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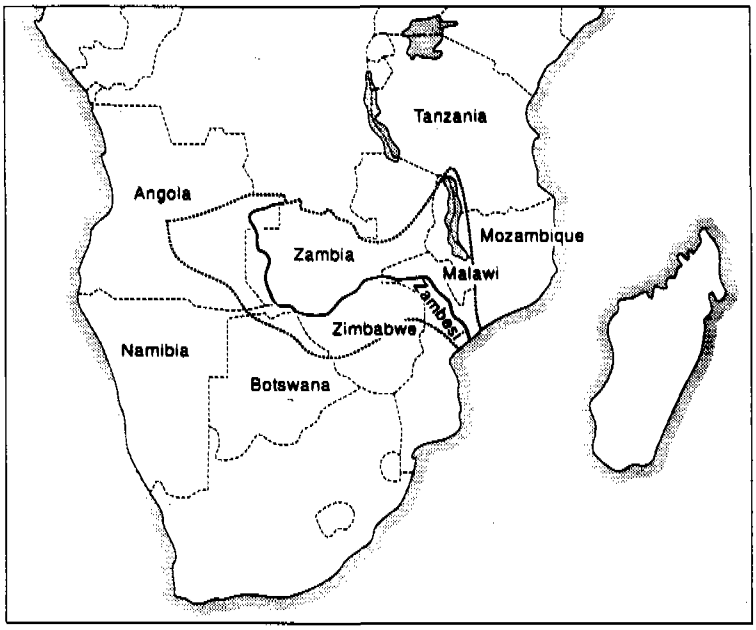

Incorporating a human health component into the integrated development and management of the ZAMBESI BASIN

A mission report prepared by
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1994
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PEEM River Basin Series 2

INCORPORATING A HUMAN HEALTH COMPONENT INTO THE INTEGRATED DEVELOPMENT AND MANAGEMENT OF THE ZAMBEZI RIVER BASIN

REPORT OF A PEEM MISSION TO
ZIMBABWE, ZAMBIA AND MOZAMBIQUE

by

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About PEEM

The Panel of Experts on Environmental Management for Vector Control (PEEM) was established in 1981 as a joint activity of the World Health Organization, the Food and Agriculture Organization of the United Nations and the United Nations Environment Programme. The Panel's objective is to create an institutional framework for effective interagency and intersectoral collaboration by bringing together various organizations and institutions involved in health, land and water development and the protection of the environment, with a view to promoting the extended use of environmental management measures for disease vector control in development projects. The PEEM Secretariat is located in the Division of Operational Support in Environmental Health of WHO in Geneva, Switzerland.

In 1991 the three Organizations were joined by the United Nations Centre for Human Settlements (UNCHS/HABITAT) and the Panel's mandate was expanded to include health issues relating to human settlements in development and to the provision of drinking water supply and sanitation, and urban environmental management for disease vector control. The global PEEM network currently consists of 45 experts in relevant disciplines and twelve collaborating centres. The International Institute of Land Reclamation and Improvement (ILRI), based in Wageningen, the Netherlands, is one of these collaborating centres and contributed substantially to the success of the mission to the countries of the Lower Zambezi Basin.

The PEEM River Basin Series contains reports of assessment missions to major river basins on possibilities for the incorporation of a human health component in their integrated development planning and management. A report on the Lower Mekong River Basin has already been published (WHO/EOS/94.52) and and a report on the Senegal River Basin is in print. Other missions will be carried out subject to the availability of financial support.

PREFACE

The PEEM mission to three of the eight countries in southern Africa that partially drain into the Zambezi River Basin has resulted in a catalogue of environmental health issues that need to be considered in the integrated development and management of this river basin. It should be seen against the broad background of the objectives of the Panel, of the global issues that have contributed to the formulation of the PEEM Medium-term Programme 1991-1995 and of the programmes of the Organizations participating in PEEM. The UN Conference on Environment and Development (UNCED), with its concern for sustainability of the development and use of natural resources, has had a particularly strong influence on national and international perceptions of the need for environmentally sound management of land and water resources.

At the eighth PEEM meeting (Nairobi, 5-9 September 1988), the Panel reviewed, at the request of the Executive Director of United Nations Environment Programme, relevant sections of the Zambezi Action Plan (ZACPLAN). Dr Tolba asked the Panel to advise UNEP how it could assist the Programme, other relevant UN organizations and regional and national institutions in implementing the ZACPLAN. The Agreement on the Action Plan for the Environmentally Sound Management of the Common Zambezi River System had been signed 15 months earlier, at a Conference of Plenipotentiaries in Harare in May 1987. In its report, the Panel identified those components of the ZACPLAN related to water resources development and health and indicated to UNEP in which way and to what extent it could assist in the implementation of the ZACPLAN. This information is contained in annex 1.

In preparation for the Panel's 12th technical discussion on "Incorporating a human health component into integrated river basin development and management" missions were organized to two river basins: the Lower Mekong and the Zambezi; a desk study on the Senegal River Basin was commissioned as well. The selection of the Zambezi was deliberately linked to PEEM's 1988 review of the Zambezi Action Plan. The mission visited three out of eight riparian countries of the Zambezi river basin, UNEP headquarters in Nairobi and the offices of the Southern African Development Conference (SADC) in Maseru, Lesotho. The three countries visited, Mozambique, Zambia and Zimbabwe, together contain 68 % of the total basin area and 65% of the total basin population.

The aim of the mission was to provide general background information on the status and potential of integrated development of the Zambezi River Basin and to identify opportunities to protect and promote human health and the environment in any such future development. This information should assist the Panel in the formulation of follow-up activities which build on its recommendations to UNEP in 1988 and which can be implemented in partnership with the local authorities. The outcome of the Panel's technical discussion at the 12th meeting (Aswan, 20-26 March 1994) is presented in this section, preceding the actual mission report.

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ACKNOWLEDGEMENTS

The authors would like to express their gratitude and appreciation to the national staff they met and worked with in Zimbabwe, Zambia and Mozambique, to the representatives of WHO and FAO and to the UNDP Resident Representatives in the three countries, to the staff at SADC/ELMS in Maseru and to the staff at the headquarters of the United Nations Environment Programme in Nairobi for the support given and information provided. A complete list of people interviewed is presented in annex 8. The mission was financially supported by a special contribution of the United Nations Environment Programme to PEEM. Some of the maps and figures in this document were specially prepared by the graphics department of the International Institute for Land Reclamation and Improvement in Wageningen, Netherlands.

ACRONYMS

AGRITEX	Department of Agricultural, Technical and Extension Services (Zimbabwe)
DBL	Danish Bilharziasis Laboratory (Charlottenlund)
EA	Environmental Assessment
EIA	Environmental Impact Assessment
ELMS	Environment and Land Management Sector (of SADC)
EMINWA	Environmentally Sound Management of Inland Waters (a UNEP programme)
FAO	Food and Agriculture Organization of the United Nations (Rome)
GNP	Gross National Product
HIP	Health Impact Programme of the Liverpool School of Tropical Medicine
HR/ODU	Hydraulics Research/Overseas Development Unit (Wallingford)
IAP-WASAD	International Action Plan - Water for Sustainable Agricultural Development
IUCN	World Conservation Union (Gland)
MAD	Mean Annual Discharge
MENR	Ministry of the Environment and Natural Resources (Zambia)
MMD	Minimum Monthly Discharge
NCDP	National Commission for Development Planning (Zambia)
NGO	Non-governmental Organization
PEEM	joint WHO/FAO/UNEP/UNCHS Panel of Experts on Environmental Management for Vector Control
SADC	Southern African Development Conference
UNCHS (Habitat)	United Nations Centre for Human Settlements (Nairobi)
UNDP	United Nations Development Programme (New York)
UNEP	United Nations Environment Programme (Nairobi)
UNICEF	United Nations Children Fund (New York)
WHO	World Health Organization (Geneva)
ZACPLAN	Action Plan for the Environmentally Sound Management of the Common Zambezi River System
ZACPRO	Zambezi Action Plan Project (19 in total)

RECOMMENDATIONS OF THE PANEL

At the twelfth PEEM Meeting in Aswan, Egypt (20-26 March 1994) a working group reviewed the report of the mission and, following a technical discussion, formulated conclusions and recommendations which were adopted by the meeting in a plenary session. The text is presented below and will also be included in the report of the meeting.

Report appraisal

The report of the mission to the Zambezi Basin gives a detailed account of the river and the lands of the watershed which extends over eight countries. Due to time limitations the mission concentrated on the three countries through which most of the Zambezi River itself flows: Zambia, Zimbabwe and Mozambique. Although one third of the river basin population lives in Malawi, this country was not included in the mission due to the prevailing difficult political situation at the time.

Whereas Zambia and Zimbabwe are conscious of their shared interest in the Zambezi River since it forms the boundary between them (they have a shared involvement in the Kariba dam and Lake and joint agreements over this), there has been little consciousness of the limits of the watershed. However, a broader awareness of a shared river basin has been recently manifest in the Action Plan for the Common Zambezi River System (ZACPLAN) signed by five of the riparian countries in 1987. This action plan provided the basis for the PEEM mission and will provide the basis for any future PEEM involvement.

Zambezi Action Plan Projects (ZACPROs)

It is clear that for PEEM to play its full part in relation to health aspects of water resources development in the Zambezi Basin as a whole, the results of ZACPRO 1 and ZACPRO 3 will be needed. It will be difficult to give soundly based advise until the nature and extent of existing and proposed developments is known, at any rate to a first approximation.

As regards ZACPRO 1, the following areas have been identified as possible elements of an inventory:

1. total population resident in each project area, planned and unplanned
2. migration patterns
3. key water-related activities (e.g. rice farming, fishing)
4. status of performed or planned EIAs
5. status of health services
6. notable health problems that have interfered, will interfere or affect operation
7. water supply and sanitation coverage
8. water quality

In case ZACPRO 2 has not reached its final formulation, it may be that PEEM could usefully contribute to this project in relation to framework legislation on health aspects of development in the basin and to water quality (in relation to pollution) aspects of ZACPRO 5 and to relevant aspects of other projects.

It is made clear in the mission report that the main role of PEEM will be in relation to ZACPRO 14, to the objectives of which it has already substantially contributed.

The following refers to the possible actions to be taken in relation to the implementation of health projects under ZACPRO 14:

ZACPRO 14.1

establishment of an inventory on water related diseases including project-related mapping.

registration of disease outbreaks by sentinel health facilities.

identification of institution(s) that can be instrumental in taking the necessary actions and serve as a focal point in relation to SADC.

reinforcement and upgrading of existing national health information systems including the establishment of a centralized data base for information relevant in the context of the river basin.

promotion of and assistance in the dissemination of existing know-ledge and experience on water resources development projects (e.g. Kariba dam) to relevant institutions.

ZACPROs 14.2-14.3

awareness creation on the drastic effects of environmental changes following project implementation and their human health implications (the risk of introducing "new" diseases).

promotion of and assistance with health impact assessments (HIAs), which should be performed for new water resources development projects as a basis for possible interventions.

putting an emphasis on the importance of vigilance by the existing health services to respond to changes in disease patterns.

ZACPRO 14.4

conduct training on health opportunities in water resources development on a regional basis (countries covering the river basin) with national follow-up seminars

ZACPRO 14.5

promotion of community awareness on health risks of water resources development projects, to be channeled through existing school systems and agricultural extension services. Where possible this promotion should make use of the PHC network (the PEEM guidelines for promotion of environmental management for disease vector control through agricultural extension services, currently under development, could be used).

ZACPRO 14.6

demonstration of the effectiveness of environmental modifications and manipulations (design and operation) in small-scale irrigation schemes in Zambia and Mozambique, based on the successful experience gained in the Mushandike pilot project in Zimbabwe.

integration of pilot water resources development projects into the "wise use" concept of the exploitation of the Zambezi wetlands.

Water resources development projects in the Zambezi River Basin

The very large Zambezi River Basin had a population of 22 million people in 1985. This gives a water availability of about 5000 cubic meters per head and a relatively sparsely populated watershed over much of its area. Population growth is, however, very rapid, approximately 3% per annum. The implications for water availability are substantial. If present population growth be maintained, the basin population will be 72 million by the year 2025 and water availability will have fallen to 1540 cubic meters per head, a level at which water scarcity is a real issue.

The perceived likely developments of water resources in the basin seem mainly to fall into three categories:

1. small scale irrigation developments;
2. the three large dams, two existing and one planned;
3. development of extensive wetlands.

Small-scale irrigation developments.

The over-riding priority that has been given to hydro-power generation by the main riparian States suggest that use of the water for irrigation at reservoir level is likely to be of a limited scale. Here the ZACPRO 1 results are crucial and what follows is based on very limited information from Zimbabwe. In that country the organization responsible for irrigated agriculture (AGRITEX) is believed to have around 50 small-scale projects at the planning stage.

Since 1984, detailed work on environmental management has been carried out as part of the rehabilitation of the Mushandike project and this has been fully documented. A similarly thoroughly documented health impact assessment of the planned Mupfure project was done in 1993 and is available as a case study. There is, therefore, a sound basis for development of other planned projects in Zimbabwe and adjacent countries which takes human health effectively into consideration, provided trained staff is available.

The three large dams.

The literature on Kariba is massive. Health aspects were debated and monitored by intermittent surveys. It was felt that little new could be added or was likely to emerge in relation to Kariba alone, through the work of the Kariba Research Station and others was very important. The downstream dam at Cabora Bassa is in a state of neglect following destruction of its power generation and transmission capacity in warfare. The need for reconstruction is obvious, but meanwhile the immediate question is whether there is a policy on regulation of water levels and discharges of the dam. Questions about the value of controlled level fluctuations are raised and need answering in terms of ecological and epidemiological effects, followed by appropriate action. The health implications of the proposed Batoka Gorge dam have already been examined and the mission report quotes from the conclusions of that assessment, mindful of the results of the Kariba dam.

Concern was expressed that, in spite of the complex health issues made evident by the Kariba dam experience, the health impact assessment so far for the Batoka Gorge project has comprised only five person/days in the feasibility study. This is surely inadequate in relation to the potential risks as well as to the scale of the proposed investment.

Attention should be given to the possible hydrological interactions (fluctuating the water levels over short periods or creating small floods) between the planned upstream Batoka Gorge dam and the Kariba dam and the potential health consequences of such interactions.

Development of wetlands.

The Zambezi Basin is notable for the large areas of important wetlands in its upper reaches. These are inhabited both by people and a diverse flora and fauna. They are viewed as important for conservation and to tourists. But the economy of indigenous inhabitants needs improvement and IUCN is aware of the need for sensitive development of the wetland areas in the interest of all their inhabitants, human or otherwise.). This provides a special opportunity for PEEM to face up to a new and important challenge. Many forms of vector-borne disease control by environmental management separate land and water sharply, destroy wetlands and reduce biological diversity. It will be of particular interest to develop, in collaboration with IUCN, ways in which to manage vector-borne diseases in a conservation setting.

Health opportunities

The mission report sets out, in its conclusions, a series of health opportunities in the Zambezi Basin. These are identified as the Mushandike Irrigation Project, the PEEM/DBL training course and the health impact assessment of the Mupfure Irrigation Project, the Zambezi Action Plan which is addressed in detail and the developments in Zambia relating to the intersectoral community-based work in Luapula and the Upper Zambezi Wetlands Project.

Recommendations

1. The inventory of present and proposed water resources development projects in the Zambezi Basin is now being undertaken by SADC/ELMS. The basic information on each project should contain, as a minimum, in addition to the hydrological and related data (cf. action plan for ZACPRO 14):

total population resident on each project, planned or unplanned;
migration patterns;
key water related activities;
status of performed or planned health impact assessments;
status of health services;
notable health problems that have interfered or will interfere or affect operation;
water supply and sanitation coverage;
issues of water quality.

2. There is a need to increase the awareness of the health consequences of water resources development project in the basin (and of PEEM activities) as currently there is little outside of Zimbabwe and intersectoral collaboration is weak. The following measures are recommended:

(a) PEEM should contribute to raising awareness by an increased distribution of its *PEEM News* and other documents to relevant institutions and individuals in the basin area;

(b) a one-day seminar for policy makers should be encouraged for the riparian countries to enhance intersectoral awareness and collaboration on health matters;

3. Advocacy and support for 1. and 2. should be formally sought from country representations of UN agencies, i.e. UNDP, WHO, UNICEF, FAO, UNESCO, UNEP, UNCHS, from representations of IUCN and from locally represented bilateral agencies, which could be used as focal points and catalysts for country programmes.

4. SADC should be encouraged to designate one of the institutions in the region or create other, new mechanisms to play a lead role in environmental management for vector control when developing shared water resources in the Zambezi River Basin and others e.g. the Limpopo Basin. The lead institution should initially focus on creating an effective and committed network of interested national institutions.

5. The PEEM collaborating centres network needs to be expanded in the Zambezi River Basin area and in Africa in general, to ensure that the network of experts takes advantage of skills and capacity on the African continent. A database of such experts for the region is needed.

6. The SADC concept of focal points for water related activities in key departments nationally in the region should be extended to cover PEEM concepts, ideas and projects (the relation between this and items 4 and 5 needs to be sorted out by the PEEM Secretariat to both ensure coverage of research, training and operation and to avoid redundancy of effort or competition). PEEM activities need to be set out in the SADC regional newsletter.

7. The recent drought in the southern Africa has increased awareness of the need for efficiency in the use of water for irrigation. There is a need for intensive research on irrigation technologies that improve water use efficiency and that have a potential to reduce vector breeding. The existing expertise and opportunities available in Zimbabwe provide a good way to tackle this.

8. In the region much of the irrigated agriculture is in the commercial sector (e.g. over 85% in Zimbabwe). The Panel needs to give adequate attention to the commercial sector both in order to learn about cost-effective approaches to water use and to ensure adequate concern for human health in commercial operations. This recommendation also has relevance to item 7.

Generic recommendations.

Several of the regional recommendations provide a basis for more general recommendations some of which might address the following issues:

1. The crucial need for basic inventories of water resources development projects, including planned development, for any area or river basin, as a basis for all subsequent work and discussion

2. Whereas the need for health impact and opportunity assessment is gaining a wider appreciation, the availability of solidly based environmental management solutions, outside the more obvious modification of settlements, is limited. PEEM needs to focus on solutions to vector-borne disease problems. This will need to be economically feasible and justified (a big issue!).

3. The Panel's outlook needs to be extended more towards commercial irrigation schemes, both to learn from their techniques of water management and to ensure that, where relevant, health safeguards instigated by legislation also cover the commercial sector.

4. In the training activities at the national and river basin level, PEEM needs to get the appropriate balance between (i) those taught to do an HIA, (ii) those taught to see the need for and evaluate an HIA, and (iii) other relevant skills and attitudes.

Dissemination and report information

The group recommends PEEM to make river basin reports available as working documents with restricted distribution. A summary of overal findings may be communicated to relevant institutions through *PEEM News*.

CONTENTS

THE ZAMBEZI RIVER BASIN

PHYSICAL CHARACTERISTICS

The Zambezi River, together with its tributaries, drains almost the entire south central region of the African continent. It flows eastwards for about 3000 km from its source on the Central African Plateau to the Indian Ocean, draining an area of about 1 300 000 square kilometers. Table 1 shows the surface area of the Zambezi Basin within the eight riparian countries and the percentages of the land area and population within the basin area for each of them.

Table 1. Zambezi river riparian states, their share of the drainage basin, and share of total basin population in each country.

Country	Catchment area (km^2)	Percentage of basin area	Percentage of total basin population
Angola	260 000	18.3	1.6
Botswana	40 000	2.8	0.1
Malawi	110 000	7.7	29.4
Mozambique	161 000	11.4	13.2
Namibia	17 000	1.2	0.2
Tanzania	28 000	2.0	4.2
Zambia	577 000	40.7	22.5
Zimbabwe	226 360	15.9	28.9
Total	1 419 960	100	100

Based on hydrology and geophysical characteristics, the Zambezi basin can be divided into the upper, middle and lower catchment areas.

The Upper Zambezi

The source of the Zambezi river is a marshy bog near Kalene Hills in Zambia at 1585 m above mean sealevel. The river flows north for about 30 km, then west and southwards through Angola for 280 km and re-enters Zambia just north of the Chavuma Falls (Map 1.1). After the falls the river begins to meander through broad, shallow and marshy plains. The last of these plains is the Barotse floodplain (7500 km^2). At an altitude of 1000 m the river enters a 100 km long stretch of rapids. After the Katima Rapids, the Zambezi flows through a sandy plain where it meanders widely and its floodwaters join with those of the Chobe river from Angola, thereby creating another permanent swamp. When the river approaches Victoria Falls it has a mean width of 1350 m.

Middle Zambezi

After its waters have plunged some 100 m down the Victoria Falls, the river flows eastwards for almost 1000 km through gorges and the man-made lakes Kariba (5200 km^2) and Cabora Bassa (2700 km^2). In the Middle Basin the river is joined by its two largest tributaries, the Kafue and the Luangwa (Map 1.2).

Lower Zambezi

At Cabora Bassa, the Zambezi begins its descent from the Central African Plateau to the coastal plain. On the Mozambique Plain it occupies a broad valley with a width up to 7 km. The river may flow in several channels in the dry season, which merge again into a single river in the wet season. The Shire river, which drains Lake Malawi, joins the Zambezi near Vila Fontes. The delta of the Zambezi is wide, marshy, and obstructed by sandbars.

Hydrology of the Zambezi Basin

The runoff varies considerably over the Zambezi Basin and has a pronounced seasonality. Before the construction of the Kariba dam (1955-1958) and the Cabora Bassa dam (1969-1974), the average ratio of maximum to minimum flow was about forty to one. This ratio would be higher still but for the influence of the extensive swamps and wetlands in the headwaters in Zambia which considerably attenuate peak flow. Swamps in the Kafue basin have the same effect on the flow of the tributaries Kafue and Luangwa. Table 2 presents the water balance of the Zambezi basin.

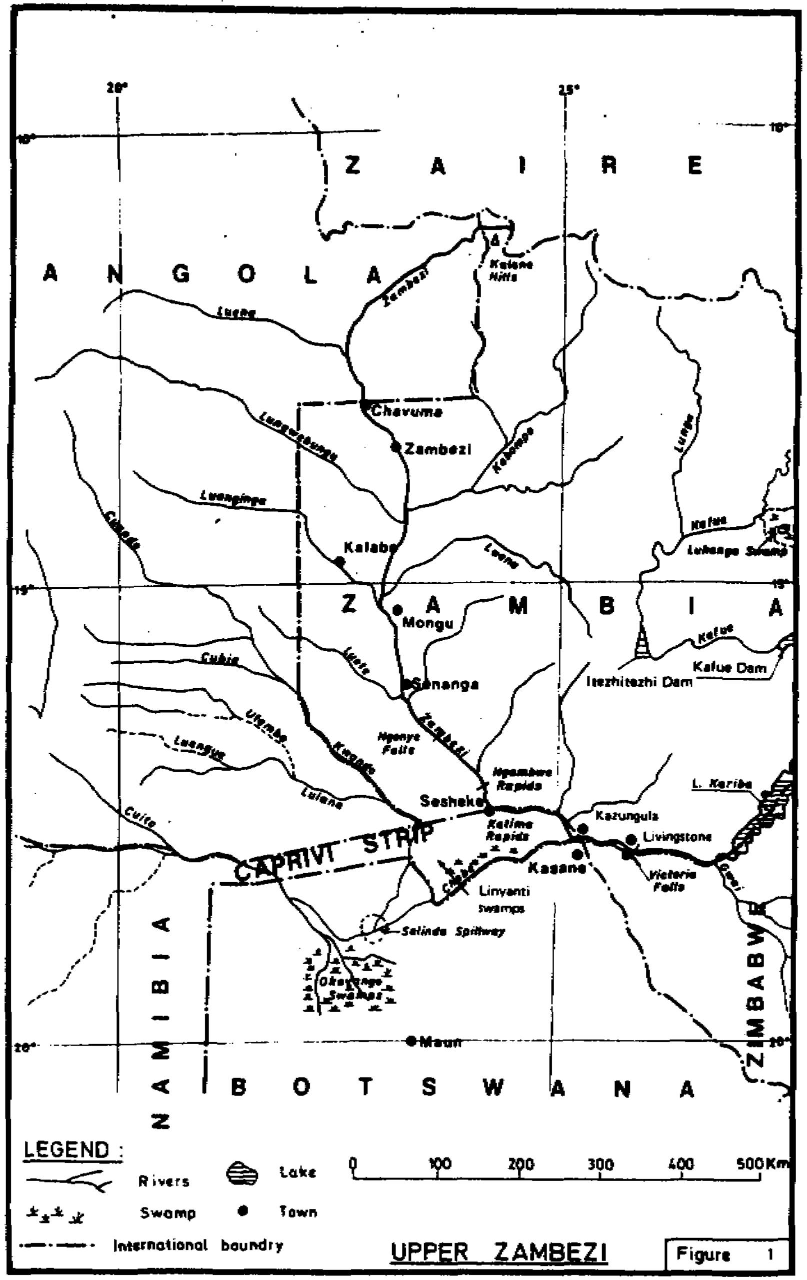
Table 2. Water Balance of the Zambezi River Basin (after UNESCO 1978)

Location	Catchment area (1000 km^2)	Rainfall (mm)	Run-off co-efficient	Run-off (mm)	Run-off (m^3/s)
Chavuma Falls	79.9	1200	0.26	312	751
Victoria Falls	360.7	1000	0.13	136	1 560
Chirundu Mouth	667.7	980	0.13	125	2 467
Indian Ocean	1 330.0	990	0.12	80	4 852

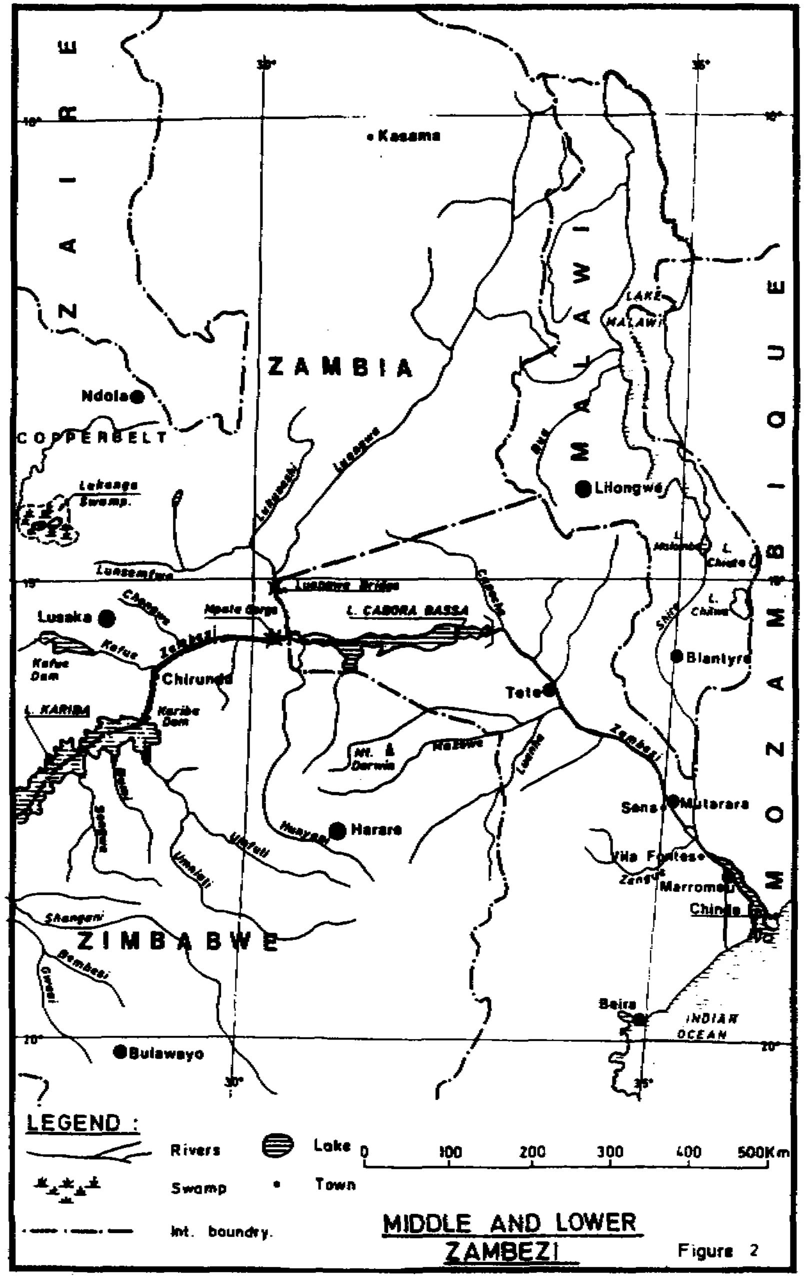
Measurements at Victoria Falls were recorded as early as 1906. Flow records at Victoria Falls show large shifts in average flow over the years (source: *World Bank/ UNDP Sub Saharan Africa Hydrological Assessment,* Regional Report SADC Countries, December 1990):

1924 to 1946: mean annual discharge of 1081 m^3/s
1947 to 1980: mean annual discharge of 1532 m^3/s
1981 to 1988: mean annual discharge of 941 m^3/s

Due to the reduction in inflow from 1981 to 1988, hydropower generation at Lake Kariba had to be reduced by 20 percent to prevent reservoir storage falling below minimum operating levels.



