ALCOM
Aquaculture for Local Community Development Programme

GCP/INT/555/SWE
GCP/RAF/277/BEL

ALCOM Report No. 23

RESERVOIR FISHERY IN EASTERN PROVINCE OF ZAMBIA

by

Henk W. van der Mheen
Aquaculturist

and

Jennie van der Mheen-Sluijer
Socio-economist

Funding Agencies:
SWEDISH INTERNATIONAL DEVELOPMENT AUTHORITY
BELGIAN ADMINISTRATION FOR DEVELOPMENT CO-OPERATION

Executing Agency:

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Harare, Zimbabwe, January 1997

ALCOM
Aquaculture for Local Community Development Programme
GCP/INT/555/SWE
GCP/RAF/277/BEL

ALCOM Report No. 23

RESERVOIR FISHERY IN EASTERN PROVINCE OF ZAMBIA

by

Henk W. van der Mheen
Aquaculturist

and

Jennie van der Mheen-Siuijer
Socio-economist

Funding Agencies:

SWEDISH INTERNATIONAL DEVELOPMENT AUTHORITY BELGIAN
ADMINISTRATION FOR DEVELOPMENT CO-OPERATION

Executing Agency.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Harare, Zimbabwe, January 1997

PREFACE

This document reports on the activities carried out under the ALCOM pilot project "Development of Small Reservoir Fisheries in Eastern province of Zambia" between December 1989 and May 1992.

The pilot project aimed at demonstrating productive small reservoir fishery management strategies which are within the capacity of national and local Government entities to plan and promote, and which are acceptable to and benefit the local communities.

The experiences of the pilot project will be useful in the SADC (Southern Africa Development Community) region, and elsewhere, for planning and implementing activities to improve the management of reservoir fisheries.

ALCOM is a regional aquatic resource management programme executed by the FAO (Food and Agriculture Organization of the United Nations). The main office of the programme is in Harare, Zimbabwe, and the programme implements pilot project in the SADC region.

ALCOM's aim is to assist member countries improve the living standards of rural populations though the practice of appropriate aquatic resource management techniques. Towards this end, pilot activities are conducted in selected countries to demonstrate new techniques, technologies and methodologies. Successes achieved, ideas derived, and lessons learned are disseminated for use in the region and elsewhere. ALCOM began its work in 1986 and is funded by Sweden and Belgium, with contributions from member countries.

Mail:	P O. Box 3730, Harare, Zimbabwe
Phone:	+263 4 724985/734797
Fax:	+263 4 736847
Telex:	26040 FAO ZW
Email:	ALCOM @harare.iafrica.com
Homepage:	http://www.zamnet.com/zamnet/alcom/alcom.htm

Contents

	Page
1. INTRODUCTION	**1**
2. DATA COLLECTION	**2**
2.1. Fish Stock Sampling	2
2.2. Catch Monitoring Survey	2
2.3. Socio-economic Study	2
3. EASTERN PROVINCE OF ZAMBIA	**4**
3.1. Reservoirs in Eastern Province	4
4. CHARACTERISTICS OF RESERVOIR FISHERY	**7**
4.1. Fish species	7
4.2. Fishing gears	8
4.3. Composition of Catches	9
4.3.1. Species selectivity	9
4.3.2. Size selectivity	11
4.4. Fishing grounds and Seasonality of Fishing gears	11
4.4.1. Fishing Grounds	11
4.4.2. Seasonality of Gear	11
4.5. Fishing Effort	13
4.5.1. Choice of Gear	13
4.6. The yield	13
4.7. Summary of characteristics	15
5. ACCESS TO RESOURCES	**16**
5.1. Access to Fishing Grounds	16
5.2. Access to Gear	16
5.3. Access to Fishing Skills	17
6. FINANCIAL EVALUATION OF FISHING METHODS	**18**
6.1. Costs	18
6.1.1. Fixed Costs	18
6.1.2. Variable Costs	18
6.2. Disposal of Catch	18
6.3. Revenues	19
6.4. Annual Incomes	21
6.5. Sensitivity Analysis on Incomes	21
7. STANDARD OF LIVING OF FISHERS COMPARED TO NON-FISHERS	**24**
8. DISCUSSION	**28**
8.1. Findings	28
8.2. Development policy	29
8.3. Management options	29
9. CONCLUSIONS AND RECOMMENDATIONS	**31**
APPENDIX 1: METHODOLOGY SOCIO-ECONOMIC STUDY	**32**
APPENDIX 2: ANNUAL INCOME DIFFERENT TYPES OF GEAR	**34**
APPENDIX 3: SENSITIVITY ANALYSIS ON INCOMES	**39**
APPENDIX 4: CATCH MONITORING SURVEY	**41**

List of tables

		Page
Table 1:	Number of reservoirs by constructing agency	4
Table 2:	Number of reservoirs by period of construction	4
Table 3:	Size distribution of reservoirs	5
Table 4:	Characteristics of studied reservoirs	5
Table 5:	Presence of different fish species per dam as found by the drottningholm method	7
Table 6:	Breakdown of number of fishers using certain type of gear per reservoir	13
Table 7:	Characteristics different types of fishery	15
Table 8:	Reasons for using certain type of gear (% of respondents)	16
Table 9:	Reasons to fish (% of respondents)	19
Table 10:	Fishers aspiration to have more fish (% of respondents)	19
Table 11:	Features of different fishing units (as determined by the socio-economic study)	22
Table 12:	Annual incomes by type of gear (zk) for makungwa dam	22
Table 13:	Annual incomes by type of gear (zk) for kangombe dam	22
Table 14:	Annual incomes by type of gear (zk) for chadewa dam	23
Table 15:	Demographic characteristics of the different household categories (h.h .= Household)	24
Table 16:	Primary sources of income (% of respondents)	24
Table 17:	Percentage of households owning certain items	25
Table 18:	Average number of months per year households lack animal protein and nshima	27
Table 19:	Consumption of meat, fish and eggs for the different household categories (in number of times per month)	27
Table 20:	Annual income net fishery (zk)	34
Table 21:	Annual income trap fishery (zk)	36
Table 22:	Annual income hook and line fishery (zk)	37
Table 23:	Annual income fishery with other gear (zk)	38
Table 24:	Sensitivity analysis net fishery (zk)	39
Table 25:	Sensitivity analysis trap fishery (zk)	39
Table 26:	Sensitivity analysis hook and line fishery (zk)	40
Table 27:	Sensitivity analysis fishery with other gear (zk)	40
Table 28:	Number of records collected during creel survey per day, dam and gear	42
Table 29:	Fishing effort, catch per hour and estimated total catch per dam and gear	43
Table 30:	Species composition in percentage in number and weight per dam and per gear	44

List of figures

		Page
Figure 1:	Distribution of reservoirs in eastern province of zambia	5
Figure 2:	Average species composition of the sampled reservoirs (in percentage of total weight)	8
Figure 3:	Species composition of catches per gear, using different data collection methods (h & 1 = hook and line)	10
Figure 4:	Seasonality of fishing gear in different dams, as determined by two data collection methods	12
Figure 5:	Relative fishing effort for three reservoirs, during the rainy season and dry season, data from socio-economic study	14
Figure 6:	Relative fishing effort for two reservoirs, during the rainy season and dry season, data from catch monitoring survey	14
Figure 7:	Disposal of catch, percentage of the catch sold, bartered, distributed (or given away), and used for home consumption	20
Figure 8:	Sales point for fish	21
Figure 9:	Percentage of respondents reporting lack of nshima during certain months of the year, by gear.	26
Figure 10:	Percentage of respondents reporting lack of animal protein during certain months of the gear, by year	26

1 INTRODUCTION

In 1987 ALCOM started project activities in Eastern Province of Zambia focusing on the development of pond aquaculture for rural communities. Although this project, in collaboration with the Department of Fisheries, realised an impressive increase in the number of fish ponds and fish farmers, it was unlikely that aquaculture would satisfy the demand for fresh fish in the Province.

The Province has few perennial streams where fishing is practised. Over the years water storage reservoirs have been constructed. There was no information about the status of the fisheries on these reservoirs. Fish harvests from the reservoirs could potentially have a significant impact on the supply of fish for the surrounding communities.

In December 1989 a start was made with the pilot project "Development of Small Reservoir Fisheries in Eastern Province of Zambia" with the objective to demonstrate productive small reservoir fishery management strategies which are within the capacity of national and local Government entities to plan and promote, and which are acceptable to and benefit the local communities.

Several activities were designed to reach this overall objective:

- development and testing of a cost-effective method for collecting and analysing fishery and socio-economic information on small reservoirs;
- development of fishery management strategies, using the above-mentioned information, which provide for sustainable exploitation of the fishery and directly benefit local people;
- test and document each proposed management strategy on selected reservoirs in Eastern Province,

Fisheries development and management strategies aim at attaining an optimum rate of exploitation of the reservoir fishery. The potential and actual fish yield set the limit for strategies for development or management of the reservoir fishery. Data required to determine these fish yields were collected through fish stock sampling with multi-mesh gillnets,

Since any fisheries management would involve and affect primarily the fishers, it was necessary to consider their values, motivations and attitudes towards possible interventions. It was also important to determine the influence of these interventions on the distribution of the benefits between fishers and non-fishers and among fishers themselves. A socio-economic study was carried out to collect this information. The socio-economic study also collected indicative information on the present fishing pressure and yield around these dams. A catch monitoring survey was designed to determine more precisely the present yield of these reservoirs. This information combined with the information of the fish stock sampling would identify possibilities for management and interventions to increase the present yield.

The authors of this report organised and supervised the socio-economic study. They were not directly involved with the fish stock sampling and the catch monitoring survey. These were carried out and supervised by other ALCOM staff members. This report however, uses the unpublished data from those studies.

2 DATA COLLECTION

The fish stock sampling was carried out on 15 reservoirs in Eastern Province, between December 1989 and May 1992. The catch monitoring survey was carried out on Rukuzyc and Makungwa dams between March 1991 and March 1992. The socio-economic study was conducted around Makungwa, Chadewa and Kangombe dam between December 1989 and March 1990.

