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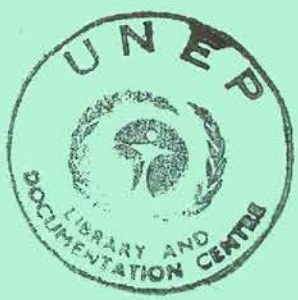
Report of the Data-definition Workshop: Part of the Zambezi Basin Water Resources Sustainability Assessment Case Study

16 - 18 January, 1995, Lilongwe, Malawi



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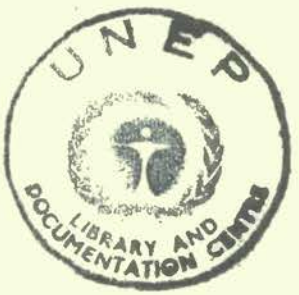

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Environment Assessment Programme
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REPORT ON THE MEETING

REPORT ON ZAMBEZI DATA SELECTION AND DEFINITION WORKSHOP
Lilongwe, Malawi, 16-18 January 1995

1. PURPOSE OF THE MEETING

1.1 The meeting was convened by the United Nations Environment Programme (UNEP) and the Southern African Development Community (SADC), to contribute to the production of a sustainability assessment of freshwater use throughout the Zambezi-basin. This assessment is part of the UNEP/GEMS-Water Programme and UNEP / Environment
Assessment Programme, and will contribute to the implementation of ZACPLAN by the SADC / Environment and Land Management Sector.

1.2 With this assessment SADC-ELMS aims to arrive at a more informed position to set priorities for the next Sector studies, as part of ZACPROs 5 and 6.
UNEP is engaged in the production of a global assessment of the sustainability of the use of freshwater resources. To facilitate countries in reporting on this topic a framework-methodology is proposed for integrated assessments on the river basin scale: the Zambezi river and the Pearl river in China will serve as illustrative case-studies for the application of this framework.

1.3 Purpose of the meeting was:

1- To identify and analyze the most important aspects regarding the links between the sectors of the societies within the Zambezi basin and the basins' freshwater resources;
2- To gather basic information on these aspects concerning the resources' past present and near future status, as described in (inter-)national (planning) documents (on land-use / forestry / agriculture, population, industry, (hydro-)power generation, ecosystems, recreation, etc), including standards.

1.4 This meeting is aimed at completion of the first three steps of the aforementioned framework methodology for integrated assessment of freshwater resources on the river basin scale, proposed to UNEP[1].
A second workshop will be necessary to explore future developments, identify sustainability problems, design and select strategies and policies to address sustainability flaws in development.

2. ORGANIZATION OF THE MEETING

2.1 FORMAT AND PROCEDURES

2.1.1 The meeting was held from 16 to 18 January, 1995, at the Capital Hotel, in Lilongwe, Malawi. It was attended by 14 experts from the Zambezi-region, invited in their personal capacity, and representatives of UNEP and SADC-ELMS. The list of participants is enclosed (annex 1).

2.1.2 The meeting was opened by Mr. Osborne Shela, SADC-ELMS, who welcomed participants and explained the interests of SADC in this joint endeavor. Mr. Gerhard Schneider, representative of UNEP, related the present initiative to UNEPs' past and future cooperation with the Zambezi-region (annex 2).

2.1.3 Mr. Shela was elected chairman of the workshop, Mr. Schneider co-chairman. The chairman proposed to discuss the meetings' *format and procedures*, and *context and aims* after presentations of the organizers' proposals for these.

2.1.4 The necessity of this meeting was questioned, given the recent SADC-workshop on *'Integrated water resources management plan for the Zambezi river basin'*, held in Livingstone, Zambia, May 2-6, 1994. Participants then drafted country reports on freshwater resources. Although these reports will be made available to UNEP for inclusion in present assessment exercise, the need for current meeting still remains, as specific information needs will follow from (discussing) the integrated assessment framework, and its supporting models.

2.1.5 The meeting accepted the proposed schedule (annex 3). Participants agreed to take part in the reporting of results of parallel sessions. Along the way the schedule of the meeting was adapted to allow for time required for supporting financial/organizational efforts. The meeting report will include results of discussions, following the topics of the meetings' schedule.
It was noted that some participants felt disadvantaged by not having received preparatory documentation in time for the meeting.

2.2 INTRODUCTORY PRESENTATIONS

2.2.6 Mr. Bert Bannink presented *the 5-step framework methodology* for assessment of the sustainability of the different uses of freshwater resources by the sectors of society in a given river basin. He emphasized the experimental nature of preparing a bottom-up, rapid overview in this pilot-assessment, using a workshop-based approach, and thanked participants for appreciating this challenge. Participants were invited to enter existing models from the region, to be included in support of this assessment exercise.

2.2.7 After discussing the *present major issues* and *future developments* regarding the freshwater resources of the Zambezi basin, Mr Arjen Hoekstra presented the water policy support model *AQUA*, and the indicators that result from AQUA application. Mr. Ton de Nijs introduced *water quality modules* to be included in AQUA if needed. Each module addresses a specific water quality topic.

3. INTRODUCTION TO THE ZAMBEZI WATER RESOURCES

3.1 PRESENT MAJOR ISSUES IN THE ZAMBEZI RIVER BASIN (Figures 1, 1a, 5)

Parallel session 1A:

3.1.1 WATER AVAILABILITY

Water is a constraint for development in most SADC countries. For example, the Luangwa river in Zambia used to be a perennial river and is presently seasonal as a result of deforestation activities in the upper catchment.

Domestic water supply is limited. In Zimbabwe water rationing already became practice in some cities. Water shortage is considered an issue of national concern, as well as of importance for sectors.

3.1.2 Priorities on water use

There is need to set priorities on water use among and within sectors of society (mining, industry, communities, tourism). At the same time, there is need for consideration for water users located downstream, both in terms of water quality and quantity.
In conclusion: priority setting should be considered at all three levels (i.e regional, national and sectoral.

3.1.3 Conflicts over shared water resources

In most regions water resources are shared by several countries. Friction over shared water is easily generated: between countries and within countries between users and/or sectoral interests such as ecology and engineering. Friction between states may well lead to future conflicts.

3.1.4 Public awareness and education

Public awareness is generally absent, and there is a lack of education on the issue of environmental degradation, particularly where water resources are concerned. There is therefore a need for public awareness education at regional and national level. Policy makers too should be made more aware of the importance of water-resources in national and regional policy and management.

3.1.5 Pollution and environmental degradation

Various forms of pollution exist in the water resources of the Zambezi basin: siltation, salinization, persistent blooms of aquatic weeds, biological contamination (=introduction of foreign species), use of pesticides and fertilizers, and discharges of industrial and communal effluent around major cities.
Highest levels of pollution from these sources were observed in the Kafue (Zambia) and the Manyami (Zimbabwe), Lower Shire (Malawi).
There is little information on the availability of groundwater in member states, so it is hardly possible to state the level of pollution of groundwater.

3.1.6 Land use changes/deforestation

This issue is of growing concern for countries like Zambia, Zimbabwe and Malawi.
Deforestation was judged to be caused by poverty and over population (high population growth rate). Poverty is seen as the main driver, it forces the population to cut down trees for firewood, for sale or to farm on marginal lands.Uncontrolled human settlements are noted in some parts of the basin, e.g. Zimbambwe, Malawi, Angola.

3.1.7 Poverty and population growth

Poverty and high population growth are the driving forces towards environmental degradation. This issue too should be addressed at both regional and national levels.

3.1.8 Legislation and enforcement

There generally is inadequate legislation and enforcement capabilities among the member states. Therefore there is need to strengthen the existing legislation and enforcement capabilities to protect the environment.
At regional level, there is presently no legislation. However, it has been noted that a protocol on shared water will (hopefully) soon be signed by SADC member states.

3.1.9 Lack of integrating mechanisms

There seems to be no water resources related integrating mechanism among member states, nor within the individual states for decision making regarding planning, management and development. On both levels (national and regional), therefore, there is strong need for such an integrating mechanism.

3.1.10 Institutional framework

It was generally recognized that in order to effectively manage the water resources within the region, an institutional framework must be put in place, to take up the responsibility of managing the fresh water resources of the Zambezi basin.
This institutional framework should be activated at a regional level.

3.1.11 Monitoring

Monitoring and regular assessment of water resources' availability and utilization was considered essential. Monitoring should not be limited to water quality and quantity, but should include the environment (i.e ecological parameters). This activity should also be implemented at regional level.

3.2 FUTURE DEVELOPMENTS IN THE ZAMBEZI RIVER BASIN

Parallel session 1B.

Future problems and issues have been identified while discussing the main eight sectors:

3.2.1 Agriculture

Recent recurring droughts have forced riparian states to introduce more elaborate irrigation programs, thereby increasing pressure on water resources. The rise in population also increases the pressure on land use and water use, particularly water quality.
The meeting agreed that within the Zambezi there is no problem related to population pressure at the moment, but problems result from poverty and uneven population distribution. Further pressures on water availability can follow if water transfers to out-basin areas are introduced.
The introduction of pesticides and insecticides into the Zambezi basin waters may in some parts be, or grow into a problem.