Map 1.1 Upper Zambezi



Map 1.2 Middle and Lower Zambezi

Source: Diagnostic Study of the Common Zambezi River System, UNEP, 1987.

Basic indicators of riperian countries

Map 1.3 shows the riparian countries of the Zambezi River. Tables 3 and 4 provide some basic indicators of these countries including economic and health data. Considerable differences exist in their living standards and levels of prosperity. For example, Botswana has a per capita GNP which is more than 30 times that of Mozambique. Similar variability is found in health status, nutrition and health services. Figures 1.1, 1.2 and 1.3 present, respectively, development assistance received, cereal imports and food aid given to seven of the eight riparian countries in the basin.

Table 3. Basic indicators of countries of the Zambezi River Basin.

	Population (millions) mid 1991	Area (000s of km²)	GNP per capita (US$ 1991)	life expectancy at birth (years) 1991	Adult illiteracy (%)	
					female 1990	total 1990
Angola	9.4	1 247	n.d.	46	72	58
Botswana	1.3	582	2 530	68	35	26
Malawi	8.8	118	230	45	n.d.	n.d.
Mozambique	16.1	802	80	47	79	67
Namibia	1.5	824	1 460	58	n.d.	n.d.
Tanzania	25.2	945	100	51	n.d.	n.d.
Zambia	8.3	753	n.d.	49	35	27
Zimbabwe	10.1	391	650	60	40	33

n.d. = no data

Source: World Development Report 1993

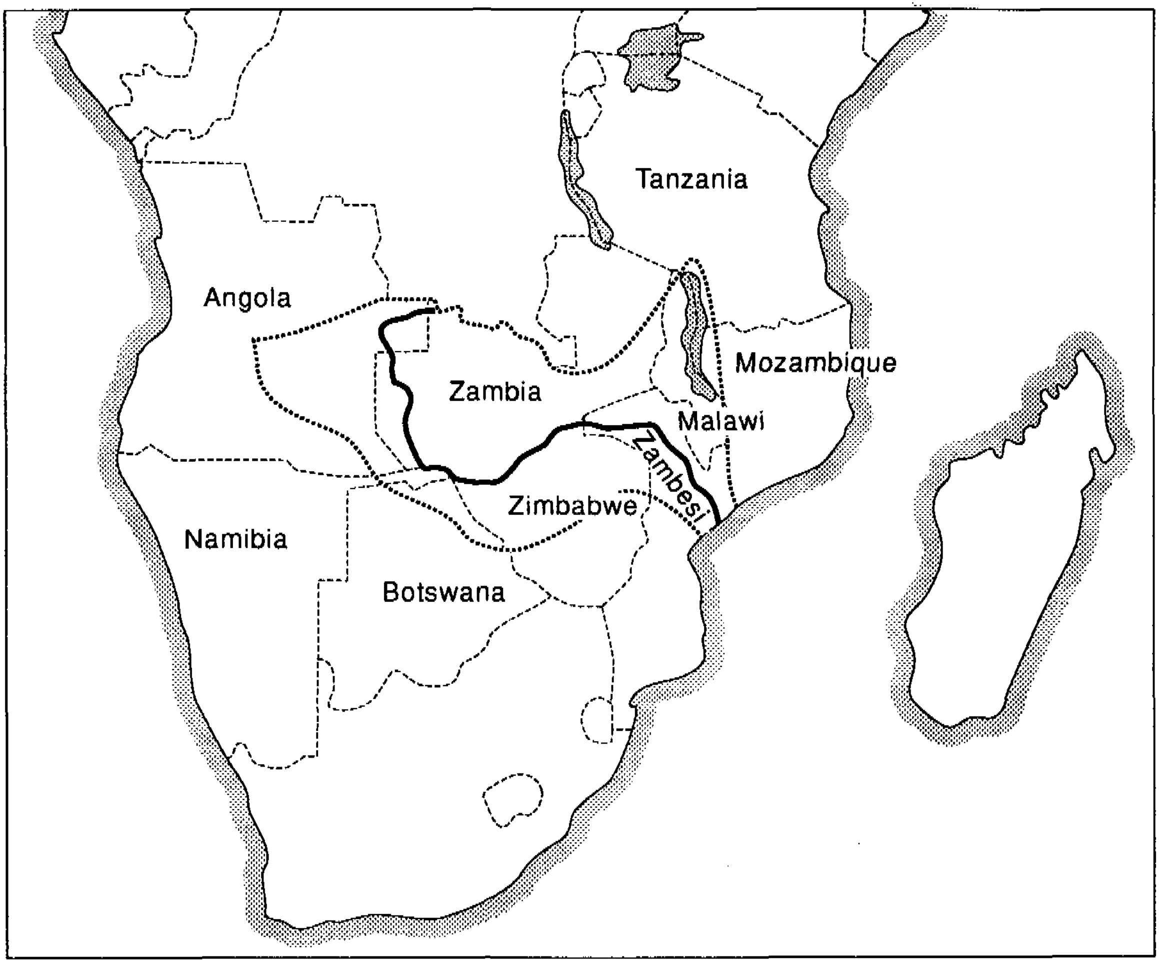
Table 4. Health and nutritional indicators of countries of the Zambesi River Basin.

	Population per physician (1990)	Population per nursing person (1990)	infant mortality rate (per 1 000 live births) (1991)	prevalence of malnutition (under 5) (1990)
Angola	n.d.	n.d.	n.d.	n.d.
Botswana	5 150	1 900	36	15
Malawi	45 740	1 800	143	60
Mozambique	n.d.	n.d.	149	n.d.
Namibia	4 620	n.d.	118	n.d.
Tanzania	24 880	5 470	115	20
Zambia	11 290	1 730	106	n.d.
Zimbabwe	7 180	1 000	48	12

n.d. = no data

Source: World Development Report 1993

Map 1.3. The riparian countries of the Zambezi River.



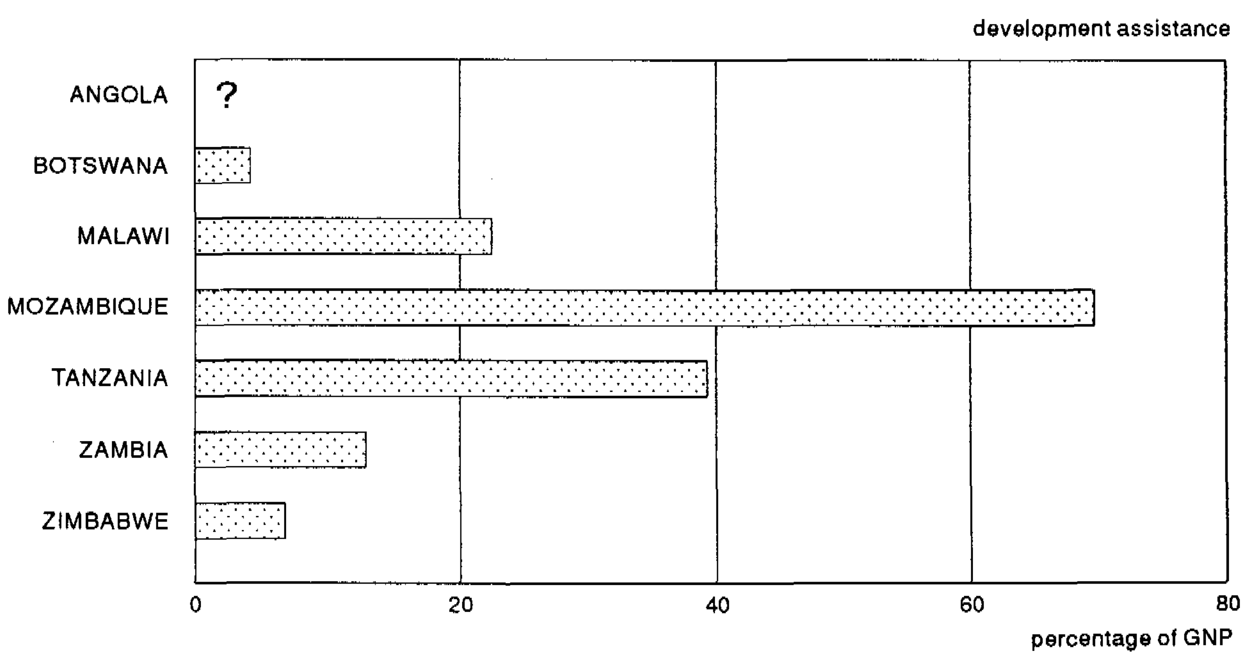


Figure 1.1. Official development assistance to riparian countries as percentage of GNP 1991.

Source: *World Development Report 1993.*

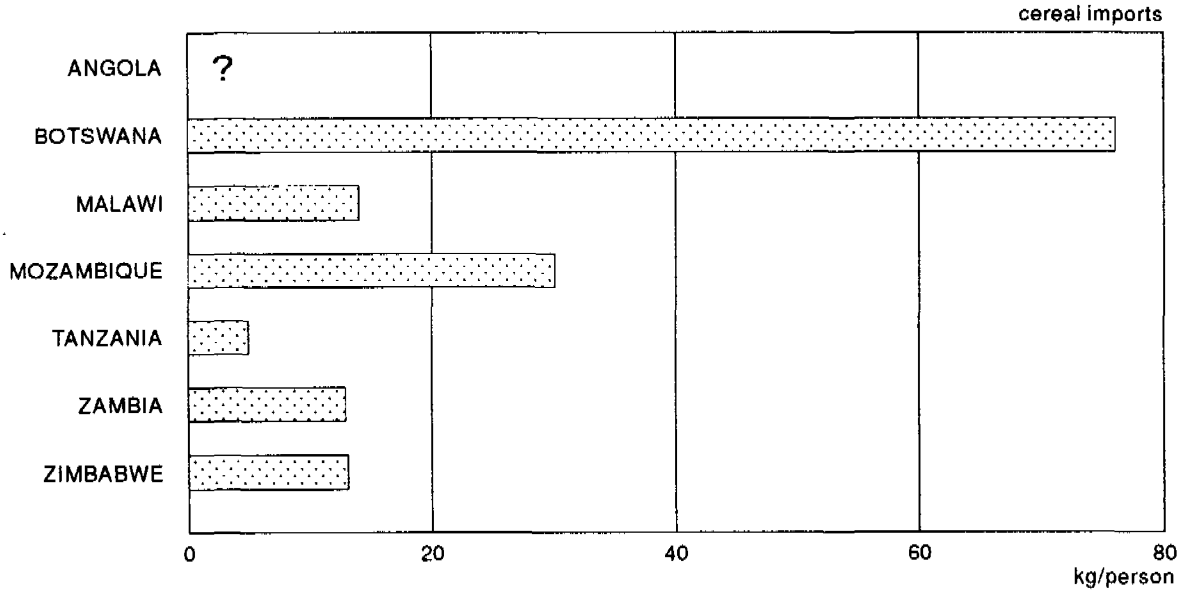


Figure 1.2. Cereal imports of riparian countries in 1990/91, in kg per person.

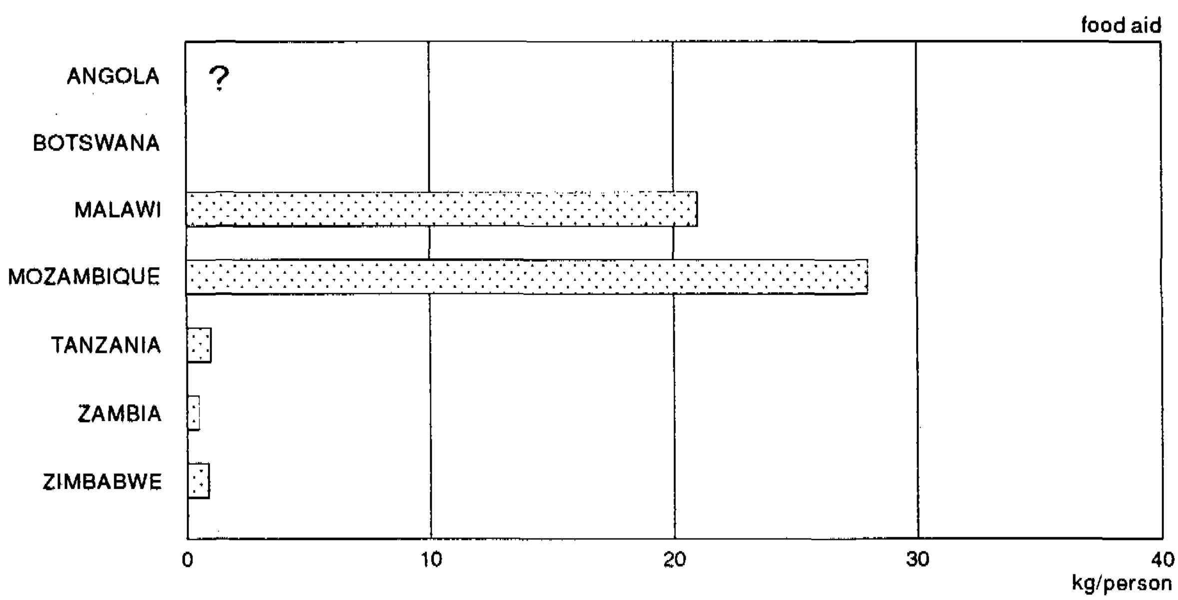


Figure 1.3. Food aid to riparian countries in 1990/91, in kg per person.

Source figures 1.2 and 1.3: *World Development Report 1993.*

Water availability constraints in the riparian countries

Water resources play a significant role in the socio-economic development of the riparian countries of the Zambezi Basin. A major proportion of the electricity in the basin is generated by hydropower plants; for example, about 4500 MW is generated by the Kariba and Cabora Bassa dams. The further development of an additional capacity of 8000 MW is in the planning phase. Of the 280 000 hectares currently under irrigation in the SADC countries, more than half lie in the Zambezi basin. It is estimated that more than 120 000 tonnes of fish per year are harvested in the Zambezi River Basin.

The Zambezi River Basin, like the rest of sub-Saharan Africa, experiences recurrent droughts and, in limited areas, floods. The droughts often create insecurities in water supply, food availability and energy generation, while floods inflict damages to property and loss of lives. Both droughts and floods may have serious health consequences and may affect the incidence of vector-borne and water-borne diseases.

Sufficient water is available in the basin to allow for a considerable economic development, but it is unevenly distributed in time and space. The rapidly growing population in the riparian countries forces a growing number of people to share the limited water resources available and serious conflicts caused by competition between drinking water supply, agriculture and industrial sectors might occur, if the resource is not managed in an integrated, efficient and environmentally safe manner.

Annex 2 provides a a summary of current and future uses of water resources in the riparian countries. The information contained in this summary is extracted from the country reports of a workshop organized by SADC in May 1994 [1].

In the section that follows water availability constraints are analyzed on a country basis, rather than basin-wide. This procedure had to be followed because of the dearth of readily available basin-wide data.

Maps 1.4-1.7 provide a rough indication of water availability constraints for each of the riparian countries. Map 1.4 is based on the ratio of the estimated total water demand in the year 2000 and the Mean Annual Discharge (MAD) available in the rivers in each country.

Total water demand was calculated as the sum of estimated water consumption in the year 2000 for irrigation, urban water supply, industrial water use and rural water supply. These estimates are based on projection of data obtained from various sources on consumptive use in each of the subsectors in the 1980s (Table 5). This Table also gives the surface and groundwater resources for each country. Data on water resources have been mostly obtained from the country reports of the World Bank/ UNDP Hydrological Assessment for sub-Saharan Africa. Table 6 specifies the surface water resources per country.

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[1] It was, therefore, not part of the mission report as it was submitted to the Panel at its twelfth meeting in Aswan, Egypt in March 1994.

Map 1.4 shows that total water demand in Zimbabwe by the year 2000 is projected at 20 to 40 percent of the Mean Annual Discharge (MAD). Using the criteria indicated in the legend of Map 1.4, Zimbabwe is listed as 'constrained in dry year', whereas the other countries are 'unconstrained'.

Map 1.5 is based on the ratio of total water demand and the Minimum Monthly Discharge (MMD). Using this ratio and the criteria listed in Map 1.5, water availability is 'seriously constrained' in Botswana, Tanzania and Zimbabwe. Mozambique will be 'constrained in normal year', leaving only Zambia 'unconstrained'.

According to Map 1.6, the exploitation of groundwater resources could solve the constraints faced by Botswana and Mozambique, reduce constraints in Tanzania, whereas Zimbabwe would remain 'seriously constrained'.

There is considerable variation, however, in the estimates of groundwater resources in various studies (Table 7). Map 1.7 uses the lowest values found in the various groundwater studies. With these estimates, the situation for Botswana changes drastically: from 'unconstrained' in Map 1.6 it becomes 'seriously constrained' again in Map 1.7. This illustrates the urgent need for adequate information on water resources.

In summary, Maps 1.4-1.7 indicate that a number of countries in the Zambezi River Basin, and especially Zimbabwe, are facing serious water availability constraints in the near future.

The largest water consumer: irrigation

Table 5 shows that irrigation for agricultural production is by far the largest consumer of water, representing 86.3 per cent of total water demand in the 1980s and some 83 per cent of the projected total water demand by the year 2000.

The water demand for irrigation is based on the FAO estimates of existing irrigation in 1982 (Table 8, Map 1.8), assuming that 1000 hectares of irrigated land require a constant flow of 1 m^3/s. The estimates of irrigated areas by the year 2000 are based on the assumption that the area under large scale irrigation will increase at a rate of 1 per cent per year and the area with small scale irrigation at 3 per cent per year. Given the serious water availability constraints, it seems appropriate to reconsider the need for irrigation as a means of achieving self-sufficiency in food production. Figure 1.4 provides an overview of the capacity of rainfed agriculture to support the expected population in the year 2000, for seven countries in the Zambezi River Basin. The calculations are based on the assumption that all of the land that is suitable for agriculture is used for food production, with traditional level of agricultural inputs. According to Figure 1.4 Botswana, Malawi, Tanzania and Zimbabwe would not be able to produce enough to feed their entire population if they rely on rainfed farming.

Figure 1.5, however, indicates that all countries could become self-sufficient in food production by increasing the level of inputs from traditional to medium level (= 50% of inputs used in commercial farming).

Table 5 Water demand in the year 2000 compared with available water resources

Country	Water demand 1980's (m^3/s)					Water demand year 2000 (m^3/s)					Water resources (m^3/s)			
											Surface water		Groundwater	
	Irr	Urb	Ind	Rur	Total	Irr	Urb	Ind	Rural	Total	MAD	MMD	GWR	GWRmin
Angola-Zaire	10	3.0	3.6	1.6	18.2	17	5.8	7.2	2.1	32.1	3800	600.0	1712	1712
Botswana	12	0.3	0.0	0.2	12.5	20	0.6	0.0	0.3	20.9	406	5.0	380	0
Malawi	20	2.4	0.1	1.7	24.2	26	5.1	0.3	2.2	33.6	589	467.0	63	63
Mozambique	70	5.2	0.5	2.8	78.5	86	12.0	1.2	2.9	102.1	2253	267.0	1014	539
Tanzania	140	12.3	1.7	4.4	158.4	226	23.5	3.3	4.3	257.1	1556	323.0	983	729
Zambia	16	14.8	1.6	0.9	33.3	22	28.0	3.1	1.0	54.1	2307	1045.0	983	983
Zimbabwe-Zambezi	130	0.7	3.8	1.6	136.1	157	1.3	7.3	2.0	167.6	698	140.0	127	127
Total per sector	398	38.7	11.3	13.2	461.2	554	76.3	22.4	14.8	667.5				
Percentage	86.3	8.4	2.5	2.9	100	83.0	11.4	3.4	2.2	100				

Table 6. Mean Annual Discharges (MAD), Minimum Monthly Discharges (MMD), and mean monthly discharges in m^3/s for the river basins of countries in sub-Saharan Africa.

	Upstream of	MAD	MMD
ANGOLA			
total		3 800	600
BOTSWANA			
Limpopo	RSA	25	0.0
Okavango	Zimbabwe	349	5.0
Chobe		32	0.0
Groundwater		3	
Total		406	5

		J	F	M	A	M	J	J	A	S	O	N	D	MAD
MALAWI														
Shire	Mozambique	532	553	636	702	714	687	643	605	542	469	479	509	589
MOZAMBIQUE														
Maputo		161	207	149	92	56	37	37	28	26	50	88	141	
Umbeluzi		27.3	30.9	16.2	10.8	7.6	5.7	5.1	4.1	4.4	6.3	9.6	14.4	
Sabie		38.4	59.9	36.4	21.3	12.8	8.9	6.9	5.5	5.1	6.2	9.7	22.1	
Incomati		123	183	110	71	43	28	22	15	13	24	50	96	
Limpopo		387	790	482	197	95	46	29	18	11	11	28	107	
Save		1136	1444	1424	616	221	99	59	39	24	14	34	181	
Buzi		202	928	1364	496	199	130	117	121	137	114	108	86	
Pungue		200	270	238	118	67	47	37	28	23	21	32	119	
Lurio		108	868	762	404	159	69	40	18	9	5	8	34	
subtotals:														
South of Zambezi		2274	3913	3819	1621	701	401	313	260	234	247	359	767	1243
Zambezi		**3423**	**4241**	**4711**	**3964**	**2984**	**2313**	**2358**	**1559**	**1352**	**1253**	**1475**	**2136**	**2647**
North of Zambezi		541	4342	3808	2018	793	347	198	89	45	24	40	171	1010
total		6238	12496	12338	7603	4479	3061	2869	1907	1640	1524	1873	3075	4901
TANZANIA														
Rufiji		1593	1559	2148	2876	1831	762	475	346	264	213	250	735	
Wami		91	52	91	258	136	63	33	26	20	18	50	68	
Pangani		34	27	25	41	41	40	34	26	22	21	26	24	
Rovuma+rest		531	520	716	959	610	254	158	115	88	71	83	245	
total		2248	2159	2979	4133	2619	1118	700	513	395	323	410	1072	1556
ZAMBIA														
Chambeshi		125	209	450	505	341	200	127	87	60	43	42	84	
Zambezi	**Zimbabwe**	**2739**	**3393**	**3769**	**3171**	**2387**	**1850**	**1886**	**1247**	**1082**	**1003**	**1180**	**1709**	
rest		2864	3602	4219	3677	2728	2050	2013	1334	1142	1045	1221	1793	2307
ZIMBABWE														
Zambezi	**Mozambique**	**3081**	**3817**	**4240**	**3568**	**2686**	**2082**	**2122**	**1403**	**1217**	**1128**	**1327**	**1923**	**2382**
Save	Mozambique	1022	1299	1282	554	199	89	53	35	21	13	31	163	
Limpopo	Mozambique	77	158	96	39	19	9	6	4	2	2	6	21	
total excl.VicFalls		4181	1881	1849	990	517	330	295	195	159	140	184	398	698

Table 7. Estimates of groundwater recharge

Country	Groundwater recharge in km³ (1)	(2)	(3)
Angola-Zaire	54	72	
Botswana	12	2	
Malawi	2	-	
Mozambique	32	17	
Tanzania	31	23	
Zambia	31	35	160
Zimbabwe-Zambezi	4	5	

(1) estimates from FAO 1987
(2) estimates from Korzoun *et al*. 1978[1]
(3) estimates from selected World Bank/UNDP SSA Hydrological Assessment Reports

Table 8. Estimates of sizes of irrigated areas (1,000 ha) for the years 1982, 2000, and 2025.