Occasionally reference is made to Lutembwe dam. Lutembwe dam is used to provide water for Chipata. People are not living directly around this dam and implementation of fisheries management or development would not have been allowed here. Only limited information was collected around this reservoir

2.1. Fish Stock Sampling

For sampling of the fish stocks ALCOM used a method developed by the Institute of Freshwater Research, Drottingholm, Sweden. This method is called the Drottingholm method, and uses multi-mesh gillnets which are set overnight. The number of nets and the areas where they are set are determined by the size of the reservoir and its maximum depth. The method uses the catch per unit of effort as a measure of abundance. For a detailed description of the method see Fjalling and Furst (1991).

2.2. Catch Monitoring Survey

The fish catches at the Rukuzye and Makungwa dams were recorded during five days per month. Since it was anticipated there would be a difference in fishing effort between week days and weekend days, two weekend days and three week days were chosen per month. Catches were recorded by enumerators, for a period of 12 hours, starting at 12.00 hours or at 0.00 hours at a sampling date, in total the catches of 127 fishermen were recorded.

2.3. Socio-economic Study

Ideas and activities are not relevant to all households and individuals in a community. To ensure that the problems of the whole community are considered in a project intervention, the community had to be divided into target groups'. Target groups have to be recognisable in the field and meaningful in terms of extension work. Therefore, from the fisheries management and/or development point of view a division into fishing gear employed was the most convenient. Non-fishers were also considered an important section of the community. The study determined whether this stratification of reservoir communities was useful and looked into possibilities for enhancing the participation of certain groups in the fishery. For this purpose, the major attributes of the different target groups (access to resources, standard of living, food security) and the various types of fishery (necessary means of production, yield) were described.

A one-moment sample survey was chosen to generate the necessary data. Two interview schedules were designed. One for interviews with fishers, and one for interviews with households whose members did not fish in the reservoirs. In total 26 net fishers, 69 trap fishers, 72 anglers, 42 persons using other gears and 97 non-fishers were interviewed. The interviews with fishers were aimed at building up as complete a picture as possible of the different fishing methods encountered in the survey areas as well as the situation of the fishers. It focused on four problems:

- description of the actual fishing effort;

- description of access to resources, like, access to fishing grounds, gear and skill to operate the gear;
- financial evaluation of different fishing methods;
- description of the standard of living of fishers.

The interviews with the non-fishing community members were carried out to study three problems:

- distribution of fish within the community;
- other uses of the dam;
- description of standard of living of community members compared to fishers.

More detailed information about data collection methods, sampling and data analysis, can be found in Appendix 1.

[1] A target group is a category of people who are sufficiently homogeneous on a number of attributes, including accessibility, to be able to benefit from the uniform information, goods and/or services offered by an organization.

3 EASTERN PROVINCE OF ZAMBIA

The majority of the rural population in Eastern Province of Zambia are small scale farmers, growing crops for home consumption and for sale. The purchasing power of these farmers is low. Nutritional problems of inadequate energy and protein consumption prevail in the whole country, although these problems are mainly seasonal and are specific to certain groups of the population. Fish consumption accounts for 50% of the animal protein intake, but the per caput consumption is declining. Important sources of fish are the main rivers and lakes located in other Provinces. Most of these fish are sold in a dried form in Eastern Province. The demand of fresh fish is high and is not met by the supply.

3.l. Reservoirs in Eastern Province

In order to determine the potential importance of the reservoir fishery in Eastern Province of Zambia an inventory of the reservoirs was made. The. inventory was mainly based on information from the Department of Water Affairs (DoWa), and gives year of construction, location, riversystem, catchment area, size of the reservoir, and whether it has been stocked by the Department of Fisheries. The inventory has information for a total of 227 reservoirs. Information is not complete for all fields in the inventory, which explains the differences in total numbers of dams per type of information.

Table 1: Number of reservoirs by constructing agencv

Constructing agency:	Department of Water Affairs	District Council	Department of Agriculture	Community	Private	Total
number	164	36	3	2	2	207
%	79	17	1	1	1	100

Most of the reservoirs (79%) were constructed by the Department of Water Affairs (Table 1). The majority of the reservoirs was constructed more than 30 years ago (Table 2). The main purpose for the construction of the dams was to store water in order to open new areas for settlement.

Table 2: Number of reservoirs bv period of construction

Period	before 1930	1930-1940	1940-1950	1950-1960	1960-1970	1970-1980	1980-1990	Total
number	0	15	54	88	37	14	6	214
%	0	7	25	41	17	7	3	100

Since the reservoirs were constructed for the purpose of storing water, the size of the reservoirs was in most cases recorded as storage capacity. Storage capacity is known for 205 of the 227 reservoirs. Fish production is more related to the surface area than to the storage capacity of a reservoir. The surface area is therefore a more useful measure of size for the planning of fisheries activities. The surface area is only known for 42 reservoirs. The following relation could be established between the surface area and the storage capacity of reservoirs smaller than 40 hectares:

$$X = 0.2135 *Y^{\circ 74010} \text{ (n=41, r=0.92)}$$

X:Surface area in hectares

Y: Storage capacity in 1000 m^3

Using this relation the surface area of 163 reservoirs was estimated (Table 3). Lutembwe 2, an exceptionally large reservoir (108 ha.) compared to the other reservoirs, was excluded for establishing the relation between surface area and volume, and is not included in Table 3.

Table 3: Size distribution of reservoirs

Size (ha.)	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	Total
number	135	43	10	5	3	5	2	1	204
%	66	21	5	2	1	2	1	1	100

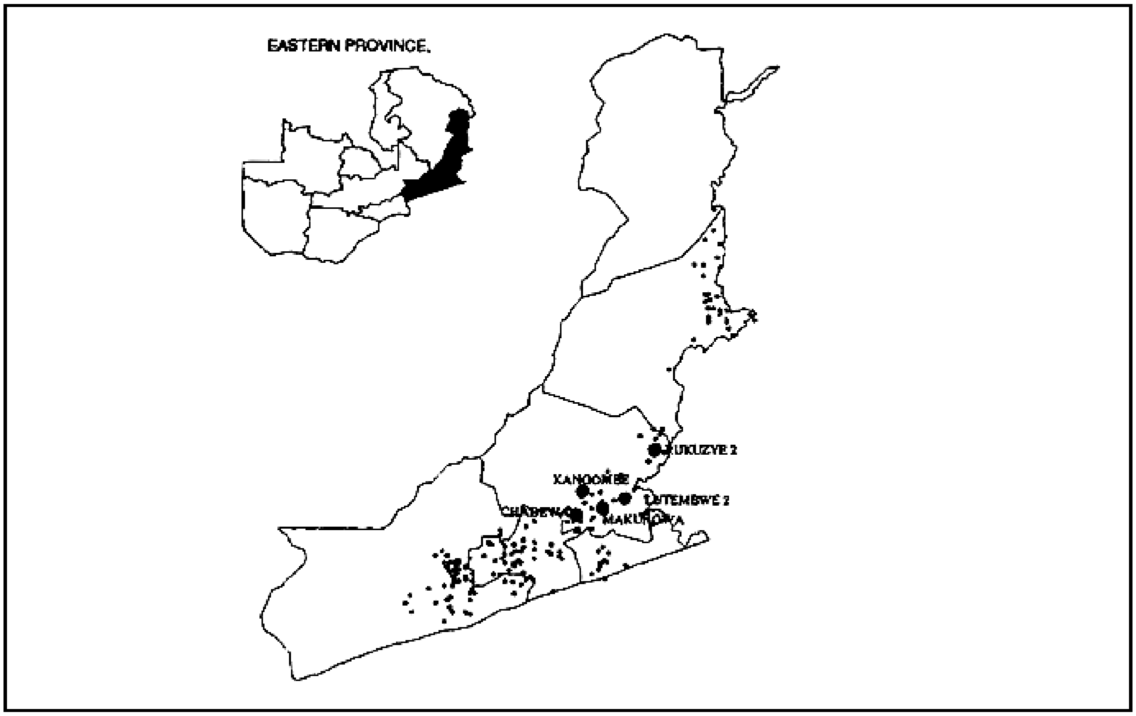
Table 4: Characteristics of studied reservoirs

Dam Name	Year of construction	Latitude South	Longitude East	River System	Capacity (1000 m^3)	Surface area (ha)	Max.Depth (m)	Avg. depth (m)
Lutembwe 2	1989	13°42'	32°36'	Lupande	5063	108	20	5.95
Chadewa	1974	13°49'	32° 14'	Lupande	325	13	6	2.50
Makungwa	1967	13°46'	32°26'	Lutembwe	177	10	5	1.77
Kangombe	1967	13°39'	32°17'	Lupande	94	6	3,5	1.57
Rukuzye 2	1958	13°21'	32°49'	Rukuzye	395	22	5	1.80

The average surface area, excluding Lutembwe 2, of the reservoirs is 5.3 hectares, which brings the total surface area to 1195 hectares, and 1303 hectares including Lutembwe 2.

The total surface area of 1303 hectares assumes that all reservoirs are still in design condition. This assumption is not correct. 52 reservoirs, with a total surface area of 224 hectares, are known to have breached and no longer hold water. Because of the age of the reservoirs and the little maintenance carried out on most of them it can be assumed that more reservoirs have breached or are completely or partly silted without being reported. Reservoirs are not always constructed according to their original design and recorded size, but instead may have been constructed smaller. Dams are very seldom constructed larger than the original design. All these factors together mean that the total surface area of small water bodies in Eastern Province of Zambia is not exactly known, but is most probably less than 1000 hectares.

Figure 1- Distribution of reservoirs in F.a stern Province of Zambia



The Department of Fisheries stocked some of the reservoirs with fish. Before 1970 thirteen reservoirs were stocked, between 1970 and 1980 five, and since 1980 only three. The main species stocked were *Oreochromis andersonii, O. macrochir* and *Tilapia rendalli.*

Characteristics of the reservoirs discussed in this report are given in Table 4. The shores and shallow areas of Kangombe dam are densely vegetated. There is also submersed vegetation in the near-shore areas. There are also a lot of stumps on the bottom which makes beach seining impossible. Makungwa dam has relatively little vegetation in the shallow areas. The biggest reservoir in the Province is the Lutembwe 2 (108 ha.), its shoreline is rich with vegetation and small islands which altogether supply a wide range of habitats. The shoreline is generally accessible for rod-fishing. There are few fishing obstacles for net fishing. Figure 1 shows the distribution of the reservoirs in the Province.

