishing and utilisation of the recreational parks are managed by the Department of National Parks and Wildlife Management. At the same time, the Authority is responsible for recommendations to ensure the effective use of the waters and other resources of the Zambezi River. Conflict arises as a result of the duplication of activities of the two enactments and there is need to review the legislations to correct the anomalies. At regional level, the Zambezi River is purportedly administered under the ZACPLAN because it is a trans-boundary and shared resource among the SADCC countries.

## Legislation relating to dambo use and conservation

The Parks and Wildlife Act was *inter alia* enacted to protect natural landscapes of Zimbabwe and the conservation of dambos is catered for within the Parks Estate. Dambos outside protected areas are found in Seke, Chihota, Zvimba, Musami and Chiwundura Communal Lands.

Over time, the degradation of dambos has become more and more apparent. Despite the enforcement of prohibitive legislation, dambo cultivation increased in both the communal lands and commercial farms. The degradation of dambos was influenced by three main factors (Whitlow 1983):

1. A continuous monoculture of wheat resulted in the breakdown of organic matter promoting instability of the fine, sandy soils.
2. The practices of ploughing across waterways resulted in gully formation and facilitated drainage of the dambos.
3. The 1940-1950 decade was unusually dry and had the overall effect of lowering water table levels.

Concern over dambo degradation led to the enactment of the Natural Resources Act of 1952 (discussed above); Intensive Conservation Committees established under the Act assist its enforcement. However, this Act was not effective as peasant farmers in low rainfall areas had to continue with dambo cultivation to ensure their survival (Whitlow, 1983). Recently a need has arisen for dambo cultivation among the urban poor as a result of unemployment and increased prices. There is conflict between the urban poor and the Harare City Council over stream bank cultivation. At the start of the rainy season, warnings are placed in the press, and on notice boards at dambo sites, to the effect that cultivated crops will be slashed. Despite such warnings and penal legislation, cultivation on dambos has increased noticeably over the past ten years. The question remains as to whether the legislation really serves any purpose and whether it is supported by the general population. These factors, and the human aspects of conservation, need to be incorporated into a workable policy and enforceable legislation on wetlands. Stream bank cultivation has become a political issue, as for the urban poor to cultivate such areas they should be members of a cooperative. This policy is contrary to the principles of wetland management.

Dambos ensure a reasonable crop even during poor rainy seasons. Dambo cropping is regarded as insurance against low yields or crop failure on the higher areas. Attempts to prevent cultivation have compromised the status of agricultural extension workers who on one hand had to ensure that malpractices in dambos were stopped, yet on the other hand had to win the trust of the farmers so that agrarian reforms could be introduced. Policy makers have advocated pasture development on dambos rather than cropping but livestock grazing has caused more degradation than cropping. Agricultural officers are currently researching methods of sustainable dambo utilisation. The research entails identification of the dambo, implementation of appropriate pilot projects and monitoring of the projects. Although the research is still at the experimental and data collecting stage, information gleaned could be utilised as guidelines or indicators for a policy framework of wetlands management.

The colonial administrators neglected wetlands at the expense of the agricultural, silvicultural and veterinary needs of farmers. Thus, there is very little field experience of wetlands among the present day managers of natural resources. For this resource to be managed on a sustainable basis there is a need for a holistic or integrated approach to dambo management.

There is no policy on dambo management in Zimbabwe *per se*, except that included in the reviewed legislation. Existing legislation is inadequate and ineffective as it ignores the human aspects of conservation. There is need for a wetland policy which is designed to provide a coherent framework for the sustainable management of these resources.

# Recommendations

Recommendations for the various institutions involved in wetland conservation and utilisation are summarised below.

## Institutional framework

The existing institutions are weak and not supportive of wetlands management. Therefore, there is need to set up institutions catering for wetlands and involving the following:

1. Development of a National Conservation Strategy with the objective of setting up an effective National Environmental Action Plan with a section on wetlands whose objectives are:
   - identification of wetlands and threats to their existence;
   - development of a wetland inventory;
   - zonation of wetlands and site protection;
   - delineation of wetland boundaries;
   - utilisation of wetlands for pasture development, cropping, fishing and freshwater habitats;
   - a study of human settlements and the benefits they derive from wetland utilisation;
   - as they are the resource users, local communities, their traditions, cultures and needs, should be involved in policy formulation;
   - provision of incentives to local people to promote long term conservation, such as being co-researchers;
   - sustainable use of natural resources;
   - conservation of biodiversity;
   - legislative review;
   - manpower development and training;
   - education in wetland issues and environmental awareness.
2. Strengthening of existing institutions.
3. Setting up of a training and research institute.
4. Incorporation of other institutes, such as the Department of Physical Planning and City Councils, into policy making on wetlands issues.
5. Setting up of information centres for wetlands.
6. Coordination of activities at inter-ministerial and inter-departmental levels.
7. Cooperation with NGOs on wetlands issues.
8. Instigation of pollution abatement and prevention of dumping of toxic wastes.
9. Monitoring of siltation and pollution, rehabilitation of rivers, and conservation of catchment areas and riverine environments.

10. Establishment of an Environmental Impact Assessment monitoring unit.
11. Establishment of social impact assessments of wetland conservation or utilisation.

## Politics

Politicians should be influenced so that they understand the importance of wetlands and are prepared to support institutional changes.

## Economics

Natural resource management must be viewed from the perspective of both production and protection. It is not enough to conserve for aesthetic values because the essence of sustainability is the combination of productivity and protection. The relationship between economic policy management at national level, and sound natural resource use at the local level, should be clearly understood and emphasised.

## Women

Since women form 51% of the farming population, they must be specifically targeted and assisted as part of policy formulation.

## Tourism

Development of tourism should take place with minimal damage to natural resources.

## Urbanisation and development

There is a need for Environmental Impact Assessments to assess the ecological effects of development.

## Legislative review

All legislation dealing with natural resources should be reviewed, including:

- mining laws and development of extractive conservation in relation to gold panning;
- laws and policies relating to land use;
- activities by river authorities.

All conventions dealing with natural resources should be ratified.

Policy reforms for grazing schemes and water extraction should be developed for the management of the 'commons'.

### A Zimbabwe wetlands policy

The first step in developing a policy is to set up a committee composed of the Ministries of Environment and Tourism (National Resources Board and the Department of National Parks and Wildlife Management), Lands, Agriculture and Rural Resettlement, Energy and Water Resources Development, Mines, Health, Local Government and Rural and Urban Development, and Finance, the University of Zimbabwe and NGOs concerned with natural resource conservation.

Once this policy has been formulated it will be decentralised at District Council level. Wetlands will be managed, in conjunction with other indigenous resources, under the umbrella body of the CAMPFIRE Programme. The sustainability of a wetlands policy is dependent upon the participation of the local communities in managing and utilising the wetlands for their own benefit. Government initiative in forming the inter-ministerial approach also plays an important role.

### Cardinal points of a proposed wetlands policy

The following points were taken into account in developing a wetlands policy in Uganda (Mafabi and Olai-Acere, 1990) and development of a wetlands policy in Zimbabwe should take them into account:

- drainage activities;
- land tenure;
- water supply and effluent treatment;
- rehabilitation of wetlands;
- environmental impact assessment;
- biological conservation of wetlands.