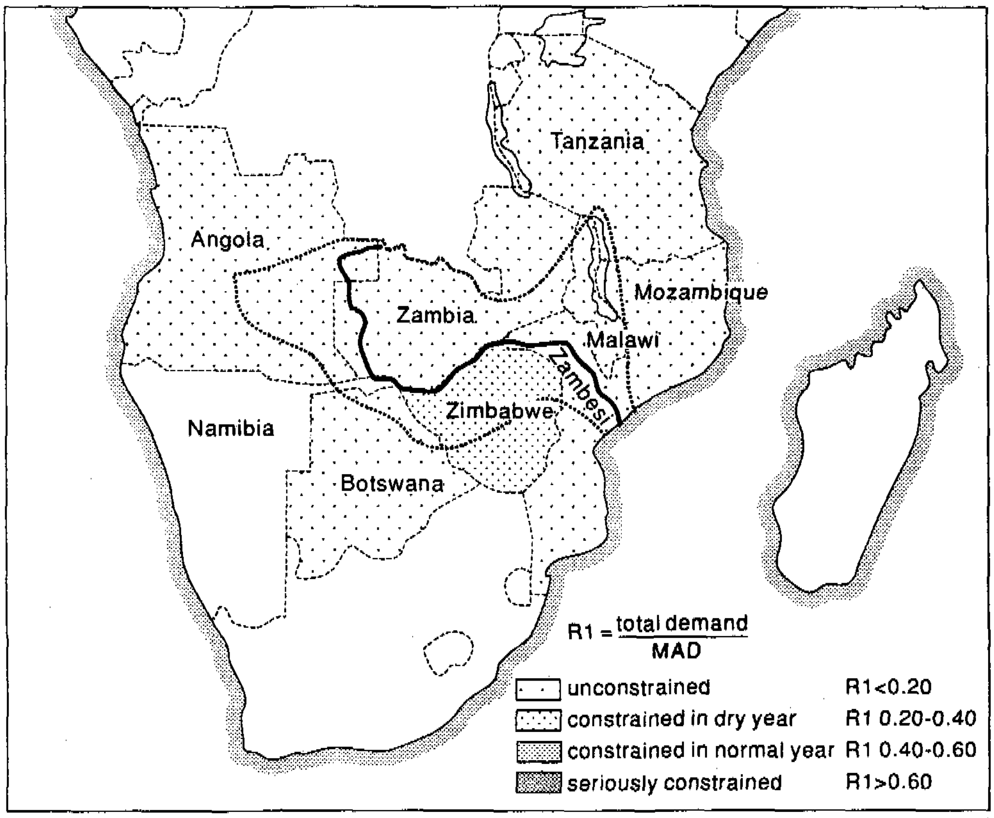
	irrigation potential	1982 modern	1982 small scale	1982 total	2000 modern	2000 small scale	2000 total	2025 modern	2025 small scale	2025 total
Angola	6 700	0	10	10	0	17	17	0	36	36
Botswana[1]	100	0	12	12	0	20	20	0	42	42
Malawi	290	16	4	20	19	7	26	25	15	40
Mozambique	2 400	66	4	70	79	7	86	103	181	284
Tanzania	2 300	25	115	140	30	196	226	39	412	451
Zambia	3 500	10	6	16	12	10	22	16	21	37
Zimbabwe	280	127	3	130	152	5	157	198	11	209

[1] Country with seriously restricted rainfed opportunities (FAO 1986)

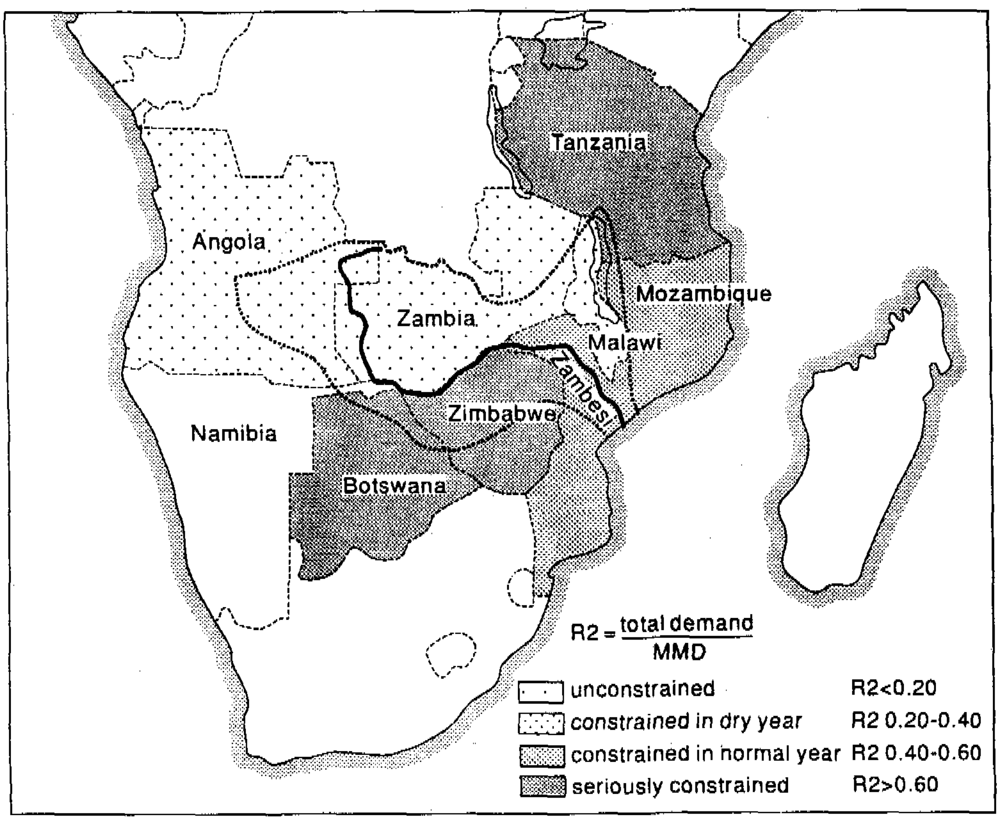
Assuming that the findings presented in Figure 1.5 are correct, development of irrigated agriculture is not essential for food production. In the context of the Zambezi River Basin it can therefore be argued that, in principle:

- water should not be allocated to the irrigation sector when it leads to water shortage or cost increase for the water supply and sanitation sector;
- water allocations for irrigation should take into account true economic value of water in competing uses (e.g. industry, hydropower);
- irrigation development should not take place at the expense of the environment, particularly wetlands; and
- irrigation development should not necessarily lead to an increase in vector-borne diseases.

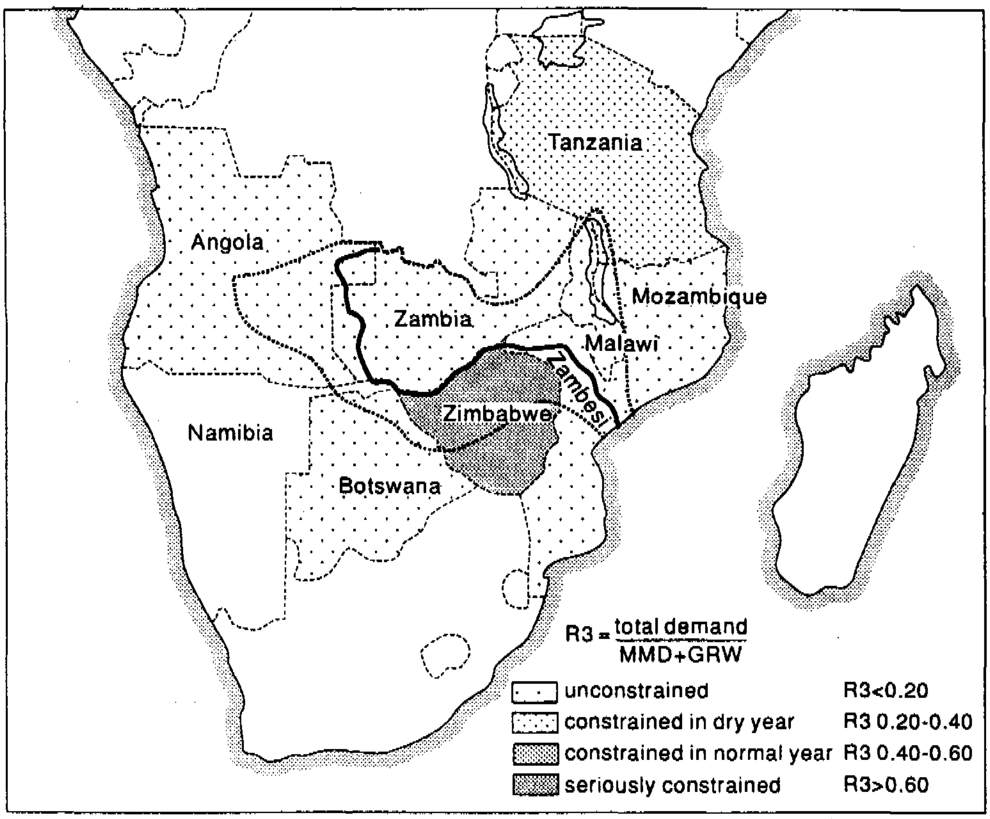
Map 1.4. Water availability constraints in riparian countries, based on ratio (R1) of total water demand in the year 2000 and the Mean Annual Discharge (MAD).



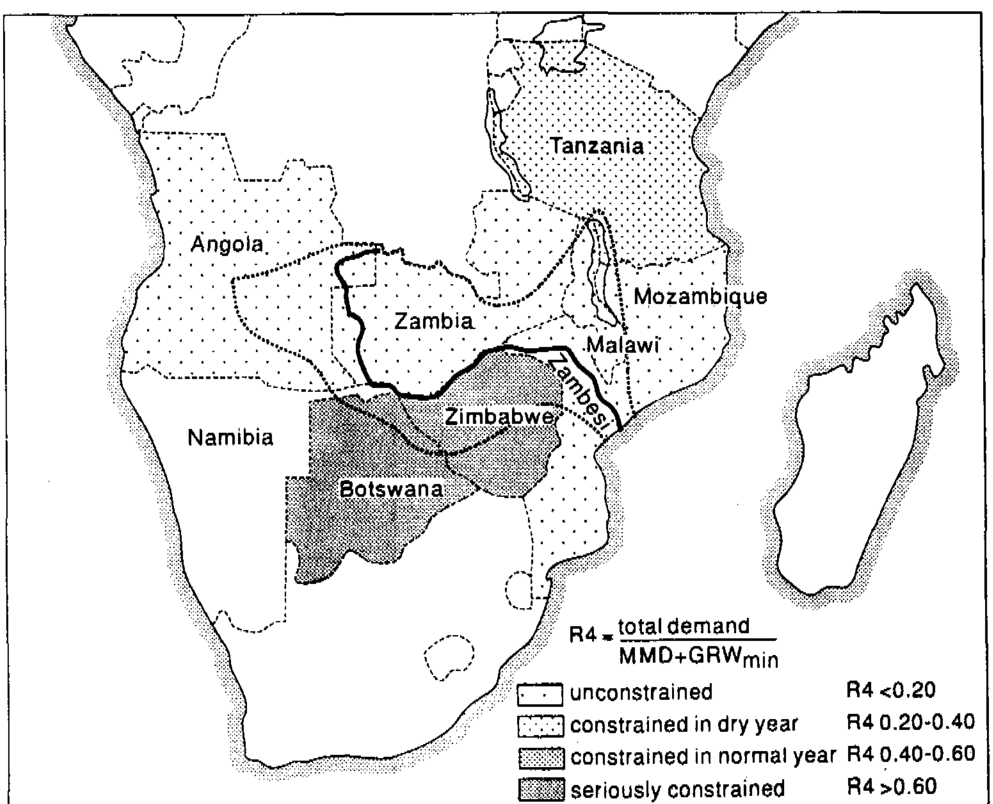
Map 1.5. Water availability constraints in riparian countries, based on ratio (R2) of total water demand in the year 2000 and the Minimum Monthly Discharge (MMD).



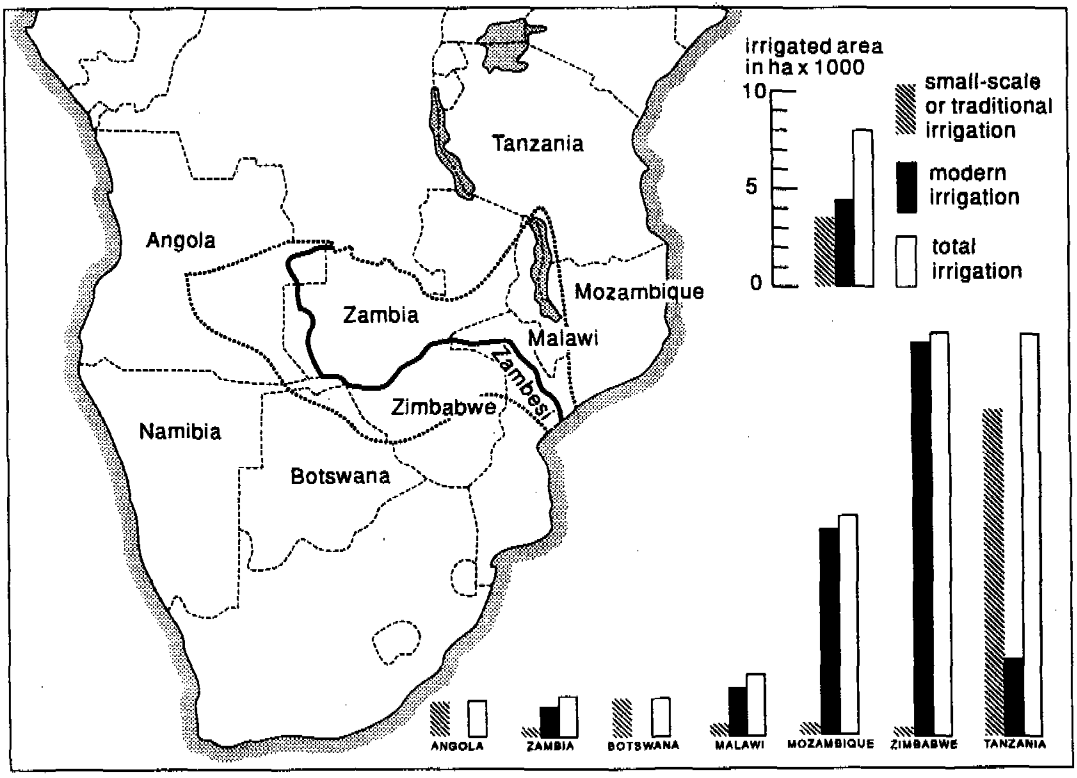
Map 1.6. Water availability constraints in riparian countries, based on ratio (R3) of total water demand in the year 2000 and the sum of Minimum Monthly Discharge (MMD) and Groundwater Resources (GWR).



Map 1.7. Water availability constraints in riparian countries, based on the ration (R4) of total demand in the year 2000 and the sum at Minimum Monthly Discharge (MMD) and Minimum Groundwater Resources (GRW min).



Map 1.8 Total irrigated acreage for each country



However, the inherent weaknes of this argument is that it does not take into account socio-economic aspects of irrigation development and the variability of yields in rainfed farming due to variations in rainfall. To base a major part of the food security of nations on rainfed farming is a risk most governments of countries in sub-Saharan Africa, where droughts are frequent and crop yields under rainfed conditions are low, are not willing to take.

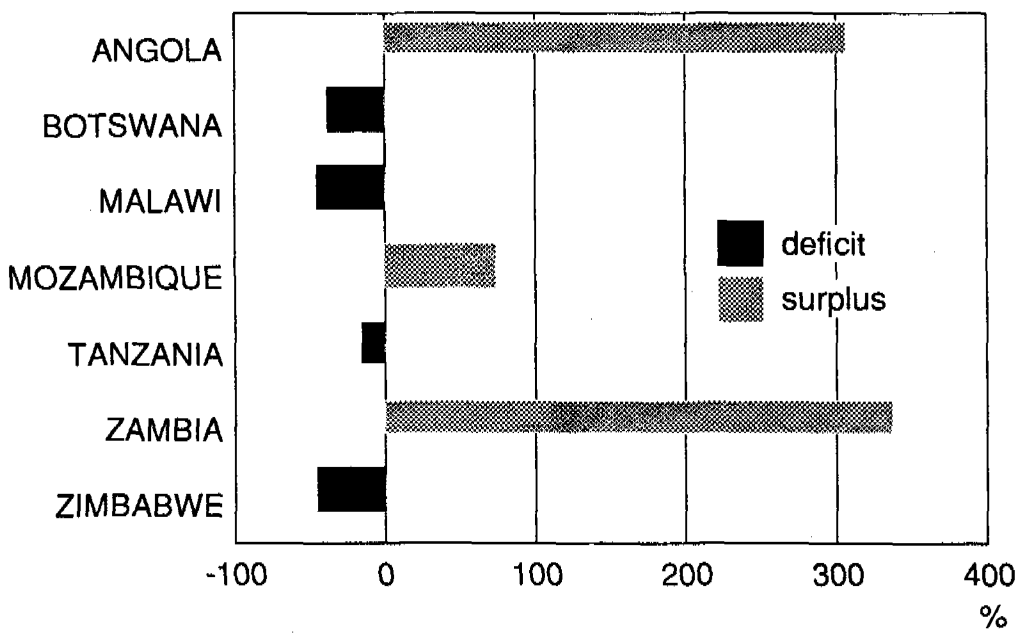


Figure 1.4. Anticipated deficit/excess in population-supporting capacity[1] of riparian countries for the year 2000, using traditional level of inputs, and without irrigation

[1] Assumption: all of the suitable agricultural land is used for food production.

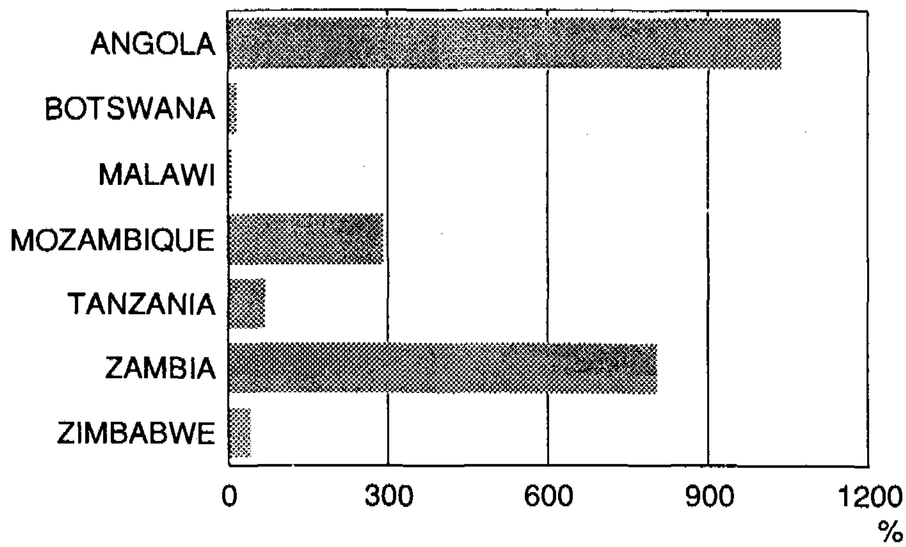


Figure 1.5. Anticipated excess in population-supporting capacity[1] of riperian countries for the year 2025, using medium level of inputs, and without irrigation.

Source Figures 1.4 and 1.5: *Potential Population Supporting Capacities of Lands in the Developing World*, FAO, Rome, 1982

Hydropower

The high discharge of the Zambezi river and its fall over 1000 m make the river an obvious choice for hydro-electric power generation. Figure 1.6 provides an overview of existing and potential sites for hydro-electric power generation on the Zambezi. Figure 1.7 presents the water balance of Lake Kariba in the period 1962-1991. It clearly shows that after 1991 all of the available inflow (minus evaporation) was used for turbine discharge. This indicates that there is very limited scope for other water uses, such as irrigation. The Regional Report for the World Bank/UNDP sub-Saharan Africa Hydrological Assessment (SADC Countries, December 1990) states: *The development of the Zambezi seems therefore likely to be tied predominantly to hydropower development rather than other consumptive uses such as irrigation and industrial and potable use, except in its lower reaches, in order to maximize power output.*

Machena (1992) describes the environmental effects of the development of the Kariba dam. A dramatic effect was the resettlement between 1956 and 1959 of about 45 000 people who lost their fertile agricultural land and had to put up with one crop a year in a dry and unfertile area, without any form of compensation from the authorities. Other effects of dam development are discussed in the following section.

Wetlands

Water resources are critical to the functioning of numerous ecosystems. In the last decades, water dependent environments have been adversely affected by interventions that modify hydrological regimes or alter water quality.

[1] Assumption: all of the suitable agricultural land is used for food production

Among the ecosystems that are likely to be affected most by water resources development activities are the aquatic and wetland ecosystems. Wetland ecosystems represent some of the most valuable components of the region's natural environment. They are among the most complex and vulnerable as well.

Wetland Resources in the Zambezi Basin

Wetlands are one of the most productive ecosystems in southern Africa and of the Zambezi Basin in particular. The Zambezi Basin is well endowed with diverse wetland systems such as swamps and/or marshes, floodplains, natural lakes, artificial impoundments, dambos, pans and natural pools. The variety of wetlands in the basin supports a diversity of land uses, flora and fauna, including large human populations; extensive areas of phragmites, typha, papyrus; and large populations of elephants, buffaloes, hippopotamus, lions, leopards, crocodiles and other game. The wetlands provide a habitat to numerous aquatic animals and birds. They also provide water and forage to wildlife and breeding sites to migratory waterfowl. In addition to the provision of habitats for wildlife, the wetlands of the Zambezi Basin provide domestic, agricultural and industrial water, fisheries, fertile agricultural soils, water transport and recreation/tourism to the populations of southern Africa.

Wetlands of the Upper Zambezi[1]

The Upper Zambezi Basin is characterised by floodplains, swamp/marsh, dambos and thin riverine wetland systems. The thin riverine wetland strips occur along the river and its tributaries and is characterised by diverse and unique vegetation, rapids and falls. The Victoria, Sioma, Chavuma and Nyamboma Falls, and Katambora Rapids constitute notable and important falls and rapids in the Upper Zambezi Basin. Swamps/marshes occur in the Chobe/Linyati system and Barotse plains. Notable swamps/marshes are Chobe and Linyati (513 000 ha) on the Namibia/Botswana border; Savuti (3 000 ha) in Botswana; Kabompo (18 000 ha), Lungue-Bungo (approximately 100 000 ha), Luena (89 669 ha), Nyengo (70 000 ha), Lueti (14 000 ha) and Lui (23 500 ha) river swamps in Zambia. The swamps/marshes are seasonally inundated by the waters of the Zambezi and its tributaries. Most streams in the Upper Zambezi support floodplains of varying sizes, the most important being the Barotse floodplain (770 000 ha). The Sesheke-Maramba (150 000 ha) on the Zambia/Namibia border and the Cuando (40 000 ha) in Angola are also important floodplains in the Upper Zambezi basin.

Wetlands of the Middle Zambezi

Two important tributaries of the Middle Zambezi support important floodplains and swamps. In its upper catchment, the Kafue flows through the Lukanga (210 000 ha) and Busanga (60 000 ha) swamps. In addition to these two swamps, the Kafue river supports the Kafue flats (566 000 ha). The Luangwa river also supports an extensive floodplain often known as the Luangwa Valley wetlands. Below its confluence with the Kafue, the Zambezi used to flood a considerably large area before the Kariba dam was constructed. However, only a small floodplain and a network of pools exist today. A notable wetland area in this zone is the Mana Pools area. Human interference has considerably altered the natural ecology of the Middle Zambezi basin. Artificial impoundments are concentrated in this zone and these include large impoundments such as Kariba, Kafue Gorge, Itezhitezhi and Cabora Bassa.

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[1] Description of wetlands is based on text provided by Mrs M. Chiuta, Wetlands Programme Coordinator. IUCN Regional Office for Southern Africa. Harare, Zimbabwe.

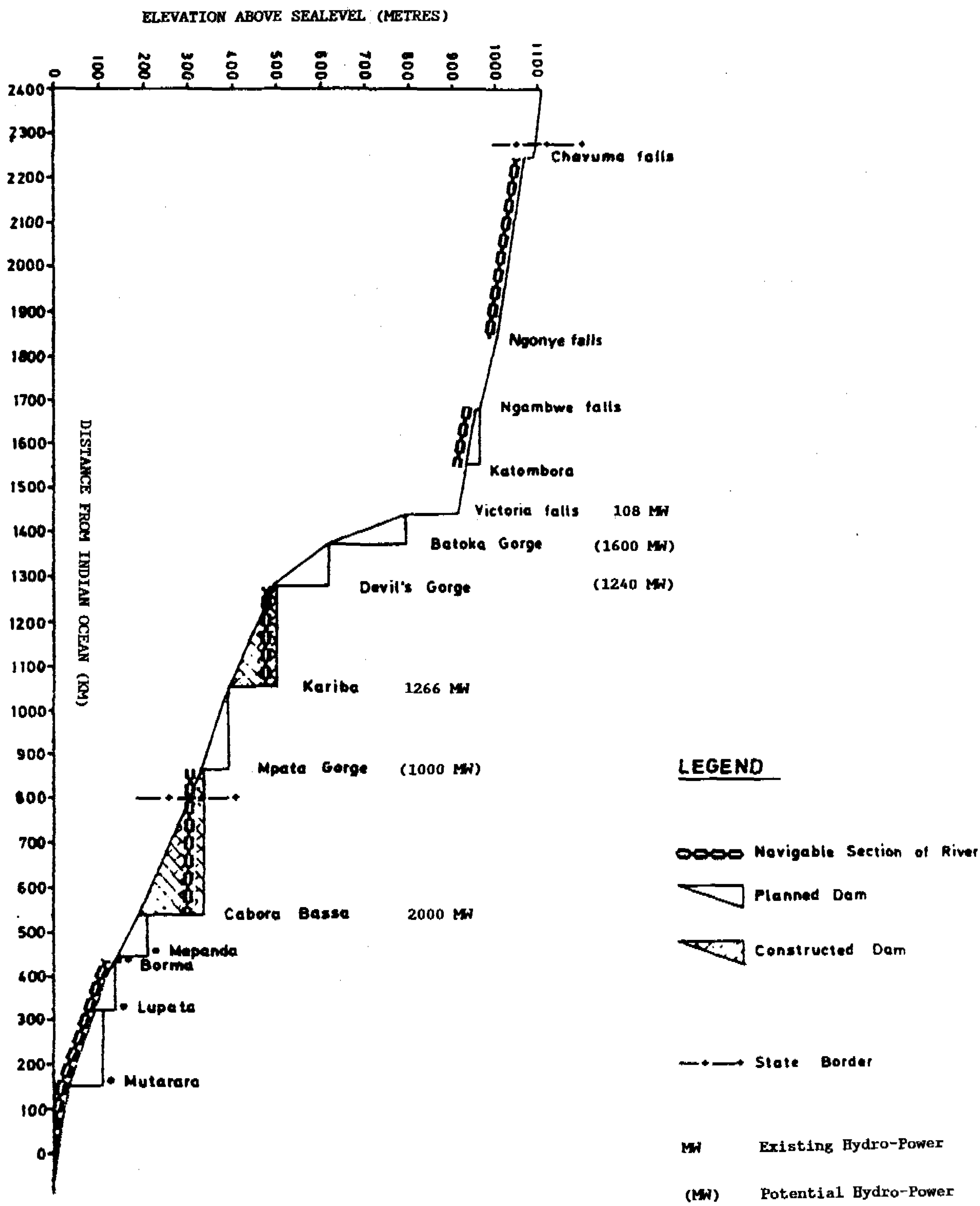


Figure 1.6. Existing and Potential Hydro-Power on the Zambezi River.

Source: Zambezi River Authority, 1991

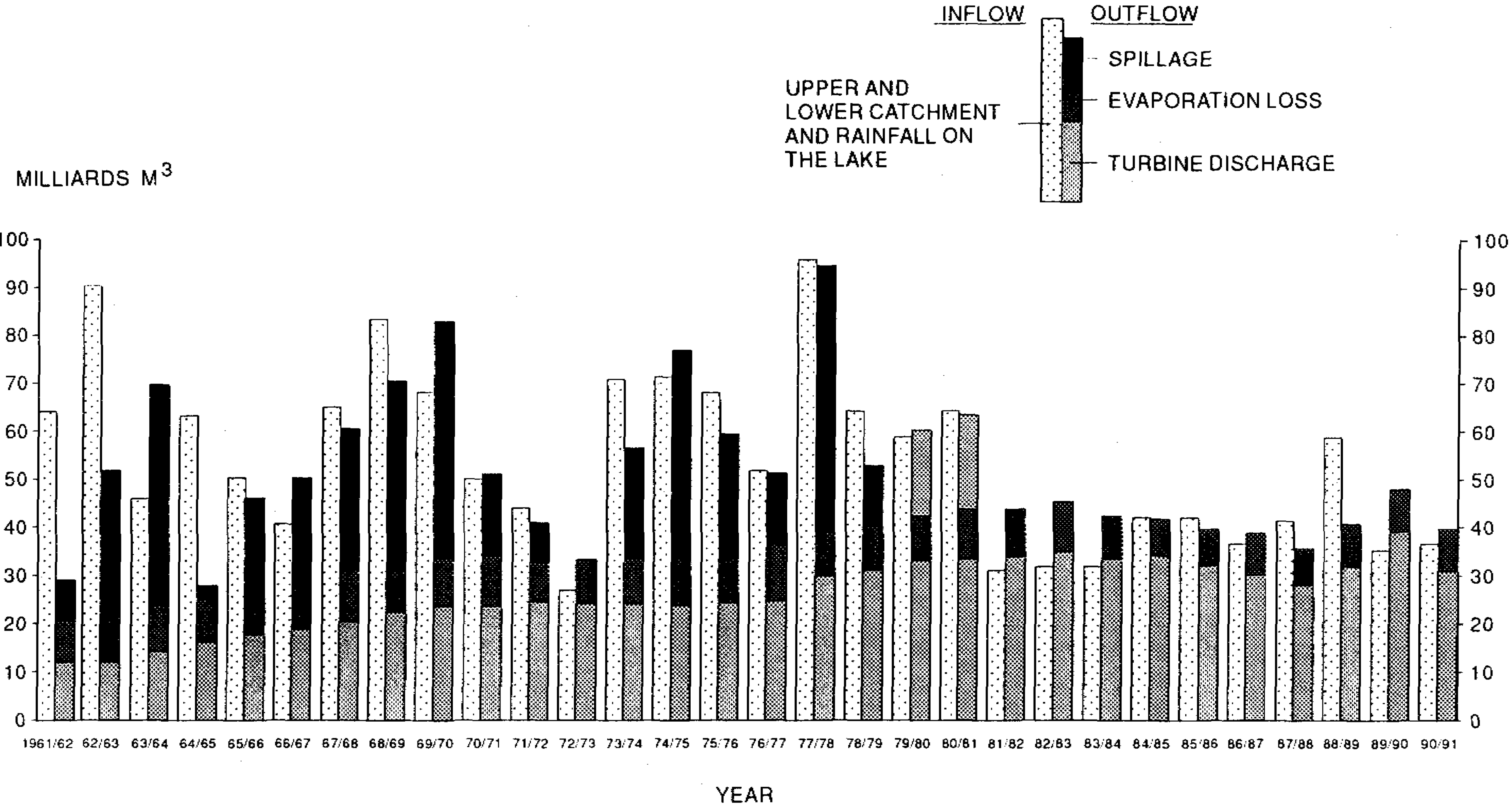


Figure 1.7. Lake Kariba Water Balance 1962-1991.