4. CHARACTERISTICS OF RESERVOIR FISHERY

4.1. Fish species

In order to determine the species composition of the reservoirs a total of 15 reservoirs in Eastern Province were sampled with the Drottningholm sampling method[2]. The species composition of these reservoirs is given in Table 5. *Barbus paludinosus* and *Labeo cylindricus* are the most widespread species, and were found in 93% of the reservoirs sampled. In most reservoirs six or more species were identified. It must be stressed that the species mentioned in the table are only the species caught with the sampling method. Sampling with gillnets is selective and not all fish species in the reservoirs may have been detected with this method.

[2] Experiences with this sampling method in southen Africa have been published in a separate report "The *Use of* Multi Mesh Gillnets for Sampling Fish Stocks in Reservoirs in Southern Africa" by H.W. van der Mheen, 1995, FAO ALOM Field Document No. 39.

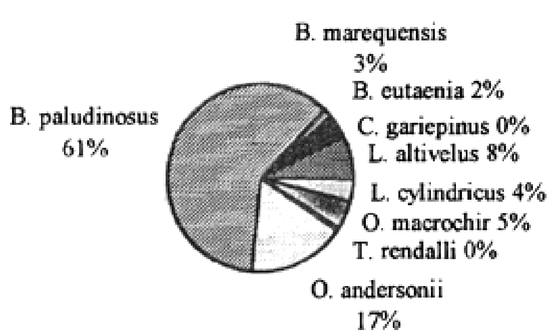
Table 5: Presence of different fish species per dam as found by the Drottningholm method

Species: Dam	B. pal	B. eut	B. mar	0 and	0. mac	T. ren	L. cyl	L. alt	H. phi	S. rob	C. gar	total
Chadewa	*	*			*		*				*	5
Chamuche	*	*	*	*	*	*	*					7
Chivungula	*				*	*	*				*	5
Jim	*			*	*	*	*		*		*	7
Kangombe	*	*		*			*					4
Lusowe	*	*		*	*	*	*					6
Makungwa	*	*		*	*		*		*	*	*	8
Mweze	*				*		*				*	3
Nsazu		*		*			*	*				4
Senegalia	*	*		*	*				*		*	7
Oliver Davis	*			*	*		*		*		*	5
Rukuzye	*	*			*	*	*				*	6
Chanchenga	*	*	*	*	*	*	*					7
Lutembwe 1	*	*	*	*	*	*	*		*		*	9
Lutembwe 2		*	*	*	*	*						7
Presence %	93	73	27	73	87	53	93	7	33	7	60	

B.pal: *Barbus paludinosus,* B.eut: *Barbus Eutaenia,* B.mar: *Barbus marequensis,* O.and: *Oreochromis andersonii,* O.mac: *Oreochromis macrochir,* T.ren: *Tilapia rendalli,* L.cyl; *Labeo cylindricus,* L.alt: *Labeo altivelus,* H.phi: *Haptochromis philander,* S.rob: *Serranochromis robustus,* C.gar: *Clariasgartepinus.*

The catch composition of the Drottningholm sampling method gives a rough indication of the fish species composition in the reservoirs. Figure 2 gives the species distribution as average for all sampled reservoirs.

Figure 2. Avarge species composition of the sampled reservoirs (in percentage of total weight)



The Barbus species clearly dominated the catches in the sampling nets, with 65% of the total weight, while the cichlids represent 22% of the catch.

4.2. Fishing gears

Fishing activities on the reservoirs can be categorized by the type of gear used. The following have been identified during the survey:

- **gill nets.** The nets were often set as bottom gill nets. The nets were left overnight and lifted the following morning. The mesh size used varied from 2 to 4.5 inches[3]. Net pieces were usually purchased in 90 metre stretched sections with a depth of 20 meshes. The rope used for mounting the nets was usually (79%) bought. Twine was bought in 43% of the cases, but floaters, sinkers as well as the needles were made from local materials. Only men were found to fish with nets.
- **seine nets.** Seine netting is prohibited in Zambia. However, this method was commonly used in the dams. Several gill nets were joined together and could have any length between 180 and 500 metres long. Often the panels with the smaller mesh sizes (2 inches) were put in the middle, those with the bigger ones (3.5-4 inches) went at the wings. The net was set, either by using dugout canoes or the fisher and his helpers walked in the water. Helpers on the beach pulled the rope attached to the wings. As the net approached the beach, the fish were driven into the net and hauled up onto the shore. Seine netting was carried out in places where there is a clear and fairly hard bottom. It is not effective amongst reeds, grasses and underwater weeds or here there are underwater obstructions such as tree stumps or among rocks. As with gillnets, seine nets are only used by men.
- **traps.** Traps were generally made from split reeds or coarse grass stems. Most traps had a cone shaped inlet through which the fish entered and then could not get out. The most common ones were about 1 m. long and had a diameter of 50 cm. at the inlet. Often traps were placed facing down- as well as up-stream so that they trapped both the fish which followed the current and those which swam against it. Sometimes fishers built a weir or fence across the stream, dambo or other water course. The traps were then set into the weir. Traps were normally emptied once a day. The catch was removed by untying the bunched material at the apex. An average number of 2 to 3 traps was used by the fishers. Trap fishing was done exclusively by men.
- **hook and line.** A single hook was set on a line. The line may or may not be attached to a rod. Fishing rods were usually made from bamboo. One or two rods/lines were used at the same time. The majority (95%) of the fishers bought the lines. The length varied between 1.5 and 4 m. Few people still knew how to twist a line from sisal fibres. Hooks were always bought in shops within the area. A variety of bait was used, e.g., worms,nshima (thick porridge of mealie meal), scorpions for catfish, grass or algae for *Tilapia rendalli.* 10% of the anglers were women.
- **bundles of grass.** This method was commonly used in shallow water. The grass was cut and tied with fibres to make it a bundle. The bundle could be up to 3 metres long. A group of people would go in the water and drag the bundle towards the shallow waters or shore. This fishing method was often used by husband and wife or groups of women.
- **spears**. Spears were usually made by the fishers themselves, using a stick and a piece of wire or a big nail which they sharpened. Spears were most often used in places where there were large congregations of fish, such as Clarias, confined to shallow pools and lagoons that were drying up or below the spillway when the fish was migrating. Fishers walked through the water throwing spears into the water in the hope of spearing a fish. They both fished in groups and individually. Spear fishing was done by men only.

[3] The minimum mesh size allowed in Zambia is 3.5 inches, Nonetheless, there are indications that many fishermen use nets with smaller meshes. During the interviews, fishermen mostly gave figures for mesh sizes which were legal.

4.3. omposition of Catches

Catches depend on what species are present in the water where the fishing is practised and also on the fishing gears used. Every fishing gear is selective, often selective for species as well as for size.

4.3.1. Species selectivity

To study the reservoir fishery three different methods were used to gather information. All these three methods collected information on the species composition of the catches of the fishers or of the sampling gear. In order to compare these data the fish species are grouped in four different categories. *O. andersonii, O. macrochir* and *T. rendalli* were grouped under the category 'bream', 'catfish' represents the *C, gariepinus,* the three barbus species were grouped under 'barbus' while the group 'other' mainly represented *L. cylindricus.*

The composition of the catches in four reservoirs were more than one of the information collection methods was used, is given in Figure 3.

The stock assessment was carried out with multimesh gillnets in order to correct as much as possible for the effect of selectivity of gillnets. The catches in these nets can be assumed to be a better reflection of the actual fish stock than the catches of the fishers using one type of gear. This docs not mean that the stock sampling gives an exact presentation of the fish stock in the reservoirs. Multi-mesh gillnets can, to some extent, compensate for size selectivity but can not correct the species selectivity of the gear. Certain species are much more vulnerable for gillnets than others. It is for instance well known that *C. gariepinus* and *T. rendalli* are not commonly caught in gillnets.

The fish stocks change over time and may fluctuate greatly between years. The stock sampling was carried out at different periods as indicated in Figure 3, while the catch monitoring survey and the socio-economic study were carried out in different years. The multiple stock sampling in Makungwa and Chadewa dam clearly shows fluctuations in fish stocks between years.

The efficiency of gill nets is dependant on the fish moving into the net and then getting gilled or tangled. Gillnets normally only catch fish of a certain size. Fish that are too large will not get gilled in the net and only a small portion gets tangled, while smaller fish will swim through the net without being caught. Seine nets do not depend on the movement of the fish and often catch a wider variety of species, and catch all sizes above a certain minimum size, which is determined by the mesh size.