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## References and bibliography

Breen, C. and G. Begg. 1987. Wetlands - A valuable natural resource. *African Wildlife* 41(5): 219-221.

Chabwela, H. 1991. Southern African Conservation programme. Draft report. IUCN, Harare, Zimbabwe. 687 pp.

Lahmann, J.-E. 1990. The Wetlands Programme in Central America. Paper presented to the Wetlands Workshop, IUCN 18th General Assembly, Perth Australia. November, 1990.

Mafabi, P.G. and T. Olai-Acere. 1990. Developing a wetland policy for Uganda. Paper presented to the Wetlands Workshop, IUCN 18th General Assembly, Perth Australia. November, 1990.

Maltby, E. 1990. Market forces, government policy and wetland loss in OECD countries. Paper presented to the Wetlands Workshop, IUCN 18th General Assembly, Perth Australia. November, 1990.

Mazvimavi, D. 1994. A review of dambos in Zimbabwe. Pages 47-53. In: T. Matiza and S.A. Crafter (Eds). *Wetlands Ecology and Priorities for Conservation in Zimbabwe: Proceedings of a Seminar on Wetlands Ecology and Priorities for Conservation in Zimbabwe, Harare Kentucky Airport Hotel, 13-15 January, 1992.* IUCN, Gland, Switzerland. 170 pp.

Roberts, N. 1988. Dambos in development; management of the fragile ecological resource. *J. Biogeography* 15:141-148.

Scotcher, J. 1987. Wetland management case study. *African Wildlife* 41(5): 267-268.

Taylor, A.R.D. 1990. Use of economic incentives in concerning wetlands outside of protected areas in tropical Africa. Unpublished report. IUCN, Gland, Switzerland.

Wangari E. and Matuka Kabala. (1972). Conservation and management of natural heritage, Insight from UNESCO's Protected Area programme. UNESCO, Rome.

Whitlow, R. 1983. Vlei cultivation in Zimbabwe. Reflection on the past or a play with a difference? *Zimbabwe Agricultural Journal* 80(3):123-135.

Whitlow, R. 1989. Factors influencing erosion in Zimbabwe; statistical analysis. *J. Environmental Management* 29:17-29.

# Floating aquatic weeds in Zimbabwe

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## Introduction

The major floating aquatic weeds of Zimbabwe are Water Hyacinth (*Eichhornia crassipes*), Water Lettuce (*Pistia stratiotes*) and Kariba weed (*Salvinia molesta*); the minor ones are Parrot's Feathers (*Myriophyllium aquaticum*) and Azolla weed (*Azolla* spp.). These weeds pose serious environmental problems for the conservation of key wetland areas in Zimbabwe by adversely affecting their unique flora and fauna. They grow extraordinarily rapidly, thus swift action is needed to limit damage to affected areas and slow the spread of weeds to unaffected wetlands.

In Lake Chivero (formerly Lake McIlwaine), Water Hyacinth and Water Lettuce form a mixed infestation whereas single species infestations are the case in Zimbabwe's other water bodies. For the last 30 or more years, fishing and recreational activities have been drastically affected by invasion of Water Hyacinth which appears to have directly reduced the fish population. In 1986, the situation in Lake Chivero was declared a national disaster as 25% of the lake surface was covered by aquatic weeds.

## Water Hyacinth

Zimbabwe first recorded the presence of Water Hyacinth in 1937 and by the end of 1988 the infestation had expanded to include the Manyame River system, Lake Chivero, Manyame Dam, Lake Mutirikwi, dams in Triangle and wetlands in Chinamora, Mutoko and Bindura. Although this weed occurs on a number of waterbodies in Zimbabwe, the main concern has been Lake Chivero which is the water supply impoundment for Harare.

In 1956, the infestation of Water Hyacinth in Lake Chivero was controlled with the herbicide 2,4-D. After the initial spraying the weed increased rapidly and 2,4-D was re-applied in 1971 but in 1980 the subsequent increase in Water Hyacinth required further applications of 2,4-D. In 1986, physical removal was adopted as the only aquatic weed management to be implemented, following concern of possible undesirable effects of 2,4-D on man and other animals using the water. However, this method was both expensive and ineffective as Water Hyacinth produces up to nine daughter plants and physical removal releases the daughter plants and becomes an indirect method of spreading the weed. Despite this, it is an environmentally safe method of control for small infestations.

There is an environmental cost in using herbicides to control aquatic weeds in Zimbabwe's wetlands. Residues of herbicides in the water and sediments may affect the aquatic environment; fish may be killed directly or by oxygen reduction caused by decaying weed. If residues are excessive, the water will be unsuitable for human consumption or irrigation. Zimbabweans are becoming more aware of the effects of pollution on themselves and their livestock and the community no longer tolerates contamination of the environment by pesticides.

The floating aquatic weed problem is worldwide and both environmental and economic costs are incurred by affected countries.

## Environmental cost

Water Hyacinth forms dense, impenetrable mats which adversely affect use of the water body. Boat traffic in watercourses, natural and man-made lakes and dams is impeded. The efficiency and operation of irrigation and flood mitigation channels is decreased. During floods, Water Hyacinth accumulates against bridges, spillways, culverts, fences and rocks, obstructing water flow and increasing the flood levels. As a result, property is damaged, people and livestock may be drowned, and serious soil erosion occurs when water is diverted from its normal course. Pumping equipment and boats may also be damaged.

Mats of Water Hyacinth impede access to fishing areas, destroy fish traps and increase populations of vectors of human and animal diseases. These changes to the aquatic environment affect the health of riverine communities by reducing the availability of fish as a protein source in their diet and by increasing the incidence of diseases such as malaria, encephalitis, schistosomiasis, bilharzia and river blindness. Populations of aquatic plants and animals are reduced as very thick mats of Water Hyacinth deplete the dissolved oxygen to such an extent that fish are killed.

Water Hyacinth has a high evapotranspiration rate. It has been estimated that the average loss of water due to evapotranspiration by Water Hyacinth is 3.5 times that from a free water surface (Gopal and Sharma, 1981). Hamdoun and Tigani (1977) estimated that one tenth of the average yield of the Nile River was lost every year due to evapotranspiration by Water Hyacinth.

## Economic cost

In 1963, the Sudanese Government tried to control Water Hyacinth by applying herbicides from a fleet of 42 boats and three aircraft along the River Nile (Beshir and Bennett, 1985). The annual cost of the chemical control operation was about one million Sudanese Pounds; in addition, the annual cost of lost time and additional maintenance and repairs to steamers due to Water Hyacinth was estimated to be 500,000 Sudanese Pounds (Hamdoun and Tigani, 1977). In spite of this massive allocation of resources, control was not achieved.

In Zimbabwe, Water Hyacinth has been a serious problem on Lake Chivero for several years. To date, up to three million Zimbabwean Dollars have been spent on physical and chemical control of Water Hyacinth, with limited success. According to the *Zimbabwe Herald*, 26 November, 1991, dead fish (breams and mudsuckers) were reported floating on Lake Chivero; Water Hyacinth had been sprayed with 2,4-D in June, 1991, after physical removal had proved ineffective and too expensive. No explanation was given for the fish deaths.