3.2.2 Domestic water supply and sanitation

Mozambique, the most downstream country in the Zambezi-basin, mentioned concern for the water quality of the Zambezi river. Botswana is mainly concerned about water quality, limited more and more by the growing basins' population, as the only additional source of water for Botswana is found at the Northern perimeter (ergo along the Zambezi).
The meeting again stressed, that integrated planning at regional level is required in order to tackle the above problems. Water resource managers are awaiting the proposed protocol to be signed by riparian states.

3.2.3 Industry and mining

Zambia experiences a water quality problem in the Kafue river, arising from discharges of mining effluents. The risks related to the presence of heavy metals in the Zambezi system has not yet been assessed yet. The trend towards more small scale industry and mining, away from only selling raw materials, but in the absence of an apt legal framework has introduced problems of pollution, due to poor effluent treatment technology. Also the technology to clean polluted environments is lacking.

The meeting agreed that there is need to introduce (a system or) legislation to implement the 'polluter pays principle'.

3.2.4 POWER GENERATION

The meeting commended efforts in power pooling at the regional level. This will be achieved by merging national grids into a regional one.

The meeting noted that drought could limit power generation capacity, especially if a regional grid is not fully developed. The meeting therefore proposed that Hydro Electric Power should be developed only at the most economical points.

The meeting deemed it necessary to approach countries outside SADC, eg Zaire for power sharing.

3.2.5 FISHERIES

There is need for sustainable management of fish resources. Current problems in fisheries are related to over-exploitation of the fish. Problems also related to flow characteristics from artificial reservoirs, which are mainly developed only for HEP generation.

3.2.6 TRANSPORT

Malawi presented the current and future problems on Lake Malawi:

Present harbors were designed to operate at much higher water levels, than the current ones. Ongoing energy production during drought conditions will increasingly aggravate problems related to low water levels, as the efficiency of power production drops with the water level. Frequently problems result from conflicting interests between transport and hydro-power, irrigation and fisheries in the Shire River, which drains Lake Malawi.

3.2.7 RECREATION AND TOURISM

The meeting recognized potential environmental impacts on the water resources as a result of further development of tourism and recreation.

3.2.8 ENVIRONMENTAL IMPACTS

Bio-diversity is high in the Zambezi and if the water quality deteriorates, it could be irreparably reduced. The meeting noted the need for an Environment Impact Legislation at basin and regional level.

4. STEP 1: SETTING THE SCENE

4.1 HYDROLOGICAL CHARACTERIZATION OF THE ZAMBEZI RIVER BASIN

Parallel session 2A:

4.1.1 DETERMINATION OF RIVER BASIN BOUNDARIES

These boundaries are clearly defined, except for the boundary with the Okawango Basin. There appears to be some exchange of surface and ground water between the two systems depending on their respective water levels.

4.1.2 GEO-MORPHOLOGICAL FEATURES

No full longitudinal profile from source to the mouth is currently available. However, the Zambezi River Authority provided a profile covering the area between Kasungula and the river mouth, showing existing and potential hydroelectric dam sites. Geo-morphological features including river bed and dimensions, may be found in Hydrological Yearbooks

which can be found in the respective governmental departments. Little seems to be known about and geo-morphological changes, as river channel and delta erosion, that resulted from the construction of hydraulic structures as the Geo-morphological and Cahora-Bassa Dams (potential for future studies).

4.1.3 RAINFALL PATTERNS AND EVAPO-TRANSPIRATION

Information on rainfall and evaporation in the basin is available at SADC ELMS, where hydro-meteorological data is being collected on a regional basis. The coverage of the network, is satisfactory, apart from lack of data from Angola due to war conditions.

4.1.4 SURFACE WATER

The flow of surface water regime was presented, using examples of typical hydrographic from selected stations. It was observed that hydrographs largely follow the hydrological year, with a significant base flow in the Zambezi river during the dry season. The extent of discharge from groundwater is not fully understood, neither the characteristics of the subsoil.

4.1.5 TIDAL/COASTAL IMPACTS

Due to the effect of dams constructed upstream, the flash erosive nature of the flow reaching the delta reduced, thereby increasing mineral deposits in channels, and increasing salt intrusion. These impacts are restricted to Mozambique. The construction of hydraulic structures have reduced flooding of rivers, reducing their peak flows.

4.1.6 ASSESSMENT OF RENEWABLE FRESH WATER RESOURCES

These assessments are already included in the existing Water Resources Master plans for countries such as Botswana, Tanzania & Malawi. Other countries in the region have yet to formulate such Water Master Plans and will include these assessments later.

4.2 HYDRO-CHEMICAL CHARACTERIZATION OF SURFACE AND GROUNDWATER IN THE ZAMBEZI RIVER BASIN

Parallel session 2B:

4.2.1 NATURAL COMPOSITION (REFERENCE STATE)

There is lack of data on the natural composition of both surface an groundwater. In most cases measurements of water quality parameters are only taken when problems arise. Therefore the approach was taken to identify problem areas. After identification of these regions which have not undergone major changes due to anthropogenic influences :- the rivers are believed to still possess a close to natural chemical composition.

4.2.2 DEFINITION OF PROBLEM AREAS

Problem areas we identified to be related to:

(i) Mining
(ii) Cities and Industries
(iii) Agriculture
(iv) Fertilizer and Oil Refinery Plants.

Figure 1 shows the matching geographical areas.

(i) Mining

The major mining areas comprise of the Copper belt region in Zambia and the Great Dyke in Zimbabwe. More information on mining is given in the SADC report entitled "*Environmental effects of mining in the SADC region*"[2] and in the research report "*The*

effect of mining activities on the water quality in the Kafue river copper belt, Zambia"[3].

(ii) Cities/towns and Industries.
The following cities/town areas are significant sources of both surface and groundwater contamination by sewage and industrial effluents:

(a) towns and cities along the railway lines in Zambia.
(b) towns and cities along the railway line from Bulawayo to Harare, and also towns near Victoria Falls and lake Kariba in Zimbabwe.
(c) Tete in Mozambique.
(d) Lilongwe and Blantyre in Malawi.

(iii) Agricultural areas.
The agricultural areas taken into account are those where fertilizer use is quite significant. Two main areas in Zambia were pointed out:

(a) the Mkushi area and
(b) the Central and Southern part of Zambia.

In Zimbabwe, the Mazowe, the Manyame and the upper Sanyabi river catchments were identified as nutrient enriched agricultural areas.

(iv) Fertilizer and Oil Refinery Plants.
The fertilizer plant in Zambia is located in Kafue, the oil refinery plant in Ndola. There are also fertilizer plants located in Harare and in Kwekwe.
(v) Location of non-anthropogenic influenced areas.
The resulting areas of no human influence are situated in the upper Zambezi region, upstream of Victoria Falls, the Upper region of Malawi and North Eastern Zambia, including the Luangwa Valley.

Information on water quality studies in these area, both on surface and groundwater, can be accessed through the departments of Water of Zambia and Zimbabwe.

4.3 HYDRO-BIOLOGICAL CHARACTERISTICS OF THE ZAMBEZI RIVER BASIN

Parallel session 2C:

The following (hydro)biological areas we discerned within the Zambezi River Basin: (see also Figure 2):

LUENA/ZAMBEZI (ANGOLA-ZAMBIA BORDER)
This area is a strong riverine system,with fast flowing clear waters. (for species composition refer to *Directory of African Wetlands*[4]).

ZAMBEZI/LUNGOE-BUNGA SYSTEM (BAROTSE FLOOD PLAIN)
Swampy grasslands with seasonal flooding and stagnant pools. The floodplain is dominated by aquatic macro-phytes. The area is a habitat for a variety of migratory birds, e.g. cranes, and wildlife such as hippos, wildebeest, crocodiles etc.

SIAMA FALL TO DEVILS GORGE
Riverine with fast slowing water and numerous rapids. The area is dominated by riparian vegetation.

LAKE GEMOLOGICAL
A man-made lake system, dominated by pelagic species, e.g Kapeute.

GEMOLOGICAL - CAHORA BASSA
Riverine system with slow lowing water, and a few pools.

CAHORA BASSA
A man-made lacustrine system, dominated by pelagic species.

LOWER ZAMBEZI
Riverine system with slow flowing water; highly turbid.

ZAMBEZI DELTA
Deltaic system with brackish water, dominated by swampy areas and mangrove system.

LAKE MALAWI/NIASA
A natural lacustrine system belonging to the old rift valley, dominated by pelagic species and cychlides.

SHIRE RIVER
A riverine/marsh system with rapids, dominated by hippos & crocodiles.

LUANGWA RIVER
Typical riverine with a very high silt load.

KAFUE RIVER
(a) The upper Kafue is a riverine system with swamps. The area is highly contaminated with heavy metals.
(b) Lake Itezhitezhi: A small man-made lacustrin system
(c) Kafue Flats: A seasonally flooded floodplain dominated by aquatic macro-phytes and lechwe *(capus kafuences)*.
(d) Kafue Gorge Reservoir: A small man-made lacustrine system; mainly cychlides.
(e) Lower Kafue: very steep & fast flowing riverine system.