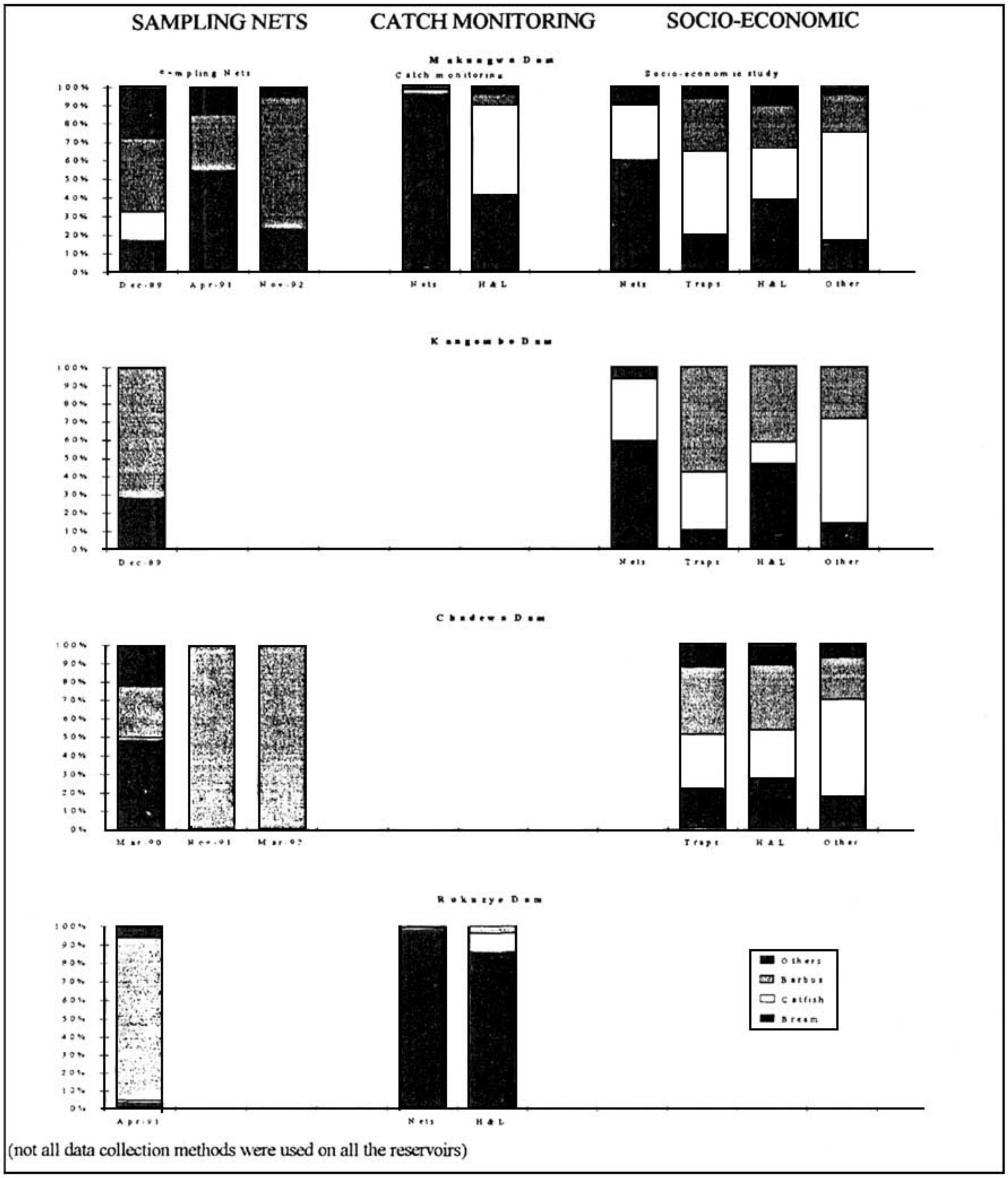
Many different species of fish can be caught on a line depending on the size of the hooks, the type of bait used, and the fishing site.

To catch fish, traps often rely on the movement of fish. During the beginning of the rainy season *Barbus paludinosus* and *Glorias gariepinus* migrate to the spawning grounds in the tributary. Therefore, they constituted the major part of the catches. When the water level goes down, the fish that return from drying areas up are caught. At the beginning of the rainy season mainly breeding fish were caught, while young fish were caught after the spawning season.

With bundles of grass, mainly smaller fish were caught. *C. gariepinus* and *Barbus spp.* made up a high percentage during the spawning season when they migrate to flooded areas.

Fishers who use spears can only catch the bigger fish. Because adult C. *gariepinus* often stay in shallow water when they are spawning, this was the principal species speared.

Figure 3: Species composition of catches per gear, using different data collection methods (H & L — hook and line)



The catch monitoring survey showed that the nets, used as seine nets, mainly caught bream species, and that the catches were much less diverse than in the stock sampling nets. This is a results of the differences in mesh sizes used. The sampling nets used both smaller and larger mesh sizes and were able to catch smaller species. The small barbus species escaped the nets used by fishers. This contrast is especially clear in Rukuzye dam where the sampling nets were dominated by the barbus while these species were not caught in the other nets. Information on the catch composition of nets obtained from interviews showed a more balanced distribution between the categories of species in Makungwa and Kangombe dams. The difference between the information of the catch monitoring and the socio-economic study is obvious. This may be a result of differences in data collection methods, but may also have been influenced by a difference in stock composition. The sampling nets showed much more catfish and other species in December 1989, the time the socio-economic study was carried' out, than in 1991 and 1992, when the catch monitoring survey was conducted.

Hook and line catches were composed of more of the catfish and barbus species than the *net* fishery in data collected with both methods. The traps and other fishing methods concentrated in general much less on the bream species, and showed a much more diverse species composition.

4.3.2. Size selectivity

The socio-economic study collected information about the largest and smallest fish caught with each fishing method, and only gave a rough indication of the size selectivity of the gears. Spear fishers obviously caught the largest fish, ranging from "hand size" to "halfway the clbow" The net fishers caught fish from a small size, "larger then a finger", up to a fairly large size, "halfway the elbow". The trap fishers targeted both the very small fish "less than a finger" as well as larger fish up to "halfway the elbow". The hook and line fishers as well as the fishers using grass bundles mainly caught small fish of a size around "a finger" although the largest fish caught by hooks were a "hand size".

The catch monitoring survey showed that the average size for the bream species caught in nets was below 35 grams, while the hook and line fishers caught breams of an average size of less than 15 grams. For catfish these average weights were around 200 and *100* grams, respectively.

4.4. Fishing grounds and Seasonality of Fishing gears

4.4.1. Fishing Grounds

The different types of gear employed in the reservoirs, exploited various parts of the dam.

Most of the gill nets were set next to reeds. Only net fishers with canoes (54%) fished off-shore. Several respondents admitted that the net was used as a beach seine net as well. Only in Kangombe dam, where there were too many stumps on the bottom and where the shoreline was overgrown with reeds, seining was rare. All of the net fishers in Kangombe had dugout canoes and thus relatively more off-shore fishing took place in this reservoir. In Lutembwe dam, nets were also set just below the spill way.

Traps were usually set up and down stream. In Chadewa and Lutembwe dam, one third of the respondents said that they also placed traps in flooded areas. This was not reported for the other two dams.

Hook and line fishery was mostly practised in shallow water. Few fishers used canoes which thus limited the fishing grounds to where a person could wade in water. The majority of the anglers fished from the shore or next to the reeds. An exception was the anglers in Makungwa dam where many fished in flooded areas and below the spillway. Anglers in Makungwa considered their catches in the dam were going down as a result of the heavy net fishing, and preferred to fish in other places.

Bundles of grass were mainly used in the flooded areas next to the dam. The possibility to employ this method in the dam depended largely on the shoreline (reeds, stumps, depth). The shoreline at Chadewa was not suitable and therefore this method was *not used* there.

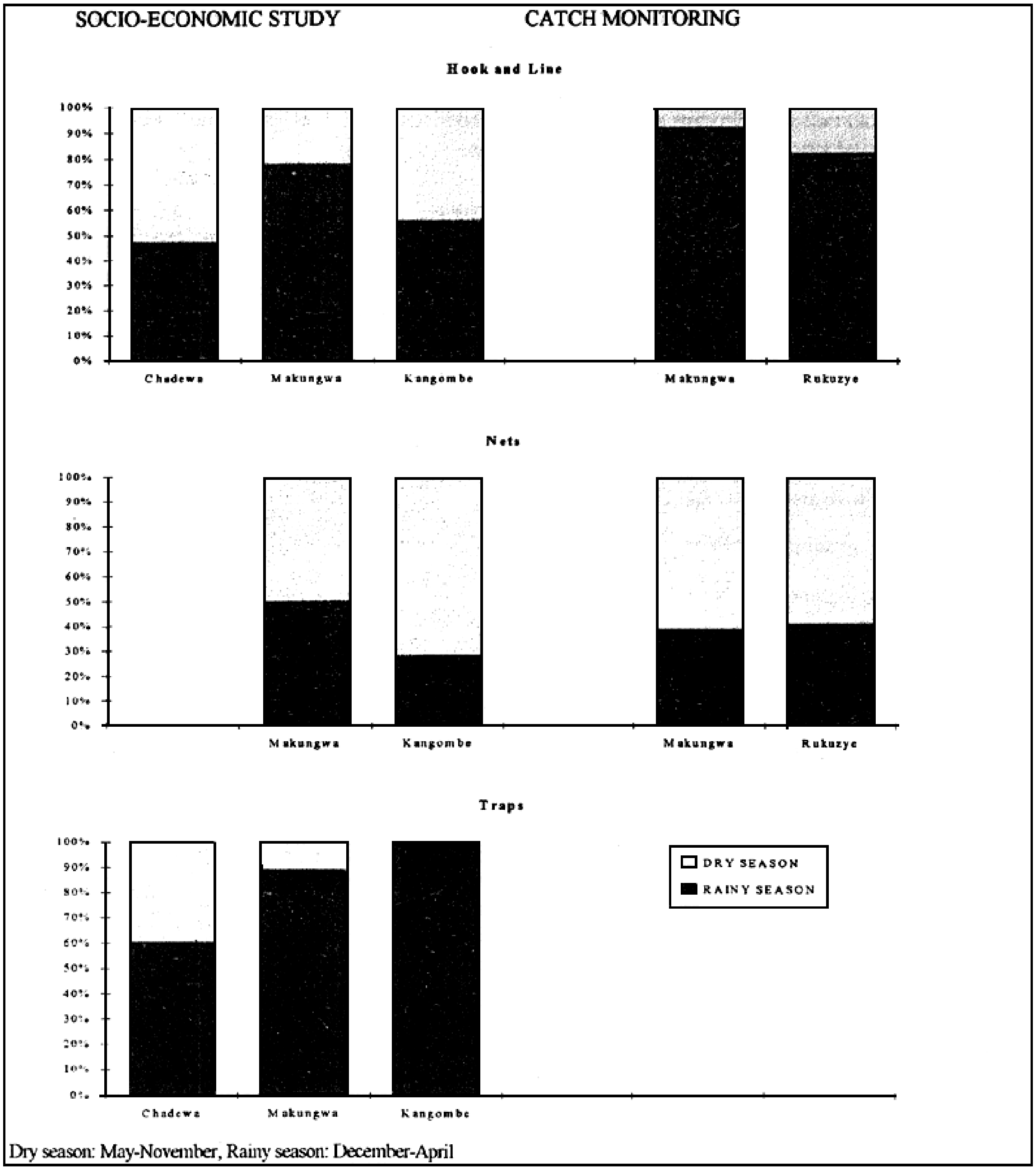
Spear fishing was also mostly done in flooded areas or just below the spillway. The water should not be too deep and be clear enough to see the fish.