Control of floating aquatic weeds using herbicides requires a high input of manpower, equipment and chemicals, and is therefore expensive. Regular inspection, coupled with further treatment must be continued indefinitely or the infestation will regenerate from scattered plants and seeds. This long term commitment is a continuing cost.

## Biological control

Table 1 gives examples of successful biological control of Water Hyacinth in several countries using the weevils *Neochetina eichhorniae* and *N. bruchi.* Given favourable conditions, 90% of the plants in an infestation can be destroyed in about three years.

Table 1 Control of Water Hyacinth by *Neochetina eichhomiae* (1) and *Neochetina bruchi* (2) at sites in several countries

| Country/site | Agent | Control time (years) | Control achieved (%) | References |
|---|---|---|---|---|
| **Argentina** | | | | |
| Dique Los | 2 | 4 | 67 | DeLoach and Cordo (1983) |
| Souces | 2 | 6 | 90-95 | DeLoach and Cordo (1983) |
| **Australia** | | | | |
| Rockhampton | 1 | 2 | – | Wright (1979) |
| **India** | | | | |
| Hebbal Tank | 1 | 2.2 | 90 | Jayanth (1988) |
| Agram Tank | 2 | 3.3 | 95 | Jayanth (1988) |
| **USA** | | | | |
| Louisiana | 1 | 1.2 | – | Goyer and Stark (1984) |

Source: Harley (1990)

In Zimbabwe, work on biological control of Water Hyacinth commenced at the Plant Protection Research Institution in April, 1988, when 399 *N. bruchi* adults and 410 *N. eichhorniae* adults were received from Florida. The insects were multiplied before being subjected to host specificity testing on 35 local plants, including other floating aquatic weeds, using the techniques of Thompson and Habeck (1989). The host specificity test indicated a high preference of the weevils for Water Hyacinth. On the basis of the tests, it was concluded that the weevils were suitable for release in Zimbabwe.

In January 1991, *N. bruchi* and *N. eichhorniae* were released; unfortunately the release sites were sprayed with 2,4-D which killed the plants and prevented establishment of the insects. In November, 1991, 200 adult weevils were released at a site on the Manyame River upstream of Lake Chivero on November 25, 1991.

### Nutrient levels

The water of Lake Chivero is nutrient rich, due to sewage and industrial effluent from Harare and Chitungwiza flowing into the Manyame River upstream of the lake and into the lake itself.

For the last two years, sewerage from the Guzha Business Centre (Chikwanha) in Chitungwiza has discharged effluent into Seke Dam, a supplementary water source for Harare and Chitungwiza. Apparently there are no spares to repair the leaking pipe. Urgent action needs to be taken to have the pump repaired as the effluent may render the dam's water unsuitable for human consumption. Because of the increased nutrient levels, floating aquatic weeds are spreading very quickly.

Legislation should be enforced for the control of nutrient and pollution outputs from the above mentioned sources both to preserve water quality and prevent aquatic weed re-infestation.

## Water Lettuce

In Zimbabwe, Water Lettuce was first identified in the 1950s. Evidence from 1988 surveys indicates that Water Lettuce has become widely distributed in Zimbabwe's wetlands. It is found in the Manyame River, Seke Dam, Lake Chivero and in Murewa, Mutoko and Mount Darwin Districts. It is reported to be increasing in lagoons on the floodplains of the Zambezi River and replacing indigenous aquatic plants.

### Biological control

The Plant Protection Research Institute, Harare, received 500 adult *Neohydronomus affinis* weevils from Queensland in September, 1987. As described for the biological control agents for Water Hyacinth, the weevils were multiplied and tested for host specificity against a number of plants important to Zimbabwe (Chikwenhere and Forno, 1991). The release of the weevils was delayed until host specificity was established.

Table 2 Number of Water Lettuce plants, mean leaf area and number of *Neohydronomus affinis* damaged plants/m$^2$ on Manyame River, upstream of Lake Chivero, April 1988 to July 1991

| Period | | Plant/m$^2$ | Mean leaf area ($cm^2$) | Weevil damage (plant/m$^2$) |
|---|---|---|---|---|
| April | 1988 | 110 | 90 | 0 |
| June | 1988 | 108 | 46 | 57 |
| July | 1988 | 113 | 44 | 102 |
| October | 1988 | 130 | 31 | 130 |
| February | 1989 | 96 | 15 | 96 |
| April | 1990 | 11 | 7.2 | 11 |
| May | 1990 | 4 | 5.4 | 4 |
| January | 1991 | 10 | 2.3 | 9 |
| July | 1991 | 15 | 2.4 | 15 |

On the 8th of April 1988, 1,586 adults of *N. affinis* were released over an area of 100 m$^2$. Table 2 shows the effect of the weevils on Water Lettuce populations over time at sites on the Manyame River system. Field releases were carried out in sites dominated by Water Lettuce and where no applications of herbicides were being undertaken. Examples of the time taken in these areas to control Water Lettuce and the levels of control achieved are given in Table 3. From these results, it appears that there is no need to use herbicides to control Water Lettuce in Zimbabwe's wetlands.

Biological control is cost effective, long lasting and environmentally safe.

Unfortunately, biological control agents of Water Lettuce have not been released further afield in Zimbabwe because of lack of resources.

Table 3 Successful control of Water Lettuce by *Neohydronomus affinis* at sites in several waterbodies of Zimbabwe

| Site | Year | Time for agent to establish (months) | Time to control infestation (months) | Reduction (%) |
|---|---|---|---|---|
| Manyame River | 1988 | 4 | 11 | 90-95 |
| Lake Chivero | 1988 | 6 | 13 | 90-93 |
| Chivake Dam | 1989 | 4 | 8 | 98 |
| Chakoma Dam | 1990 | 7 | 15 | 86 |
| Kaitano Dam | 1991 | 5 | 7 | 64 |

## Kariba weed

Kariba weed (*Salvinia molesta*) has been described as one of the world's worst aquatic weeds. It has caused major problems in a number of tropical and sub-tropical countries (Australia, Botswana, India, Indonesia, Kenya, Papua New Guinea, Malaysia, Namibia, the Philippines, Sri Lanka, Zambia and Zimbabwe (Doeleman, 1989).

*S. molesta* occurs in Lake Kariba and on some small farm dams in Karoi but is not currently causing concern. Most of the work done on *S. molesta* was initiated soon after Lake Kariba was created. The most important factor decreasing the extent of *S. molesta* appeared to have been the release of *Paulinia acuminata*, an aquatic grasshopper with a marked preference for feeding on young *S. molesta* growth.

However, results of a survey conducted in November 1991 on lake shore areas of Gachegache, Nyaodza, Wafawafa Training Camp, Tsetse Camp and Charara have shown that the weed was infested by a weevil, most probably *Cyrtobagous* sp. Samples of the weevils have been sent to Commonwealth Scientific and Industrial Research Organisation in Australia for correct identification. Recent reports from Zambia indicate that a weevil, *Cyrtobagous salviniae*, was released to control *Salvinia molesta* in the Kafue Dam and *C. salviniae* may have established in Zimbabwe.