Source: Zambezi River Authority, 1991.

Wetlands of the Lower Zambezi

Marshes/swamps, floodplains, natural lakes, dambos and delta characterise the wetland systems of Lower Zambezi basin. The wetlands associated with Lake Malawi are considered part of the Zambezi basin since the Shire river drains from the lake. Notable wetland systems include the littoral zone wetlands of Lake Malawi (Karonga Lakeshore Plain, Limpasa Dambo, Nkhotakota Lakeshore Lowlands and Salima Lakeshore Plain), Shire Marshes (74 000 ha) and Zambezi Delta (130 000 ha).

Hydrological functions of wetlands

Wetlands of the Zambezi Basin, apart from providing products to the people of the basin, perform invaluable hydrological functions that maintain the *status quo* of the basin ecosystem. The wetlands of the Zambezi basin and their associated riparian habitats perform important functions such as flood storage and conveyance, erosion control through river/stream bank stabilization and sediment trapping, and pollution control by retaining and absorbing toxic substances and effluent.

Wetlands act as "sponges" absorbing rainfall and runoff, thereby reducing peak flows. For example, the Barotse Floodplain in Upper Zambezi regulates the flow of the Zambezi river by storing and gradually conveying flood waters. The Barotse Floodplain has a storage capacity of 8600 x 10^6 m^3 at normal flood and 27 000 x 10^6 m^3 at high flood. The Kafue basin, above Itezhitezhi is subject to significant regulation by the Lukanga, Busanga and other swamps. In addition to performing hydrological functions, wetlands of the Zambezi Basin support very important fisheries, wildlife habitats and provide recreation and sites of aesthetic value to the population of the region. Agricultural development, especially irrigation agriculture in the basin is often based on wetlands. The much needed water is provided by riverine wetlands of the basin.

Environmental concerns

Dams considerably alter the downstream hydrological regime. The functioning of hydropower plants and the support of dry-season flows for the purpose of downstream navigation and water abstraction (e.g. water supply to irrigation schemes and water distribution networks) require annual storage of water. As a result, discharges downstream of a dam usually are lower during the natural peak-flow period of the river while dry-season discharges are higher. Dams that are used for the single purpose of flood protection only affect peak flows. Downstream peak discharges are reduced; dry-season flows remain unchanged. In both cases, floods no longer occur or are substantially reduced, which leads to a loss of wetland area (floodplains, riverine swamps, marshes and shallow lakes), e.g. the Cabora Bassa dam (Mozambique) prevents the flooding of the Lower Zambezi. Consequently, much of the benefits of wetlands are lost by this development.

The disappearance of high flood stages also results in the lowering of the water table in riverine areas, which in turn has a detrimental effect on riverine and gallery forest, water supply to wells (e.g. for drinking water), and floodplain vegetation and productivity.

Reduced flooding adversely affects natural fertilization of low-lying lands as silt is no longer deposited. This phenomenon causes soil degradation in former floodplains and riverbank erosion (middle Zambezi River below the Kariba Dam). Far downstream, coastal erosion may occur as river-borne sediments no longer compensate the erosive action of waves, tides, current, and wind.

A decrease in wetland area may also result in the loss of breeding and spawning grounds for fish, and, eventually, a decrease in river fish stocks or diversity. Dam construction has led to large reductions in fishery yields from the Zambezi river floodplains below the Cabora Bassa dam. Downstream river flows are not only affected in terms of their seasonal variations, they also tend to be more regular. Flow regulation means an end to the dynamics of the downstream hydrological regime. This obviously alters the functioning of seasonal wetlands; it also prevents the flushing of riverine areas by floodwater. The latter often is the only means of "cleaning" riverbanks and low-lying areas. Infestation of river beds and shallow water bodies by macrophytes and phytoplankton following the elimination of floods has been reported for the Zambezi river after impoundment. Seasonal and inter-annual river dynamics also support vegetation regeneration and may be essential to keep ecosystems in balance.

Possibilities for environmental beneficial action

Some examples of techniques that would benefit water-related environments are described below.

The first example concerns controlled flooding. In Africa, experience with controlled flooding is not extensive, but "artificial floods" are receiving increasing attention as a means of environmental management. Releases from the Itezhitezhi Dam in Zambia are not optimal but they have avoided the total destruction of the valuable downstream floodplain, the Kafue Flats. Experience gained with the Pongolopoort and Manantali dams, in, respectively, the Republic of South Africa and Mali, clearly show the benefits of controlled flooding on the downstream environments and production systems along the Pongolo and Senegal rivers. In the Senegal Valley, such practices are increasingly gaining support, even from those who initially expressed concern and thought of controlled flooding as a threat to hydropower production and irrigated agriculture.

The second example concerns manipulation of the water level in a reservoir - e.g. in combination with releases for the purpose of controlled downstream flooding - to allow seasonal flooding of adjacent lands. This offers opportunities for the development of flood-recession and flood-rise agriculture, grazing lands, wildlife habitats (birds, fish, mammals, etc.) and wetlands in the drawdown area of the reservoirs. For instance, local people already harvest *Echinochloa stagnina* fields in the drawdown area of Kainji Lake in Nigeria. Development of flood-recession agriculture and "wetland grazing" by livestock and wildlife is also reported from various African reservoirs, including Kariba Lake in Zambia and Zimbabwe, Lake Volta in Ghana and Lake Nasser in Egypt.

Reforestation in the upper parts of river and lake basin is a third example. Forested areas effectively check soil erosion and delay run-off. Reforestation reduces sediment loads of rivers, protects downstream works such as reservoirs, irrigation schemes or drinking water supply plants, and diminishes siltation of wildlife habitats. By delaying run-off, forested areas attenuate flood peaks and reduce the need for downstream flood-control works.

ENVIRONMENTAL HEALTH IN THE ZAMBEZI BASIN

This chapter focuses on the impacts of water resources development on environmental health with particular reference to the Zambezi River Basin area in Zimbabwe, referred to as the Zambezi Valley. The situation analysis and possible options for reducing health risks presented in this chapter apply, in general terms, to the whole of the Zambezi River Basin.

Introduction

A central component in the development of Zambezi Valley is to prevent the onset of major health problems arising from environmental change. A clear understanding of the interrelationship between human health and the management of natural resources and the environment is required if economic activity and other developments being planned for the Valley are to be sustainable. Environmental issues related to health can be put into two main categories:

Those associated with socio-economic development.
The human population in the Valley is bound to increase as people move in with their livestock in areas where the tsetse fly (*Glossina morsitans*) has been eradicated. Health problems may arise if public health resources such as clinics, latrines and water supplies are unable to cope with the expanded population. Most of the soils in the Valley are infertile and poor. Inappropriate farming methods may result in the depletion of the natural resources leading to low food production and if continued, eventually, to malnutrition; whilst improper use of agricultural chemicals may lead to occupational health hazards.

Those due to ecological changes.
Water and not land is the main constraint to agricultural activity in the Valley. Therefore, the water of Lake Kariba, the Zambezi River and its tributaries including potential dam sites, offer some degree of potential for irrigated agriculture. An increase in the amount of surface water may bring about changes in the environment that may introduce or increase the transmission of vector-borne diseases such as schistosomiasis and malaria.

In the following discussions, attention is focused on the second category of issues and in particular on the problems of schistosomiasis. Options for controlling the disease will be presented as part of an integrated development strategy for the Zambezi basin area.

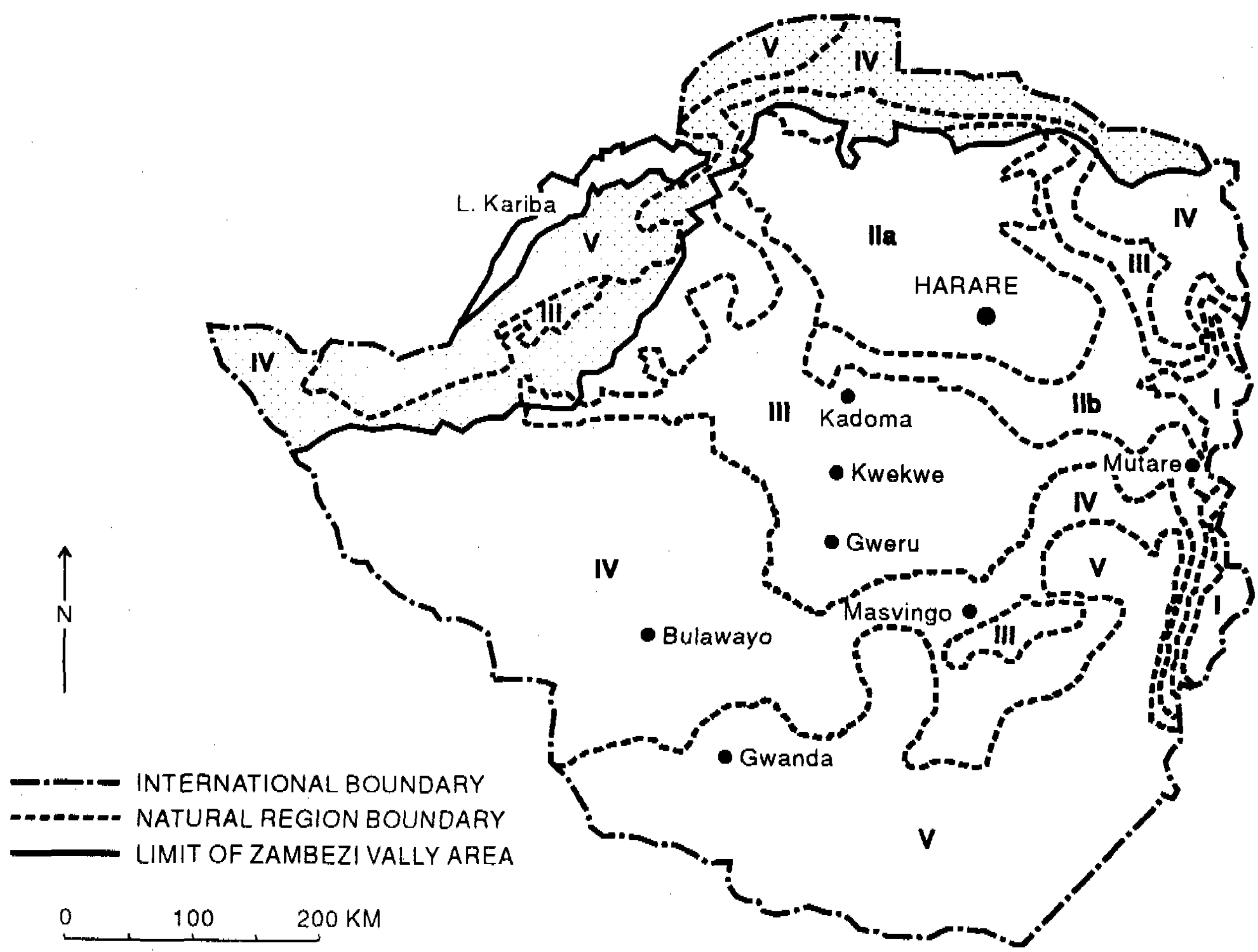
Available evidence suggest that knowledge of the epidemiology of malaria, particularly the dynamics of drug-resistant strains, is of vital importance to formulating effective strategies for controlling malaria and the anopheline vector mosquitoes in the context of development projects. Such strategies are essential to prevent outbreaks of the disease which could have catastrophic implications on development in the Valley.

Background to the Zambezi Basin Area

In Zimbabwe, the Zambezi Valley is a vast region that is relatively under-developed compared to other parts of the country. It includes parts of eleven districts spread over the provinces of Matebeleland North, Mashonaland West and Mashonaland Central (Map 2.1). Population density is low and settlements are sparsely distributed, except for the eastern parts of Mount Darwin and Rushinga where density ranges between 15.9 and 24.1 persons per square kilometer.

Spontaneous migration into the Valley by groups living on the relatively densely populated plateau is expected to increase as more land becomes available due to the current programme to eradicate the tsetse fly. The population in the valley is predominantly rural. There are only four urban centres with populations that exceed 2500, i.e. Hwange (population 39 202), Victoria Falls (8114), Kamativi Mine (4947) and Kariba (12 387) (source: 1982 Census).

Map 2.1. The natural regions of Zimbabwe (I-V): most of the Zambezi Valley (shaded) falls within regions IV and V which are characterized by low and unreliable rainfall.



Four ethnic groups in the Valley are the Ndebele that live in Lupane and parts of Hwange districts, the Kalnga in Hwange, the Tonga in Binga and Western parts of Nyaminyami and a variety of sub-ethnic Shona groups that live in parts of the north-eastern plateau region. Location and occupational differences among the different ethnic groups may influence the patterns of schistosomiasis and malaria infection.

The Tonga live in predominantly stable malaria areas in the Valley and are likely to have developed some immunity against the parasite. They are mainly fishermen, an occupation which puts them at great risk of contacting schistosomiasis. The Shona, on the other hand, are mainly agriculturalists who live on the highveld plateau where transmission of schistosomiasis and malaria are markedly seasonal (Chandiwana and Christensen, 1988; Taylor and Mutambu, 1986). If non-immune migrants on the plateau who are not on prophylactic protection enter the malarious areas in the Valley, exposure is likely to have catastrophic consequences.

The climate of the Valley is hot and dry and soils are fragile and infertile. Rainfall is low (approximately 450 mm per annum) and unevenly distributed during the rainy season (November-March). The Zambezi River Basin (including Lake Kariba and associated tributaries) has some potential for irrigated agriculture to supplement the inadequate rainfall and to overcome periodic droughts. This would extend the range of crops from the recommended rainfed crops such as cotton, sorghum, millet and maize to irrigated crops that include wheat, sugarcane, coffee, tea and citrus. As will be discussed below, irrigation may introduce or extend the problem of schistosomiasis and malaria.

The problem of schistosomiasis and malaria

Schistosomiasis and malaria are the most important vector-borne diseases affecting the Valley population. If irrigation is introduced in the Valley, increased transmission of the two diseases is bound to take place. This is because these diseases are transmitted by snails and mosquitoes whose populations tend to flourish under prolonged and wet conditions created by irrigation schemes.

Other vector-borne diseases found in the Valley, trypanosomiasis, filariasis and plague are considered to be of minor public health significance (see Roberts *et al.* 1971; Mackenzie and Boyt 1974; Taylor *et al.* 1981). Nevertheless, trypanosomiasis could become a serious health problem once more, would the resettled areas be re-invaded by the tsetse fly in future.

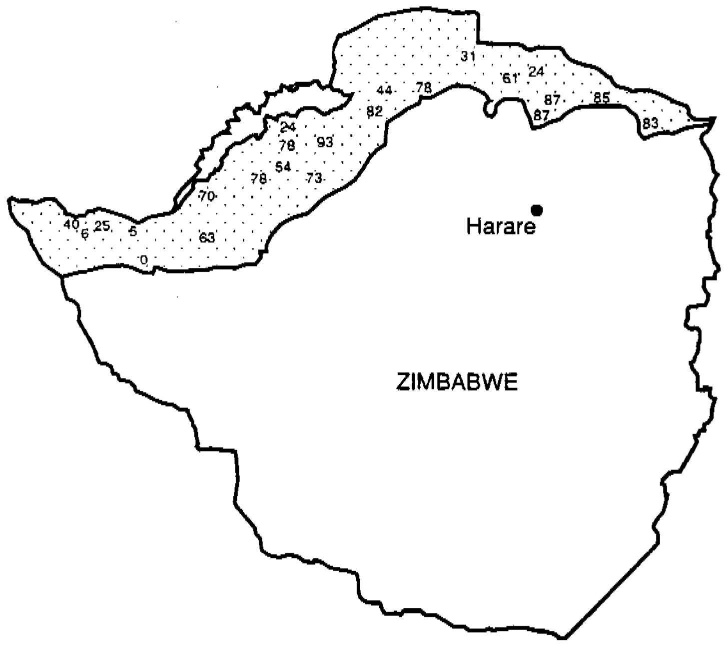
In contrast to most areas of Zimbabwe, high prevalences of hookworm infection have been reported in the Zambezi Valley (Chandiwana 1987). Available information on the prevalence of this infection in the Valley is, however, patchy. There is need to update information on its distribution and prevalence in the Valley so that priorities for control can be set proportionate to the extent of the problem.

Spatial distribution pattern of schistosomiasis and malaria

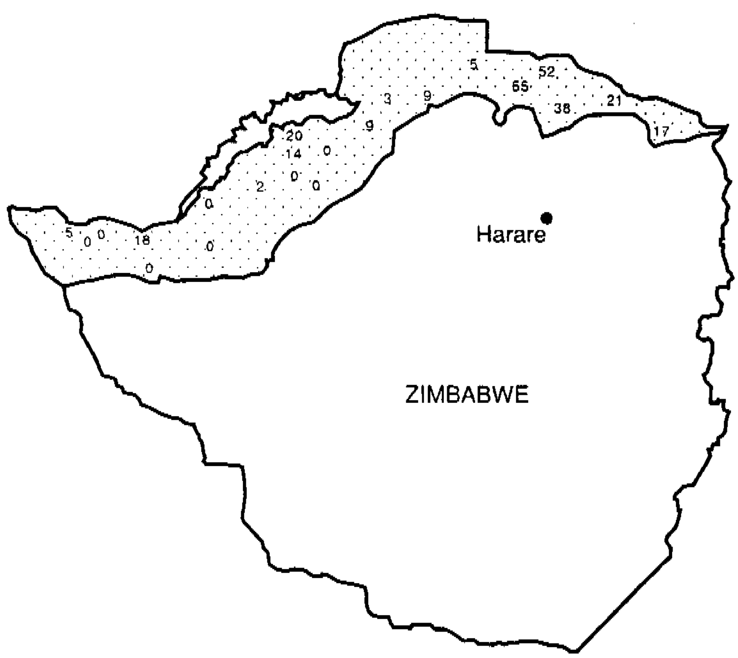
Schistosomiasis

The distribution and prevalences of urinary schistosomiasis (caused by *Schistosoma haematobium*) and that of intestinal schistosomiasis (*Schistosoma mansoni*) in the Zambezi Valley are shown in Maps 2.2 and 2.3. A comprehensive national survey carried out in 1981-1982 by the Blair Research Laboratory showed marked heterogeneity in prevalence by locality; clear-cut regional variations in prevalence were not observed. Nevertheless, the prevalence data for the Valley shown in Maps 2.2 and

Map 2.2. The percentage of 8-10 year old children infected with *Schistosoma haematobium*, based on sampling of every school in the Zambezi Valley. The prevalence figure is shown overlying the geographic location of each school.



Map 2.3. The percentage of 8-10 year old children infected with *Schistosoma mansoni*, based on sampling of every school in the Zambezi Valley. The prevalence figure is shown overlying the geographic location of each school.



(Adapted from Ann. Trop. Med. Parasit. 1985: 79, page 289)

2.3 suggest that the availability of surface water, as primarily determined by rainfall and soil type, in combination with prevailing temperatures, are the major factors governing the distribution and prevalence of schistosomiasis.

High prevalences in isolated foci may be associated with villages located near a dam or river where increased amount of activities requiring water contact are likely to take place. It should be borne in mind that the low prevalences in some areas of the Valley represent areas which, apart from being unsuitable for colonization by snail intermediate hosts, are also unsuitable for human settlement due to aridity and poor soils as well as the problem of tsetse infestation. This reduces their significance in absolute terms on the overall picture of schistosomiasis in the Valley. It is clear that activities which increase the amount of surface water such as water impoundment and irrigation schemes not only almost certainly increase the risk of schistosomiasis but also attract larger human populations.

The results of the national survey clearly show that *Schistosoma haematobium* is the main cause of infection in the Valley, whereas *S. mansoni* is mostly confined to the north-east plateau and is largely absent in the dry western region of the Valley (Maps 2.2 and 2.3). This reflects the greater adaptability to the biologically unstable freshwater environments of *Bulinus globosus*, the snail host for *S. haematobium*, in comparison with *Biomphalaria pfeifferi*, the snail host for *S. mansoni* (Chandiwana and Christensen 1988).

The typical pattern of distribution of schistosomiasis by age in an endemic area is that prevalence increases to a peak usually in children and young adults, and then decreases with advancing age. The decline in adulthood is attributed to acquired resistance. This is exemplified by *S. haematobium* data from two communal areas on the highveld plateau where prevalence and intensity of infection peaked in the 7-20 year age group, which is also the age group with the highest potential of contamination the fresh water habitat with *S. haematobium* eggs (Figure 2.1). In parallel with the overall distribution of infection, the prevalence of heavy infection (> 200 eggs/10 ml of urine) in the younger age groups exceeded markedly that in the older age groups.

Overall, the distribution of the *S. haematobium* infection was overdispersed with most individuals harbouring relatively light infections. Thus, 73.6% harboured light infections (< 200 eggs/10 ml urine), 26.4% harboured heavy infections (200 < x < 1200 eggs/10 ml) and 4.7% harboured very heavy infections (>1200 eggs/10 ml) (Chandiwana and Christensen 1988). From these findings it appears a limited proportion of the population is responsible for a significant contribution to the total contamination of the freshwater environment with schistosome eggs.

Malaria

Plasmodium falciparum is the predominant parasite species causing malaria in Zimbabwe. It reaches hyperendemic proportions in the low lying areas of the Zambezi Valley with an incidence of over 400 cases per 100 000 population and a high prevalence of 30.5% (Taylor and Mutambu 1986). This contrasts sharply with hypoendemic areas on the central plateau where malaria incidence is negligible and prevalence is very low (about 1%) or absent. The other species of malaria reported in the Valley, *Plasmodium malariae* and *Plasmodium ovale* occur at low prevalence levels and as yet they do not appear to constitute a major public health problem.

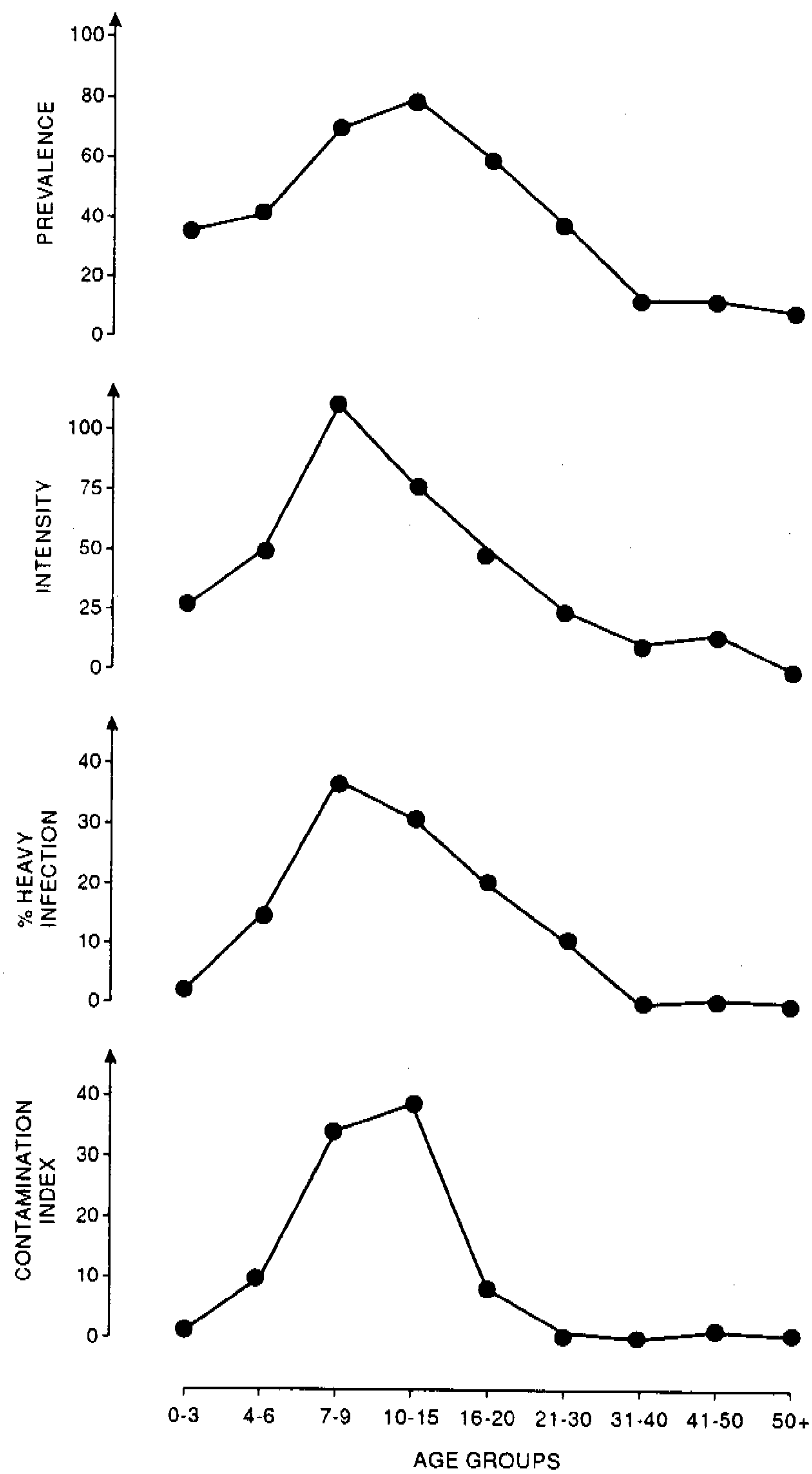


Figure 2.1. Prevalence (%), geometric mean intensity of infection (eggs per 10 ml of urine), frequency (%) of heavy infection (>200 eggs per 10 ml) and relative index of potential contamination (%) in *Schistosoma haematobium* infections in different age groups in two communal areas on the highveld plateau of Zimbabwe (combined data) (redrawn from *Trop. Med. Parasit. 1988: 39,* page 189).