In case the shoreline was suitable for seining, it was also suitable for hook and line fishery, bundles of grass and spear fishery. Competition could thus occur between these fisheries. During the short time the depressions surrounding the dam were flooded, there was a severe fishing pressure from hook and line, trap, bundles of grass and spear fishery. Hook and line fishery also completed with gill net fishery when these were set *next to* the reeds.

4.4.2. Seasonality of Gear

The fishing frequency per season and per gear was obtained by multiplying for each gear the percentage of respondents fishing in the different seasons with the number of times they reported to fish. The seasonality is shown in Figure 4.

Figure 4: Seasonality of fishing gear in different dams, as determined by two data collection methods



In general, net fishing took place throughout the year, but was intensified during the dry season. Traps were usually set in running water. Because many streams dried up during the dry season, they were mostly used during the rainy season. Angling was done throughout the year, although the fishers were of the opinion that catches were better during the rainy season. The lower temperatures in the dry season, negatively influenced the catches. Bundles of grass were mainly used when the water level in the dam had gone down. Alternatively, they were being utilized in flooded depressions next to the dam during the rainy season. Spear fishery was practised both during the dry and rainy season, depending on the fishing grounds. Some fishers waded in the dam when the water had gone down considerably, others tried to catch the fish which swam with or against the current in the spillway during the rainy season.

4.5. Fishing Effort

4.5.1. Choice of Gear

The socio-economic study revealed that there were between 9 and 12 villages for each reservoir which fished more or less regularly. A breakdown of number of persons per type of fishery in each reservoir is given in Table 6.

Table 6: Breakdown of number of fishers using certain type of gear per reservoir

Reservoir	Total number of households	NUMBER OF PERSONS USING				
		Nets;	H&L	Traps	Other	TOTAL
Chadewa	884	2(0.3%)	341 54.2%)	45(7.2%)	24138.3%)	629(100%)
Makungwa	559	6(1.5%)	278(68.1%)	32 (7.8%)	92 (22.5%)	408 (100%)
Kangombe	529	5(1.4%)	154 (43.0%)	45 (12.6%)	154(43.0%)	358 (100%)
Average percentage:		**0.9**	**55.4**	**8.7**	**34.9**	**100**

This information was obtained during interviews with village elders. The figures may not be completely accurate, but they give an indication of the level of fishing taking place. These data clearly show that the use of hook and line is the most common technique. It should also be noted that there may be more than *one person in* a household fishing in the dam. Therefore, these data do not give a definite answer with regard to the number of households engaged in fishing.

The fishing effort was estimated for net, trap and hook and line fisheries per season, by multiplying the number offishers with the fishing frequency per season. The number of respondents who reported to fish all year round were added to the categories 'rainy' and 'dry' season. The results for Chadewa, Makungwa and Kangombe dam are represented in Figure 5. The majority of the trap fishers set their traps overnight and checked them every day. Therefore, the fishing frequency for this category was rather high. The other fishers normally fished several times a week.

No net fishers were found in Chadewa dam during the time of the survey. Although the number of net fishers in Kangombe and Makungwa dams did not differ substantially (5 and 6 respectively), the fishing effort has been much higher during the rainy season in Makungwa. The net fishers in Makungwa dam did not come from the surrounding villages. They put up a camp next to the dam and were 'full-time' fishers for four to five months. Whereas the local fishers in Kangombe were mainly occupied with their farming activities during that time.

There were relatively few trap fishers around Makungwa dam. The ethnic group (Ngoni) which lived near the dam and stream had no fishing history. They were thus less skilled in 'traditional type of fishery' which depended on the transfer of skills from (grand) parents to children.

In all three dams there were many (150 - 340) anglers who fished on a regular basis.

During the catch monitoring survey only four net fishers were identified on both Rukuzye and Makungwa dams, while only 24 and 95 hook and line fishers were interviewed, respectively. These numbers do contrast the figures obtained with the socio-economic study. Figure 5 gives the relative fishing effort as obtained with the socio-7 economic study while Figure 6 gives this information as obtained with the catch monitoring survey.

4.6. The yield

A catch monitoring survey was carried out to estimate the total yield at Makungwa and Rukuzye dams between March 1991 and March 1992. During that period the catches of 28 different men were analysed at Rukuzye on 29 sampling days. In Makungwa catches of 99 different men were recorded on *49* sampling days. No women were met during the survey. Catches were recorded from hook and line and net fishing only. The nets were in all occasions used as seine nets.

Figure 5: Relative fishing effort for three reservoirs, during the rainy season and dry season, data from

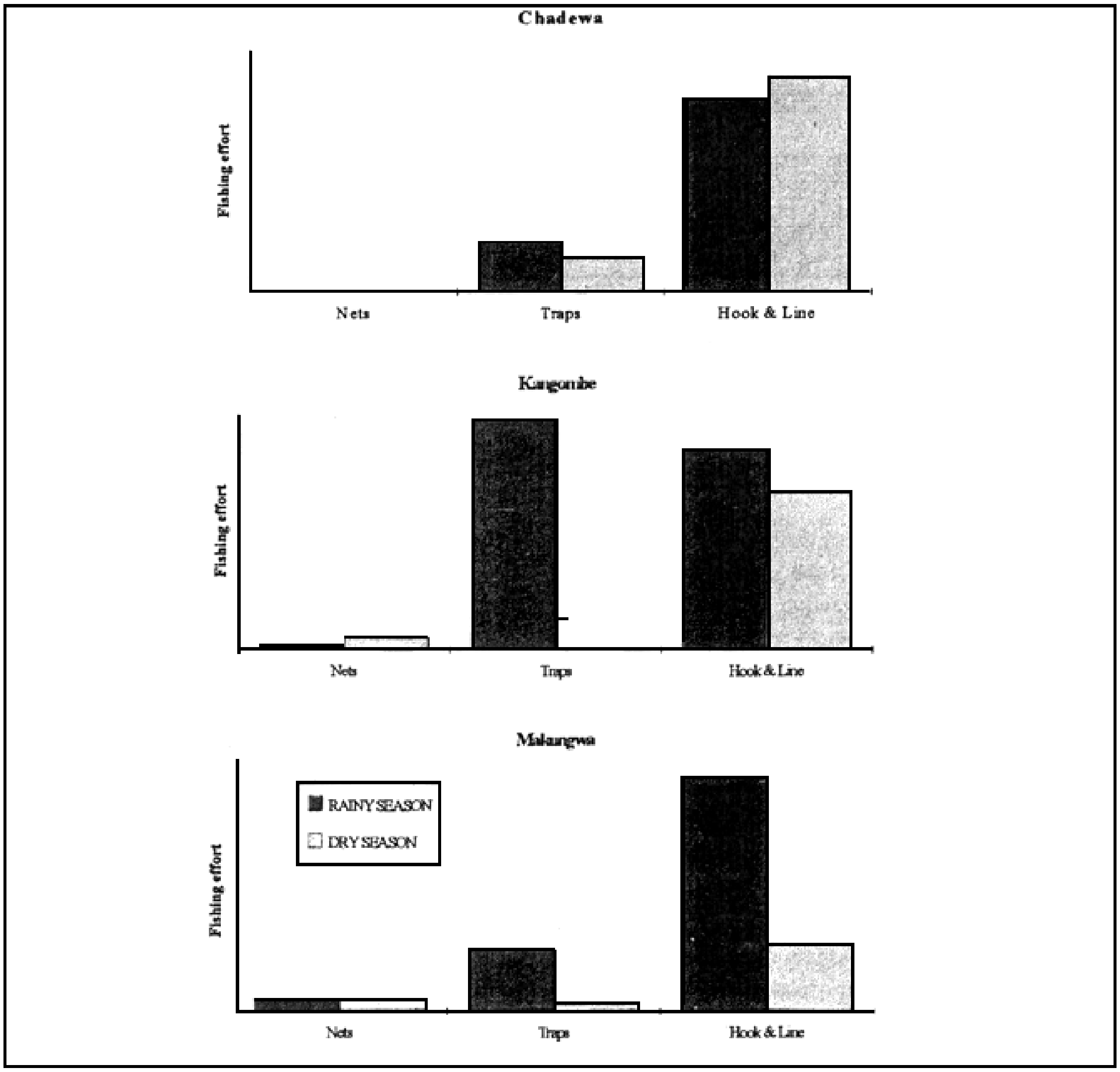
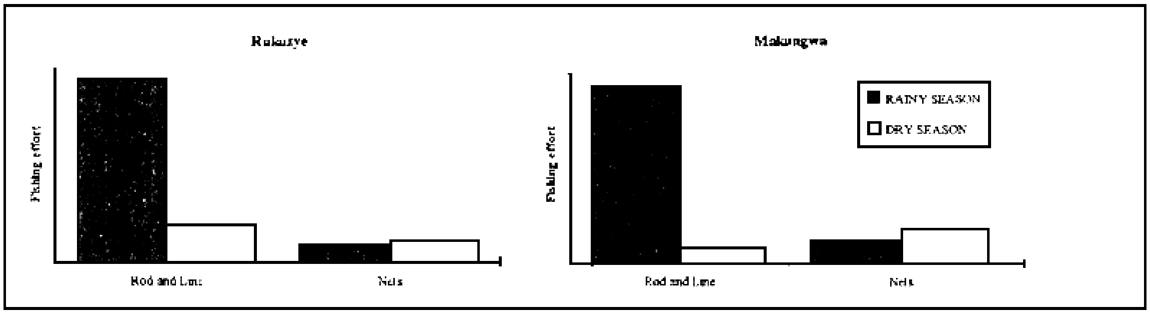


Figure 6: Relative fishing effort for two reservoirs, during the rainy season and dry season, data from catch monitoring survey



The total yield was calculated by multiplying the estimated fishing *effort* by the catch per unit of effort for nets and hook and line fishing. The total yield from the hook and line and net fishery is estimated at 6000 kg/yr. For Makungwa dam (94% for net fishery and 6% for hook and line) and at 2200 kg/yr. for Rukuzye dam (79 and 21% for nets and hook and line, respectively). Yields per hectare per year are 600 and 100 kg, respectively. The monitoring of catches was done during a year of extreme drought and the water level in Makungwa dam was very low. It was easy for the net fishers to reach all areas with their seine nets, and as a consequence they fished *out* most of the fish. The high catches at Makungwa were probably unique for that year only and can not be considered sustainable. The estimated yield is therefore more related to the biomass of the reservoir than to its production.