*Cyrtobagous salviniae* feeds on *S. molesta* in Brazil and has become the agent of choice for the control of *S. molesta* as it is voracious and strongly host specific (Forno, 1983). The Australians have achieved spectacular and lasting control of Salvinia within twelve months using this weevil and the team responsible was awarded the 1985 UNESCO Science Price.

A large number of countries have sought assistance with their *S. molesta* problems, including Botswana, India, Ivory Coast, Kenya, Malaysia, Namibia, Papua New Guinea, the Philippines and Zambia, (Doeleman, 1989). The technology has been successfully used in Papua New Guinea where *Cyrtobagous* weevils consumed two million tonnes of *S. molesta*, and the plant is now rare (Doeleman, 1989).

## Others

Parrot's Feathers (*Myriophyllium aquaticum*) occurs on the Manyame River and may invade Lake Chivero in the near future if no control measures are undertaken.

*Azolla* is widespread in Zimbabwe but is not yet a serious problem.

# Recommendations

## Water Hyacinth

There is need to implement biological control of Water Hyacinth in Zimbabwe as soon as possible. The use of herbicides should be limited to Lake Chivero and properly coordinated with implementation of biological control. Action should be taken by the Government of Zimbabwe to reduce nutrient input from industrial sites and sewage from cities and towns into Zimbabwe's wetlands.

A public awareness campaign should be implemented throughout the whole country to sensitise the population to the dangers of floating weeds. The public should be assisted to recognise these weeds and discouraged from introducing them into new areas.

## Water Lettuce

The biological control of Water Lettuce should be extended to infestations throughout Zimbabwe and to other neighbouring countries. For example, on 19th November 1991, 500 adult weevils of *Neohydronomus affinis*, collected from Zimbabwe, were released on Pistia stratiotes in the Kafue Dam in Zambia.

# References

Beshir, M.O. and F.D. Bennett. 1985. Biological control of Water Hyacinth on the White Nile, Sudan. Pages 491-496. In: E.S. Delfose (Ed.). *Proceedings VI International Symposium Biological Control of Weeds.* August, 1984, Vancouver, Canada.

Chikwenhere, G.P. and I.W. Forno. 1991. Introduction of *Neohydronomus affinis* for biological control of *Pistia stratiotes* in Zimbabwe. *Journal Aquatic Plant Management* 29:53-55.

Confrancesco, A.F. 1984. Biological control activities in Texas and California. *Proceedings 18th Annual Meeting Aquatic Plant Control Research Program, U.S. Corps Engineers.* Management Paper A-84-4:57-61.

Doeleman, J.A. 1989. Biological Control of *Salvinia molesta* in Sri Lanka: an assessment of costs and benefits. Australia Centre for International Agricultural Research, Canberra. ACIAR Technical Report No 12. 14 pp.

DeLoach, C.J. and H.A. Cordo. 1983. Control of Water Hyacinth by *Neochetina bruchi* (Coleoptera: Curculionidae: Bagioni) in Argentina. *Environmental Entomology* 12:19-23.

Forno, I.W. 1983. Native distribution of *Salvinia auriculata* complex and the keys to species identification. *Aquatic Botany* 17:71-83.

Gopal, B. and K.P. Sharma. 1981. *Water Hyacinth* (Eichhornia crassipes) *The Most Troublesome Weed of the World.* Hindasia, Delhi.

Goyer, R.A. and J.D. Stark. 1984. The impact of *Neochetina eichhorniae* on Water Hyacinth in southern Louisiana. *Journal Aquatic Plant Management* 22:57-61.

Hamdoun, A.M. and K.B. El Tigani. 1977. Weed Problems in the Sudan. *Pans* 23:190-194.

Harley, K.L.S. 1990. The role of biological control in the management of Water Hyacinth, *Eichhornia crassipes*. *Biocontrol News and Information* 1:11-22.

Jayanth, K.P. 1988. Successful biological control of Water Hyacinth (*Eichhornia crassipes*) by *Neochetina eichhorniae* (Coleoptera: Curculionidae) in Bangalore, India. *Tropical Pest Management* 34:263-266.

Thompson, C.R. and D.H. Habeck. 1989. Host specificity and biology of the weevil *Neohydronomus affinis* (Coleoptera: Curculionidae) a biological control agent of *Pistia stratiotes*. *Entomophaga* 34:299-306.

Wright, A.D. 1979. Preliminary report on damage to *Eichhornia crassipes* by an introduced weevil at a Central Queensland liberation site. Pages 227-229. In: *Proceedings of the 7th. Asian-Pacific Weed Science Society Conference, 1979.*

# Administrative structures and mechanisms for management of natural resources in Zimbabwe

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## Introduction

Although Zimbabwe is self-sufficient in food at the national level, this does not guarantee that all people have access to adequate food at all times. The government, therefore, recognises the importance of addressing household food insecurity in addition to attaining national food self sufficiency. At the household level, food security is defined as the access of families to adequate amounts of food, either through home production, purchases or exchanges, to satisfy minimum human requirements throughout the year. Food security is affected by employment opportunities, productivity, access to and quality of land resources, and access to water resources.

The major area of food insecurity is the communal area sector. The drought years of 1981-82, 1982-83, 1983-84 and 1986-87 have highlighted this problem for households in the low rainfall areas of Zimbabwe. These areas cover 91% of the communal lands and provide an economic base for approximately 55% of Zimbabwe's population of 100,000 farm households. During the drought years, the majority of households in the communal areas experienced reduced incomes and food shortages and relied on food transfers from the government. Approximately 350,000 households have received government support through commodity food aid or 'food for work' programmes since 1981.

Food security is a serious consideration of every rural household, malnutrition is the largest killer of children between the ages of two and five and 30% of Zimbabwe's children under five years of age are chronically malnourished. For rural women, food security and income generation depends on exploitation of natural resources, such as the use of land and water for cash and subsistence cropping and sale of fuel wood. Thus women constantly make decisions about trade-offs or practical alternatives when it comes to conserving natural resources or exploiting them.

Considering the constraints facing rural farmers, Zimbabwe needs seriously to explore alternatives for the survival of the population. There is evidence that the wetland resources have not been fully exploited. Could they be possible solutions to the land crisis?

The lack of attention paid to wetland cultivation of vegetables, rice and traditional crops such as 'tsenza' and 'madhumbe' as alternative survival strategies for household food security and income generation has compromised peasant farmers. Wetland crops are not included in crop production statistics and are not directly assisted or controlled by any one ministry. There are no clear guidelines on wetland utilisation for peasant farmers. NGOs and ministries involved in wetland projects operate under different management procedures and sometimes contradict each other.

In Zimbabwe, some farmers have undertaken crop production in dambos with seemingly little effect on stream flows. This suggests that there is a good case to modify legislation on wetlands cultivation.

## Administrative instruments for natural resource management and environmental conservation

Several ministries and educational institutions are included in the administration of natural resources, including wetlands.

### Ministry of Environment and Tourism

#### Department of Natural Resources

The statutory mandate of the Department of Natural Resources (DNR) is derived from the Natural Resources Act (Cap. 150) as amended in 1981. Its functions are to promote the adoption of objectives or standards relating to environmental quality and pollution control; mitigate any adverse environmental impacts of new projects; and provide Zimbabweans with information on environmental issues. The DNR has a responsibility to influence other government departments and to work with provincial authorities and the public to conserve and enhance the quality of the environment.