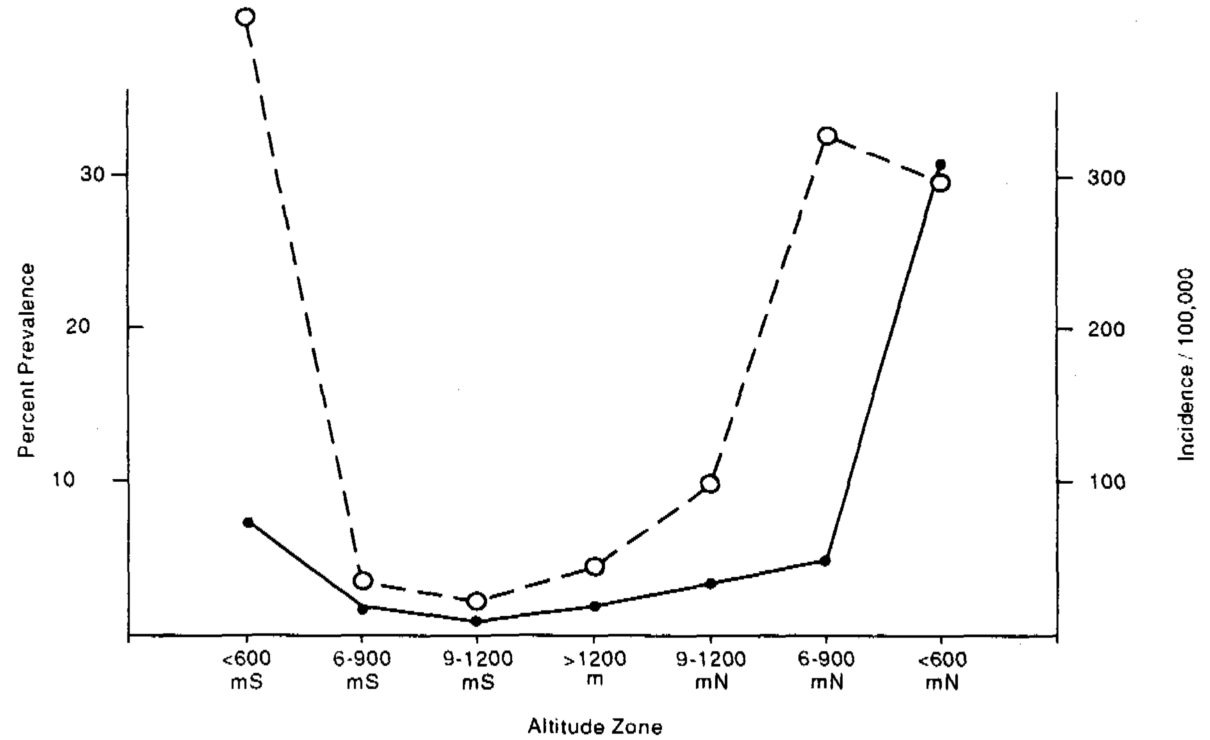


Figure 2.2. Average annual incidence/100 000 population (open circles, dashed lines) of malaria by altitude zone in Zimbabwe for the years 1972-1981. Average prevalence of malaria (closed circles) by altitude zone in Zimbabwe during the period 1969-1981. (Redrawn from *Trans. Roy. Soc. Trop. Med. Hyg. 1986: 80,* page 13).

Malaria in the Zambezi Valley may be described as hyperendemic and stable as it corresponds to the area to the north of the central watershed that is below 600 m above sea level (Figure 2.2). With the exception of the central highveld and some areas below 600 m where there is no transmission, in other altitude zones, malaria is meso-endemic and unstable resulting in periodic epidemics (Figure 2.2). In hyperendemic areas, prevalence of *P. falciparum* reaches a peak in the 5 to 9 year age group, a pattern which has not been demonstrated in areas of unstable malaria (Taylor and Mutambu 1986). Thus, endemicity of malaria is markedly influenced by altitude varying from hyperendemic in the low altitude areas such as the Zambezi Valley to hypoendemic or absent on the central watershed.

Vector mosquitoes that transmit malaria belong to the *Anopheles gambiae* species complex of which three, *A. gambiae, A. arabiensis* and *A. quadriannulatus* are found in Zimbabwe. *A. arabiensis* is the major vector of malaria and year-round breeding takes place in the low altitude Zambezi Valley. Nevertheless, in low altitude areas, malaria transmission decreases after the rains due to a reduction in vector population density and vector longevity brought about by a reduction in breeding sites and low humidity.

Developments taking place in the Valley, particularly the tsetse eradication programme, will open up land for potential resettlement by groups coming from hypoendemic areas of the country. In the Valley, malaria transmission is high enough to maintain a high prevalence of malaria and presumably a high frequency of acquired immunity in the indigenous population. Non-immune immigrants, however, have no such protection and serious epidemics may arise unless proper protective measures are taken before their entering into the area.

The situation in the Valley is compounded by the recent demonstration of chloroquine-resistant *P. falciparum* malaria (Mutambu *et al.* 1986). In view of cross-border movements, the authors suggested that the chloroquine-resistant malaria may have originated from neighbouring Zambia where resistant parasites were isolated earlier.

Nevertheless, the extent of the problem of drug resistant malaria in the Valley is not well known due to lack of comprehensive and critical surveys to determine the changing pattern of sensitivity of *P. falciparum* to chloroquine. With the recent case of concurrent chloroquine- and Fansidar^{R}-resistant *P. falciparum* malaria imported into Zimbabwe (Dallas *et al.* 1986) health workers should maintain proper records to facilitate surveillance of this potentially more dangerous type of drug resistance.

Pattern of temporal variation in transmission

Schistosomiasis

Climatic conditions, primarily rainfall and temperature, influence human water contact patterns, the snail host population density and the rate of the intramolluscan schistosome development. Through these mechanisms they affect markedly the transmission of schistosomiasis from year to year and fromseason to season.

On the highveld plateau, the level of transmission of *S. haematobium* is high during the hot dry season (September-November), markedly reduced during the cool dry season (June-August) and variable but occasionally intensive during the warm post-rainy (March-May) and the rainy (December-February) seasons (Chandiwana and Christensen 1988). The transmission of *S. mansoni* appears less well defined although the warm, post-rainy season appears to be rather important (Chandiwana and Christensen 1988). Incidence studies on the highveld also showed year to year variations in transmission of both species of schistosomes.

In the Zambezi Valley, overall warm conditions suggest that temperature has less influence on seasonal variations in transmission. In contrast, rainfall is markedly seasonal and rivers flow for only 4-5 months of the year and are dry for most of the year. Such drastic changes in water level and water availability have a dramatic influence on densities of snail populations and in the pattern of human water contact, and thus cause marked differences in transmission between the dry and wet seasons.

Malaria

Rainfall and temperature markedly affect the transmission of malaria which appears to be related to the bionomics of the vector mosquitoes. Mosquito breeding sites are adversely affected by flooding and drought; vector longevity by low humidity. Peak numbers of mosquitoes occur towards the end of the rainy season. Thus, most malaria transmission occurs from February to May each year. There is little evidence for transmission occurring during the cool dry season (June-August) and the hot dry season (September-November). With annual variations in rainfall, transmission may occur with the onset of rains in November, or even October.

In spite of the fact that in the Zambezi Valley warm conditions prevail throughout the year, transmission tends to be seasonal. In the dry summer months the transmission potential is reduced due to low humidity and scarcity of breeding sites. Nevertheless, for some time in the dry season, transmission may continue at a low level due to vector mosquitoes that persist by taking advantage of pools left by major rivers before they dry up.

Strategies for controlling vector-borne diseases in the Valley

The preceding paragraphs have highlighted the health risks (particularly schistosomiasis and malaria) associated with developing the Zambezi Valley. The question now is what steps should national authorities and external support agencies take to minimize the increased health risks associated with such development. At the national level this calls for greater cooperation and coordination between the various government agencies which will be involved in the implementation of the various projects (horizontally between the relevant public sectors, i.e. health, agriculture, irrigation, extension, water and natural resources; vertically, between the different administrative levels of government) in order to minimize the negative aspects of development and, in fact, use opportunities to promote human health in the context of development to their maximum benefit.

Specifically, three main areas need further consideration:

Policy debate and project implementation

Before major development programmes in the Valley are initiated, policy-makers and planners should be made aware of the health risks associated with developing the region. Control of vector-borne diseases such as schistosomiasis and malaria presents a major technical and social challenge to irrigation engineers, hydrologists, agricultural and social scientists as well as health professionals. Therefore, workers from the various disciplines need to cooperate and collaborate in the planning, implementing and operational aspects of the different development projects.

At the implementation level, there is need to formulate practical, cost-effective and sustainable control measures and strategies for reducing the increased risk of schistosomiasis and malaria in the Valley. The resource base of the project area is limited and therefore to be sustainable, control approaches need to make use of low-cost and preferably locally-developed health technologies and methodologies. This choice is made with the realization that constraints on financial and manpower resources make most alternatives unrealistic.

Health education and training

Health education can be used effectively to modify human behaviour with a view to reducing exposure to infection. Thus residents of the project area should be made aware of the occupational and environmental hazards associated with vector-borne diseases. This is particularly important in new settlements, especially irrigation schemes where farmers and their families are likely to be less knowledgeable of the problem of vector-borne diseases.

It is also essential that workers involved in developments in the Valley understand how vector-borne diseases are transmitted and the conditions under which the vectors that transmit the diseases flourish and how they can be controlled. This will require training and education regarding both diseases and their vectors, and discussion on how aspects of the engineering, agricultural development and agricultural practices could be incorporated in control programmes. Thus education and training should be directed to cadres from various disciplines involved in the implementation and operation, ranging from those who plan and design, for example, the irrigation schemes to those who operate and maintain them. Once schemes are operational there is ample scope to involve agricultural extension workers in the dissemination of environmental management oriented health messages.

Research and control

While the health risks associated with development due to ecological changes in the environment are being increasingly recognized, much needs to be done by way of research and control projects to demonstrate the health and economic benefits that accrue from interventions.

An example of such projects can be found in the small holder irrigation schemes at Mushandike in south-east Zimbabwe, where researchers have been investigating the extent to which engineering and environmental measures may be applied to control the transmission of schistosomiasis (see Chandiwana *et al.* 1988). In this project attempts were made to reduce the population densities of the snail hosts by careful design of the hydraulic structures in the canal system as well as the operation of the irrigation works. Environmental measures included efforts to reduce human exposure to infection and was primarily done through siting villages as far as possible from the irrigation canals and night storage dams, by providing latrines in the fields and safe water sources for domestic purposes.

Because of its vastness and the far-reaching development projects planned for the Zambezi Valley, control of schistosomiasis is likely to be more complex. The basic principles for controlling schistosomiasis that have been the subject of studies at Mushandike will, nevertheless, apply. In addition to a mainstay of engineering, environmental and educational measures, chemical and biological control provide a means of control that eliminates or at least reduces the densities of the snails hosts responsible for transmitting the disease in persistent foci. Snail control using the only available synthetic molluscicide, Bayluscide[R], may not be cost-effective, certainly not on a sustained basis. Therefore, great hope is placed on the potential application of *Phytolacca dodecandra,* an indigenous plant molluscicide that is widely distributed in Zimbabwe and can be used for snail control on a community self-help basis.

Since independence, the national malaria control programme that involves indoor application of an insecticide (DDT and more recently, Deltamethrin) has been extended to include areas of stable malaria and a more frequent spraying cycle has been introduced (see Taylor and Mutambu 1986).

One consequence of this spraying program is that the Zambezi Valley is increasingly becoming an area of unstable malaria and therefore prone to epidemics. The situation could be aggravated by the increase in population due to immigration into the Valley and the growing problem of drug resistant strains of malaria. Social mobilization of the people as well as intensive health education is required to ensure that proper doses of antimalarials are taken and keep the development of single or multiple drug-resistance at bay.

Serious consideration should be given to strengthen and intensify the mosquito control programme in the Valley so as to reduce the incidence of epidemics. Mosquito control through the use of insecticides should be directed and monitored by competent health personnel to prevent the problems of pesticide resistance and ensure safe application of pesticides.

Options to reduce health risks in developing the Zambezi River Basin

- Governments should formulate and adopt policies, strategies and programmes to support and strengthen public health authorities in their efforts to effectively control the incidence of vector-borne diseases in the basin

  Special attention should be paid to immigrants resettling in the areas where the tsetse fly has been eradicated. Some of these immigrants may introduce drug resistant strains of malaria while others who are non-immune are at great risk of developing severe malaria;

- Governments should formulate appropriate policies to facilitate better coordination and cooperation between professionals with different disciplinary backgrounds (irrigation engineers, agricultural scientists, health professionals etc.) fostering an integrated planning and implementation of development projects in the basin, which minimizes the risk of negative environment and health impacts;

- Public health authorities should launch an intensive health education program directed at those at risk, primarily the local population, so that they adopt behaviour types which reduce exposure to infection. Planners of the various development projects should be made aware of the possible health hazards e.g. the risk of schistosomiasis associated with irrigation development;

- Planners of development projects should also be urged to incorporate at the design stage steps (i.e. the physical infrastructure, operation and maintenance procedures) to control the transmission of the vector-borne diseases;

- Research and demonstration activities should be conducted in the context of the project to assess the effectiveness of environmental management measures and to provide policy makers and health planners with information to compare the benefits of prevention and control in terms of reduced incidence of disease with estimates of likely economic and social consequences of not having a control programme.

INSTITUTIONAL ARRANGEMENTS FOR ENVIRONMENTAL MANAGEMENT

International: The Zambezi Action Plan

A a first activity following the launching of UNEP's programme on Environmentally Sound Management of Inland Water (EMINWA, aimed to assist governments with the integration of environmental concerns into the management of water resources) was to assist the governments of the Zambesi River Basin countries in the development of the Zambezi Action Plan. The Agreement of the Action Plan for the Environmentally Sound Management of the Common Zambezi River System (ZACPLAN; Annex 3) was signed in Harare on 28 May 1987 by the representatives of the riparian countries.

The Zambezi Action Plan is based on the findings of a diagnostic study on the state of the ecology and the environmental management of the Common Zambezi River System (UNEP, 1987b). The problems identified in this diagnostic study resulted in the formulation of 19 projects or ZACPROs. Annex 4 gives an overview of ZACPROs 1-19.

Major constraints identified in the diagnostic study were the lack of information on resources and resource utilization. It was also clear that countries needed enabling legislation and an agreement that would allow them to manage the Zambezi River System as a common resource. UNEP therefore decided to fund ZACPROs 1, 2 and 5. This would provide an inventory of completed and ongoing project (ZACPRO 1), a protocol enabling legislation (ZACPRO 2) and a water monitoring system for the Zambezi (ZACPRO 5). The total amount for the three projects is US$ 335,000.

UNEP considered ZACPROs 1, 2 and 5 as 'catalytic projects'. Their successful completion was expected to attract donors and other agencies into supporting other ZACPROs. The Environment and Land Management Sector (ELMS) of the Southern African Development Community (SADC) is the implementing agency for ZACPROs 1,2 and 5. SADC/ELMS is located in Maseru, Lesotho.

The Follow-up and Evaluation Section of UNEP conducted an evaluation of ZACPROs 1, 2 and 5. The Evaluation Report (August 1993) states that ZACPRO 1 has not achieved most of its objectives. The inventory of projects within the Zambezi system has not been produced. Instead, a computer model for Environmental Impact Assessment has been developed and some training in its use has been achieved.

The UNEP Evaluation reports significant progress on ZACPRO 2, which produced an analysis of national water legislation in SADC countries and a draft protocol on shared water course systems in the SADC region. The PEEM mission was informed by SADC/ELMS in Maseru (January 1994) that the signing of the Protocol by all member States was slightly delayed because of the need of its translation into Portuguese.

ZACPRO 5 produced a report on the Development of a Basin-Wide Unified Environmental Monitoring System Related to Water Quality and Quantity. The UNEP Evaluation Report indicates that while the report was well received, it has not officially been adopted nor has the implementation plan been developed.

The UNEP evaluation report concludes: "*The implementation of these projects have been dogged by poor coordination and lack of flow of information within the SADC ELMS and the member states and between SADC/ELMS and UNEP. Present institutional arrangements within SADC have not been adequate to ensure smooth and effective implementation because the SADC/ELMS Unit has neither the staff nor the capacity to coordinate or supervise the implementation of these projects. While UNEP has put money into these projects, the monitoring and follow up have been inadequate resulting in delays in taking corrective action*".

At the SADC/ELMS Unit in Maseru, the PEEM mission learned that the Unit had recently been strenghtened by the appointment of a liaison officer and a water resources advisor. These posts are funded by the Scandinavian countries, who will also provide the funds to implement the development of an integrated water management plan for the Zambezi basin (ZACPRO 6). The inventory of projects in the Zambezi, which was initially intended to be implemented under ZACPRO 1, is currently being carried out as part of ZACPRO 6.

Bi-Lateral: The Zambezi River Authority

The Zambezi River Authority is a statuary body jointly owned by the states of Zambia and Zimbabwe. It came into being in October 1987, following the reconstitution of its predecessor, the Central African Power Corporation. The main objective of the Authority is to achieve the greatest possible benefit from the efficient utilisation of the waters of the Zambezi River for the production of electric energy and for any other mutually beneficial purpose for the economic , industrial and social development of the two contracting states. The functions of the Authority include:

- operate, monitor and maintain the Kariba complex;
- investigate the desirability of constructing new dams;
- collect and process hydrological and environmental data of the Zambezi river;
- make such recommendations to the Council of Ministers as will ensure effective and efficient use of the waters and other resources of the Zambezi.

A major new project is the proposed Batoka Gorge Hydro-electric Scheme, the size of which is stupendous by any international standards. The proposed dam, 54 km downstream of the Victoria Falls, may become the highest dam in Africa. It would reduce the fast flowing water downstreams of the Victoria Falls to a stagnant water body, thereby eliminating the important 'white water rafting' tourist industry. The feasibility study for the Batoka scheme includes an Environmental Impact Assessment, which has a section on Public Health (September 1993). The analysis and recommendations in this section conform largely with chapter 2 (Environmental health in the Zambezi Basin) of this report. The summary and conclusions of the Public Health section read: "*Much of the future health of the people of the region will depend on the extent to which construction villages and future settlements are adequately planned. Provision for such developments is essential- at the planning stage. It is hopeless to proceed with a major construction and to then expect central and local Government to fill in the gaps at a later stage. Such provisions must include housing (designed to meet local needs), reticulated supplies of adequately treated water, and sanitation and waste disposal. Facilities should be acceptable to residents. Planning should further provide for hospitals and clinics. Preventive health services and health education services will be essential for all the settlements*".

National

Zimbabwe

Environmental policy

Although Zimbabwe has had EIA's carried out for several projects in recent years, there is no policy and procedure in place for requiring, specifying, reviewing, approving and implementing the results of environmental assessments of development proposals.

The Ministry of Environment and Tourism produced a *Prospectus for Environmental Assessment Policy in Zimbabwe* in September 1993. The prospectus has been prepared to provide stakeholders in environment and development an opportunity to participate in the preparation of an environmental assessment policy for Zimbabwe. Part I of the prospectus contains the overall goals, principles, objectives and issues proposed to be addressed in an environmental policy programme. Part II sets out an interim policy proposal for EIA to be applied to development projects, including proposals for prescribed activities and screening guidelines. Subject to public review and input, it is proposed that Part II, or a modified version, be implemented on a two or three year trial basis, as a practical step and capacity-building approach to finalizing a more comprehensive EA policy.

The prescribed activities and screening guidelines are drawn from international experience with EIA and experiences in Zimbabwe. Although some of the screening guidelines could be interpreted as having a bearing on environmental health, they do not specifically mention health.

Water Resources Policy

Zimbabwe does not at the present have a comprehensive strategy for water supply and use. The Department of Water Development, in the Ministry of Lands, Agriculture and Water has been pressing for the development of such a strategy. An increased awareness of the urgency for initiating some action was brought about by the recent drought. On request of the Government of Zimbabwe, the British Overseas Development Authority appointed consultants to prepare the terms of reference for the formulation of a Water Resources Management Strategy. The Draft Terms of Reference were presented in July 1993, together with an Action Plan for the Development and Implementation of a Strategy. An important feature of the draft document is that it insists on utilising local resources to maximum effect and, being based on the active participation of the stakeholders, it will satisfy one of the major requirements for sustainability. While the document does not explicitly mention vector-borne diseases as an area of concern, the list of stakeholders puts the Ministry of Health under the heading of 'Regulators' and Health Workers under 'Advisers and Trainers'.

At the time of the PEEM/DBL Seminar in Harare (27 to 29 November 1993, follow-up to the PEEM/DBL training course), the agencies concerned were engaged in a workshop to reach consensus among the major stakeholders on the proposed Action Plan.

National Action Programme on Water and Sustainable Agricultural Development
On the invitation of the Government of Zimbabwe, a seven member mission, which included two members of the PEEM Secretariat (A. Kandiah and R. Bos), assisted in the preparation of a draft National Action Programme on Water and Sustainable Agricultural Development, in August 1993. Table 9 provides an overview of the 5 sub-programmes formulated by the mission. Details of Project no.5.3 (*Capacity Building for Optimal Use of Health Opportunities in Irrigation Development*) of Sub-programme 5 on *Environmental Protection and Health of Rural Communities* are presented in Annex 5. The outputs of the Action Programme are intended to be used as inputs on irrigation aspects to the Water Resources Management Strategy discussed on the previous page.

Zambia

Environmental policy
At the time of the mission's visit (January 1994), Zambia had no legislation or long-term policy on the environment. At the end of 1991 a new Ministry of the Environment and Natural Resources/MENR was established as an off-shoot of the Ministry of Agriculture. The preparation of a National Environmental Action Plan started in October 1993 and is expected to be completed by March 1994. On behalf of MENR and the National Commission for Development Planning/NCDP, The World Conservation Union/IUCN has developed a proposal for an environmental planning programme for Zambia. This programme supports the establishment of an Environmental Planning Unit in MENR and provides environmental economics expertise in NCDP. The programme includes The Zambezi Wetlands Planning Project, which serves as a pilot project with the Project Planning Unit of one Province, to strenghten environmental planning and management skills at the local government level.

Health Policy
The Ministry of Health launched a programme of health reforms in October 1992. The health reforms were considered necessary due to the following problems:

- A run-down physical health infrastructure;
- Epidemics of cholera, dysentry, malaria, tuberculosis and AIDS;
- Chronic shortage of drugs and medical supplies;
- Run-down plant and hospital facilities;
- Demoralized health workers due to unfavourable working conditions;
- Uncontrolled population growth;
- Unreponsiveness to the prevailing health needs.

The main elements of the new health policy and strategy include:

- Restructuring of the Ministry of Health with a district focus (primary health care approach), which emphasizes community participation;
- Renewed emphasis on manpower development and retention;
- Introduction of health financing with emphasis on community participation;
- Establishments of mechanisms to ensure financial and management accountability.

Table 9. Objectives of sub-programmes for the National Action Programme on Water and Sustainable Development (Zimbabwe).

SUB-PROGRAMMES	OBJECTIVES
Sub-programme 1	
Irrigation policy, strategy, master plan and legislation	a. To formulate a comprehensive national irrigation policy and strategy for Zimbabwe to enable the country to achieve its agricultural production and economic development goals on a sustainable basis.
	b. Under the framework of the policy and in accordance with the strategy to develop a master plan for national irrigation development covering all types of irrigation schemes, in terms of scale, land ownership and management.
	c. To develop a legal and institutional framework for irrigation water users' associations. These will include river basins and irrigation management committees.
Sub-programme 2	
Water resources database, groundwater hydrology and river basin management	a. To establish a computerized surface water resources database, including surface runoff, potential yields, demand, supply and potential for further development. Data will also include information pertaining to dam storages and irrigation water usage.
	b. To study the groundwater potential of the country in a systematic manner with reference to the capacity of selected high potential aquifers, their yields and hydrogeological characteristics.
	c. To develop a methodology and apply such a methodology for an integrated river basin planning approach for irrigation development with particular reference to the Save Basin.
Sub-programme 3	
Irrigation development, research, technology transfer and socio-economic aspects	a. To develop guidelines for the planning, development and management of smallholder irrigation projects, adopting an integrated approach, and apply such guidelines in a smallholder irrigation project from planning to construction and operation.
	b. To improve operation and maintenance of irrigation schemes through the assessment of performance and the introduction of appropriate measures.
	c. To strengthen irrigation research and extension base and technology transfer mechanisms.
	d. To develop a methodology for an integrated economic and social viability assessment of irrigation development and apply the developed methodology in assessing the viability of current and future projects.
Sub-programme 4	
Human resources development and institutional strengthening	a. To strengthen post-graduate training, particularly at MSc level, in irrigation engineering and water management.
	b. To enhance the technical capacity of professionals in the field of irrigation, water resources development and environmental protection.
	c. To strengthen water users' associations, including river boards and irrigation management committees.
Sub-programme 5	
Environmental protection and health of rural communities	a. To strengthen national capacity to monitor water pollution and implement pollution control.
	b. To develop EIA guidelines and application of the guidelines for new and existing projects.
	c. To build national capacity to enable incorporation of health components in irrigation projects.

Source: Kandiah, A. *et al. Country and sub-regional action programmes - Zimbabwe*. International Action Programme on Water and Sustainable Agricultural Development/IAP-WASAD. Draft Report of a Mission to Zimbabwe, 2-22 August 1993. FAO, Rome, 94pp

Mozambique

Environmental policy

A first step towards putting environmental issues on the national agenda was the creation of a National Environment Commission/CNA in June 1992. In October 1993, the CNA organised a workshop on the planning process of developing a National Environment Management Plan. The process is funded by the World Bank with support from UNEP and UNDP and will take place through four phases over the next few years. The process aims to provide a cross-sectoral plan for the management of the environment of Mozambique and the development impacts on the environment after 30 years of war (IUCN 1993).

Health policy

The Ministry of Health has outlined a strategy for post-war reconstruction. The primary objective of the plan is to restore the rural primary health care network to its mid 1980 levels. This would signify coverage rates of between 40 to 60 percent of the population (Nkamany 1994). Over 1993, more than 60 percent of total expenditures in the health sector depended on foreign assistance. This is in sharp contrast with the Government's limited management capacity and affects its ability to shift from emergency action towards rehabilitating and sustaining the health care system.

In spite of these difficulties, the PEEM mission was much impressed by the competence and commitment of the staff of the Department of Hygiene, who are responsible for programmes on Environmental Health. The mission was equally impressed by the quality of the research and publications - especially *Revista Médica de Moçambique* - of the National Health Institute.

HEALTH OPPORTUNITIES IN ZAMBEZI RIVER BASIN DEVELOPMENT

Regional experience

The Mushandike Pilot Project

A Pilot Study initiated in 1984 on the Mushandike Irrigation Project in Zimbabwe provides a regional example of disease vector control in rural water resources development projects through environmental management. The study was a joint effort of the Blair Research Laboratory and the Department of Agricultural, Technical and Extension Services (AGRITEX) in Zimbabwe and the Overseas Development Unit of Hydraulics Research (HR/ODU), Wallingford, UK.

The Mushandike experience was included in a case-study document prepared for the *FAO/UNICEF/UNDP/World Bank/WHO Technical Consultation on Integrated Rural Water Management*, held at FAO, Rome, from 15-19 March 1993 (FAO, 1993). Annex 6 contains the section of this document pertaining to Mushandike.

Zimbabwe training course on health opportunities

PEEM and the Danish Bilharziasis Laboratory/DBL developed a two week training course entitled *Health Opportunities in Water Resources Development*. A first trial course was held in Darwendale, Zimbabwe, from 7 to 18 September 1992, with the Blair Research Institute in Harare as the local counterpart (WHO, 1993).