The socio-economic study also estimated the yield in the reservoirs. The number of gears used can be multiplied with the normal fishing frequency and a typical catch. All these figures are obtained from interviews and *not* through direct observation. The final results after multiplication are therefore very questionable. However, the figures do show a much greater participation in the fishing from the fishers using gear other than nets, and also mat they harvest a significant part of the total catch.

4.7. Summary of characteristics

Table 7 summarizes the most important characteristics of the five most common types of fishery in the Makungwa, Kangombe, Lutembwe and Chadewa reservoirs.

Table 7: Characteristics different types of fishery

ITEM	NETS	TRAPS	HOOK & LINE	GRASS BUNDLES	SPEARS
-Sex fisher	men only	men only	90% men	men and women	men only
-Application	0.9%	8.7%	55.4%		34.9%
-Fishing site	56% next to reeds 22% off-shore	42% up stream 45% down stream	33% next to reeds 32% on beach 19% flooded areas	shore flooded areas	flooded areas shore
-Fishing season	all year	rainy season	all year	mainly dry season	dry + rainy season
-Fishing frequency	46% > 1t/week 27% > 1t/month	42% > 1t/week 38% every day	41% > 1t/week 24% > 1t/month 21% 1t/week	36% > 1t/week 36% > 1t/month	50% > 1t/week 25% > 1t/month
-Species caught	58% Bream 30% Catfish	39% Barbus 32% Catfish 21% Bream	37% Bream 35% Barbus 20% Catfish	Catfish and Barbus	Catfish
-Size class smallest fish	> finger	1/2–1 finger	1 finger	1 finger	a hand
-Size class biggest fish	> finger - halfway elbow	halfway elbow	1 finger		halfway elbow

5. ACCESS TO RESOURCES

Entry into the fishery was determined by three factors: access to fishing grounds, access to gear, and access to fishing skills.

5.1. Access to Fishing Grounds

The dam is normally owned by the village which possessed the land prior to the construction of the dam. The use of the reservoir is free to all surrounding villages. The only restriction is net fishery. All ihose who want to fish with nets need to apply for a licence with the District Council. Those who receive a licence should show it to the ward chairman[4] in whose ward the reservoir is located. However, most of the fishers (also) seek approval from the headman of the village owning the dam. In spite of this, the headmen do not really have control over the net fishery. The fishing license does not state the type of gear nor the fishing method permitted. At times the headmen did try to discuss, in their view, the destructive fishing methods (seine netting with long nets and small mesh sizes) employed by the fishers but they felt incapable to regulate the fishers. They thought that the licence covered any type of net and any type of net fishing in the dam. Only in case a fisher socially misbehaved or fished in waters outside the actual dam did the headman or chief interfere.

The fishers who used traps, hook and line or other gear, hardly ever asked for permission to fish (respectively 6%, 3% and 6% of the respondents said to have done so). There are two reasons for this. One is that most of these fishers live in villages surrounding the dam and are thus entitled to use this common resource. The second reason is that these gears were not considered as effective as net fishing by the community and thus will not deplete their common resource.

In principle, both men and women had access to the fishing grounds.

Few fishers declared to have made arrangements with other fishers with regard to fishing places. Eight percent said that each net fisher had his own place to set a net. Of the trap fishers, 27% had their own fishing ground. Some even said that they inherited it from the grandparents, In case someone infringed on their fishing place, the trespasser had to share the catch as a form of payment to the owner.

No distribution of fishing rights was reported for the other fisheries. Even when there were already a large number of people angling, others will still join them. Everyone tried his or her own luck.

[4]A ward chairman is elected by the members of a ward to represent their interests for a number of years, A village headman is a traditional leader

5.2. Access to Gear

The majority of the fishers felt nets were the most efficient gear and blamed their low catches on the ineffectiveness of their own gear (traps 41%, hook and line 31%, bundles of grass and spears 56%). Those who fished with nets either bought these themselves or they were owned by someone in town who then employed several people to fish for him. Twenty percent of the net owners had obtained credit from their father (13%) or from other relatives (7%) to purchase a net. The loan was reimbursed after crop sales (13%) or fish sales (7%).

The expenses for hooks and lines were entirely financed by the fishers themselves Hooks and lines were usually available in local stores. Nets had to be bought in town where the supply was irregular.

Those who used other gear than nets to fish, did not have the money to purchase nets. Most of them chose these methods because they were cheap and easy to operate (see Table 8).

Table 8: Reasons for using certain type of gear *(%* of respondents)

Item	Cheap	Easy access	Easy to use	Good catches	Other reasons
Nets	0	0	0	79	21
Traps	65	1	13	4	17
Hook *&* Line	56	15	25	0	4
Other gear	29	8	27	3	33

An important other reason for some people choosing traps is that it was not time consuming. One could do other things while the trap was in the water. The choice for bundles of grass or spear fishing was also stimulated by the fact that this method was taught to them by the (grand) parents and was the only method they knew.

There was no real trade in traps, bundles of grass and spears. These were made and repaired by the owners themselves. Often the parents, grandparents or other close relatives had taught them how to make and repair the gear (traps 70%, grass bundles 53%, spears 70%). Since trap and spear fishing is traditionally practised by men, the skill to make and operate these gears are not transferred to women. Women do have access to the knowledge to make bundles of grass.

The respondents who had stopped fishing (86% of them were anglers) did so because they were discouraged by the low catches, the distance to the dam and they were too busy with other activities. Eighty one percent of them would like to start again if they could use improved gear. Of those who never fished before, only 38% would like to take up fishing. Forty-five percent of the interested respondents would like to use nets. The irregular availability and cost of gear were the most important factors which inhibited the entry into the fishery of the male non-fishers. Only 33% of the women saw this as a constraint.

5.3 Access to Fishing Skills

The skill to mount and fish with nets and hook and line was mostly transferred between friends, whereas the technique to operate traps, bundles of grass and spears was mainly taught by (grand) parents. This also included the use of magic charms 'juju'. Amongst trap fishers, the use of these charms was *common* (51% of the respondents said they used them[5]). Whereas only 14% of the net fishers reported to use them and 16% each for anglers, spear fishers and fishers using grass bundles. Mostly roots or herbs were used as charms which were mixed with the bait or tied to the gear.

In Kangombe, there was a considerable number of fishers who blamed their meagre catches on their lack of fishing skill (traps 8%, hook and line 35%, other gear 9%). The fishers at the other reservoirs *felt* quite competent in fishing.

There were examples of transfer of fishing skills from men to women as far as angling is concerned. Since bundles of grass were used by both men and women, women also had access to these skills. Net, trap and spear fishing were a 'male domain' and a change in attitude is needed if one wants to expose women to these fishing techniques.

It is noteworthy that when female respondents said someone in their household was interested in fishing, they always mentioned a male member as the interested person.

[5] Many respondents were not at ease when this question was asked. Therefore, the percentages given are likely an underestimation of reality.

6. FINANCIAL EVALUATION OF FISHING METHODS

6.1. Costs

6.1.1. Fixed Costs

Fixed costs, i.e. those costs that do not change with the level of fishing effort, arc the canoe, fishing gear, licensing fees, interest due on borrowed capital and depreciation of the different assets. The biggest component of the annual fixed costs for net fishing is the depreciation of the net. The costs of mounting the net were included in the total price of nets (an average of ZK 85[6] for rope and ZK 82 for twine). The lifetime of nets is variable and was difficult to estimate. It depended on whether they were used as seine or gill nets and also whether there were many stumps in the reservoir. From the survey and informal discussions with officers from the Department of Fisheries, it was expected that nets could last about 2 to 3 years. No interest was charged on the loans made.

The average life expectancy of dug-out canoes was also estimated at 2 to 3 years. It depended on the material used to build them and how long they were in the water. Because all net fishers in Kangombe used canoes, their fixed costs were higher than those for Makungwa dam.

There were no fixed costs for the other types of gear.

6.1.2. Variable Costs

Variable costs, *i.e.* those costs which vary with the level of fishing effort, can include bait, repairs of gear and canoe, crew's wages and/or shares, and transport.

The two components of variable costs for net fishing were repairs of nets and crew's shares. Nets were usually repaired by the fishers themselves with local materials. Therefore, the financial costs involved were minimal.

Two types of crew were employed, depending on the fishing method used and whether the owner lived in a nearby village or was an outsider. If he was a local fisher and thus only fished part-time, he would also 'employ' his helpers on a part-time basis. These helpers could be relatives, friends or farm workers who assisted him during the fishing. In the latter case, the fishers camped at the dam site and fished full-time. These fishers usually came with regular workers who assisted them continuously. For gill netting one or two persons can set and haul the net. However, for seining more people were needed to pull the net. If the net is not hauled fast enough many fish escape. Therefore, often helpers from nearby villages were asked to assist with seining. These were just hired for the day. Exact details of crew remuneration were not obtained during the survey. During informal discussions with other fishers, it was learnt that the remuneration of the local helpers depended entirely upon the owner of the gear. No agreements were made before fishing started. If these helpers thought they did not receive a fair share of the catch they could complain to the village headman. The headman could try to negotiate with the net owner but could not dictate the amount to be paid to the crew. The regular workers were either paid in fish, which they could then dispose of if they wanted, or were given a fixed salary.