CUADO/LINYATI/CHOBE SYSTEM
Flood plain with scattered aquatic macro-phytes.

4.4 GROUNDWATER WITHIN THE ZAMBEZI RIVER BASIN

Parallel session 2D:

4.4.1 GROUNDWATER USE

Generally, there seems to be a preference for the use of surface water for all purposes. However, for public water supply, ground water is used if
(a) there is not enough surface water. Examples:
- Bulawayo-area (Zimbabwe): 20-25% withdrawal from ground water
- Major cities, e.g Lusaka: 50% public water supply from ground water

(b) the quality of the surface water is insufficient.

Also important are the groundwater withdrawals in mining areas, e.g. copper belt Zambia (Kabwe): 7.5 m3/s groundwater withdrawal, discharged into the Kafue river.
Little is known about private groundwater withdrawals. There are probably concentrated in rural areas and consist of shallow wells and boreholes.

4.4.2 GROUNDWATER TABLE DECLINE PROBLEMS

major cities - Lusaka, monitored since 1993

mining areas - Copper belt Zambia between 1972-1979: 12m decline

4.4.3 GROUNDWATER QUALITY PROBLEMS

The following potential groundwater problems were identified:

- salinity (natural) - Zambia, but apart from Mozambique not in Zambezi Basin
- fluor (natural) - Tanzania/Kenya, not in Zambezi Basin
- salt intrusion only near the coast - Mozambique.
- heavy metals - Copper belt Zambia stressing the need for careful planning of dumping sites, mines.
- pesticides - no problems reported
- bacteriological pollution connected to major cities

4.4.4 CONCLUSIONS ON GROUND WATER VULNERABILITY

There seems to be exploitation now, except by the major cities and the copper belt area in Zambia.

The use of ground water may well increase in the near future. Info on current rates and on sustainable limits of groundwater withdrawal is scarce.

In Zambezi region, no major groundwater quality deterioration has been reported yet.

5. STEP 2 - PRESSURES

5.1 MINING, INDUSTRY AND ENERGY

Parallel Session 3A

This section identifies sources of pressure arising from mining, industry and energy production on the water systems of the Zambezi Basin. (Partly shown in Figure 3)

5.1.1 MINING

Pressures from mining were identified as follows:

- Emissions of dissolved and particulate metals in the effluents from mines, metallurgical and refinery process plants.
- Water spillage from tailings dams, which may contain high concentrations of acidic compounds.
- Sulphide/heavy metals emissions to the air from metal smelters.
- Groundwater depletion for mining itself and by pumping water from aquifers (mine drainage). Groundwater extraction lowers the groundwater table and may well cause problems for community water supply and vegetation.
- Mercury/cyanide emissions both to air and water from small scale mining.

It was noted that there is no quantitative data on emissions to both surface and groundwater, and air. However, emissions may be related to production figures, as given in Annex 4.

Mining activities are expected to increase as a result of changing investment policies in the SADC region and the provision of good incentives to investors. The marketing efforts of mining projects in the region are on the upswing (e.g SADC Mining Investment Forum, 7 - 9 December, 1994, Lusaka, Zambia).

With emerging peace scenario in Mozambique it is expected new mines will be opened and developed.

5.1.2 INDUSTRY

Pressures from industry on the water system of the Zambezi basin ensue from the following industrial activities:

- Fertilizer plants (see also chapter 4.2, hydro-chemical characterization of surface and groundwater)
- Oil refineries in Zambia (Ndola), and Zimbabwe (Harare).
- Dairy plants in the Bulawayo-Harare region.
- Sugar refineries (molasses emission) in Mazabuka, Zambia, and Malawi.
- Saw mills e.g. Mulabezi in Zambia and in Malawi.
- Steel mill in Zimbabwe at Red Cliff.

An increase in water availability in the Zambezi basin will positively impact on the growth of agriculture, which in turn may give rise to the growth of most of these industries.

5.1.3 ENERGY

Pressures arising from the energy sector result from hydropower production and power plants fueled by coal and oil. These are as follows:

(i) Hydropower dams are expected to:

- directly affect ecosystems: the imposition of the transition from terrestrial to aquatic systems.
- develop changed hydrology, lower peak flows, and increase base flows.
- undermine mangrove ecosystems and the shrimp population in the delta of the Zambezi.

(ii) Coal and Oil Energy Plants (including the use of coal smelters)

- emission of dusts, containing heavy metals and sulphide compounds

Growth in energy supply is expected to increase given the following future developments.

- Extra hydropower dams are planned downstream of Cahora Bassa and downstream of the Victoria Falls, where feasibility studies have been done;
- One extra planned dam downstream of the Kafue river;
- Dams earmarked for construction on tributaries of the Zambezi river,
- New coal burning plants planned in Zimbabwe.

5.2 AGRICULTURE, FISHERIES AND DOMESTIC WATER SUPPLY & SANITATION

Parallel session 3B

The relative extent of pressures from these sectors are presented in overview table 1, included at the end of this section. (See also Figure 3)

5.2.1 AGRICULTURE

The agricultural sector relates in different ways to the water resources in the Zambezi basin:

Gravity Irrigation. Present irrigation schemes exist in Kafue; Sinazongwe cotton plantations (L. Kariba); Sucoma/Dwangwa sugar plantations in Malawi; Kapriri strip, also sugar plantations.

Evidence of pesticide pollution has been found in some of these places (source of information: LKR- Station).

Pumped Irrigation. In general, water demand for pumped irrigation is higher than for gravity driven irrigation. In Zimbabwe demand by pumped irrigation is medium.

Livestock. Water is hardly contaminated by livestock (negligible).

Deforestation implies loss of ground cover, contributing to excessive surface run-off, soil

erosion, siltation of rivers, reduced recharge of groundwater. Some rivers, once perennial, dry up occasionally and become seasonal.

Water demand for agricultural is quite high in Zimbabwe. The problem of salinization in the area is minimal. Where irrigation is abandoned, it is due to mis-management of irrigation systems.
If food production has to be increased, there will be need for upgraded or additional irrigation systems, since otherwise most water from major rivers will be wasted. This of course implies building dams to create reservoirs for further extraction of water for irrigation, in addition to enhanced direct pumping from the rivers.

5.2.2 FISHERIES:
The way this sector relates to the basins' freshwater resources varies depends on the type of fisheries performed:
Capture Fisheries. The main threat of course is over-fishing, e.g. Kapenta on Lake Kariba; In the upper Zambezi some over-fishing is noticeable, and there is locally some over-fishing in Southern Lake Malawi.
Fish Farming is increasingly encouraged in the region to supplement catches from capture fisheries in Zambia, Malawi and Zimbabwe. If water from fish farms is returned to the surface water systems, fish farming will have an impact on these water systems due to nutrient enrichment, with possible negative eutrophication effects.
Recreational Fishing. The impact here remains limited to pollution of the surrounding area, by empty cans, etc.
Ornamental Fishing The only need for legislation here derives from the general desire to prevent over-fishing.

Table 1. Pressures from the sectors Agriculture, Fisheries and Domestic Water Supply on the freshwater resources of the Zambezi river basin/

SECTOR	DEMAND Surface Water H M L	ON Ground Water H M L	IMPACT ON Surface Water H M L	Ground Water H M L
Agriculture/Land use:				
Gravity Irrigation	X		X	X
Pumped Irrigation	X		X	
Livestock	X			
Deforestation			X	
Fisheries:				
Capture fishing				
Fish farming	X	X	X	
Recreational fishing				
Ornamental fishing				
Domestic Water Supply:	X	X	X	

5.2.3 Domestic Water Supply

Domestic demand for proper drinking water is generally high. The domestic water supply mainly uses surface waters for raw material; the demand for groundwater as source is still medium.

The level of instalment of operational sewage treatment plants is low throughout the basin. Regulations guiding treatment may exist, but enforcement is the problem. Although impacts of untreated sewage discharges is substantial, they remain localized around big cities.

5.3. TRANSPORT & RECREATION

Parallel session 3C

5.3.1 PRESSURES FROM RIVER-TRANSPORT.

Pressures are to be reviewed at the regional, national and local level. First question to be answered is where navigation is regarded possible and/or important. In the Zambezi basin eight such areas were distinguished (table 2, and depicted in figure 4).

Some pressures from the transport sector onto the water resources are related to the

Table 2. Navigable areas within the Zambezi basin.

Name	Pressures from demands related to type of boats / shipping (for codes: see table 3)	Type of Pressures (for codes: see table 4)
Lake Malawi	a / e; level: 475m +/- 1m, 1m clearance	1
Shire River	b + d	7 (option)
Lower Zambezi: - Tete =>Rapids - Confluence S.R. => Sea	(Alternative for Railroad) (Alternative Tete Inland Port)	7 (option)
Cahora Bassa	d (+ b + e)	
Kariba	d (+ b + e)	
Kafue Flats	a + b + e	
Upstream Vic. Falls	d + e	
Upper Zambezi (Barotse Plains)	d + e	7 (option) + 5

Table 3. Types of shipping

Types of Shipping / Boats	
a.	Ferries / Passenger Ships
b.	Fishing Boats
c.	Freighters
d.	Motor Boats / Commercial Boats / Recreation Boats
e.	Traditional

requirements of this sector for water management, f.i. those related to level control, flow control as a result of navigability demands, as keel-clearance (draft) or current patterns.The degrees of freedom of quantitative water management becomes restricted through these requirements.
Since the pressures on the water resources from the transport sector are related to the requirements of apparent shipping, the type of frequent shipping is of importance. Five types of shipping and related different pressures (and demands) are noted (See also tables 3 and 4).