The 28 course participants were middle level managers from the health, agriculture, water resources and planning sectors of the Government of Zimbabwe, from the country's National Economic Planning Council and from the University of Zimbabwe. The participants were divided over six groups, each of which was multisectoral in composition.

The first week consisted of information transfer and skill development in areas relevant to the incorporation of a health component into the different phases of the project cycle: policy/planning, health impact assessment, design of environmental management measures, economic evaluation of options for interventions and strenghtening health services. In the second week the six groups were given the assignment of doing a health opportunity assessment of a proposed irrigation scheme (Mupfure project).

At the end of the course, the participants got an appreciation for how development policies may fundamentally affect human health. It became clear that planning policies in Zimbabwe can be improved to ensure that environmental concerns are developed early in the development of water resources and human health issues are dealt with adequately. This awareness led to the participation of the WHO and FAO members of the PEEM Secretariat in the mission that formulated the Zimbabwe National Action Programme on Water and Sustainable Development (see page 35/ annex 5).

The Health Impact programme of the Liverpool School of Tropical Medicine, the Blair Research Institute and DBL jointly carried out an in-depth health risk appraisal of the planned Mupfure Irrigation Scheme, which was the subject of the second week assignment of the course. The material collected provides a case study that can be used in future courses. In this manner, course material developed in Zimbawe can be used for training of professionals in other countries in southern Africa (Konradsen, 1994).

Health opportunities

Zambezi Action Plan Project 14

The agreement on the Zambezi Action Plan specified 19 projects or ZACPROs, of which ZACPRO 14 specifically addresses prevention and control of water related and water-borne diseases (Table 10).

Table 10. Zambezi Action Plan Project/ZACPRO 14

	Prevention and control of water related and water-borne diseases in the Zambezi Basin. The health projects should be implemented in close cooperation with the World Health Organization and local health institutions.
14.1	Evaluation and information on the prevalence of water related and water-borne diseases in the Zambezi River Basin.
14.2	Guidelines on health protection measures in the planning, design, construction and operational phases of water projects in the Zambezi River Basin.
14.3	Guidelines on the prevention and control of water related and water-borne diseases in the Zambezi River Basin.
14.4	Seminar on prevention of water related and water-borne diseases in the Zambezi River Basin and promotion of training of technical personnel involved in water projects as a follow-up to this seminar.
14.5	Promotion of community awareness of prevention and control of water related and water-borne diseases in the Zambezi River Basin utilizing mass media and community level education.
14.6	Pilot project on the control of water related and water-borne diseases in the Zambezi River Basin.

In spite of considerable delays in the implementation of various other ZACPROs (refer to pages 33 and 34), it is important to bear in mind that the Governments of the riparian states have made the commitment to *'take all appropriate measures for the expeditious and effective implementation of the Zambezi Action Plan'* (Agreement on the Action Plan for the Environmentally Sound Management of the Common Zambezi River System, Final Act, Harare, 26-28 May 1987, Article 1, section 5).

The development of an integrated water management plan (ZACPRO 6) which will be undertaken by SADC/ELMS provides an opportunity to include obtaining and evaluation of information on the prevalence of water-related and water-borne diseases (ZACPRO 14.1). PEEM could advise SADC/ELMS how to obtain and process this information. Subsequently, the PEEM guidelines could be used in producing the guidelines specified under ZACPRO 14.2 and 14.3.

On the basis of these guidelines and the experience obtained with the training course on *Health Opportunities in Water Resources Development* (Zimbabwe, September 1992, see page 39) PEEM, together with the Blair Reserach Institute as its regional collaborating counterpart, would be in an excellent position to help organizing the seminar specified under ZACPRO 14.4.

Zimbabwe

With respect to experience with environmental management for vector control, it is quite clear that Zimbabwe is ahead of the other countries in the region. This allows Zimbabwe to play a lead role in disseminating knowledge on environmental management in the region. At the same time, there appears to be some reluctance - especially among high ranking officials and policy-makers - to spend the nation's scarce resources on environmental issues, because this does not produce immediate economic benefits. The following exerpt from PEEM News (No.1, June 1993) illustrates these reservations:

> *From: PEEM News number 1, June 1993*
>
> Minister Stamps agrees to planned follow-up
>
> In an informal meeting with the PEEM Secretary during the 46th World Health Assembly in May of this year, Dr Timothy Stamps, Minister of Health and Child Welfare of Zimbabwe, acknowledged the need for a follow-up to the Darwendale course. He warned, however, that in these times of economic transition enthusiasm was waning for the incorporation of environmental and health safeguards into development projects if this implied greater investments with the same economic returns. Any attempt to promote policy change that would bring health promotion into the budgetary realm of other public sectors would require a good deal of basic advocacy in order to be accepted.

The PEEM Zambezi mission occasionally encountered the same type of initial reluctance, and not only in Zimbabwe. In such encounters, the mission was fortunate to have PEEM documentation readily at hand which emphasizes the Health *Opportunities*, rather than the term Environmental *Impacts* which appears to be interpreted often as negative impacts only.

The authors prefer to consider the above reluctance as a challenge and an opportunity to prove that environmental management is a worthwhile investment. Zimbabwe offers excellent opportunities for conducting research on irrigation technologies that improve water use efficiency and therefore have a potential to reduce vector breeding. Due to extreme drought experienced in 1991/2, there is considerable awareness of the need to improve water use efficiency. The analysis of water constraints on pages 7 and 8 also shows the extent and urgency of this need.

With some 90 percent of irrigated crops grown on commercial farms, Zimbabwe has considerable experience in making irrigation cost-effective, while the Blair Research Institute has the capacity to investigate the effects of improved irrigation efficiency on vectors and on transmission of diseases.

Zambia

In addition to the activities related to ZACPRO 14, there are two other programmes in Zambia which represent opportunities for incorporation - or strenghtening -of a health component.

One is a Community Based Survival and Development Programme in Luapula, which has adopted an intersectoral approach for achieving multiple objectives, such as:

- building the capacity at district and provincial level in planning and implementation of participatory development;
- supporting the development of an efficient Health Care System at health community level;
- building capacity at community level to plan and implement nutrition relevant actions;
- providing community members safe and adequate water by constructing and rehabilitating shallow wells;
- strenghtening district level capacity to plan and implement rural water supplies.

The programme is a joint effort of the Ministry and Departments of Health, Agriculture, Public Works and various NGO's at the national, provincial and local level, and is supported by UNICEF and WHO. This programme has a pilot function in implementing the new health policy. It seems important, therefore, to ensure that those involved in the programme are aware of the potential for environmental management for vector control.

Another important programme is the proposed Upper Zambezi Wetlands Resource Planning Project. This is an initiative of the National Environmental Council of Zambia and the World Conservation Union/IUCN. This project is intended to promote the wise use of the Zambezi wetlands and the surrounding natural resources with which they are functionally linked. The project will be implemented through existing institutions in four Districts of Western Province and at Provincial level. Key issues listed in the project proposal include:

- consultation with resource users;
- development of biodiversity and natural resources data base;
- development of 'wise use' criteria;
- establishment of pilot 'wise use' projects;
- develop planning guidelines;
- institutional support;
- development of an environmental monitoring, reporting and evaluation system;
- development of an environmental component in the Provincial Development Plan;
- training in EIA and wetland management.

At present, the proposed programme does not explicitly mention environmental management for vector control. During discussions with Mrs. Tabeth M. Chiuta (Wetlands Programme Co-ordinator) at the IUCN Regional Office for southern Africa, it appeared that there was considerable interest and scope to include this aspect. In this respect it is relevant to recall the conclusions of Dr Martin Birley's testing in Zambia of the Guidelines for *Forecasting the vector-borne disease implications of water resources development*. Dr Birley found that while most irrigation projects in Zambia seem to have a relatively low risk as regards malaria and schistosomiasis, the construction of polders and subsequent rice-cultivation in swamp-lands and wetlands represents a considerable risk (Euroconsult 1987).

REFERENCES

Chandiwana, S.K. 1987. Epidemiology and control of intestinal helminthiasis. *Proceedings of the Seminar on Helminthiasis Control in Burma Valley, Zimbabwe.* 111 pp.

Chandiwana, S.K. and Christensen, N.O. 1988. Analysis of the dynamics of transmission of human schistosomiasis in the highveld region of Zimbabwe. A review. *Trop Med Parasit 39*: 187-193.

Chandiwana, S.K., Taylor, P., Chimbari, M. *et al.* 1988. Control of schistosomiasis in newly established small holder irrigation schemes. *Trans Roy Soc Trop Med Hyg 82*: 1-14.

Dallas, A.B.C., Okwanga, P.N., Mutambu, S.L. *et al.* 1986. Concurrent chloroquine- and Fansidar-resistant *Plasmodium falciparum*: an imported case into Zimbabwe. *J Trop Med Hyg 89*: 265-268.

Euroconsult, Delft Hydraulics Laboratory and Royal Tropical Institute, 1987. *Study on Options and Investment Priorities in Irrigation Development*. Country Report, Zambia. Annex E: Health. 14pp.

FAO, 1982. *Potential population supporting capacities of lands in the developing world.* Food and Agriculture Organization of the United Nations, Rome.

FAO, 1986. Consultation on irrigation in Africa. *Irrigation and Drainage Paper no. 42*. Food and Agriculture Organization of the United Nations, Rome.

IUCN, 1993. *Southern Africa Environment Update.* Regional Office for Southern Africa, Harare, Zimbabwe. 16pp.

Korzoun, V.I. *et al.*, 1978. World Water Balance and Water Resources of the Earth. *Unesco Studies and Report on Hydrology No. 25.* 663 pp. Unesco, Paris.

Machena, C. Dam development and their environmental effect: The Kariba experience. p.27-42 in: Matiza,T. and H.N.Chabwela (Eds), 1992. *Wetlands Conservation Conference for Southern Africa.* Proceedings of the SADC wetlands conference held in Gabarone, Botswana, 3-5 June 1991. International Union for Conservation of Nature and Natural Resources/IUCN, Gland, Switzerland. x+224 pp.

Mackenzie, P.K.I. and Boyt, W.P. 1974. The epidemiology of human trypanosomiasis in Rhodesia. *Cent Afr J Med 17*: 101-102.

Mutambu, S.L., Dallas, A.B.C. and Olweny, C.L. 1986. Chloroquine-resistant *Plasmodium falciparum* malaria in Zimbabwe. *Br. Med J* 292: 522.

Nkamany, K. 1994. *Current Status of Health Services in Mozambique.* Document to be presented at the WHO/AFRO Regional Programme Meeting in Yaounde Cameroon, from 16-19 February 1994. World Health Organization, Mozambique. 34pp, World Health organization Regional Office for Africa, Brazzaville.

Republic of Zambia. Ministry of Health, 1992. *National Health Policies and Strategies.* Lusaka, 89pp.

Roberts, C.J., Mckeag, A. and Gelfand, M. 1971. *A perstans* and *W. bancrofti.* A filarial survey in a game reserve in the Zambezi Valley. *Cent Afr J Med 17*: 101-102.

Taylor, P. and Makura, O. 1985. Prevalence and distribution of schistosomiasis in Zimbabwe. *Ann Trop Med Parasit 79*: 287-299.

Taylor, P. and Mutambu, S.L. 1986. A review of the malaria situation in Zimbabwe with special reference to the period 1972-1981. *Trans Roy Soc Trop Med Hyg 80*: 12-19.

Taylor, P., Gordon, D.H. and Isaacson, M. 1981. The status of plague in Zimbabwe. *Ann Trop Med Parasit 75*: 165-173.

UNEP, 1987a. *Agreement on the Action Plan for the Environmentally Sound Management of the Common Zambezi River System.* Final Act. Harare, 26-28 May 1987. 24pp.

UNEP, 1987b. Diagnostic Study on the Present State of Ecology and the Environmental Management of the Common Zambezi River System. EMINWA Programme. *UNEP/ IG.78/Backgound Paper 1.* 101 pp.

World Bank/UNDP. *Sub-Saharan Africa Hydrological Assessment,* Regional Report SADC Countries, December 1990.

World Bank, 1993. *World Development Report, Investing in Health.* Published for the World Bank by Oxford University Press, Inc. New York. 329pp.

World Health Organization, 1988. Report of the eighth meeting of the joint WHO/ FAO/UNEP Panel of Experts on Environmental Management for Vector Control (PEEM). *Document VBC/88.4,* PEEM Secretariat, WHO, Geneva.

World Health Organization, 1993. *Health opportunities in water resources development.* Report of a training course in Zimbabwe (Darwendale, 7-18 September 1992). PEEM Secretariat, document WHO/CWS/93.2, WHO, Geneva.

Zimbabwe, 1993. *Prospectus for Environmental Assessment Policy in Zimbabwe.* Public Background and Discussion Paper. Ministry of Environment and Tourism. 21 pp.

Annex 1

PEEM REVIEW OF THE ZAMBEZI ACTION PLAN
(Nairobi, 1988)

At the eighth PEEM Meeting the Panel was asked by the Executive Director of UNEP to review the Zambezi Action Plan, to comment on issues of relevance to the Panel's mandate and to formulate recommendations on how the expertise of the Panel could be applied in support of the Action Plan's implementation.

The Panel welcomes the practical proposals contained in the Zambezi Action Plan, based in part on Resolution 1/1 of the first session of the African Ministerial Conference on the Environment (Cairo Programme for African Cooperation) and offers its expertise and capabilities to assist in the implementation of those components of the Plan that concern the Panel's field activities.

The Panel especially welcomes the mention of specific health-related project within the Action Plan, but notes the absence of any reference to expected migration patterns and their effect on vector-borne disease distribution or to the need to establish a uniform monitoring system for vector-borne disease implications of water resources development.

In particular, the Panel can offer the expertise of its members and its collaborating centres in:

Category I projects:

With respect to ZACPRO 3 and 4	Reviewing survey results on national capabilities in terms of vector-borne disease control, and assisting in institutional strengthening through training and by establishing links with PEEM collaborating centres.

Category II projects

With respect to ZACPRO 13	Reviewing the proposed water management guidelines before their finalization to assess whether vector-borne disease implications have been given sufficient consideration and recommending modifications to the guidelines if necessary.
With respect to ZACPRO 14 and 16	Providing guidance and expertise to support activities for the prevention and control of water-related vector-borne diseases such as organizing regional seminars and training to promote proper institutional arrangements for smooth intersectoral collaboration in all the countries involved.

In addition the Panel prpposes to investigate the possibility of designating a PEEM collaborating centre in the project area.

In view of the potential importance of the Zambezi Action Plan agreement, the Panel wishes to have more detailed information on the operational status of the relevant components of the plan, to be kept informed of the progress of the plan and to be provided with copies of the diagnostic study for purposes of review and further orientation of the Panel.

If the countries of the Zambezi Action Plan so require and provided fundsa are made available, the Panel iswilling to send a consultant and, subsequently, a multidisciplinary group to assist with the relevant aspects of the implementation of the plan. In particular, the Panel might be able to assist in four specific "suggested actions":

- Assessment of water-borne and other water related diseases an their effects on human health (Section C, Environmental assessment, paragraph 28 (1))
- Environmentally sound development of water resources ... (Section D, Environmental management, paragraph 29 (f))
- Integration of environmental managemetn components in decision-making on water and water-related projects (Section D, Environmental management, paragraph 29 (i))
- Intensive training courses should be formulated (Section F, Supporting measures, paragraph 36)

Clearly, if sustained action in the field were supported, the Panel could assist with both the planning of projects and the provision of short multidisciplinary training courses, in close collaboration with national institutions in the Zambezi Basin.

= = =

Annex 2

Current and future water use in the riparian countries of the Zambezi Basin
Summary country reports.

(Information extracted from draft proceedings of a workshop on the development of an integrated water resources management plan for the Zambezi River Basin, held at Livingstone, Zambia from 2 to 6 May 1994)

4.1 Angola

4.1.1 Country Report Summary

Summary of a report presented by J.L. Casinda

In Angola the Zambezi river basin is located in the province of Moxico between latitudes 11° and 13°s and longitudes 22° and 24° E. The catchment area of the Zambezi river and its tributaries in Angola is 127 160 km². These main tributaries are the Lumbage, Luvna, Luisavo, Lupeo, Lunache, Lufuige and Macondo.

The mean annual rainfall in the region ranges from 1200 to 1400 mm and the rainy season spans from late September to late April. The daily mean temperature is 22.2° C.

The mean annual flow of the Zambezi river in Angola is approximately 30 m^3/s. However, due to poor infrastructure and lack of peace it is difficult to monitor the Zambezi river basin in Angola.

Agriculture in the region of the Zambezi river basin is mainly subsistence crop farming, and subsistence fisheries.

Industries

The provincial governments of Moxico and South Lunda envisage possibilities of hydropower development on the Chivumbe river in Dala, to supply industries in the area with power.

Hydropower Schemes

There are no hydropower plants operating in the Zambezi catchment in Angola. However, the following potential hydropower sites have been identified:

Lumage river potential of dam construction:
1 km long and 30 m high.

Zambezi river potential of dam construction:
500 m long and 20 m high.
another site (not specified exact location)
potential dam construction : 400m long and 8 m high

Luvna river potential of dam construction:
200 m long and 7 m high.

Luisavo river potential dam construction:
1 km long and 60 m high.

Lupeo river potential dam construction:
1 km long and 40 m high.

Lunache river potential dam construction:
2 km long and 20 m high.

Lufuige river potential dam construction:
4 km long and 60 m high

Macondo river potential dam construction:
200 m long and 20 m high.

4.1.2 Discussion

After the Presentation, chairman brought the paper to the floor for discussion. Denconsult wanted to know if it was adviceable for them to visit the area for data collection the answer was it is not safe therefore any data required will be made available to the sector studies consultant.

4.2 Botswana

4.2.1 Country Report Summary

Summary of a report presented by B. Khupe and J. Muzila

Water Resources

In Botswana the low rainfall and deep sandy soils result in low rates of surface runoff and low rates of recharge to groundwater. Annual recharge to aquifers from rainfall reaches a maximum of about 40 mm in some areas in Chobe district.

Water Demand

Water demand in the Zambezi basin (Chobe district) is low and is not expected to grow rapidly. The main water consumers in that area are wildlife settlements and to a limited extent, irrigation. For example, the demand forecast for Kasane is as follows:

Water Demand in 10^3 m^3

Consumer	1990	2000	2020
Domestic	91	192	392
Industrial/ Commercial	13	31	69
Institutional	33	77	169
Mining,Energy and Losses	46	100	210
Total	183	400	840

Meeting Botswana's Water Needs

The needs of the population centres in the eastern part of Botswana can be met up to the year 2020 by a two-phase dam project in the north east of the country, without tapping from the Zambezi river system. However, additional water needs (beyond the year 2020), will probably be met from the Zambezi river system. Currently the use of the Okavango Delta to supply local communities is still open to further considerations.

Due to scarce water resources, the government of Botswana has given up its plans for self-sufficiency in food. Therefore it is not its intension (currently) to develop water-intensive agriculture and industry.

Botswana is also committed to preserving its rivers and the country's greatest treasure, the Okavango. Hence any developments with potentially negative environmental impacts on these are strongly opposed by Botswana.

4.2.2 Discussion

At the end of the session it was unanimously agreed that coordination between the member states in the Zambezi river basin should be encouraged in the various water resources development undertakings. This should begin by preparation of the methodology and common data base in the region.

4.3 Malawi

4.3.1 Country Report Summary

Summary of a report presented by O.N. Shela

Geography

Malawi is located between latitudes 9° 22' S and 17° 08' S and longitudes 32° 40' E and 35° 55' E. It shares borders with Tanzania to the north and north-east, Mozambique to the east, south and south-west, and Zambia to the west. The total area of Malawi is approximately 118,484 km^2, divided into 94,276 km^2 land and 24,208 km^2 lakes. Lake Malawi, the third largest fresh water lake in Africa, occupies 20% of Malawi.

Climate

Malawi experiences three district seasons. The cool-dry season from May to July, the hot-dry season from August to November, and the hot-wet season from December to April. The annual mean temperature varies from 14°C in the highlands to 27°C in the Lower Shire Valley to the south of the country. The average annual rainfall is approximately 1100 mm, varying with geographical position from 700 mm in the dryer areas of the Lower Shire to 2000 mm in the highland areas such as Mulanze massif, Zomba and Nyika plateaus.

The main controlling feature of the climate of Malawi is the Intertropical Convergence Zone (ITCZ). The ITCZ moves over Malawi generally between December and March resulting in widespread rains while between April and May, the ITCZ moves north resulting in generally dry weather conditions.

Hydrology

Malawi is generally rich in water resources. Apart from the presence of one of Africa's largest fresh water lakes, Malawi is relatively well endowed with rivers, lakes and groundwater resources. The average annual runoff expressed as a percentage of the average annual rainfall (runoff coefficient) varies between 4% and 54%. The lower runoff occurs in the drier parts of the plains and the rift valley while high runoff occurs in the highlands where most streams are perennial.

Malawi has two main types of aquifers, the weathered pre-cambrian basement complex and the alluvial aquifers. The weathered Pre-Cambrian aquifers which occur in the plateaus are generally low yielding, with thinner aquifer thicknesses (15 to 30 m). The alluvial aquifers on the other hand occur along the lakeshore and the Lower Shire valley, have more thickness and generally yield up to 15 litres/sec.

Water Resources Development and Management in Malawi

Malawi currently faces great water demand on its available water resources. Major water demand areas include domestic supply, irrigation, hydropower generation, fisheries, navigation, and recreation.

Existing and future water resources and water related developments and management plans are categorised into; water and sanitation, food and agriculture, energy and industries, and environment and amenities as follows:

Water and Sanitation

The government Policy on water resources and water related development as described in the government statement of policies (1987-1996) adhere to the principles of the International Water Decade. Thus, they relate to provision of clean potable water to all people so as to reduce incidences of water borne diseases. Another important government responsibility is seen to be conservation and protection of Malawi's ground and surface water resources from pollution.

The government of Malawi has established a number of water supply schemes for both rural and urban centres. The urban supplies for the cities and tows of Lilongwe, Kasungu, Mzuzu and Zomba are met through construction of dams. While the city of Blantyre depends on direct abstractions from the Shire River at Walker's Ferry.

To supply rural settlements there are currently approximately 9,7000 boreholes 5,000 protected shallow wells in the country, and there are plans to construct 16,400 new boreholes and rehabilitate 5,500 boreholes in the next decade.

The provision of water for the cities of Lilongwe and Blantyre are the responsibility of the Lilongwe water Board and Blantyre water Board respectively. The rest of the urban schemes are operated by the central government. There are currently 53 government schemes and there are plans to have 9 new urban water supply schemes together with the constructions of Zomba dam.

Table 1 below shows the 1993 and projected 2010 water demands for Malawi, and Table 2 gives the present distribution of population being served by the various water supply schemes.

Table 1. Total water demands for Malawi

Source	1993	2010
Ground Water	62,000 m^3 / day	215,000 m^3 / day
Surface Water	138,000 m^3 / day	335,000 m^3 / day
Total	200,000 m^3 / day	550,000 m^3 / day

Table 2. Present Water Supply situation, (1993)

Water Supply Category	Persons	Share of total
City water supplies (Blantyre Water Board) (Lilongwe Water Board)	600,000	6%
District (Urban) Water Supplies	330,000	4%
Rural piped Gravity Supplies	2,020,000	16%
Rural Ground Water Supplies	1,450,000	22%
Private Boreholes wells and Traditional Sources	4,800,000	52%
Total	9,200,000	100%

Malawi's population is presently covered by any or a number of the following sanitation systems:

(i) Waterborne sanitation: about 100,000 persons (in Blantyre, Lilongwe, Zomba and Liwonde only).

(ii) Septic tanks; about 230,000 (in most of the towns and urban centres).

(iii) Pit Latrines; about 5,780,000.

The remaining one third of the population uses no standard sanitation system at all.

Management problems in relation to water resources and water related development and management include:

- The existence of several institutions or government Ministries or departments dealing with water and sanitation related issues.
- The latest National Water Resources Plan, completed in 1986, requires updating.
- The existing legislation on water resources is inadequate to protect the resources against over exploitation, pollution and degradation.

Food and Agriculture

This includes irrigation, farming and landuse management, agriculture production, food security, agroeconomy, and land resource conservation.

Irrigation

Current need for increased food production has translated into higher demand for irrigation. Presently, approximately 25,000 hectares are being irrigated for crop production (e.g. sugarcane and rice) while some 860 hectares of supplementary irrigation is being carried out on tobacco and tea estates of Southern and Central region. In addition, some 2,000 hectares is irrigated under self help schemes. Table 3 below shows existing Irrigation schemes (1986).

Table 3. Existing Irrigation Schemes

Scheme	District	Area (ha)	Cropping,1986 Summer	Cropping,1986 Winter
Small Scale				
Lufira	Karonga	320	Rice	Rice
Wovwe	Karonga	170	Rice	Rice
Wovwe II	Karonga	250	Under Cons.	Rice
Hara	Karonga	268	Rice	Rice
Limphasa	Nkhata Bay	378	Rice	-
Bua	Nkhotakota	300	Rice	Rice, maize
Mpamantha	Nkhotakota	60	Rice	Rice
Domasi	Zomba	506	Rice	Rice, Maize
Khaunda	Zomba	74	Rice	-
Njala	-	52	Rice	-
Chiriko	-	18	Rice	-
Segula	Zomba	34	Rice	-
Likangala	-	430	Rice	Rice, Maize, Wheat
Kasinthula	-	195	Rice,Research	Rice
Muona	Chikwawa	415	Rice	Rice
Nkhate	Chikwawa	220	Rice	Maize
Sub total		3690		
Large Scale				
Sucoma	Chikwawa	9000	Sugar	Sugar
Dwangwa	Nkhotakota	7000	Sugar	Sugar
Sub Total		16000		
TOTAL		19690		

The policy of the government of Malawi towards agriculture as outlined in the government statement of Development Policies 1987/88 is to enhance the social welfare and income of the agricultural commmity and the prosperity and stability of the nation as a whole by means of both improving self sufficiency in food products and expanding and diversifying export receipts from agricultural produce.

57 potential irrigation schemes have been identified in the Northern Plateau Region, Northern Lakeshore region, Central Lakeshore region, Southern Lakeshore region and Lower Shire, totalling over 100 000 hectares. Presently, feasibility studies have been completed on the Lower Shire valley project (Lower Shire) and the Buranje valley project (Central Lakeshore) and environmental impact assessment studies are being awaited.

Energy and Industries

Malawi's energy sector is supported by petroleum, power, coal and fuelwood. Fuelwood provides 90% of the country's energy requirements, particularly for household and industrial use. Petroleum products provide 4% of the total energy requirements of the country, principally used by the transport sector, and agricultural estates. Currently 3% of the country's energy needs are met by hydropower generation.

Hydropower generation, in Malawi is mainly concentrated in the middle Shire. This is dominated by the Tedzani falls and Nkula fall hydropower stations, Table 5.

Table 5. Main Generating Interconnection Hydro-Electric Energy System

Hydro-Electric Station	River	Available Capacity (MW)
Nkula A	Shire	24
Nkula B	Shire	100
Tedzani (I,II,III)	Shire	140
Total		264

Several hydropower sites still exist in Malawi, mainly along the Shire itself, Table 6. Currently construction of the Wovwe mini-hydro power scheme to produce 4 MW is underway. A feasibility study has been completed for the Kapichira project to produce 125 MW.

Navigation and Lake Transport

Lake Malawi and the Shire play an important role in the transport system of the country. The lake currently provides an effective goods and passenger transport service. Lake level management is therefore a complex issue that has to ractify navigation, hydropower, irrigation and wetland management requirements.