The Research and Technology Branch is in charge of environmental monitoring and research; the Extension Branch promotes environmental awareness; and the Inspectorate is in charge of compliance with environmental regulations, particularly the Natural Resources Act.

DNR emphasises environmental awareness, environmental research, soil conservation, water resources management, forest management and the monitoring of mining activities.

Short term interventions to combat the effects of erosion (such as gully reclamation) do seem to have deflected DNR funds from equally necessary long term investments in attacking the causes of degradation. The withdrawal of funds for control of water weeds is due to an institutional overlap between DNR and the Department of National Parks and Wildlife Management, and to the fact that these interventions are limited to waterways within state lands and under the control of the latter Department. This lack of on-going funding is important as aquatic weeds have serious deleterious effects on wetlands.

DNR is the implementing agency for the Natural Resources Board (NRB) - the public committee with the power to monitor environmental quality. The NRB is a government body of 12 members. It has eight subject subcommittees and, at local level, there are 202 conservation committees. The DNR has undergone a transition from a secretariat for the NRB to a fully fledged department with research, policy, regulatory and programme delivery functions. According to both the National Conservation Strategy and the National Development Plan, top priority should lie with strengthening the Research Branch, where there is a need for more scientific personnel and laboratory equipment, particularly for environmental monitoring purposes.

### Department of National Parks and Wildlife Management

The Parks and Wildlife Act of 1975 established a Parks and Wildlife Board and the Department of National Parks and Wildlife Management (DNPWM). The activities of the Department are governed by this Act which also makes provision for the proclamation of national parks, safari areas and recreational parks. The legal responsibilities of the DNPWM are limited to state land and the department has no legal obligations to work in communal lands except where stray, indigenous animals represent a threat to human life.

The aims of the Department are to conserve wildlife and biological diversity and to promote sustainable use of wildlife. The Parks and Wildlife Policy is implemented through conservation and management of all parks and safari areas. During the past decade the Department has been working with other agencies to develop the Communal Areas Management of Indigenous Resources (CAMPFIRE) programme which has enhanced the conservation of natural resources and economic development in communal lands.

## Ministry of Lands, Agriculture and Rural Resettlement

### Agricultural, Technical and Extension Services

As its name implies, the Agricultural, Technical and Extension Services (AGRITEX) provide agricultural advisory, technical and extension services, emphasising soil conservation and land use planning at farm level. AGRITEX operates in all land regardless of tenure. The conservation works which AGRITEX recommends are carried out by the owners of the land or, in communal lands, by the local communities.

Within AGRITEX, the Institute of Agricultural Engineering deserves special mention for the pioneering work it has done in respect of conservation tillage and other soil conservation techniques. This research has attracted widespread interest throughout the SADCC region and abroad. Constraints to implementation of these soil conservation practices in the communal lands includes lack of both draught power and equipment.

Agricultural extension services generally favour the small scale farmer because the extension package is relatively expensive, including inputs such as pesticides, fertilizers, improved seeds and credit. AGRITEX tries to work through farmers' groups, thus often cutting across other group structures such as village development committees (VIDCOs). Another constraint is that the extension packages do not sufficiently respond to the specific conditions in communal lands. These packages are geared to increase production (and as such they have been rather successful) but they lack an environmental education component.

### Department of Research and Specialist Services

As well as agricultural research and provision of specialist services, the Department of Research and Specialist Services executes certain regulatory functions, including the registration of agricultural pesticides, phytosanitary regulations and the integration of pest control regulations. The Department has not yet moved into applied research and services for communal lands.

### Department of Veterinary Services

The Department of Veterinary Services is responsible for prevention and control of animal disease. Its activities include extension and dipping services in communal lands, where its interventions have been recently strengthened.

### The Surveyor General's Department

The Surveyor General's Department is responsible for the full range of surveying and mapping of Zimbabwe and it is expanding into remote sensing. Strengthening of this Department would allow adequate mapping for environmental monitoring and more frequent aerial photography.

## Agricultural Development Authority

The Agricultural Development Authority (ADA) is a major parastatal organisation, employing 25,000 persons and farming 400,000 ha. It is responsible for the state farming enterprises of agriculture and livestock production. More significant in respect of the environment, ADA is also charged with planning, coordinating, implementing, promoting and assisting agriculture in Zimbabwe. It is thus directly involved in rural resettlement, particularly in the Zambezi Valley, and in major rehabilitation exercises. ADA engages in, or commissions, detailed land use planning for its resettlement projects.

## Ministry of Energy and Water Resources Development

### Department of Water Resources and Development

The Department of Water Resources and Development is in charge of the provision and conservation of water.

### Department of Energy Resources and Development

The Department of Energy Resources and Development is responsible for development and implementation of the National Energy Policy and thus for identification of energy issues, energy plans, development of energy resources, coordination of energy projects, controlling energy organisations, and promotion of energy conservation.

## Ministry of Local Government, Rural and Urban Development

State funding to the district development fund, and to district councils for construction of roads, bridges, building, dams and boreholes in communal lands, is provided by the Ministry of Local Government, Rural and Urban Development.

### Department of Physical Planning

Responsible for regional and urban planning, the Department of Physical Planning (DoPP) advises local authorities on spatial planning matters regarding local, district, provincial and regional plans as well as the planning and development of state lands. Despite its background in town planning, DoPP has become involved in planning in communal lands, particularly in the planning and development of growth centres.

### Department of Rural Development

The Department of Rural Development (DRD) is responsible for planning and implementation of resettlement schemes and rural development projects, and the formulation of draft rural development policies. DRD is organised in two branches - operations and technical support - with staff at provincial and scheme levels.

## University of Zimbabwe

The Centre for Applied Social Studies has been very active in research on socio-economic aspects of wildlife management in communal lands and was instrumental in the early development of the CAMPFIRE programme. Other departments of the University of Zimbabwe which engage in environmental research are:

- the Department of Biological Sciences (botanical, zoological and ecological research in collaboration with the DNPWM);
- the Department of Geography (very active in the study of natural resources, particularly soil erosion problems in communal lands);
- the Department of Rural and Urban Planning (involved in research on resettlement and rural development);
- the Faculty of Agriculture (conducts basic research in agriculture).

## Other training institutions

The following training institutions have environmently related curricula:

- Natural Resources College, Mazvingo, under DNPWM;
- Zimbabwe College of Forestry at Nyabara;
- Veterinary Training Institute, Mazowe;
- Agricultural Colleges at Chibero, Esigodini, Gwebi and Mlezu.

## The Central Government at provincial and district levels

### Provincial level administration

The highest political authority at the provincial level is the Provincial Governor. The Provincial Development Committee includes provincial representatives of the central line ministries. Its main purpose is to produce the Provincial Development Plan for the coordinated development of the province. This plan should reflect the district and urban council development plans, provincial development committees' ideas and resources, the provincial plans of ministries and Government's national policies.

### Locally elected district councils

With powers under the Communal Lands Act, 1982, to control the occupation and use of communal land, district councils can assign lands for grazing and crop cultivation, control the types of crops grown, and prescribe conservation measures. District Natural Resources Sub-committees (composed of equal numbers of councillors and non-councillors) have to arbitrate between politicians and technical staff and meet the expectations of both the people and central government.