Table 4. Types of Pressures on Water Resources

Types of Pressures	Where? (codes refer to II-2-2)
1. Level Control Related	Lakes, Weir ed Rivers
2. Pollution	At (a + d)-locations: a + d
3. Disturbance	d
4. Dredging / Harbor Facilities	a + c
5. Clearing of Weeds	River Channels, Flood Plains
6. (Hazard of) Accidental Spills	a + c (Cross Ferries)
7. Channelization / Groins, Weirs, Locks	

A distinct example of hazards of accidental spills are the Kazungula cross-ferries: at this point traffic meets at this four country-point, crossing North-South the Zambezi river. Definite risks exist with far ranging effects. if a truck-load of pesticides or other chemicals were to end up in the river following a ferry accident. (A major bridge is considered to be constructed here).

5.3.2 PRESSURES FROM RECREATION.
Recreation exerts pressures on specific characteristics and values of the water resources within the basin. An summary overview is given in table 5.

Table 5 Pressures resulting from recreation / tourism.

Pressure from recreation	Resource characteristic affected
Noise / Disturbance on / around surface waters	Wild life
Increased demand for: - drinking water supply and sanitation (DWWS) - fire wood	To stress: - available installations for public DWSS - increased deforestation-effects
Introduction of unfamiliar species / weeds	- Species diversity, ecological stability - Waterways management
Game-park management, aimed at concentrating big mammals at water points	Concentration (and therefore augmentation) of damage done to present eco-systems
National parks coincide with wetlands	Wetlands eco-systems
Concentrations of people	Increased risks for: - Eutrophication - Water borne diseases

6. STEP 2 - REQUIREMENTS

6.1 ECOLOGY REQUIREMENTS

The Amoeba-approach (figure 6.1) was proposed: it could work in the Zambezi basin, to demonstrate and illustrate changes resulting from human activities, provided the data could be found. Data problems result a.o. from data taken away from the region after completion of (temporary) research projects carried out by scientists from developed countries. Therefore cooperation with local institutions / universities is necessary, and should become mandatory ('code of conduct'?). UNESCO might assist in promoting such conduct.

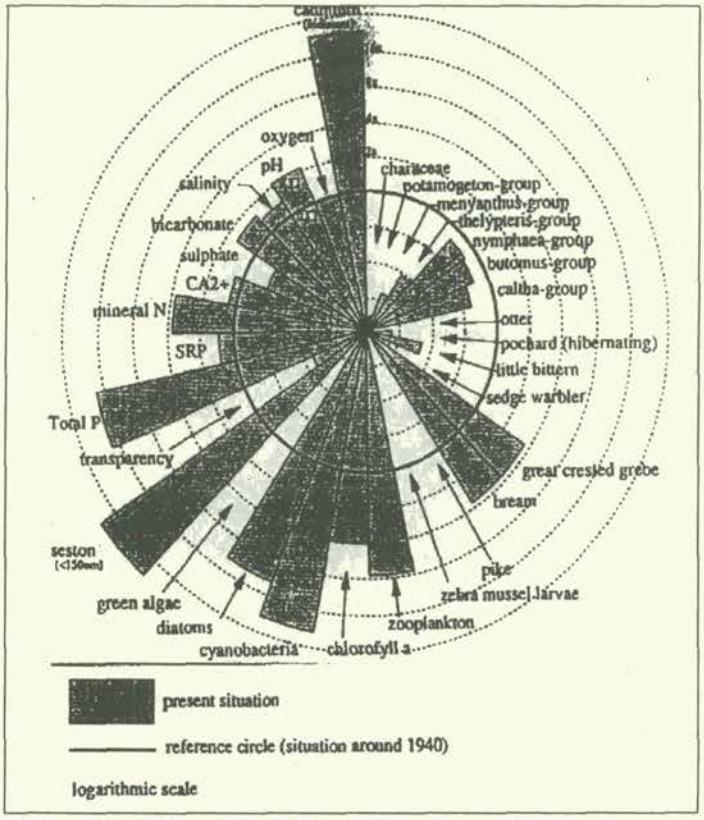

Figure 6.1 The AMOEBA radar plot, relating a current situation to a (past) reference.

The day-to-day operational regulation of power dams does not take ecological requirements into consideration. This is partly due to absence of clear and implementable ecological requirements, partly due to the fact that energy interests take priority over ecological considerations. Anadromous fish (as salmon) lay their eggs upstream. In order for a river to contain such fish, limits are set to flow rates and turbidity, and free passage is required (or fish-ladders, as required by law in Malawi). Of course rivers should be perennial. However most rivers in the region (Zimbabwe) are seasonal, and therefore contain no fish. Some rivers became seasonal because of increased demand for water.

6.2 MINERAL EXTRACTION

The mines require large amounts of water (See ref 2 and 3); they will be required to supply water to communities. Mineral extraction has no major requirements for the quality of the freshwater resources.
Gold panning in Zimbabwe should be brought under the law, so that water quality demands can be included in permits to be issued.

6.3 AGRICULTURE

The Agriculture Departments of the Zambezi countries should be visited to receive particulars on present and projected future agricultural water demands. The use of DDT in the basin still is a problem, although the use of DDT is now banned in all riparian countries. Elevated concentrations of DDT are found in Lake Kariba. In the Okavango impacts of DDT on fish have been reported.

6.4 POWER GENERATION

Siltation of reservoirs a problem, so power generation poses minimum silt load requirements to in flowing river water. Consequently, good land use practices upstream reservoirs is required.

Plans exist for a new large dam on Sonyale (Synijatte?) river in Zimbabwe. Implementation will have an influence on the Zambezi too.
Impact studies are presently going on for Lake Kariba; environmental nor social considerations are included in operational management of Kariba and Kafue dams: its main aim remains energy production.
A recent study (Institute of Hydrology) was made on the water balance of Lake Malawi: effects of deforestation are apparent. 100% forest cover in the Lake Malawi area would lead to reduced lake levels. Presently high water levels are controlled by the hydro power generation in the Shire river.

6.5 WATER SUPPLY AND SANITATION
Is health affected by the Zambezi Water Irrigation Project? The project will cause a concentration of people, but will it also increase bilharzia and malaria? In Zimbabwe, in new projects, irrigation canals are emptied regularly (daily) to prevent bilharzia. Information and sources are obtainable from Mr. Makadho. Also the Water Decade Reports and UNICEF should give sufficient documentation on drinking water supply coverage.

6.6 INDUSTRY
The paper & pulp industry will certainly be associated with organo-chlorine loads in effluents.

6.7 OTHER SECTORS
No requirements were suggested for the remaining sectors: Fisheries, Transport and Recreation.

7. STEP 3 - SYSTEM IDENTIFICATION AND SELECTION

7.1 SPATIAL SCALES; PARAMETERS & INDICATORS.

7.1.1 Discussions on 'system identification and selection', the third step in the assessment process, were not substantially held. The workshop apparently showed itself not a suitable format to define the mathematical set up of relationships. Some general comments were made instead, and it was expected that proposed sets of relationships could better be discussed on later occasions.

7.1.2 For this rapid assessment the same sub-basin division as in ZACPRO 6 should be used if possible (Spatial Scales).

7.1.3 Also, if possible, biological indicators should be used to describe eutrophication (Parameters). A SADC/UK-study (3½ years)into the present species composition of Lake Malawi is mentioned. It is feared that new species have already been irreversibly introduced. In Lake Kariba *Salvinia spp.* are studied in relation to eutrophication (the Lake Kariba Research Station). The Environmental Council of Zambia recently completed a study on weeds (water hyacinth) in smaller water, upstream of Lake Kafue.

7.1.4 Chemical data should be available from areas where chemical pollution is well known, examples:Kafue River (Lake Malawi, Lake Kariba).

7.1.5 It is regarded important to pay attention to suspended silt loads.

7.2 POLICY OPTIONS / IMPOSSIBILITIES.

7.2.1 Which policy options should be prepared for the next workshop; which stumbling blocks are expected to be presently in the way to a sustainable development for the river basin.

7.2.2 For 'stumbling blocks' one is referred to para 3.1.

7.2.3 It was recommended that a few example-policies, prepared in advance, could be presented. It would be better, that while inviting participants to the workshop, participants are requested to produce suggestions for policy options they would like to see discussed at the workshop.

7.2.4 In general one could think of
- Policy options to increase supply
- Policy options to decrease demand
- Deforestation/afforestation

7.2.5 In Zimbabwe, f.e.the water policy sets priorities for water being supplied to:
1. Municipal use for drinking water
2. Mining and industry
3. Agriculture

7.2.6 Water use efficiency should be increased. Recycled water is used in Harare. Bulawayo does not want water to be recycled, but wants its needed water to come from the Zambezi.