Table 6. Potential Hydropower Sites

Scheme	River	Total Capacity (MW)
Kholombidzo	Shire	140
Mpatamanga	Shire	120
Kapichira Falls	Shire	125
Fufu Falls	South Rukuru	125
Chizuma	Bua	24
Chasomba	Bua	18
Malenga	Bua	24
Mbongozi	Bua	21
North Rukuru	North Rukuru	2.0
Wovwe	Wovwe	4
Total		600.4

4.3.2 Discussion

Ports have been established on Lake Malawi but due to low levels of the lake it is not possible to use them. There is a conflict of interests caused by barrage control to ensure adequate hydropower generation on the Shire, while maintaining sufficient levels on the lake for navigation.

There are proposals to dam small rivers leading to the lake on the Malawi side. There are also joint projects with Tanzania on the northern part of the lake and some in southern Shire with Mozambique, Zimbabwe and Zambia.

4.4 Mozambique

Summary of a report presented by P. Napica

4.4.1 Country Report Summary

The Socio-political condition in Mozambique has greatly hampered monitoring of hydrological systems, the Zambezi included. The Zambezi river basin in Mozambique extends for about 820 km and covers an area of approximately 14000 km^2.

Geology, Soil and Mineral Resources

The northern part, from the boundary with Zambia and Zimbabwe to the city of Tete, is underlain by Precambrian rocks. The southern part, on the other hand, is underlain by the Karoo system. As a result of its geological composition the region is well endowed with minerals and has fertile deep soils.

Climate

The mountainous zones and plateaus have low temperatures of approximately 18 to 20^{0}C and high rainfall (1000 to 1400 mm) while the valleys have temperatures up to 28^{0}C and rainfall, around 400 mm.

Water Resources and Drainage Network

The river enters the country at the confluence with river Luangwa. It traverses the country within a well defined channel down to the inundated plain where it has a width of 3 to 5 km and meanders for 350 kms towards the Indian Ocean.

The droughts which occurred during the 1980s affected agricultural production in the basin, particularly subsistence farming, which is practised over the major part of the basin area. Conversely, the floods of 1977/78 affected large areas of the provinces of Tete, Manica, Sofala, and Zambezia.

Cahora Bassa Dam

The Cahora Bassa dam which was completed in 1977 was mainly constructed to produce hydroelectric power for export to the South African Market. The capacity of the plant is 2,075 MW with a possibility of upgrading to 4,000 MW. However, the exportation of the power has not been fully realized due to the destruction of power lines.

The dam reservoir occupies some 2,665 km^2 with a storage capacity of approximately 39,200 m^3. The Cahora Bassa has abundant fish resources and serves as a transportation route for passengers and produce.

Mineral Exploitation

The exploitation of coal deposits being carried out in the province of Tete may lead to pollution of waters of the Ruvubwe river. Other minerals that exist in the basin are gold, graphite, copper, Iron and asbestos. however, their exploitation at present is either insignificant or non-existent.

Other Environmental Problems

- The absence of waste water treatment facilities and consequent dumping of raw sewage into the Zambezi at Tete city.

- Deforestation around main population centres.

Present State

The reservoirs at Mepanda Ucua is at feasibility study stage and the reservoir at Baroma is at project stage, both reservoir locations are downstream of the Cahora Bassa.

The understanding of the basin hydrologic status is out of date and current undertakings and plans are those geared towards the rehabilitation and construction of infrastructure and basic requirements such as schools, hospitals etc. Therefore hydrologic research among other activities has fallen short in federal financial backing.

4.4.2 Discussion

The country lacks a comprehensive monitoring hydrometric network due to the current political situation. As a result, it is not possible to determine the extent of pollution from upstream users and countries. It was therefore recommended that in future it would be important to locate a water quality monitoring station at the outlet of the major rivers from neighbouring countries.

Major environmental problems are sea /salt intrusion as a result of regulated flows from the Cahora-Bassa. In addition untreated waste water discharges from urban industrial and domestic processes find their way into the main river system.

4.5 Namibia

4.5.1 Country Report Summary

Summary of a report presented by P. Heyns and L. Rukira

In Namibia the Zambezi river basin occupies the Caprivi region. The main river is the Livambezi.

The rainfall season in the region is from October to April with the average annual rainfall at Katima Mulilo being 680 mm (40 year record). The average annual class A pan evaporation is 2480 mm which is equivalent to approximately 1740 mm open water surface evaporation.

The Eastern Caprivi has two drainage systems: The Zambezi and the Kwando-Linyati-Chobe river systems.

The Kwando-Linyanti-Chobe river system has a combined catchment area of 120 000 km^2. The Kwando, rising in Angola has a mean annual runoff of 1.22×10^9 m^3 at Kongola. The Kwando drains into the Linyanti swamps, and then follows the Linyanti river.

The Zambezi, draining Angola and Zambia has a catchment area of 334 00 km^2 at Katima-Mulilo. The mean annual runoff at Katima-Mulilo is 47 474 million m^3 or approximately 1.5×10^3 m^3/s. Peak flows usually occur in April and the maximum recorded flow is greater than 10 000 m^3/s while the minimum recorded flow is about 200 m^3/s.

Due to flat gradients in the Kwando-Linyanti-Chobe, backwater effects are significant. Flow in the Bukalo Mulapo coincides with high flow in the Zambezi but backwater effects due to the Liambezi Lake have not been quantified. Also the connection between the Okavango system and the Kwando-Linyanti-Chobe system via the Selinda Spillway and Savuti channel is not known.

Aquifer recharge along the Kwando-Linyanti-Chobe river system is evidenced by steep piezometric gradients parallel to the rivers. Regional ground water flow is from South West to North East.

Water Supply

1. Urban

Katima Mulilo supplied from Zambezi river
: Capacity - 8240m^3/day
: Demand - 4000m^3/day

Chinchimane supplied from a branch of the Linyanti river
:Capacity - 240m^3 /day
: Demand - 104m^3 /day

Linyati supplied from the Linyanti river
: Capacity - 300m^3/day

: Demand - 60m^3/day

Bukalo supplied from two boreholes
: Capacity - 260m^3/day
: Demand - 130m^3/day

2. Rural

Rural water supply is attained through hand dug wells, boreholes or from perennial rivers. The pipeline along the Kangola-Katima Mulilo tar-road supplies some 8.8×10^{-3} m^3/s to rural settlements. The source of the pipeline is from the Zambezi at Katima Mulilo and Kwando at Kangola.

3. Irrigation

Approximate 3.5 m^3/s is extracted from the Zambezi river at Katima Mulilo, and 1.2 m^3/s from the Linyanti river at Linyanti, for Irrigation.

A sugar plantation project of approximately 10 000ha near Lake Liambezi with water requirement of approximately 250 million m^3/annum (7.9 m^3/s) is in its feasibility study.

Waste Water Treatment in the Caprivi consists of septic tanks and evaporation ponds and none of the treatment plants discharge their effluent into the perennial rivers.

4.5.2 Discussion

A major recommendation from the presentation was the need to establish a water balance study in the basin. This should be done over and above the water demand studies and the expected projections. A need to appraise available hydrological data and coordination of monitoring activities was also emphasised.

4.6 Tanzania

4.6.1 Country Report Summary

Summary of a report presented by I. Kivugo

In Tanzania the Zambezi river basin is represented by the Lake Malawi/Nyasa catchment. The main rivers draining into Lake Nyasa from Tanzania are the Songwe, Ruhuhu and Kiwira rivers. Other major tributaries include: the Lufirio, Kumakali, Luyagala, Nkiwe, Mbaya and Malisa rivers.

The mean annual rainfall for the catchment varies between 800 and over 2600mm with the majority of the rainfall occurring from November to May. The area with the highest rainfall is in Northern Lake Nyasa.

Runoff

The average runoff of the Kiwira river in the highlands is approximately 40 l/s/km2 over an area of 1660km^{2}. The maximum flow is experienced in March to April.

Ground Water

The basin is underlain by the Basement complex, Karoo and Neogene deposits. In the Basement complex the average well yields are 3 to 7 m^3/hr. Well yields in the Karoo aquifers are generally higher than those in the Basement complex and perennial ground water occurs very commonly. In the Neogene deposits, the alluvial deposits are the most prosperous source with well yields up to 10 m^3/hr.

Water Quality

Ground water quality is a concern in wells drilled in Neogene deposits. Problems of high chloride, fluoride and iron content sometimes exist.

Water Supply

Most rural settlements are supplied by ground water using a 30 l/c/d and 400 m from household criteria.

With regards to urban water supply, the strategy is to meet the year 2002 water for all. In order to secure water supply for the urban area of Songea the following developments are planned:

To reinforce the Matogoro intake to supply 1050m^3/day.

To install two pumps with capacity of 820m^3/day at Matogoro.

To construct 31 shallow wells with handpumps which can supply 630m^3/day.

To construct a dam across the Ruvuma river within the Matogoro area.

4.6.2 Discussion

The figure for flow into lake Malawi/Nyasa were not available but could be provided, if required. The field of each catchment will be addressed by sector studies.

4.7 Zambia

4.7.1 Country Report Summary

Summary of a report presented by M. Mutale

Background

The Republic of Zambia is located between latitudes 8 and 18 south and longitudes 22 and 34 east. Its total area is 752, 614 Km2. the country is divided into six drainage basins, namely: Kafue, Zambezi, Lwangwa, Chambeshi, Luapula and Lake Tanganyika.

Estimates of Available Water Resources

The annual runoff from Zambia is estimated at 100, 000 million cubic metres, groundwater storage at 1, 740, 340 million cubic metres with recharge of some 160, 000 million cubic metres per annum. the water resources in Zambia are adequate for the users in general, however, their distribution in time and space is uneven.

In terma of water resources allocation Zambia has committed the bulk of its water to hydropower generation, followed by irigation and by water supply for domestic and industrial use. Zambia is currently engaged in formulation of a water policy, reorganisation of the water sector, preparation of a National Water Resources Master Plan as well as a specific action plan for the Kafue River Basin.

Food and Agriculture

At the moment, 50 000 hectares of land are under irrigation in the whole country, with about 6,000 ha utilizing the waters of the Zambezi River. The total irrigation potential along the Zambezi River Basin is estimated at 200, 000 ha with annual water reqiuirement of 1, 120 million cubic metres.

The government of Zambia has adopted the policy of agriculture development for attaining economic recovery while ensuring self-sufficiency in food production. Hence, there are plans to extend irrigation farming along the shores of lake Kariba and on the Zambezi river upstream of Victoria falls. The planed schemes include:

- Gwembe Development Company (2,100 ha)
- Buleya Malima (23 ha)
- Chiyabi Irigation Scheme (10 ha)
- Siatwinda (13 ha)

The government run Chiawa Banana Scheme located below the Kariba Dam is also expected to expand, with possible doubling in water demand.

There is also a proposal for irrigating 10,000 ha of rice in the Namwala district (part of the Kafue Flats).

Approximate water requirements for potential irrigation areas (net evaporative water requirement):

Catchment	Total Potential Irrigation Area (ha)	Water Req. (mcm/yr)
Upper Zambezi	112,000	1,120
Kafue	165,000	1,650
Lwangwa	14,000	140

The policy of the Fisheries department of the government of Zambia, is to ensure that both the fishing and aquaculture sectors contribute to the economy through income generation and creation of enumerative employment opportunities and contribute to improve nutritional status.

The table below gives statistics of the catchment assessment survey (CAS) and frame survey (FS). In CAS the amount of fish caught is evaluated while FS includes the number of boats, fishermen and fishing villages:

Fishery	Catch	Fishermen	Boats	Villages
Kafue River	8,724	1,424	1,478	169
Lake Kariba	1,197	2,306	2,013	297
Lower Zambezi	333	199	155	17
Upper Zambezi	9,243	2,159	3,403	291
Lukanga Swamps	3,318	689	1,392	71
Itezhi-tezhi	610	845	419	94
Zambezi West	-	324	333	86

Estimated annual fish production from aquaculture is 3,500 tonnes. Of the 20 commercial fish farms in the Zambezi River Basin most are along the Kafue River and lake Kariba.

On-going Fisheries projects on the Zambezi River Basin:

1. Introduction of Kapenta in lake Itezhi-tezhi - sponsored by GRZ.

2. Lake Kariba small scale fisheries development project - Established in 1991, funded by GRZ.

3. The Zambia/Zimbabwe SADC fisheries project - Started in 1988, second phase is due to start in 1996, funded by NORAD and DANIDA.

Water and Sanitation

At present there are no accurate figures in terms of access to water and sanitation facilities. The following are guidelines:

Access to safe drinking water:

Urban	70%		
Rural	33%	Total	47%

Access to adequate sanitation:

Urban	43%		
Rural	30%	Total	37%

At the moment there exists no clear cut national plan on water resources develpment, the figure below gives some guidelines on the potential surface water development points:

Energy and Industries

Almost all of Zambia's power is derived from hydropower. Existing major plants are Kafue gorge, Kariba North Bank and Victoria Falls representing over 95% of the total installed capacity of approximately 1,600 MW in Zambia (in 1991). The dependency on hydropower had severe negative effects during the 1991/91 drought period.

The Zambezi basin supports two major areas of navigation importance, at Lake kariba and in the Upper Zambezi.

Tourism is primarily wildlife based, with 8% of the country's total area (some 64,000 km2) covered by 19 national parks and a further 162,000 km2 by 33 game management areas.

The mining sector in Zambia is dominated by copper, mined mainly by the ZCCM limited. Environmental issues related to mining activities include:

1. Effects of dissolved and suspended solids from mining operations on aquatic life in streams and rivers.

2. Effects of dust and effluent from coal mining on the environment.

3. Environmental risk posed by mine tailing dams.

4.8 Zimbabwe

4.8.1 Country Report Summary

Summary of a report presented by H. Williams and A. Mlalazi

Water & Pollution

Table 1 below lists the major dams built in the Zambezi river catchment area.

Commitments and completed projects/programs by subcatchment:

(a) Gwayi river system:

Future intention of supplying Bulawayo with water from the Gwayi and ultimately the Zambezi river.

(b) Sanyati river system:

Supplies the towns of Gweru, Redcliff, Kwekwe, and Kadona. The main dams in the catchment are along the Sebakwe, lower Zivagwe, Ngasi and Claw.

When built, the Kudu dam on Munyati will irrigate cotton in Sanyati and Gokwe areas and supply Kodona, Kwekwe and Gweru.

(c) The Mupfure/Manyane/Mazowe/Nyagui system:

Mupfure weir serves the Chegutu irrigation.

Manyane dam serves Harare, Chitungwiza and Chinhoyi.

Mazvikadei - is primarily for irrigation.

Mazowe catchment dams serve irrigation, Bindura to other smaller centres.

Smaller dams on upper Nyagui serve Marondera.

(d) Actual Zambezi River system:

Zambezi river supplies the towns of Kariba, Churundwe, Hurange, Victoria falls and Binga. Howevr, these represent an insignificant percentage of the Zambezi runoff.

Table 2 below outlines the utilization of surface water in the Zambezi catchment.

Pollution

The following problems related to pollution can be identified:

Table 1.
The following are the major dams that have been built in the Zambezi River Catchment Area.

Name of dam	River	Year completed	Town(s) served	Capacity 10^6m^3	Remarks
Mazowe	Mazowe	1920	-	39	Wholly Irr.
Chivero	Manyame	1952	Harare	247	Mainly Urban
Manyame	Manyame	1976	Harare/ Chinhoyi	480	Mainly Urban
Mwenje	Mazowe	1969	Bindura	36	Mainly Irr.
Mazvikadei	Maquaddzi	1988	-	344	Mainly Irr.
Claw	Musweswe	1973	Kadoma	65	Urban & Irr.
Ngesi	Ngesi	1946	-	23	Originally for power station. Now Irr.
Sebakwe	Sebakwe	1957	Kwekwe	266	Mainly Irr.

Note that the following dams have been raised, Mazowe in 1961, Mwenje in 1986, Sebakwe in 1986 and Claw in 1991.

Table . Some of the major dams to be built in the next 10 to 15 years

Name of Dam	River	Year to be completed	Town(s) served	Capacity 10^6m^3	Remarks
Musami	Shavanhoe	+-2005	Harare	+-200	Linked to other towns
Biri	Manyame	+-1998	Chinhoyi	+-360	Mainly Irrigation
Bindura	Mazowe	1998	Bindura	80	Mainly Irrigation
Nyagui	Nyagui	+-2010	Harare	+-1200	Linked to other towns
Mbondoro	Mupfure	+-2000	Chegutu	+- 200	Mainly Irrigation
Kudu	Munyati	+-2005	Kadoma+ Kwekwe	1400	Mainly Irrigation
Gwayi-Umguza	Gwayi	1998	Bulawayo	290	Mainly Urban
Gwayi-Shangani	Gwayi	+-2000	Bulawayo	630	Mainly Urban
Zambezi	Zambezi	+-2005	Bulawayo	-	Urban
Zambezi-Kariba	Zambezi	+-2015	Harare+ other towns	-	Urban

Table : Main Plans and Studies undertaken

PLAN NAME	LEVEL	STATUS
ZAMBIA/ZIMBABWE SADC FISHERIES PLAN	International	Being Implemented
NATIONAL DEVELOPMENT PLAN	National	Planning stage
NATIONAL CONSERVATION STRATEGY	National	Being Implemented
ZAMBEZI VALLEY MASTER PLAN	National	Planning stage
CAMPFIRE	National	Being Implemented
MATABELELAND NORTH FIVE YEAR DEVELOPMENT PLAN	Provincial	Being Implemented
MIDLANDS FIVE YEAR DEVELOPMENT PLAN	Provincial	Being Implemented
MASHONALAND WEST FIVE YEAR DEVELOPMENT PLAN	Provincial	Being Implemented
MASHONALAND CENTRAL FIVE YEAR DEVELOPMENT PLAN	Provincial	Being Implemented
MASHONALAND EAST FIVE YEAR DEVELOPMENT PLAN	Provincial	Being Implemented
HARARE COMBINATION MASTER PLAN	District	Being Implemented
BULAWAYO MASTER PLAN	District	Being Implemented
SEBUNGWE REGIONAL PLAN	District	Superseded
KARIBA DISTRICT FIVE YEAR DEVELOPMENT PLAN	District	Being Implemented
BINGA DISTRICT FIVE YEAR DEVELOPMENT PLAN	District	Being Implemented
KARIBA DISTRICT ANNUAL DEVELOPMENT PLAN	District	Being Implemented
BINGA DISTRICT ANNUAL DEVELOPMENT PLAN	District	Being Implemented
KANYATI DEVELOPMENT PLAN	District	Being Implemented
OMAY LAND USE PLAN	District	Under Review
KARIBA TOWN LOCAL DEVELOPMENT PLAN	Town Council	Being Implemented

Pollution problems in Hurange, Kariba and Binga:

> Hurange discharges acid waste into the Deka river. Kariba sewerage system is overloaded and Binga relies on septic tanks.

In Lake Kariba boats spill out oil and raw sewerage into the water.

Food and Agriculture

The Zambezi catchment area produces cattle, grain, livestock, fisheries and wildlife. The area in question has Zimbabwe's largest game parks. Lake Kariba is a large source of fish.

The catchment area can be *subdivided* into two zones:

Zone 1 covering the immediate valley, has low rains and mainly practices subsistence farming.

Zone 2 between the central watershed and valley area with rich soils, good rains and supportive infrastructure is dominated by commercial farms. This area is the grain basket for Zimbabwe.

Energy and Industries

Five power stations are located within the Zambezi catchment. These include, the Hwange thermal station, the Kariba Hydroelectric station. Other power stations are thermal stations at Bulawayo, Harare and Monyati.

There are plans to develop a 1600 MW hydroelectric plant at Batoka upstream of lake Kariba. This will be developed jointly between Zambia and Zimbabwe. The hydropower plant would significantly reduce exhaust waste like Co_2, So_2 and No_xs associciated with thermal plants.

Table below lists major dam projects intended for development within the next 10 to 15 years.

Annex 3

Agreement of the Action Plan for the Environmentally Sound Management of the Common Zambezi River System/ZACPLAN

Source: UNEP, 1987. *Agreement on the Action Plan for the Environmentally Sound Management of the Common Zambezi River System*. Final Act. Harare, 26-28 May 1987.

AGREEMENT ON THE ACTION PLAN FOR THE ENVIRONMENTALLY SOUND MANAGEMENT OF THE COMMON ZAMBEZI RIVER SYSTEM

The Governments of the Republic of Botswana, the People's Republic of Mozambique, the United Republic of Tanzania, the Republic of Zambia, and the Republic of Zimbabwe, being Parties to this Agreement and referred below as the Parties,

Having in mind the recommendations of the United Nations Conference on the Human Environment, the Mar del Plata Action Plan on Water Development and Administration, and the resolution 1/1 of the first session of the African Ministerial Conference on the Environment,

Aiming to develop regional co-operation in the spirit of the Lagos Plan of Action and the Southern African Development Co-ordination Conference (SADCC), on environmentally sound water resources management of the common Zambezi river system and to strengthen their regional co-operation for sustainable development,

Appreciating the efforts of the United Nations Environment Programme (UNEP) and other United Nations Organizations to promote this co-operation,

HAVE AGREED AS FOLLOWS:

Article 1

ACTION PLAN

1. The Parties hereby adopt the Action Plan for the Environmentally Sound Management of the Common Zambezi River System, hereinafter referred to as "the Zambezi Action Plan", contained in Annex I to this Agreement.

2. The Parties respectfully request that the Zambezi Action Plan should be endorsed by the Council of Ministers of the Southern African Development Co-ordination Conference, as a concerted action programme of the Southern African Development Co-ordination Conference.

3. The region covered by the Zambezi Action Plan encompasses the territories within or related to the Zambezi river basin of the following countries: Angola, Botswana, Malawi, Mozambique, United Republic of Tanzania, Zambia, Zimbabwe and the illegally occupied territory of Namibia.

4. The Zambezi Action Plan will be implemented through various projects developed according to the relevant guidelines contained therein. The projects for the initial implementation of the Zambezi Action Plan are identified in the appendix I to the Zambezi Action Plan.

5. The Parties will, individually and/or jointly as a regional activity of the Southern African Development Co-ordination Conference, take all appropriate measures for the expeditious and effective implementation of the Zambezi Action Plan.

Article 2

INSTITUTIONAL AND FINANCIAL ARRANGEMENTS

1. Two options are open to the Council of Ministers of SADCC to implement the Zambezi Action Plan:

(a) through the normal institutional and financial arrangements of SADCC, or

(b). by establishing an Intergovernmental Monitoring and Co-ordinating Committee, a Co-ordinating Unit and a Trust Fund along the lines suggested in Annex II to this Agreement.

Article 3

NATIONAL FOCAL POINTS

1. In order to achieve efficient and well co-ordinated co-operation, national focal points should be established (or an existing structure should be designated) at a high level in each of the participating Governments to harmonize, on the national level, all matters concerning the Action Plan.

2. The role of national focal points should be:

(a) To act as the official channel of communication for national organizations participating in the Action Plan;

(b) To co-ordinate, as appropriate, the participation of national institutions and agencies in the Action Plan;

(c) To consult with all relevant organizations in theib national Governments on the activities and progress achieved in implementing the Action Plan.

Article 4

IMPLEMENTATION OF THE PLAN

1. The Parties confirm the urgent need for immediate implementation of the Zambezi Action Plan as adopted.

2. The Parties request the Executive Secretary of SADCC and Executive Director of UNEP to start immediate consultations regarding the implementation of the Zambezi Action Plan and the raising of external finances to ensure that implementation of the Plan starts before the end of 1987.

Article 5

FINAL CLAUSES

1. This Agreement shall enter into force on the date of signature thereof.

2. Any party may withdraw from the Agreement by giving six months written notification to the other Parties and to the depository.

3. Any amendment to this Agreement mutually agreed upon by the Parties shall be effected in writing.

4. The original of this Agreement, the English text of which is authentic, shall be deposited with the Executive Secretary of the Southern African Development Co-ordination Conference.

5. The Agreement shall remain open for accession by the People's Republic of Angola, Malawi and Namibia, represented by the United Nations Council for Namibia and shall enter into force for Angola, Malawi and Namibia on the date of the deposit of their instruments of accession.

IN WITNESS WHEREOF the undersigned, being duly authorized to that effect, have signed this Agreement.

DONE at Harare this twenty eighth day of May one thousand nine hundred and eighty seven in one original in the English language. The original text will be deposited with the Executive-Secretary of the Southern African Development Co-ordination Conference.

H.E. Mr. A.M. Mogwe

For the Republic of Botswana

H.E. Dr. Joao Mario Salomao

For the People's Republic of Mozambique

H.E. Mr. N.M. Lugoe

For the United Republic of Tanzania

H.E. Mr. Fitzpatrick Chuula

For the Republic of Zambia

H.E. Mrs. Victoria Fikile Chitepo

For the Republic of Zimbabwe

IN WITNESS WHEREOF the representatives have signed this Final Act.

DONE at Harare this twenty eighth day of May one thousand nine hundred and eighty seven in one original in the English language. The original text will be deposited with the Executive-Secretary of the Southern African Development Co-ordination Conference.

H.E. Mr. A.M. Mogwe

For the Republic of Botswana

H.E. Dr. Joao Mario Salomao

For the People's Republic of Mozambique

H.E. Mr. N.M. Lugoe

For the United Republic of Tanzania

H.E. Mr. Fitzpatrick Chuula

For the Republic of Zambia

H.E. Mrs. Victoria Fikile Chitepo

For the Republic of Zimbabwe

Annex 4

Programme activities for the Zambezi Action Plan; ZACPRO's 1-19

Source: UNEP, 1987. *Agreement on the Action Plan for the Environmentally Sound Management of the Common Zambezi River System*. Final Act. Harare, 26-28 May 1987.

PROGRAMME CATEGORIES FOR THE ZAMBEZI ACTION PLAN

Projects related to ZACPLAN should constitute the basis of the programme and be implemented in phases based on the selection guidelines outlined in part III of the Action Plan. The Zambezi Action Plan projects (ZACPRO) for the period of 1987-1989 are as follows. (See paragraph 45 of the Action Plan for categorization of projects into category I and - II.):

A. Category I projects

(The complete or phase I implementation of projects in this category should meet the short-term goals indicated in paragraph 44 of the Action Plan and have definite outputs by 1989)

ZACPRO 1 Up-to-date compilation of all completed, ongoing and planned development projects which can be related to the ZACPLAN, and the evaluation of major key projects which have been implemented in order to gain experience, to avoid overlapping with other development programmes, to do proper and detailed planning including co-operation with donors and United Nations agencies to avoid mistakes for future project implementation and to start a basin wide exchange of information.

ZACPRO 2 Up-to-date compilation of national and international laws of the river basin countries related to the utilization and the protection of water and the environment.

In order of priority requirements develop and adopt regional convention on the environmentally sound management of the common Zambezi river system and additional protocols to promote the further development and implementation of the ZACPLAN.

Technical assistance and advice on the drafting of national legislation for the effective implementation of regional conventions and their protocols.

ZACPRO 3 Survey of national capabilities and means to respond to environmental problems including scientific and administrative institutions, manpower requirements, research facilities and equipment and the need for human resources development.

ZACPRO 4 Development or strengthening of relevant national research institutes, laboratories and institutions in order to enable them to develop water-related environmental research and training policies and priorities in collaboration with INFOTERRA and to carry out the analysis and research.

ZACPRO 5 Development of a basin-wide unified monitoring system related to water quality and quantity.