The variable costs for hook and line fishery were made up of hooks and line only. The bait was never bought. The variable costs for the other types of fishery were nil.

It is clear that the operational costs for all types of fishery were kept to a minimum. The main inputs were labour and time. The majority of the fishers fish part-time, i.e., only when their other activities did not demand their input. Therefore, the opportunity costs for labour approached zero.

The relatively high initial capital investment of buying a new net, restricted the entry into net fishery

[6] May 1990 Exchange Rate USS1 = ZK40

6.2 Disposal of Catch

Catches were kept for home consumption, sold, given away to relatives and friends or were bartered for other essential commodities. The distribution of the catch over these four categories differed per dam and per fishery *(*see Figure 7).

In general, the biggest part of the catch was consumed by the fisher's own household with the exception of net fishers in Makungwa dam. These full-time fishers had to make their living from fishing and they also had higher

catches. The net fishers in Kangombe, on the other hand, consumed 46% of the catch and only sold fish if the catches were good.

Table 9: Reasons to fish *(%* of respondents)

Item	Net	Trap	Hook & Line	Other Gear
For consumption	11	58	74	70
For sale	11	1	1	0
Both	78	41	25	30

The reasons for fishing are summarized in Table 9. These results partly correspond to the way the fishers actually disposed of the catches. Apparently, many fishers would like to sell their surplus, but only 19% of the trap fishers, 16% of anglers and 3% of those using other gear did so. It is thus not surprising that nearly all fishers said they wanted to catch more fish (see Table 10).

Table 10: Fishers aspiration to have more fish *(%* of respondents)

Item	Net	Trap	Hook & Line	Other Gear
No	0	2	2	0
Yes, for consumption	61	89	83	88
Yes, for sale	94	62	50	49

The data also highlight the fact that the actual catches did not even satisfy the demand for fish for home consumption.

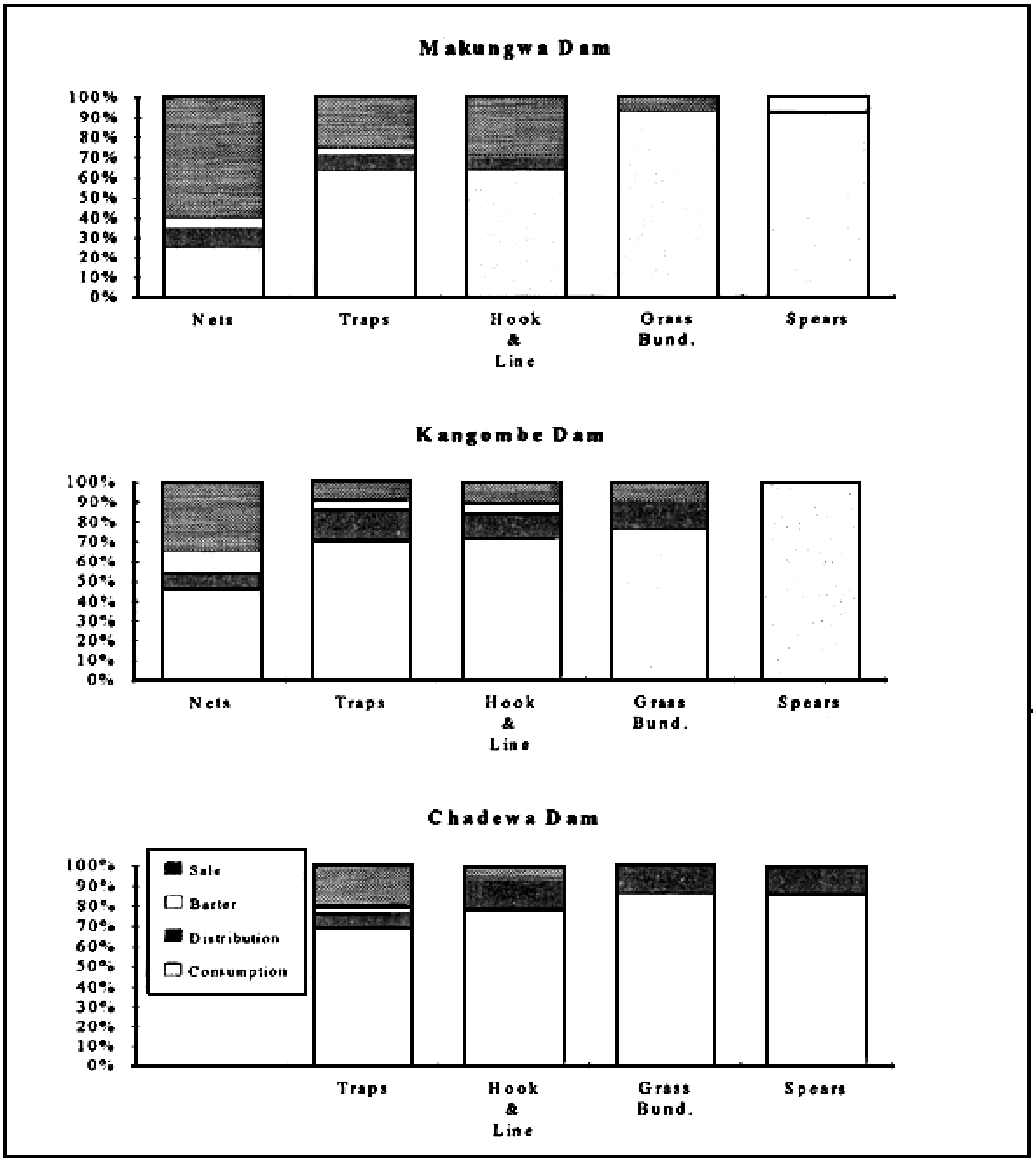
At Makungwa most of the fish was marketed at the dam because it was close to the main road (Chipata-Lusaka). This specific location has increased the prices and consequently, limited the access to fish for the non-fishing community members. In Makungwa, only 29% of the non-fishers occasionally bought fish. In Kangombe and Chadewa, the figures were. 79% and 51%, respectively. In Kangombe and Chadewa, fishers also tended to share fish more often than in Makungwa. Twenty seven percent of the non-fishers in Kangombe and 32% in Chadewa did receive fish every now and then, while this was only 5% in Makungwa.

The catches were often sold at different places. Some customers came to the dam to buy the fish. The remainder was taken for sale in the villages or at the roadside. It was rare that fishers sold fish from their homes. The 'sales system' differed for each dam, depending on its location with regard to the villages, main roads and towns. Figure 8 depicts the places where the majority of the non-fishers in the communities surrounding the dams bought their fish from.

6.3. Revenues

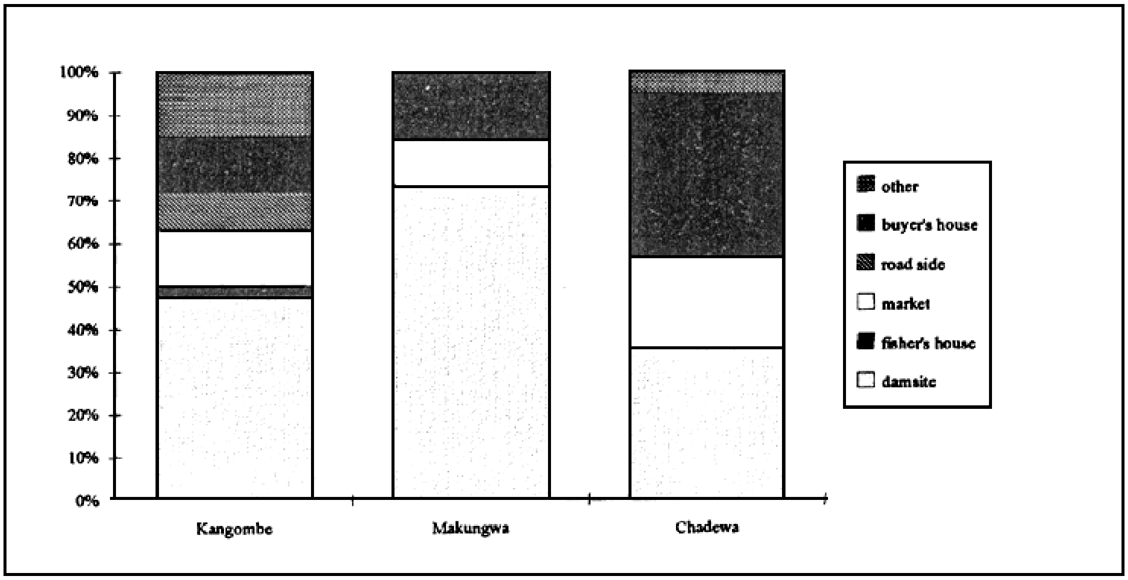
Fish were sold in cups or small plates (Barbus spp.), in heaps (bream) or per piece (bigger size catfish and Labeo). The prices differed per species. Catfish was the most expensive, followed by bream and Labeo. Barbus was relatively expensive. In general, a cup of small fish equalled the price of 3 to 4 medium size breams. The prices also varied per dam. As said before, the highest prices were obtained at Makungwa Dam. For example, the average price of a catfish here was up to 60% higher than in the other dams, and on average bream cost more than twice as much. There were probably seasonal variations in prices as well, but these could not be detected with this short survey.

Figure 7: Disposal of catch, percentage of the catch sold, bartered, distributed (or given away), and used



The revenues for a fisher consequently depended on the catch composition and the size of fish caught by the gear used. The catches for net fishers in Kangombe dam were considerably lower than those in Makungwa dam. The fishing pressure in Kangombe was more or less constant throughout the year (it varied with the labour demands for the agricultural activities). The local fishers fished in the dam year after year, while in the Makungwa reservoir no net fishing had taken place for several years. The full-time fishers only stayed there for several months. When the catches went down they moved to another reservoir.

Figure 8. Sales point for fish



During the study, the portion of fish allotted to home consumption, barter or to give away to friends or relatives was registered separately. It was assigned a market value to compare the revenues of the different types of fishing units. Table 11 summarizes certain features of the different fishing units.