7.2.7 Inter-basin transfer of water is being discussed: from the Zambezi basin to RSA and Gaborone. It is in principle possible for countries where two basins meet to consider inter-basin water transfer as a national option. For instance Zambia: water from the Zaire river could be transferred to the Zambezi region.

RECOMMENDED LITERATURE

1. A Framework Methodology for Integrated Assessment of River Basins, Heij G.J., B.A. Bannink, RIVM-The Netherlands, September 1994, (in prep).

2. Environmental Effects of Mining in the SADC Region, Bergström J., J. Hollaway, E. Zulu, SADC-ELMS, August 1992.

3. The effect of mining activities on waterquality in the Kafue river copperbelt, Zambia, Pettreson U., J. Ingri, Luleå University of Technology, 1993.

4. A directory of African Wetlands, Hughes R.H., and J.S. Hughes, IUCN-UNEP-WCMC, 1992.

ANNEXES

ANNEX 1

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ANNEX 2

SPEECH OF THE UNEP REPRESENTATIVE AT THE UNEP/SADC MEETING "ZAMBEZI BASIN WATER RESOURCES ASSESSMENT CASE STUDY"

Ladies and Gentlemen,

I would like to welcome you to this workshop on behalf of the United Nations Environment Program.

UNEP's interest in this workshop:

We have had a longstanding interest and involvement in the region. UNEP was an active partner in the Zambezi Basin, namely in the process leading to ZACPLAN, and the various ZACPRO initiatives. More recently, an initiative in the region is the Global Environment Facility (GEF) project on Lake Malawi, where UNEP also is a partner. While the focus of this 'Lake Malawi' GEF project lies on the preservation of its unique biodiversity, there is also a component dealing with land-based sources of pollution, related problems such as loads of sediments, nutrients, and pesticides into the like. This component, addressing basically the land use practices in Lake Malawi's catchment, is of strong interest to UNEP, and we will make our expertise available to it.

During this workshop, very interesting and sophisticated models are to be presented to you. Running those models for us is not an end in itself, but rather they are supposed to be tools to facilitate decisions in water resources management. Although the technical aspects of running/using those models are to be focused on at this workshop, we also are very keen in getting your views on various aspects. Especially with regard to data availability, and questions related to the institutional framework both at SADC and its individual member countries, we have to get your opinion. Your views are crucial for developing this approach further, and to make it meaningful for addressing the needs within the Zambezi Basin.
Our colleagues from the RIVM have been working hard on developing those models, and will try to bring them nearer to you.

Although this is formally an activity under 'environmental assessment', we feel that it is crucial to link up assessments and management of resources closely. That's why not only our RIVM colleagues, currently contracted by UNEP's 'Environmental Assessment' program, are here, but also myself from UNEP's freshwater program, which is looking more into management aspects.

I took the liberty to exhibit some recent UNEP publications. Although not directly on the subject of this workshop, they are relevant to various issues on the agenda. The ones which are still available you can order from my office in Nairobi, of the other ones I just leave one copy to our local hosts here. Especially the volumes on Phosphorus Cycles, and the brochures for decision-makers are of direct relevance to our workshop here. This brings me to the 'Lake Chad' Diagnostic Study and Action Plan, and UNEP's EMINWA program.

UNEP's EMINWA Approach

In our EMINWA approach, first step is to compile relevant physical and socio-economic data, as well as major uses /user conflicts within a given lake or river basin.
This 'Diagnostic Study' normally does not just contain compiled scientific or other published data on a given basin. Rather, in a consultative process involving governmental departments, other international agencies, stakeholders such as communities and NGO's, a comprehensive view on major water-related problems is sought. After this process, the Diagnostic Study again is submitted to involved parties, seeking their approval. After it has been formally adopted (thus being an intergovernmental document, next step is to translate the findings into an Action Plan. After this Action Plan has been drafted, again all concerned parties come together, and adopt it formally. Ideally, bilateral and international donors and technical aid agencies will be involved strongly, so that for priority activities external funds can be made available. However, one should avoid stressing too much the role of outside funds, and not forget the required commitment from the parties concerned themselves.
The 'Lake Chad' documents exhibited here may give you an idea of this process

You will see that the 5-step approach our colleagues will present here basically is not very different from this, apart from using much more computer models and optimization tools.

Economic Instruments Workshop

I should also mention that we will hold a workshop on the application of economic instruments in water resources management at UNEP Headquarters in Nairobi, in June 1995. Those of you who would be interested, or who know colleagues who might be interested, can get the application forms from me.

In this sense, I wish all of us a very fruitful and exciting workshop.

PROPOSED AND REVISED WORKSHOP SCHEDULES

PROPOSED SCHEDULE ZAMBEZI BASIN DATA DEFINITION WORKSHOP
16-18 JANUARY 1995, LILONGWE, MALAWI

TIME	PI	\\	DAY 1 16 JANUARY		PI	\\	DAY 2 17 JANUARY			PI	\\	DAY 3 18 JANUARY
08:00					X		10. STEP 1: Setting the Stage - Introduction					13. STEP 2 - REQUIREMENTS
08:30			1. REGISTRATION			X	- Hydrology		OS	X		Ecological Requirements
						X	- Hydro Chemistry		AH	X		14. 4*5'-Presentations of WG-results
						X	- Hydro Biology		BB			+ 40' Discussion (part 1)
						X	- Vulnerability Groundwater		TdN			
09:00	X		2. WELCOME by SADC and UNEP	OS / GS	X		5'-Presentations of WG-results + 5' discuss.					
09:30	X		3. FORMAT and PROCEDURES	BB								14. 4*5'-Presentations of WG-results
10:00			*Coffee*									+ 40' Discussion (part 2)
10:30	X		4. CONTEXT & AIMS + Discuss.	OS / BB			*Coffee*					*Coffee*
11:00	X		5. THE 5-STEP ASSESSMENT FRAMEWORK + Discuss.	BB			10. STEP 2. PRESSURES					15. STEP 3. Final Discussion on SYSTEM IDENTIFICATION
						X	Transport	Agriculture				- Spatial Scales
						X	Mineral Extraction	Fisheries				- Parameters / Indicators
						X	Power Generation	Industry				- Policy Options / -Impossibilities
						X	Recreation	Domestic WW&S				
11:30												
12:00												16. Draft Report
12:30			*Lunch*				*Lunch*					*Lunch*
13:00												
13:30		X	6. - a: Present Major Issues		X		10. 4*5'-Presentations of WG-results					17. EVALUATION of WORKSHOP
		X	- b: Future Developments				+ 40' Discussion (part 1)					
14:00												18. ANY OTHER BUSINESS
14:30	X		7. Presentation of Results + Discuss.	GS	X		10. 4*5'-Presentations of WG-results					19. CLOSURE
15:00			*Tea*				+ 40' Discussion (part 2)					
15:30			8. MODELS				*Tea*					
			- AQUA	AH								
16:00			- Water quality Modules	TdN			11. STEP 2. REQUIREMENTS					
						X	Transport	Agriculture				
						X	Mineral Extraction	Fisheries				
						X	Power Generation	Industry				
						X	Recreation	Domestic WW&S				
16:30												
17:00			- Discussion	GS								
17:30			9. Draft Report									
18:00												
			RECEPTION				12. Draft Report					

REVISED SCHEDULE ZAMBEZI BASIN DATA DEFINITION WORKSHOP
16-18 JANUARY 1995, LILONGWE, MALAWI

TIME	PI	\\	DAY 1 16 JANUARY		PI	\\	DAY 2 17 JANUARY		PI	\\	DAY 3 18 JANUARY
08:00					X		9. STEP 1: Setting the Stage - Introduction				11. STEP 2 - REQUIREMENTS
08:30			1. REGISTRATION			X	- Hydrology	OS	X		Ecological Requirements
						X	- Hydro Chemistry	AH	X		Industry, Mining & Energy
						X	- Hydro Biology	BB			Agriculture, Fisheries & Domestic WS&S
						X	- Vulnerability Groundwater	TdN			Transport & Recreation
09:00	X		2. WELCOME by SADC and UNEP	OS/GS							
09:30	X		3. FORMAT and PROCEDURES	BB							
10:00			*Coffee*								
10:30	X		4. CONTEXT & AIMS + Discuss.	OS/BB			*Coffee*				*Coffee*
11:00	X		5. THE 5-STEP ASSESSMENT FRAMEWORK + Discuss.	BB	X		Presentation of WG-results + discuss.				12. STEP 3. Final Discussion on SYSTEM IDENTIFICATION - Spatial Scales - Parameters / Indicators - Policy Options / -Impossibilities
11:30											
12:00											
12:30			*Lunch*				*Lunch*				*Lunch*
13:00											
13:30		X	6. - a: Present Major Issues				10. STEP 2. PRESSURES				13. EVALUATION of WORKSHOP
		X	- b: Future Developments			X	Industry, Mining & Energy				14. ADOPTION OF WORKSHOP REPORT
14:00						X	Agriculture, Fisheries & Domestic WS&S				15. ANY OTHER BUSINESS
14:30						X	Transport & Recreation				16. CLOSURE
15:00			*Tea*				*Tea*				
15:30	X		7. Presentation of Results + Discussions	GS	X		10. Presentations of WG-results + Discussions				
16:00	X		8. MODELS - AQUA - Water quality modules	AH TdN							
16:30											
17:00			- Discussion	GS							
17:30											
18:00											
19:00			RECEPTION								