5.1 Within the eight riparian countries and with particular emphasis on the Zambezi basin itself, review of existing and planned data collection, transmission and storage systems and data currently stored. This would be concerned with data relevant to the needs of the overall projects such as physiographical, meteorological, hydrological, land-cover and land-use data. The hydrological data should relate to both surface and ground water, to sediment loads and water pollution and to water quality in general including chemical and biological parameters.

5.2 On the basis of project 5.1 and a thorough analysis of the data needs of ZACPLAN, preparation of proposals for the strengthening of relevant data collection and storage activities and their regional co-ordination. These should be prepared and costed at three levels: a minimum proposal, an optimum proposal and an intermediate proposal. It is anticipated that these proposals will include the following activities:

(a) Assessment of the need for physiographic, land-use and land-cover data and their updating. Presentation of specific proposals for acquiring additional data (possibly using satellite data or aerial surveys) and storing and processing them;

(b) Assessment of the need for long-term and medium-term meteorological, hydrological and related time-series data. Evaluation of available data and presentation of specific proposals for overcoming deficiencies by using data from other sources or by augmenting existing networks of stations;

(c) Assessment of the need for real-time data for the continuous monitoring of the water environment of the Zambezi river basin, including data on precipitation, streamflow and lake and ground-water levels, water quality, floods, flood-plain and soil moisture. Evaluation of present facilities for the provision of such data and presentation of specific proposals for overcoming deficiencies in the short and long term, possibly by using meteorburst or satellite-based transmission systems, including the training of the personnel that will be needed;

(d) Consideration in all the above of the need for a uniform or at least compatible system of data collection and storage, compatible not only with project 5, but also with the data collected and used by other ZACPLAN projects. Identification of national data centres and a potential regional data centre and preparation of specific proposals as to how these might be strengthened with computing facilities and trained staff to meet the needs of ZACPLAN.

5.3 Commencement of the implementation of the minimum proposals arising from projects 5.2 to the extent possible within the first phase of ZACPLAN. This will involve:

(a) The promotion of a fuller utilization of existing mechanisms for the exchange of water-related environmental data information between the countries at regional and sub-regional level with inputs from INFOTERRA and other similar systems which has national focal points in and/or information on the Zambezi basin countries;

(b) A minimum augmentation of the present station networks and data transmission facilities, possibly an additional five to ten stations using satellite transmission;

(c) With reference to ZACPRO 3 and 4, strengthening of manpower and facilities at some national data centres and at a regional data centre, by the provision of hardware and specific tried and tested software and training people to use the hardwares and softwares;

5.4 Development and implementation of Phase I of the regional hydro-electric hydrological assistance project of SADCC in co-operation with the implementation of activities in 5.1 5.2 and 5.3 of ZACPRO 5.

ZACPRO 6 Development of an integrated water management plan for the Zambezi basin based on sub-basin plans prepared as a first phase. The project includes, inter alia:

(a) Assessment and utilization of water resources for sustainable development;

(b) Flood control, flood plain and watershed management including drainage and control of other water related natural hazards;

(c) Conservation and improvement of the productive capacity of water related ecosystems;

(d) Development of safe drinking water supply and sanitation conditions including water pollution and accidential pollution control, waste-water reuse.

ZACPRO 7 The design and implementation of promotion campaigns to persuade communities, schools and individuals to provide for themselves:

(a) Sufficient drinking water of acceptable quality;

(b) Good sanitary facilities;

(c) Soil conservation measures;

(d) Forest protection and fuelwood plantation.

The campaigns will be a follow-up action of the African Ministerial Conference on the Environment which at its first session called for pilot and promotion projects in three villages in each country. It includes the implementation of environmentally sound watershed management projects in several villages in the Zambezi river basin.

These projects should be based on a revision of past experience in some of the river basin States which may have carried out such campaigns. Special emphasis should be laid on proper operation and maintenance procedures and training of personnel at all levels.

In order to implement the campaigns the following actions must be taken:

(a) Preparation of written and audio-visual materials in English and Portuguese for secondary school teachers to enable them to teach their pupils about the Zambezi Action Plan and the concepts behind it, in collaboration with the Environmental Training Branch of UNEP;

(b)Training of a small number of personnel to ensure the successful implementation of the first phase of the ZACPLAN with emphasis on participation of women as "end users" of water in the integration of water systems, especially drinking water supply, purification and sanitation facilities.

ZACPRO 8 Development of unified water engineering planning and design criteria and manuals for major elements of non-piped and piped drinking water supply and sanitation schemes including appropriate treatment when required.

B. Category II Projects

(Implementation of projects in this category should be commenced in the period 1987-1989, if financial resources become available)

ZACPRO 9 Basin-wide harmonization of existing and planned methodologies on environmentally sound water resources management and their application in the decision-making on selected drinking water supply, sanitation, irrigation and hydroelectric power projects.

ZACPRO 10 Development and strengthening of the capability of the States of the region to prepare environmental impact analysis of major development projects and plans in order to incorporate the environmental dimension in the planning and implementation of socio-economic development programmes.

ZACPRO 11 Promotion of increased technical and financial support for environmentally sound management practices within ongoing national, regional and internationally supported economic development activities, so that they will have a demonstration effect.

ZACPRO 12 The energy projects listed below should be implemented in close co-operation with the SADCC Energy Sector, including the countries which are directly involved.

12.1 Assessment of major sources of conventional and non-conventional energy and their potential uses within and outside the river basin States.

12.2 Assessment of the potential for energy conservation measures in the fossil fuel and hydropower systems for energy production and use and formulation of guidelines and recommendations on measures to achieve optimal efficiency in the exploitation of these resources.

12.3 The feasibility of linking the major hydroelectric power plants including marketing analysis.

12.4 Environmental impact assessment (EIA) analysis for existing and potential energy schemes which are likely to be developed or to be selected for further studies.

12.5 Implementation of field demonstration projects on improved fuelwood utilization and application of other renewable sources of energy, including measures to ensure adequate replication throughout the river basin.

ZACPRO 13 Adoption of watershed management guidelines based on the assessment of the effects of modification on the relationships between forest cover, water and land utilization with a view to introducing environmental planning concepts in the management of catchment areas. Soil erosion and siltation studies should be carried out before and after implementation in order to evaluate the projects.

ZACPRO 14 Prevention and control of water related and water-borne diseases in Zambezi basin. The health projects listed below should be implemented in close co-operation with the World Health Organization and local health institutions.

14.1 Evaluation of information on the prevalence of water-related and water-borne diseases in the Zambezi river basin.

14.2 Guidelines on health protection measures in the planning, design, construction and operational phases of water projects in the Zambezi river basin.

14.3 Guidelines on prevention and control of water-related and water-borne diseases in the Zambezi river basin.

14.4 Seminar on prevention of water-related and water-borne diseases in the Zambezi river basin and promotion of training of technical personnel involved in water projects as a follow-up to this seminar.

14.5 Promotion of community awareness of prevention and control of water related and water-borne diseases in the Zambezi river basin utilizing mass media and community level education.

14.6 Pilot project on the control of water-related and water-borne diseases in the Zambezi river basin.

ZACPRO 15 Limnological studies of Lake Malawi/Nyasa, Lake Kariba, Lake Cahora Bassa and Lake Chilwa. Special attention should be given to fisheries, creation of fish farms, and management of fish genetic resources.

ZACPRO 16 Development and application of ecologically sound elements into vector control programmes in the Zambezi river basin. Priority should be given to tsetse and mosquito control operations.

16.1 Survey of ongoing operations for tsetse control, development and testing of a model integrated tsetse control package and promotion of its field application at the regional level (pilot demonstration project).

16.2 Promotion of environmental training as a corollary to tsetse control with insecticides (within the context of FAO training and applied research for Glossina control in the dry savannah zone, FAO Training Centre, Lusaka).

16.3 Survey of ongoing operations for mosquito control by pesticides and their impact on the environment.

16.4 Development of programmes for mosquito control and training programmes for staff to implement such control programmes.

ZACPRO 17 Studies of inter-basin transfer of water including water demands for sustainable development outside the river basin and the impact on the Zambezi river system.

ZACPRO 18 The establishment and implementation of living resource conservation programmes within the river basin and in accordance with the national and world conservation strategies.

ZACPRO 19 Research on aquatic plants and on the eradication and prevention of the spread of harmful flora such as Salvinia.

Annex 5

SUB-PROGRAMME 5 : ENVIRONMENTAL PROTECTION AND HEALTH ASPECTS OF IRRIGATION DEVELOPMENT

Project No. : 5.3

Project Title : Capacity Building for Optimal Use of Health Opportunities in Irrigation Development

Justification :

Irrigation development in Zimbabwe carries with it a number of health risks (specifically, malaria and schistosomiasis) as well as opportunities to protect and promote the health status of communal farmers. The problems will need to be attacked in two directions; (a) using chemicals to control breeding sites (chemotherapy) and (b) adapting environmental management measures (including engineering and water management methods) to control breeding sites as well as minimize vector-human contact. In the context of environmental management it has already been demonstrated in the Mushandike irrigation scheme that the introduction of self-draining drop structures and the lining of canals can indeed significantly reduce the incidence of schistosomiasis among the farming communities.

However, the incorporation of health opportunities such as environmental management measures should be an integral part of the irrigation planning, development and management processes. One of the reasons for this not being implemented at the moment is the lack of national capacity, both trained personnel and institutional strength to implement health components in irrigation development. This project aims to build national capacity for integrating health opportunities in irrigation development.

Objectives :

To strengthen the capacity of relevant ministries and institutions to enable the integration of health opportunities and safeguards in irrigation development through:

- training of professionals,
- institutionalizing health education in tertiary education systems,
- introducing appropriate health measures through agricultural extension.

Outputs :

- About 100 trained professional staff at the end of this project.
- A programme to introduce health aspects in university curriculum for BSc Agricultural/Engineering level
- Trained farmers and rural communities on health aspects of irrigation, water supply and rural sanitation

Inputs : International Consultants
National Consultants
National Counterparts
National training courses

Duration : 3 years

National Implementing Agency : Ministry of Health

Collaborating Agencies : Agritex, Blair Research Institute, University of Zimbabwe, Department of Water Development, CFU, ZFU, ARDA

Estimated Cost : in 1993 prices

	NATIONAL ZIM $	INTERNATIONAL US $
Personnel International Expert		
International Consultant (4 pm)	-	60 000
National Consultant (3 pm)	-	14 000
National Counterparts	40 000	-
Equipment Materials Vehicles	 10 000 -	10 000 20 000
Training - Professional Training Courses - Farmer Training	 10 000 20 000	 40 000 20 000
Operational costs	20 000	8 000
Miscellaneous (10%)	10 000	17 000
Total	110 000	189 000

Environmental management for disease vector control in rural water resources development projects: four case studies

As one of its activities as a Collaborating Centre of the WHO/FAO/UNEP/UNCHS Panel of Experts on Environmental Management for Vector Control (PEEM), ILRI collected and reviewed literature on malaria control under the colonial administration of the Dutch East Indies — now Indonesia — prior to 1940, with special emphasis on measures related to land and water development. For this paper, three case studies from Indonesia have been selected (Figure 1). The Indonesian examples demonstrate the benefits of integrated rural development, both in terms of improved agricultural productivity and effective control of vector-borne diseases. They also show that building up knowledge and experience of environmental management for vector control leads to better cost-effectiveness.

A Pilot Study initiated in 1984 on the Mushandike Irrigation Project in Zimbabwe provides a recent example of disease vector control in rural water resources development projects through environmental management. This study was a joint effort of the Blair Research Laboratory and the Department of Agricultural, Technical and Extension Services in Zimbabwe and the Overseas Development Unit of Hydraulics Research, Wallingford, UK.

THE MUSHANDIKE PILOT PROJECT: A RECENT EXAMPLE

A Pilot Study initiated in 1984 on the Mushandike Irrigation Project in Zimbabwe provides a recent example of disease vector control in rural water resources development projects through environmental management. The study was a joint effort of the Blair Research Laboratory and the Department of Agricultural, Technical and Extension Services in Zimbabwe and the Overseas Development Unit of Hydraulics Research, Wallingford, UK.

The Mushandike dam and canal were built in the 1930s to irrigate ten commercial farms. Seven of these farms with a total area of 600 ha have now been purchased by the government for resettlement of some 400 families.

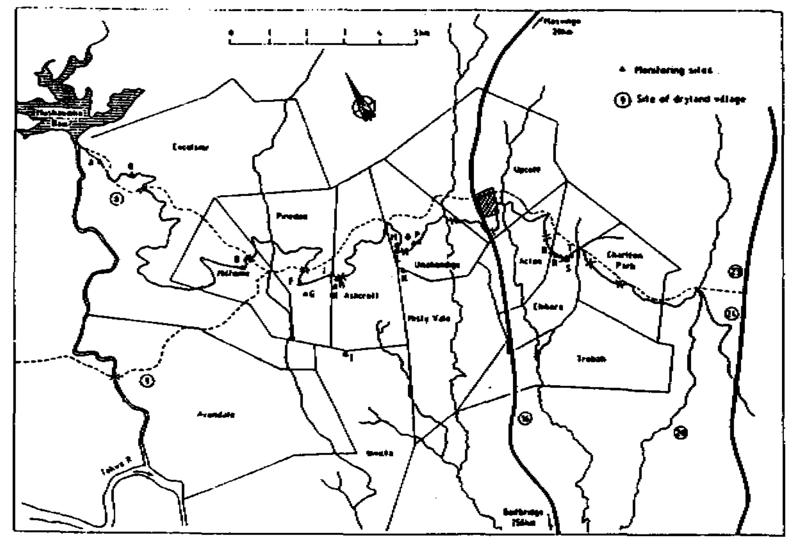
The area is located at 20 km from Masvingo (Figure 13) at 875 above sea level and receives an annual rainfall of 615 mm, which falls during the summer months (November to April). The majority of the settlers come from the surrounding communal land, where lack of water is the main constraint on agricultural production.

Measures to control schistosomiasis

Irrigation

Engineering measures aimed at preventing the creation of favourable conditions for snail colonization and breeding in the irrigation system:

FIGURE 13
Mushandike Irrigation Scheme : General Plan (reproduced from Chimbari *et al.* 1991)



Canal lining. All secondary and tertiary canals were lined with concrete to eliminate vegetation, allow higher flow velocities and rapid and complete drying of the canals when not in use.

Free draining structures. Standard designs for drop structures with sunken stilling basins have been replaced with a free-draining drop structure using baffle blocks. Long weirs for regulating upstream water level at canal off-takes have also been avoided, because these weirs prevent complete drainage of the canal section upstream.

Water scheduling. Micro-computer assisted irrigation scheduling was introduced to *improve efficiency of water use and to operate canals and reservoirs in such a way* that the time a particular canal remains dry is maximized.

Routine maintenance. Weed clearance of canals and reservoirs were done when the canals were dry, to avoid infection of the workers. Canals and structures were periodically checked for cracks, to avoid pools and swamps in which disease vectors can breed.

Water supply and sanitation

Village location. Villages should preferably be located as far as possible from the main canal and night-storage reservoirs. Safe drinking water should be provided nearer to the houses than the irrigation canals. Application of these criteria was not always possible in Mushandike, as the location of several villages had been determined by existing boreholes.

Domestic water. Villages were supplied with locally made handpumps to extract water from the boreholes that already existed on site. Laundry slabs with adequate drainage were constructed to discourage the use of irrigation canals.

Sanitation. All households were encouraged to have their own pit latrine, by issuing free cement for this purpose, and several communal latrines were built in the irrigated fields.

Monitoring and results

The transmission of schistosomiasis was monitored by a field team comprising two research technicians and various field assistants. All settlers were screened for *S. haematobium* (diagnosed from urine specimens) and *S. mansoni* (using stool specimens) infections, soon after their arrival. Infected settlers were treated with praziquantel. Repeat surveys were undertaken at three-monthly intervals. Figure 14 gives the prevalence (the number of positive cases as a percentage of the number of people surveyed) of *S. haematobium* for three settler schemes and for the Chikore farm, where no control measures were taken. The graphs show that prevalence fell rapidly after blanket treatment with praziquantel. The prevalence at the Misty Valley and Invicta schemes remained below 5%. At Ashcroft, however, prevalence increased until it reached a level comparable with that at Chikore.

Monthly sampling of snails, during three years, in the main canal reaches passing through the redeveloped schemes produced only 12 *Bulinus globosus* (host of *S. haematobium*). In contrast, more than 600 snails a year were caught in the reach passing through the Chikore farm. For *Biomphalaria pfeifferi*, the host snail of *S. mansoni*, these figures were 3 and 196, respectively.

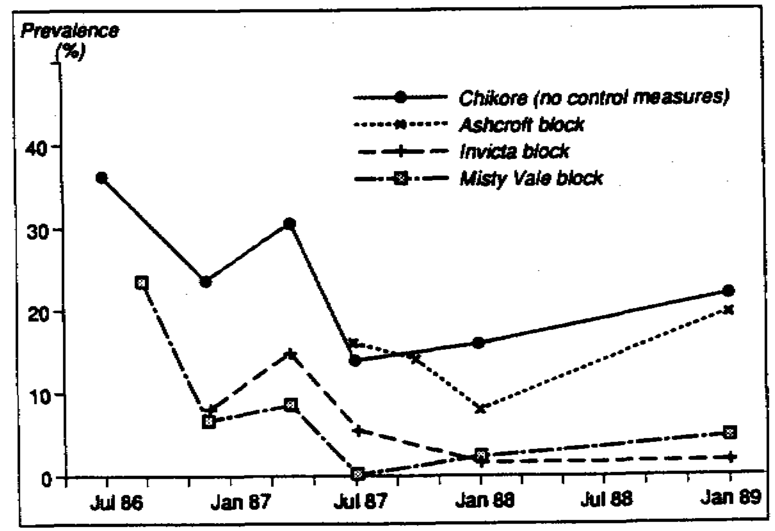
Appreciable numbers of snails were found in night-storage ponds. The lined canals and in-field structures of the redeveloped schemes remained free of aquatic snails. On the Chikore farm considerable numbers of snails were found at the in-field structures and in pools behind deteriorated canal linings (Chimbari *et al.* 1991).

Discussion and conclusion

The surveys indicate that control measures implemented at the settler irrigation schemes aimed at reduction of snails were effective. The high level of prevalence at the Ashcroft scheme, however, shows that this reduction is not enough to control transmission. The researchers suspect that high prevalence at Ashcroft is caused by its proximity to the main canal.

Another important factor is the availability of safe water supply. Although boreholes have been provided for the resettlement villages, their number is low (one per 40 to 50 households), pump breakdowns occasionally occur and users have expressed reluctance to wash clothes in the "hard" water.

FIGURE 14
Prevalence of *S. haematobium* in adults and non-school children (reproduced from Chimbari *et al.* 1991)



Equally important for the reduction of disease transmission is the availability and proper use of latrines.

Dr. Peter Bolton of Hydraulics Research, when addressing the Forum on performance of irrigated agriculture in Africa in Nairobi in January 1988 stated:

> "The most important conclusion which I have reached from my involvement in the Mushandike study is that, although physical measures can contribute towards reducing the transmission of schistosomiasis, the control of the disease can never be reduced to a set of physical criteria alone. Close cooperation with other disciplines is required together with a willingness to see engineering control measures as only one element within a combined strategy of disease control incorporating all the available methods of control at our disposal."

Annex 7

Itinerary of PEEM Zambezi Mission

08.01.94	Snellen from Wageningen to Nairobi
10.01.94	Chandiwana from Harare to Nairobi
12.01.94	Team from Nairobi to Maseru
14.01.94	Team from Maseru to Harare
21.01.94	Team from Harare to Victoria Falls
22.01.94	Team from Victoria Falls to Harare
23.01.94	Team from Harare to Lusaka
27.01.94	Team from Lusaka to Harare
01.02.94	Team from Harare to Maputo
04.02.94	Chandiwana from Maputo to Harare
	Snellen from Maputo to Wageningen

Annex 8

List of persons interviewed

United Nations Environmental Programme/UNEP, Nairobi, Kenya
Dr.Habib N.El-Habr, Programme Officer, Water & Lithosphere Unit
Dr.Walter Rast, Senior Programme Officer, Water & Lithosphere Unit
Mr.Backson Sibanda, Programme Officer, Follow-Up and Evaluation Section
Mrs.Elisabeth Khaka, Programme Officer, UNEP/WHO/UNESCO/WMO Programme on Global Water Quality Monitoring and Assessment
Mr. Lal Karukulasuriya, Programme Officer, Environmental Law and Institutions/ Programme Activities Centre

Southern Africa Development Community/SADC, Environment and Land Management Sector/ ELMS, Coordination Unit, Maseru, Lesotho
Professor Paul S.Maro, Technical Advisor
Mr.Osborne N.Sheila, Liaison Officer, Hydrology and Water Resources
Mr.Egil Skofteland, Water Resources Advisor
Mr.Eduardo A.Coelho, Information Officer

Zimbabwe
Dr.L.A. Arevshatian, WHO Representative
Mr.Kunene, Principal Environmental Officer, Department of Natural Resources
Mr.T.Chigudu, Deputy Secretary, National Planning Commission
Mr.Mawere, Planning Division, Department of Agricultural, Technical and Extension Services/AGRITEX
Dr.H.B.Williams, Department of Water Development, Ministry of Lands, Agriculture and Water Development
Mr.J.M.Makhado, Director AGRITEX
Mr.J.A.Stoutjesdijk, FAO/UNDP Programme of Technical Assistance to AGRITEX

Mr.Dennis Nkala, Programme Officer for Rural Development, UNDP
Mr.C.Charasika, Planning Officer, Agricultural and Rural Development Authority
Ms.Tabeth M.Chiuta, Wetlands Programme Co-ordinator, IUCN Regional Office for Southern Africa
Dr.Peggy L.Henderson, Health Programme Officer, UNICEF
Mrs.Therese Dooley, Project Officer on Water & Environmental Sanitation, UNICEF
Mr.B.Manyame, Health Project Officer, UNICEF
Dr.Peter Morgan, Chairman of Board of Trustees, The Mvuramanzi Trust for appropriate water supplies and sanitation in the rural and peri-urban areas of Zimbabwe.

Zambia
Mr.David Howells, Health Policy Adviser and Acting WHO Representative
Mr.Amos Muchanga, National Programme Officer, UNDP
Dr.Magan, Health Development Officer, UNICEF
Mrs.Justina Mapulanga, Project Officer, UNICEF
Mr.Alfred Sampule, Assistant Director, National Commission for Developmrent Planning
Mr.S.T.Kisanga, Chief Medical Inspector, Ministry of Health
Mr.Mpande, Dep.Chief Medical Inspector, Ministry of Health
Mr.Willie Shawa, Project Manager, Lusaka Water & Sewerage Co.
Mr.A.S.Murty, Senior Engineer, Zambezi River Authority
Mr.Imataa M.Akayombokwa, Chief Agricultural Specialist, Department of Agriculture, Ministry of Agriculture, Forestry, and Fisheries

Mozambique
Dr.Kabamba-Nkamany, WHO Representative
Mr.Evaristo Baquete, Head of Environmental Hygiene Department, Ministry of Health
Mr.Jose Henriques, Head of Sanitation and Water Sector, Environmental Hygiene Department, Ministry of Health
Dr.Miguel Aragon, Head of Immunology Unit, Ministry of Health
Eng.Antonio Cabral, Technical Officer, Unidade Technica Projecto Sabi-Incomati, State Secretariat for Agricultural Hydraulics/SEHA
Eng.Nelson Melo, Director for Hydraulic Technology, SEHA
Dr.Carlos Fidalgo, Permanent Secratary, Fund for Development of Agricultural Hydraulics/FDHA
Dr.Rui Gama Vaz, Director, National Institute of Health
Dr.Gerito Augusto Traquinho, Department of Parasitology, National Institute of Health
Eng.Pedro Cambula, Water Resources Department, National Directorate for Water DNA
Mrs.Lily Nomburo, Water Quality Section, DNA
Mrs.Cecilia Gjerdrum, Senior Programme Officer for Water, UNICEF
Dr.Peter Wurzel, Chief, Water & Sanitation Sector, UNICEF
Mr.Boudewin Mohr, Senior Programme Officer for Health, UNICEF
Dr.Glria M.Kodzwa, Programme Officer, Section Head Health and Nutrition, UNICEF
Mrs.Gitte Hundahl, Professional Officer on Water & Sanitation, UNDP

Annex 9

PEEM TECHNICAL DISCUSSION 1994

Incorporating human health component into integrated river basin development and management

Terms of Reference for River Basin Missions

Two fact-finding missions to international river basins are proposed in preparation for the technical discussion on the agenda of the 12th PEEM meeting (Aswan, 20-26 March, 1994): one to the Lower Mekong Basin, the other to the Zambezi Basin. This document contains the terms of reference for the mission to the Zambezi River Basin.

PURPOSE AND ACTIVITIES

The Zambezi River Basin mission will provide a case study to facilitate the Panel's discussion and formulation of outputs on the following issues identified as the objectives for the technical discussion 1994.

1. To review current water sector policies, including water allocation among sectors, and their impact on human health.

2. To devise mechanisms for national and local capacity-building to facilitate the incorporation of health safeguards in river basin development.

3. To evaluate tools for the assessment, surveillance and monitoring of health risk factors in the planning, development and management of river basins.

4. To define appropriate environmental management measures, for implementation at river basin level, which consider water availability, water quality, disease vector habitats and disease transmission potential.

5. To develop strategies to promote people's participation in all phases of project development and management, as a basis for sustainability.

The scope of the following listed field activities encompasses a comprehensive investigation of the existing and potential health status of populations within the framework of a major river basin management system. It is fully recognized that constraints of time and data availability are unlikely to permit so comprehensive a study. The mission, as soon as possible after arrival in their region, is therefore asked to make an initial estimate of those aspects considered to require major attention and emphasis in its studies and reports, while covering the other aspects at whatever depth is feasible.

The mission will carry out an assessment of human health status within the basin, with particular reference to the identification of areas of actual or potential health risks and of vulnerable groups of the population in relation to the development or management of basin resources and to any associated impacts on the environment, the economic or social conditions, including employment, settlements and supporting services.

The above studies will be complemented by simultaneous investigations into the current and projected status of river basin development and management, including policies and mechanisms for sectoral and intersectoral cooperation in development, and the integration of practices and facilities for the management of basin resources of land, water etc. These two components of the mission will combine to define the areas of present and future concern and needs for community health activities, and will indicate opportunities for health protection and improvement within the context of river basin plans and programmes.

The existence of, and the requirements for institutional arrangements relating resource development to health, and for capacity-building to ensure the functioning of these, will form an element of the investigation, as also will the assessment of the adequacy and needs for promoting the informed participation of the affected populations. This will call for a review of current health surveillance practices and a review of measures and procedures for monitoring river basin resources and the effects of their development and management. The mission should consider and report on means for integrating health indicators within these monitoring and surveillance procedures. Measures designed primarily for the protection of the environment against damage and degradation resulting from basin resource development should be studied for their potential benefit, or otherwise, in protecting or improving community health.

The mission will make a broad review of economic, fiscal and social policies governing, guiding or influencing the development and management of the river basin at various levels (e.g. international, national, sectoral, urban, rural). Plans and proposals for the protection and promotion of the health of the community will be reviewed in relation to potential environmental, social and economic impacts arising from decisions or changes in such overall policies.

The Zambezi mission will submit its report to the PEEM Secretariat within one month of completing field activities. The report will be aimed primarily at the provision of factual material in relation to objectives 1 to 5 listed above, but it should also contribute to the formulation of policies, strategies or technical measures which may enhance existing or projected plans for the development and management of resources in the river basin.