### Local level administration

At the local level there are two units of organisation: Village Development Committees (VIDCOs) and Ward Development Committees (WADCOs). Each VIDCO has six members, at least four of which are elected and the remainder represent youth and women's mass organisations. The functions of VIDCOs are to assist villagers to identify and articulate their needs, coordinate village development, facilitate the growth of decentralised planning and link villagers with the WADCO. For each VIDCO, there is a village development centre. There are some 6,000 VIDCOs in the country. Six VIDCOs constitute a ward, which in turn has a

WADCO with functions and structures similar to a VIDCO. VIDCOs and WADCOs are becoming the backbone of local participation and community development as they perform a crucial role in local decision making on matters relating to natural resources management. However, this new system faces problems, such as:

- harmonising with the traditional power structure of chiefs, headmen and kraal heads;
- responding to outside pressure from donors and NGOs wishing to use VIDCOs for the delivery of sectoral services, (health, education, etc.);
- competition with parallel structures such as farmers', savings and literacy groups and marketing-and-supply cooperatives.

## Other local structures

### Conservation committees

The Ministry of Natural Resources and Tourism has promoted 202 conservation committees nationwide, with a brief to integrate soil conservation measures with agricultural land use. These committees represent the major extension services of the DNR. District council conservation sub-committees are primarily concerned with communal lands; intensive conservation area committees serve the commercial farming land and there are also conservation committees for resettlement areas. DNR provides grants to the conservation committees.

### Youth brigades and women's clubs

Youth clubs, promoted by the Ministry of Youth, Sport and Culture, and women's clubs, promoted by the Ministry of Political Affairs, are used as an environmental vanguard. They have been involved in rural afforestation programmes.

### Farmers' groupa

Farmers' groups, including the National Farmers' Association of Zimbabwe, are promoted as counterparts to different extension services. They perform an important role in the implementation of soil conservation measures.

### School societies

Many schools have conservation clubs that are under-resourced and inadequately serviced by volunteer organisers, usually teachers, who lack information on environmental issues.

### Education campaigns

The Government is involved in education campaigns regarding environmental issues. DNR is in charge of education and extension on resource use in communal lands. Large gatherings of farmers are held where talks are given by the DNR, AGRITEX and, depending on location, by Parks and Wildlife Officers. DNR officers go into schools, youth organisations and women's clubs to discuss the meaning of natural resources management. District conservation committees also run field days on conservation topics.

### Non-governmental organisations

There are several national and international NGOs working in the field of environment and natural resource management. Unfortunately they are uncoordinated and sometimes duplicate efforts or contradict each other.

## Natural resource management in Zimbabwe

While the administrative structures are present for effective management of natural resources, Zimbabwe would improve the performance of the above agencies if the following issues were tackled.

### Land tenure or land reform

The issue of land reform needs particular attention as the demand for land increases daily. The situation is particularly difficult for women in communal areas who do not have direct access to land. Lack of control over resources affects commitments to management. Improvement of infrastructure and provision of credit facilities would enhance women's development.

### Participation of the communities

Community participation at the grassroots level is lacking in the established approaches being used to confront environmental problems. To depart from the usual 'top down' approaches, the involvement of the people affected by environmental problems is necessary. The four broad types of community participation which should be incorporated into environmental management, taking into account gender issues, are:

#### Involvement

The strategy and content of environmental projects within wetlands should be determined by collaboration with local communities so that the rural poor benefits from these activities.

#### Organisation

The formal organisations which currently exist are very fragile and sometimes contradict traditional institutions. The challenge is not to create more new institutions but to enable existing ones to improve the execution of their duties.

#### Community Development

The structures for community development exist but there is a need for meaningful participation by the rural poor, especially women, in resource conservation. Whilst participation might manifest itself in a variety of forms, essentially it is to do with the rural communities becoming involved in the management of their natural resources.

**Empowering**

Rural communities must gain access to and share in the resources required for sustainable environmental programmes, and participate actively in the development processes. From the environmental perspective, little action has been taken to put Zimbabwe onto a sustainable path. Policy makers are sufficiently informed but the problem is to change the tide of history, by fundamentally altering the pattern of access to resources which has become entrenched over the past 100 years since colonisation. Not only are technocratic changes required but significant political shifts are needed to alter the distribution of resources in favour of the masses. So far the Economic Structural Adjustment Programmes does not show signs of doing this.

### The role of women in natural resources protection

It must be recognised that direct incentives are necessary for women to be induced to undertake the task of environmental protection. It should not be seen as another aspect of women's unpaid labour or an extension of their 'natural' role. Women should not be expected to bear the heavy burden of conserving wetlands without access to relevant planning and decision making processes and without reaping direct benefits from this work. With a holistic approach, the triple aims of environmental conservation, economic growth and social progress of women, can be pursued together. A balance has to be struck between the protection of the environment, the immediate needs of the rural poor and the demands of Zimbabwe's developing economy for agricultural production. The knowledge, experiences and involvement of women are crucial to finding and achieving that balance.

The management of Zimbabwe's natural resources has been viewed as being separate from matters of agricultural production and continues to underestimate the role of women in the development of sustainable environmental programmes. How women perceive environmental issues at household level depends on their ability to utilise the benefits of a resource base in terms of crop production, livestock rearing and the provision of water for household purposes. The production process involves issues of management of basic renewable resources such as water, soils, plants and wildlife.

## Conclusion

Zimbabwe has developed an administrative system, and a local government system, which should be able to address environmental problems. However, this system has limitations as it lacks adequate funds and qualified personnel. There are also institutional overlaps and conflicts both at central and local level.

There is a very real need to raise environmental consciousness among administrators and councillors involved in rural development and decision making. The DNR needs more qualified environmentalists.

The administrative and local structures facilitate delivery of government policies and services on one hand, and local participation on the other. However, this structure is rather fragile due to lack of resources, the short time that local institutions have been in existence and inherent local conflicts. The fragility has to be taken into account when promoting initiatives for environmental protection and improved management of natural resources at local level. With few exceptions, the main needs are strengthening existing institutions rather than creating new ones, promoting cross-sectoral linkages and improving the flow of information between various agencies.

Women must be taken into account as active managers of natural resources if the productivity of the land is to be maintained and rural famine avoided. Traditional knowledge of farming techniques and local plants, crops, soils, weather and water resources can be harnessed towards the protection of the local environment. This indigenous technical knowledge is crucial for the proper management and conservation of wetlands. However, local women need training and assistance to protect and rehabilitate their environment and to develop sustainable agricultural methods. Women should be able to contribute their own invaluable, local experience and expertise to the development of training programmes, if these are to be appropriate and effective for sustainable development.

# Current threats to the wetlands of Zimbabwe

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## Introduction

Zimbabwe covers approximately 390,308 km$^2$ and has a population of over 9 million persons. Much of the country is plateau, with an altitude range of 200 to 2,000 m; precipitation is low, ranging from 400 to 1,200 mm. Although Zimbabwe is a dry country by regional standards, she has numerous wetlands, mostly small in size, which are largely associated with the major hydrological systems.