ANNEX 4

TABLE 6 SADC - MINERAL PRODUCTION 1989 - 1993

Asbestos (Tons)

Country	1989	1990	1991	1992	1993
Swaziland	27,290	35,940	13,888	32,361	33,862
Zimbabwe	187,100	161,071	141,697	150,158	158,810
Total	**214,390**	**197,011**	**155,585**	**182,459**	**192,672**

Coal (Tons)

Country	1989	1990	1991	1992	1993
Botswana	663,000	794,040	783,873	901,452	890,000
Malawi	41,700	41,200	49,056	42,000	52,752
Mozambique	620,010	62,010	50,832	12,800	663
Swaziland	165,100	152,710	122,502	100,200	49,644
Tanzania	46,000	50,710	33,213	21,795	40,248
Zambia	394,800	381,500	345,330	421,898	301,496
Zimbabwe	4,680,000	4,978,160	5,274,161	4,168,000	4,616,540
Total	**6,610,610**	**6,460,330**	**6,658,967**	**5,668,256**	**6,000,987**

Cobalt (Tons)

Country	1989	1990	1991	1992	1993
Botswana	220	210	208	208	205
Zambia	4,488	4,410	4,634	4,699	4,212
Zimbabwe	100	123	105	100	113
Total	**4,808**	**4,743**	**4,947**	**5,007**	**4,526**

Copper (Tons)

Country	1989	1990	1991	1992	1993
Botswana	23,400	20,610	20,576	20,413	22,000
Namibia	38,000	33,190	31,928	37,656	34,788
Zambia	450,900	426,250	366,627	441,554	403,451
Zimbabwe	15,700	14,698	13,811	9,673	8,187
Total	**528,000**	**494,748**	**432,942**	**509,296**	**468,426**

Chromite (Tons)

Country	1989	1990	1991	1992	1993
Zimbabwe	627,400	573,103	563,634	522,013	252,033

Diamonds (Carats)

Country	1989	1990	1991	1992	1993
Angola	1,320,000	1,132,851	960,559	1,219,890	89,706
Botswana	15,250,000	17,351	16,506,000	15,946,000	14,730,000
Lesotho	20,000	10,000	9,547	14,791	1,555
Namibia	930,000	672,837	1,186,874	1,549,260	1,141,191
Swaziland	60,000	40,000	57,420	50,546	61,686
Tanzania	80,000	90,000	110,990	67,304	40,847
Zimbabwe	-	-	-	40,654	43,850
Total	**17,660,000**	**1,963,039**	**18,831,39**	**17,304,734**	**16,108,835**

Gold (kg)

Country	1989	1990	1991	1992	1993
Botswana	67	500	200	163	192
Mozambique	-	72	394	296	149
Namibia	340	1,454	1,709	2,072	1,954
Tanzania	10	1,710	3,073	3,155	3,370
Zambia	149	129	124	218	266
Zimbabwe	16,000	16,900	17,820	18,278	18,565
Total	**16,566**	**20,765**	**23,320**	**24,185**	**24,497**

Nickel (Tons)

Country	1989	1990	1991	1992	1993
Botswana	21,310	19,020	19,294	18,873	19,700
Zimbabwe	11,600	11,441	11,313	10,350	11,097
Total	**32,910**	**30,461**	**30,607**	**29,223**	**30,797**

Lead (Tons)

Country	1989	1990	1991	1992	1993
Namibia	44,180	35,129	33,367	31,656	31,236
Zambia	3,950	3,900	2,893	2,466	1,856
Total	**48,130**	**39,029**	**36,260**	**34,122**	**33,092**

Zinc (Tons)

Country	1989	1990	1991	1992	1993
Namibia	79,810	72,480	68,098	68,571	
Zambia	12,910	10,460	5,916	7,278	
Total	**92,720**	**82,940**	**74,014**	**79,175**	

Questionnaire
Zambezi Data-definition Workshop, LILONGWE 16-18 JAN. 1995.

BENEFITS DERIVED FROM THE WORKSHOP:

Did you become more aware, more knowledgeble about water resources sustainability?

Yes	No	No reply
9	4	1

More aware of water-situation and of large efforts required to address this issue (especially in Zambezi-region
more aware of (presented) complexity; not on sustainability, but on key parameters to be included in
water resource planning and management; a broad cross-section of info on key issues in focus regarding Zam
freshwater resources management & policy; learned about matters outside my field;

Do you intend to share knowledge gained with collegaes? How?

Yes	No	No reply
13		1

Discussions with collegeas, circulate docs, give presentation on Framework to
staff/collegaes; internal reports; by a different approach in work;
info is important as building blocks for development focussing on sustainable resources management
in Zambezi-basin;

Is water resources sustainability an urgent problem in your country?

Yes	No	No reply
9	2	3

Urgency not recognized by decision makers; Water Res. Mgmt. Strategy was not preceeded by integrated
assessment of river-basins; droughts were making shortages clear; many developments increasing pressures;
ecological and socio-economic data are usually left out in water resources planning;
shortages downstream result from upstream use; lack of integrated management has a negative
impact on water resources; problems are still localized;

What is your opinion of the Framework Assessment Methodology?

Confirming	Challanging	Rejecting	No reply
12	2		

Applicability to be tested: methodology requires huge (too large) data-sets; very useful, but difficult to apply:
data-shortage in Zambezi-basin and complexity of problem; approach reasonable; essentially sound;
provides for a rapid assessment, leading to policy issues / concerns focussed on a multi-national approach
to sust. resources mgmt; real issue probably lack of political will and nationalism; simple & appropriate;
logically and professionally justified, but to be tested; AQUA model could be useful;

EVALUATION OF THE WORKSHOP:

Were all important topics addressed?

Yes	No	No reply	Uncertain
11	2		1

Which were missing?

The socio-economic driving forces; background documents not received prior to workshop, so
pressures and requirements not adequately covered, due to lack of information; sector costs;
emphasis on pressures from population (growth) on env.;

Step 3: socio-economic pressures and requirements:
Suggestions for improvement?

Yes	No	No reply
8	1	5

Invite socio-economic experts; collect more basin-info prior to workshop; provide info prior
to workshop; invite grassroots operating NGO's; remain practical, informal and well prepared;
mail available models to participants;

Participants given enough time?

Yes	No	No reply
10	3	1

Not enough time for preparation before workshop; provided participants were motivated to speak out;

Enough time for you to discuss your country's problems?

Yes	No	No reply
9	2	3

Focus on basin, not on country; not received prior information; reluctance noted of participants
to discuss national problems;

Do you have suggestions for alternative ways of organizing similar workshops?

Yes	No	No reply
9	0	5

Pre-inform more on AQUA, include 5-10' presentations on country-reports;
invite wider range of disciplines; to ask participants to prepare themselves better;
avoid per diem problems; send info in advance; be more clear on objectives of workshop;
critical factor remains participants themselves: avoid per diem issues;
involve SADC-ELMS in organizing regional workshops;

General Comments?

Yes	No	No reply
10	0	4

Include options for hotels; per diem-debates could have been avoided; per diem debates were disrupting
per diem matters!; enjoyed discussions; pay the participants for their input; invite formally;

Figure 1
Basic Geography and Population Centres

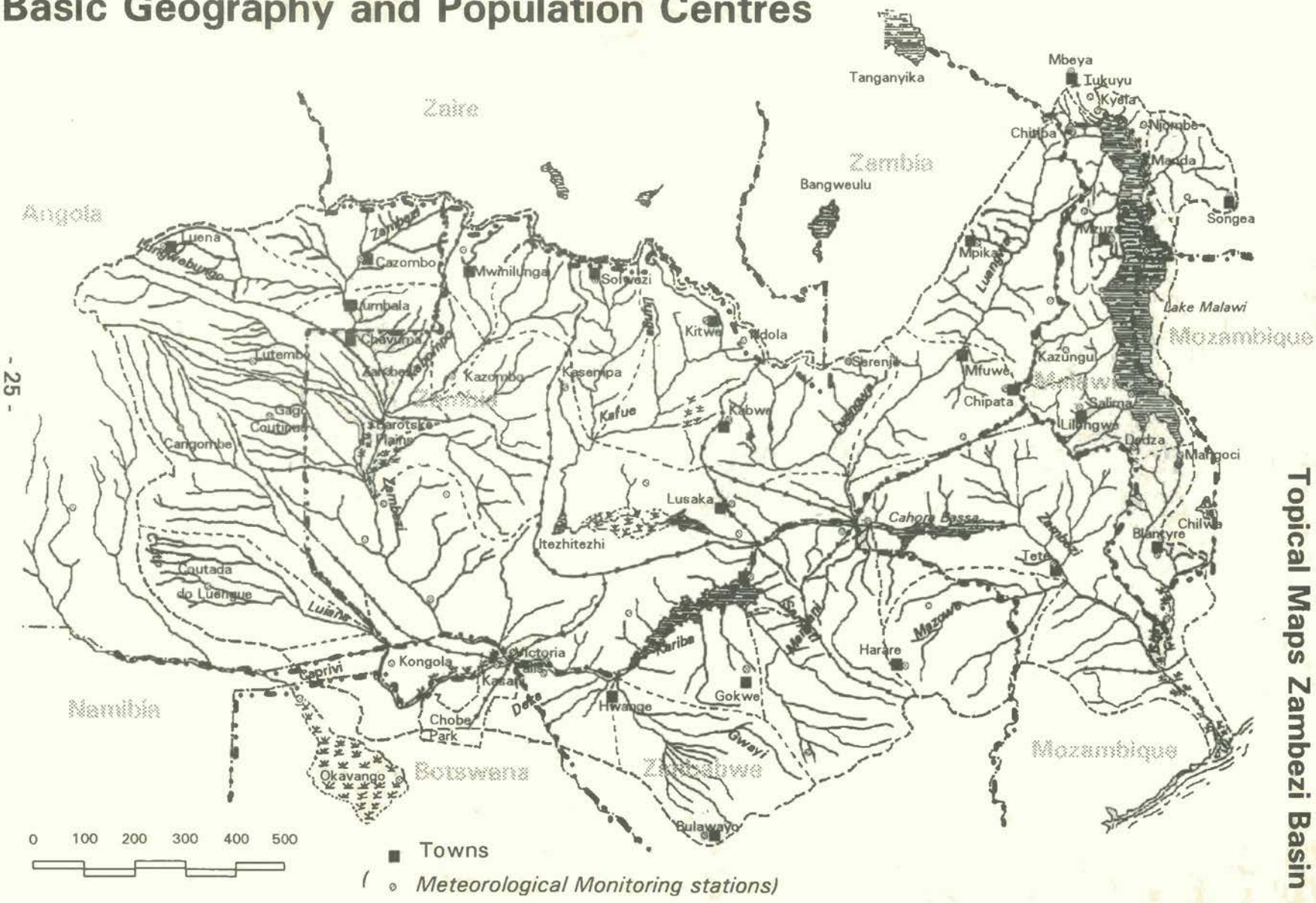


Figure 1a
The Zambezi river and its basin

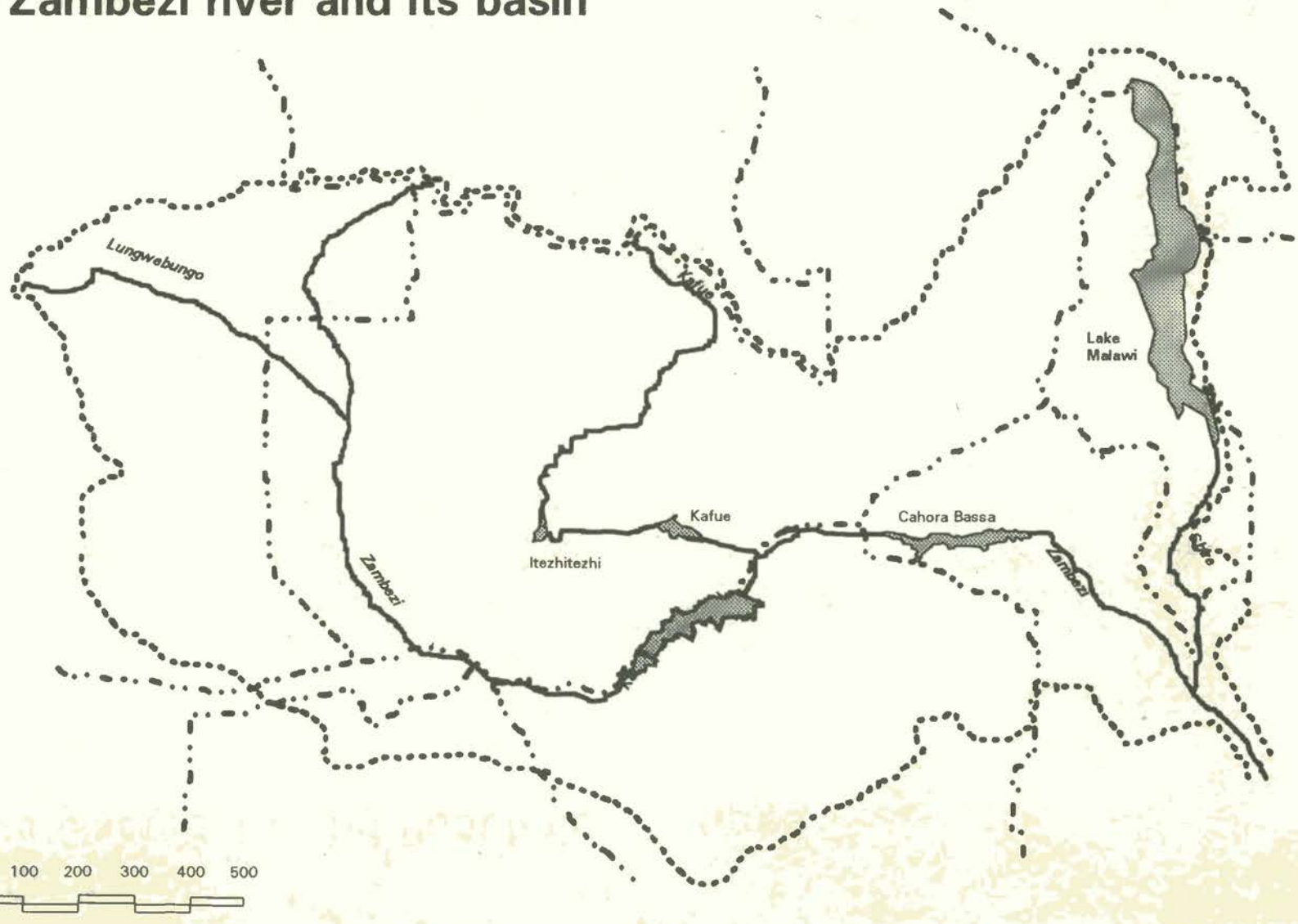
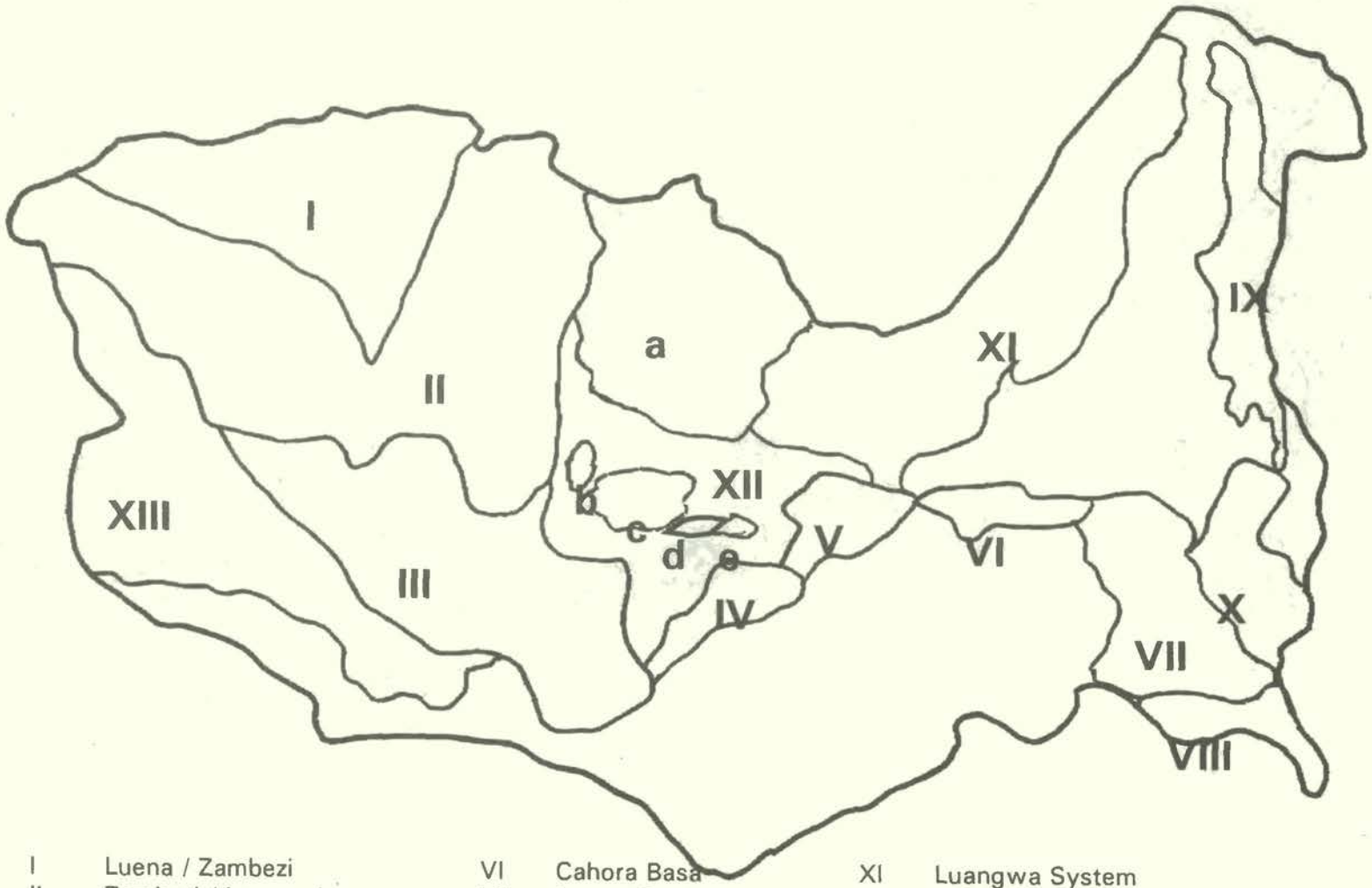