The wetlands of Zimbabwe are considered extremely valuable but some are drying out or are severely threatened by human actions and drought; wetlands are disappearing, being destroyed or dying and as a result they are losing productivity. The rate of wetlands alteration is increasing and, in some cases, wetlands are severely polluted.

The paper discusses the various wetland types in Zimbabwe, their values and how they are threatened.

## Wetlands: what are they?

The following two wetland definitions are commonly used in wetlands conservation:

1. Under the RAMSAR Convention of 1971, 'wetlands' are defined as:

   "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres".

   This definition is widely used (Denny, 1985: Dugan, 1990).

2. The United States Fish and Wildlife Service defines 'wetlands' as:

   "lands transitional between terrestrial and aquatic systems where the water is usually at or near the surface or the land is covered by shallow water."

   (Cowardin *et al.*, 1979).

Thus, wetlands are zones of overlapping aquatic and terrestrial environments. Whereas wetlands may be different in structure and function, conditions for their formation are invariably the following: sufficient supply of water, a stable substrate, relatively low topography and a sufficient period of wetness.

## Types of wetlands and their distribution

The general classification of wetlands has been given by Cowardin and others (1979) and Morant (1983). Of the five wetland systems that are recognised (marine, estuarine, riverine, lacustrine and palustrine) only the last three occur in Zimbabwe. The distribution of wetlands in Zimbabwe has been described by Chabwela (1991) and are shown in Figure 1 in the paper by Matiza (1994), this volume.

### Riverine systems

Riverine system wetlands are composed of small, localised floodplains and swamps which occur along the main hydrological systems in Zimbabwe. Important floodplains occur along the Zambezi River and at the Save-Runde confluence.

### Lacustrine systems

The lacustrine systems of Zimbabwe consist of artificial impoundments constructed in the major hydrological systems. The major artificial lakes are Kariba, Darwendale, Chivero and Kyle.

### Palustrine systems

Springs, pans, pools, lagoons and dambos comprise the palustrine systems of Zimbabwe and occur in many parts of the country. Dambos, however, are found in the highlands and at the headwaters of most streams.

## Wetland values

Global wetland values are described in detail elsewhere (Sather and Smith, 1984; Larson *et al.*, 1989; Dugan, 1990). A general summary of wetland values are given in Table, 1 while the values of wetlands peculiar to Southern Africa have been discussed elsewhere (Chabwela, 1991).

Table 1  A list of the values of wetlands

| Function | Products | Attributes |
|---|---|---|
| Groundwater recharge | Wildlife resources | Biological diversity |
| Groundwater discharge | Fisheries | Aesthetic values |
| Flood control | Forest resources | Ethnic values |
| Erosion control | Forage resources | |
| Sediment/toxicant retention | Agriculture resources | |
| Nutrient retention | | |
| Biomass export | | |
| Storm protection | | |
| Microclimate stabilisation | | |
| Water transport | | |
| Recreation | | |

Source: P. Dugan (1990)

## Threats to wetlands

Globally, wetlands are threatened by various man-orientated activities. Dams built on rivers alter the hydrology of the catchment (Adams, 1989; Dixon *et al.*, 1990; Scudder, 1989; Chabwela and Ellenbroek, 1990). Wetland resources, such as fisheries, wildlife, forests and forage, are often overexploited (WWF/IUCN, 1985). Water extraction for irrigation, industrial and municipal purposes is often excessive (Kortenhorst, 1985; Oosterbaan, 1988). Industrial effluents, herbicides, pesticides, sewage and agro-chemicals are often carelessly discharged into wetlands (Rast and Holland, 1988). Drainage of wetlands is a significant problem and is carried out not only for agriculture but also for settlements and road and railway developments (Maltby, 1986; Dugan, 1990). The hydrology of catchment areas is altered by excessive destruction of vegetation (Glantz and Orlovsky, 1983).

Zimbabwe's wetlands are subjected to specific threats (Chabwela, 1991).

Climatic extremes predispose Zimbabwe to drought and threaten crop production, human life, livestock and property. Zimbabwe, being largely a watershed, is sensitive to environmental alteration. Destruction of vegetation results in very severe soil erosion and causes problems of sedimentation in the lower areas. Deforestation has occurred in the watersheds of the Save and Limpopo Rivers and has been caused by overgrazing in the communal lands.

Conflicts between land use classification and land tenure practices do not favour environmental protection. The need to earn foreign exchange, by either increasing cash crop tonnages or through exports of minerals, may increase the risks of overexploitation and pollution; eutrophication of urban wetlands occurs due to pollution by municipal and industrial wastes. Poor management, caused by institutional weakness and deficient legislation, has accelerated destruction of resources, particularly forests, fisheries and wildlife. Although the obvious effects of these threats are erosion, siltation, floods and increased risk to human life and property, wetlands can ultimately lose productivity, experience diminished functions or die. Already, there are indications that some wetlands are drying out.

## Management and conservation

Wetlands should be managed to increase their productivity. However, methods of managing wetlands vary considerably with wetland type, size and other factors. In Zimbabwe, achieving conservation goals will depend on the following considerations:

- existing institutional arrangements to support wetlands initiatives;
- the existence of a legal framework which is supportive of wetlands programmes;
- levels of community awareness and the need for training in wetlands matters; and
- the involvement of communities in the conservation of wetlands.

In conclusion, wetlands are important to mankind, but unless they are understood as systems, and unless their values are recognised, their conservation will continue to be uncertain.

## References

Adams, W.M. 1989. Dam construction and the degradation of flood plain forest on the Turkwel River, Kenya. *Land Degradation and Rehabilitation* 1:189-198.

Chabwela, H.N. 1991. Southern African Wetlands Programme, draft report. IUCN, Harare, Zimbabwe. 687 pp.

Chabwela, H.N. and G.A. Ellenbroek. 1990. The impact of hydroelectric developments on the lechwe and its feeding grounds at Kafue Flats, Zambia. Pages 95-101. In: D.F. Whigham, R.C. Good and J. Kuet (Eds). *Wetlands Ecology and Management: case studies*. Klumer Academic Publishers, Boston, USA.

Cowardin, L.M., V. Carter, F.C. Golet and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States.* Fish and Wildlife Service, USA Department of the Interior. 103 pp.

Denny, P. 1985. The Ecology and Management of African Wetland Vegetation. *Geobotany* 6. Junk Publishers, Dordrecht, Netherlands.

Dixon, J.M., L.M. Talbot and G.J.M. Le Moigne. 1990. Dams and the environment, considerations in the World Bank Projects. World Bank Technical paper no. 110. Washington D.C. 46 pp.

Dugan, P.J. 1990. *Wetland conservation: A review of current issues and required action.* IUCN, Gland, Switzerland. 96 pp.

Glantz, M. and N. Orlovsky. 1983. Desertification: A review of the concept. *Desertification Control* 9:15-22.

Kortenhorst, L.F. 1985. The existing farming system: A neglected criterion for irrigation project design. Annual report. International Institute for Land Reclamation and Improvement. Netherlands.

Larson, J.S., D.R. Adams and E.J. Clairain Jr. 1989. *Functional assessment of freshwater wetlands: a manual and training outline.* Environmental Institute, University of Massachusetts, Amherst, USA. 62 pp.