Figure 2
(Hydro-)biological Zones



I	Luena / Zambezi	VI	Cahora Basa	XI	Luangwa System
II	Zambezi / Lungwebungo	VII	Lower Zambezi	XII	Kafue System
III	Sioma Falls / Devils Gorge	VIII	Zambezi Delta	XIII	Cuando / Linyatti / Chobe System
IV	Lake Kariba	IX	Lake Malawi / Niassa		
V	Kariba / Cahora Bassa	X	Shire River System		

Figure 3
Mining, Agriculture and Industry

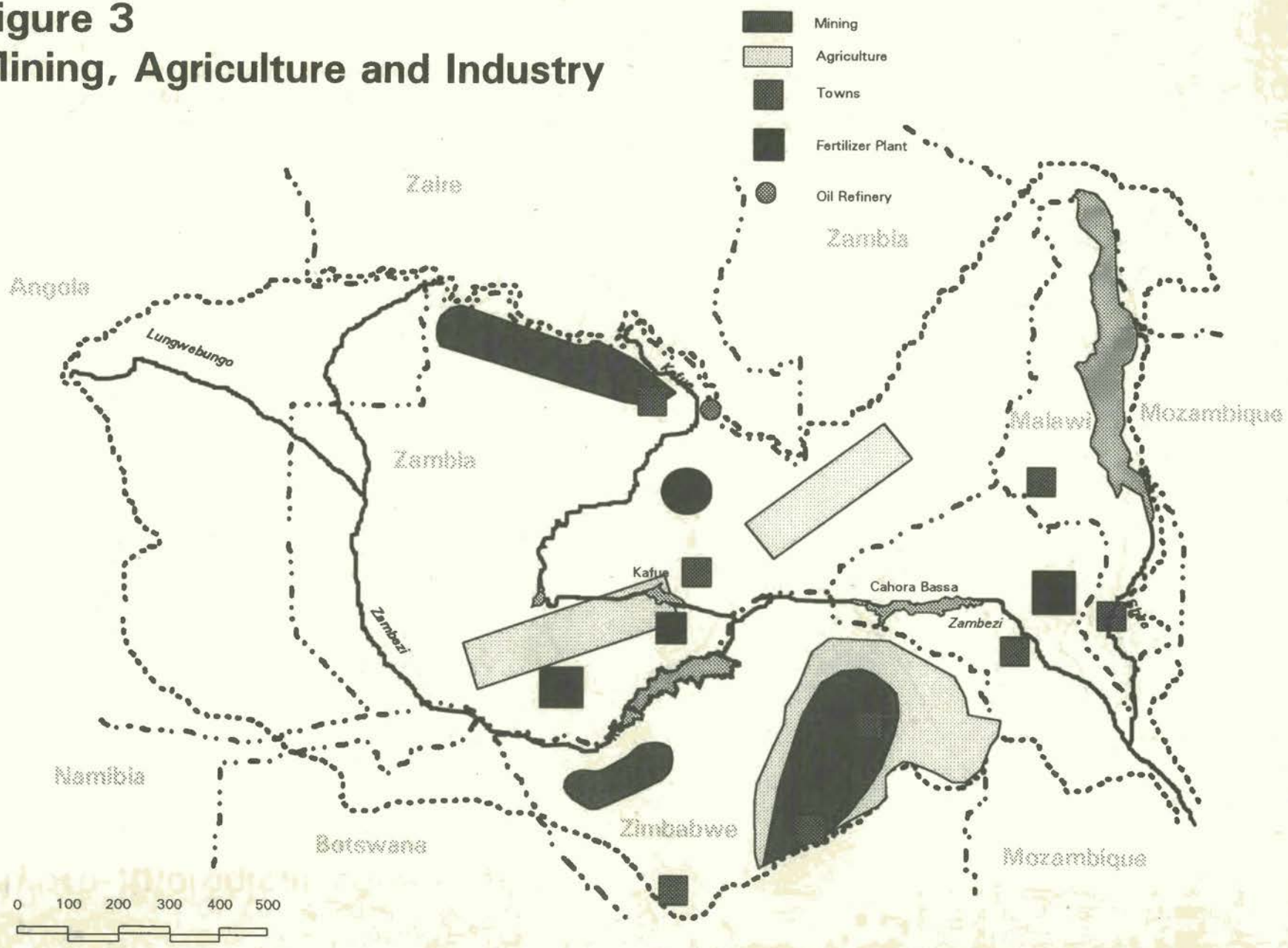


Figure 4
Recreation and Navigation

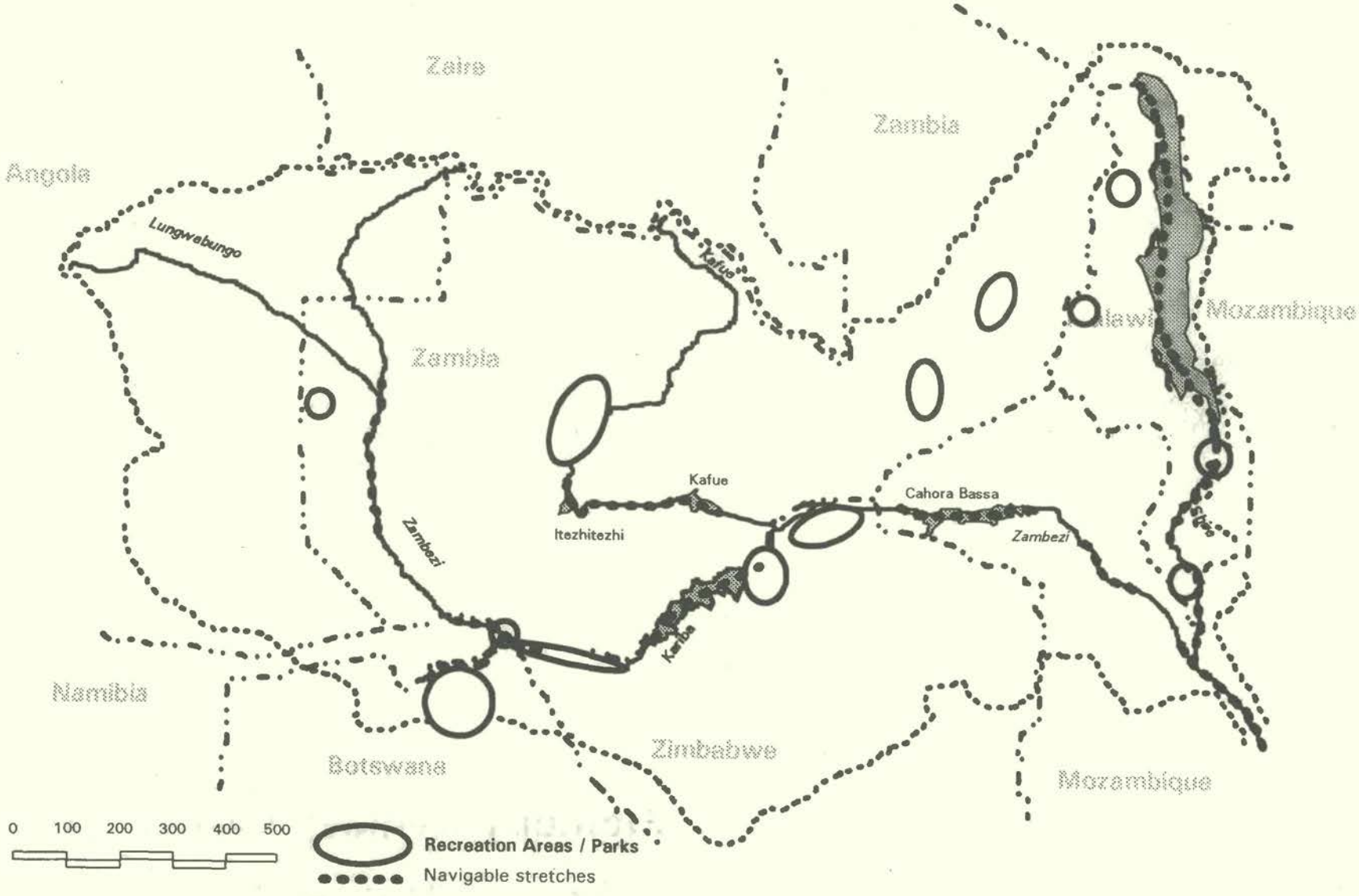


Figure 5
SADC chosen Zambezi Tributary Basins or Sub-basins.