Maltby, E. 1986. *Waterlogged wealth. Why Waste the World's Wet Places?* International Institute for Environment and Development. London. 200 pp.

Matiza, T. 1994. Wetlands of Zimbabwe: an overview. Pages 3-10. In: T. Matiza and S.A. Crafter (Eds). *Wetlands Ecology and Priorities for Conservation in Zimbabwe: Proceedings of a Seminar on Wetlands Ecology and Priorities for Conservation in Zimbabwe, Harare Kentucky Airport Hotel, 13-15 January, 1992.* IUCN, Gland, Switzerland. 170 pp.

Morant, P.D. 1983. Wetland classification: towards an approach for Southern Africa. *J. Limnol. Soc. Sth. Afr.* 9(2):76-84.

Oosterbaan, R.J. 1988. Effectiveness and environmental impacts of irrigation projects: A review. Annual report. International Institute for Land Reclamation and Improvement, Netherlands.

Rast, W. and M. Holland. 1988. Eutrophication of lakes and reservoirs: a framework for making management decisions. *Ambio* 17(1):2-12.

Sather, J.H. and R.D. Smith. 1984. *An overview of major wetland functions and values.* Fish and Wildlife Service, USA Department of the Interior. Washington D.C.

Scudder, T. 1989. Conservation versus development, river basin projects in Africa. *Environment* 31(2):4-32.

WWF/IUCN. 1985. Threats, life at the water's edge. Wetlands pack 3. WWF-Wetlands Campaign. WWF and IUCN, Gland, Switzerland.

# Seminar resolutions and recommendations

During three days of presentation and group discussions, the participants took note of the concerns on wetlands conservation and management in Zimbabwe. The formulation of a National Wetlands Programme was endorsed and the following recommendations and comments were made.

## Information

Based on the seminar presentations and group discussions, it was established that there is a very disturbing lack of information on wetland systems. Despite the long history of research on dambos, these systems and other wetlands are not well understood and information on wetland ecosystems is not readily available. The seminar recommended that:

- A Wetlands Programme for Zimbabwe should initiate the collection and compilation of information on wetlands. This information should be in a form that is easily disseminated and appropriate to the target groups, which should include politicians, policy makers, planners and the general public.
- Research institutions should distribute and disseminate the information they gather.
- A common access database on wetlands should be established; the Natural Resource Board was identified as a possible institution to house the database.
- A review and collation of the available information on wetlands should be conducted and the product used to produce booklets and newsletters targeted to specific groups.
- The Natural Resources and National Parks Boards and their clubs should be used as organs for the dissemination of wetlands information.

## Awareness

At all levels of Zimbabwean society, a lack of awareness regarding wetlands was recognised; a massive campaign was recommended to increase public understanding of wetland values, functions and products. Target groups for the wetlands awareness campaign were identified as including:

- manufacturers;
- urban consumers;
- rural users and managers of dambos;
- the mining industry;

- water and hydropower generation engineers;
- policy makers and planners in the Ministries of Lands, Agriculture and Rural Settlement, Energy and Water Resource Development, and Local Government, Rural and Urban Development.

## Education and training

An urgent need for education and training in wetlands conservation and management in Zimbabwe was recognised; it was recommended that:

- The curricula at all levels of learning, including tertiary institutions, should be improved to incorporate wetlands issues.
- A training programme, with the strategy of first training trainers, be established; the trainers would then strengthen and train the Natural Resources Board, personnel of the Department of Natural Resources, AGRITEX, Ministries of Community and Co-operative Development, and Local Government, Rural and Urban Development, and the local leadership and structures.
- Informal training in indigenous traditional knowledge should be encouraged.
- Training in the form of small projects at undergraduate level should be encouraged.

## Wetlands inventory

As a matter of urgency, an inventory of Zimbabwe's wetlands should be undertaken and the inventory should be compiled in a form that is usable by all sectors of society.

IUCN-ROSA should establish a refereed journal on wetlands, and a Zimbabwe Wetlands Group be established with a role of influencing the Research Council of Zimbabwe to include a session on wetlands in the Research Council's annual conferences.

## Policy and legislation

The current policies on wetlands legislation are outdated as they emanated from the colonial era; it was recommended that:

- The current policies be reviewed to take into account the changes that have taken place since independence.

- The Ramsar Convention's definition of wetlands

  "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres",

  was adopted as the working definition of wetlands in Zimbabwe.
- An amalgamation of current policies should be carried out to develop a single wetlands policy. Once the policies are amalgamated, coordination is therefore required.
- A review and amalgamation of the current legislations related to wetlands should be carried out with the purpose of producing a single legislation to cover the wetlands concept as defined above.

## Organisation and institutional arrangements

There is lack of coordination and intersectoral communication among the institutions involved in wetlands conservation and management. The seminar recommended the streamlining of institutions and organisations involved in wetlands. Institutional responsibilities should be clearly stated and intersectoral communication should be encouraged and established.

## Zimbabwe Wetlands Conservation Programme Action Plan

Research on the ecology of wetlands, and conservation and management projects were established as important activities for the Zimbabwe Wetlands Conservation Programme.

### Research

The research needs of Zimbabwe's wetlands were identified by wetland class.

#### Dambo wetlands

Most of the research that has been conducted was at the academic level with an emphasis on dambo uses. It was recommended that dambo research should focus on the morphology, hydrology, management and conservation techniques for wetlands and that the public should be made aware of the research and its results.

#### Rivers and floodplains

Due to the lack of research on riparian wetlands, future research should include riverine wetlands and floodplains.

#### Artificial impoundments

On-going research is taking place on all dams that are under the Department of National Parks and Wildlife Management. However, the majority of small impoundments that service communal and commercial areas have not been studied. Research on impoundments outside the jurisdiction of the Department of National Parks and Wildlife was recommended.

#### Swamps and pans

Swamps and pans have received little attention from researchers and the current status, conservation and management of these areas need to be fully investigated.

### Conservation and management projects

The seminar proposed and recommended the following projects.

#### Dambos

- Investigation of dambo types, and the processes governing dambo hydrology, to be undertaken as a comparative study of different catchments.
- Sustainable and suitable uses of dambos and the identification of suitable crops and management techniques.
- Monitoring and evaluation of dambo degradation.
- Assessment of attitudes and socio-economic and cultural perspectives of sustainable dambo utilisation.

#### Riverine wetlands and floodplains

- The rehabilitation and monitoring of the Save Catchment, and the identification of conservation and management strategies.
- Database of the Zambezi Valley including:
  - Impact assessment of Batoka Hydropower Scheme;
  - Monitoring of habitat changes in resettlement schemes.
- A pre-impoundment, ecological study of the Osborne dam site and the catchment.
- Biological control of Water Hyacinth.
- Investigation of gold panning activities and conservation of riverine wetlands.

#### Artificial impoundments

- Carry out a national survey of basic data on dams to assess their fisheries potential.
- Biological control of floating aquatic weeds.
- Waste water reclamation.

**Pans, swamps and springs**

- The ecology, hydrology, utilisation and conservation of pans.
- Conservation and utilisation of hot springs.
- A national research and management project on swamps.

# Conclusion

The seminar concluded by forming the Zimbabwe Wetlands Working Group and elected a committee to oversee the activities of the Working Group.

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