6.4. Annual Incomes

Tables 12, 13, and 14 indicate the annual incomes for each gear type operating in the three reservoirs. It is clear from these estimates that the net fishery was the most profitable fishery on Makungwa dam. On the other reservoirs, the trap fishery gave the highest profits (Appendix 2 gives details on how costs and income was calculated).

6.5. Sensitivity Analysis on Incomes

A sensitivity analysis *on* incomes of net fishers, trap fishers, anglers and those using other gear is given in Appendix 3.

For Kangombe and Lutembwe dams where catches were reported to be relatively low for net fishers, the incomes were most sensitive to changes in catches (a 10% increase in catch would increase their profit with 61.5% and 56.5% respectively) compared to 21% for Makungwa (at a constant cost price).

The effect of an increase in the selling price of fish depends on the percentage of catch being sold, In general incomes of net fishers were more sensitive to a price increase than the other type of fishery because they sold the highest proportion of their catches. Of course higher prices may bring about a shift in the way the catches are used.

All net fishers will loose part of their income when costs increase. An increase in the fixed costs (price of nets, canoes, and licensing tees), has the biggest effect on fishers in Kangombe (-30.5%) and Lutembwe (-21.5%). With a 10% increase of the variable costs, the fishers in Makungwa would loose 11%, in Kangombe 21% and in Lutembwe 25%. The incomes of the net fishers in Makungwa are more sensitive to an increase in variable costs than fixed costs because they spend a relative large amount on payment of regular workers and casual helpers.

Since there were no financial costs for trap fishers and those using other gear (spears and grass bundles), an increase in costs does not affect them. The costs of lines and hooks for anglers was so low that their annual income would not change if costs increase by 10%. However, the initial investment may discourage lower income people (to which women often belong) to angle.

Table 11: Features of different fishing units fas determined bv the socio-economic studv)

ITEM	NETS	TRAPS	H & L	OTHER GEAR	
				GRASS BUNDLE	SPEARS
Reason for fishing					
Consumption	*	*	*	*	*
Sale	*				
Efficiency					
High	*	*			
Moderate	*		*	*	*
Low	*				
Required Investment					
High	*				
Moderate			*		
Low		*		*	*
Running cost & Recurrent expenditures					
High	*				
Moderate			*		
Low		*		*	*
Profit margins					
High	*	*			*
Moderate	*		*	*	*
Low					
Disposal of fish					
Consumption	41%	64%	72%	84%	93%
Distribution	11%	9%	9%	9%	7%
Barter	5%	2%	2%	0%	0%
Sale	41%	24%	17%	6%	0%

Table 12: Annual incomes by tyne of pear (ZK) for Makungwa dam

Item	Nets	Traps	Hook & Line	Other Gear
Fixed Costs	1 172	0	0	0
Variable Costs	18 844	0	17	0
Total Costs	20 016	0	17	0
Total Revenues	37 605	14 925	6 986	11864
Profit	**17 589**	**14 925**	**6 969**	**11864**

Table 13: Annual incomes by type of gear (ZK) for Kangombe dam

Item	Nets	Traps	Hook & Line	Other Gear
Fixed Costs	1 306	0	0	0
Variable Costs	916	0	16	0
Total Costs	2 222	0	16	0
Total Revenues	2 652	12 925	2 581	12 314
Profit	430	12 925	2 565	12 314

Tahle 14: Annual incomes by tyne of sear (ZK) for Chadewa dam

Item	Nets	Traps	Hook& Line	Other Gear
Fixed Costs	N/A	0	0	0
Variable Costs	N/A	0	16	0
Total Costs	N/A	0	16	0
Total Revenues	N/A	12 219	7 248	5 976
Profit		12 219	7 232	5 976

Figures are based on the results of the questionnaires. Prices for May 1990 were used.

The sensitivity analysis shows the greater vulnerability of the incomes of the local net fishers in Kangombe and Lutembwe compared to those in Makungwa. It also shows that the trap fishery, rod fishing and fishery with other gear are able to absorb adverse changes in the fishery more successfully than the net fishery. However, this sensitivity analysis does not show how the first three categories of fishers value their time. It is possible that although the fishery is still profitable, some fishers may stop or reduce their fishing efforts because they prefer to do something else with their time.

7. STANDARD OF LIVING OF FISHERS COMPARED TO NON-FISHERS

When comparing the standard of living of the fishers with the non-fishing households, the household sizes and composition had to be taken into account (see Table 15) as these may determine a household's activities and relative well-being. Although the anglers were relatively young, the composition of the household they were members of was comparable to those of the other fisher categories. The main difference was that the anglers were often dependants while the other fishers were heads or spouses of heads of households.

Table 15: Demographic characteristics of the different household categories (H.H .= Household}

	Dam	Nets	Traps	H & L	Other Gear	Non Fishers
Avg. Age Respondent		36	37	26	34	43
Median H.H. Size		11	10	7	8	8
Avg. H.H. Size		7.8	8.5	6.9	8.3	5.9
Dependency Ratio	Chadewa		1.5	1.2	2.1	2.3
	Makungwa	1.2	1.6	1.2	1.6	1.9
	Kangombe	1.4	1.7	1.4	1.4	1.5

The household size of the net fishers was large but many of its members were in the productive age group. Therefore, their dependency ratios[7] together with those of the anglers, were low compared to the other household categories. The dependency ratios for the non-fishers were relatively high although the difference with the other four categories was not significant. Female-headed households as well as households headed by elderly people were over represented in this group. These households often had fewer people in the productive age group while they still had the same number of children to look after. The resulting time and labour constraint partly explained their household's lack of interest in taking up fishing.

Table 16: Primary sources of income *(%* of Respondents)

	Farming	Vegetable Gardening	Piece work	Husbandry	Fishing	Other
Nets	58.5	0	8.5	0	22	11
Traps	61.5	5	13.5	2	7	11
Hook & Line	56	14	19	0	3	8
Other gear	42	7	32	0	8	11
Non fishers	64	6	13	2	-	15

All fishers had other income generating activities. For the majority, farming was the major source of income, sometimes supplemented by money derived from fishing (see Table 16). Generally it was the net fishers who considered fishing as an important economic activity. Twenty two percent of them mainly relied on fishing for their income, while 38.5% ranked it as their next most important source of income.

Calculations concerning significant differences in primary sources of income between the five categories of households were made. While net fishers obtained an income from fishing, many households in the other fishing groups made a living from vegetable gardening. The fishers employing "other gear" derived relatively little income from farming. On the other hand, there was a high percentage of this category whose primary source of income was from piecework. It is difficult to give a satisfactory explanation for this fact. The standard of living for this group did not differ considerably from that of the trap fishers, anglers and non-fishers (which can thus not explain the high incidence of working for others). Neither did the household composition differ significantly from the other categories.

Considering the figures in Table 16, it is understandable that most fishers gave priority to fanning rather than fishing when there were labour constraints. Apart from the net fishers in Makungwa, all fishers fished on a part-time basis.

Table 17: Percentage of households owning certain items

ITEM	DAM	NET	TRAP	HOOK & LINE	OTHER GEAR	NON FISHERS	SIGN. LEVEL
COWS	Chadewa		27	20	42	33	1%
	Makungwa	50	24	26	36	13	0.5%
	Kangombe	56	54	30	18	10	0.5%
GOATS	Chadewa		43	7	50	33	0.5%
	Makungwa	67	53	47	57	35	0.5%
	Kangombe	78	62	52	36	36	0.5%
PIGS	Chadewa		70	80	92	60	0.5%
	Makungwa	67	71	63	64	68	0.5%
	Kangombe	56	69	57	64	28	0.5%
CHICKENS	Chadewa		70	60	83	67	0.5%
	Makungwa	67	71	74	86	71	0.5%
	Kangombe	89	100	91	82	77	0.5%
WHEEL-BARROW	Chadewa		10	7	8	10	Not s.
	Makungwa	50	35	37	36	10	0.5%
	Kangombe	11	0	4	5	5	2.5%
OXCART	Chadewa		17	0	8	13	0.5%
	Makungwa	33	18	11	7	6	0.5%
	Kangombe	22	23	13	0	3	0.5%
BI-CYCLE	Chadewa		57	33	33	37	0.5%
	Makungwa	50	53	47	50	29	0.5%
	Kangombe	78	54	39	27	18	0.5%
CHAIRS	Chadewa		67	27	75	60	0.5%
	Makungwa	67	76	84	71	58	0.5%
	Kangombe	78	62	52	55	49	0.5%
TABLES	Chadewa		43	27	42	43	5%
	Makungwa	83	53	79	71	39	0:5%
	Kangombe	56	69	43	73	51	0.5%
RADIO	Chadewa		30	20	25	30	Not s.
	Makungwa	50	35	47	14	16	0.5%
	Kangombe	67	38	26	36	23	0.5%
BED	Chadewa		47	27	58	43	Not s.
	Makungwa	83	41	79	57	52	0.5%
	Kangombe	56	46	35	45	41	Not s.
HOUSE + TIN/ ASBESTOS ROOF	Chadewa		0	0	0	0	Not s.
	Makungwa	33	24	32	14	0	0.5%
	Kangombe	22	0	4	0	8	0.5%
MEDIAN RESOURCE INDEX	All Three Dams	51%	27%	23%	30%	17%	0.5%

A comparison was made for certain indicators of prosperity between households of different categories (see Table 17). Although animal husbandry was not mentioned as an important source of income, the majority of households \ in all categories did keep animals. Apparently it was more seen as an investment than a commodity to trade. The net fishers in Makungwa and Kangombe kept more cows and goats than the other households. While it was anticipated that the trap fishers would have more animals than the anglers and non-fishers (because of their age and status in the community) this only held true for Kangombe dam and to a lesser extent for Chadewa dam.

A resource index, combining all these indicators of prosperity, was developed. The results for the five target groups are also reproduced in Table 17 as a percentage of the total possible score (29), The median rather than the average scores were given because of the high variation in answers. The differences in scores for the resource index were significant for all three dams. The non-fishers and lhe anglers were the poorer groups in the community while the net fishers were relatively prosperous.

Figure 9: Percentage of respondents reporting lack of nshima during certain months of the year, by gear.

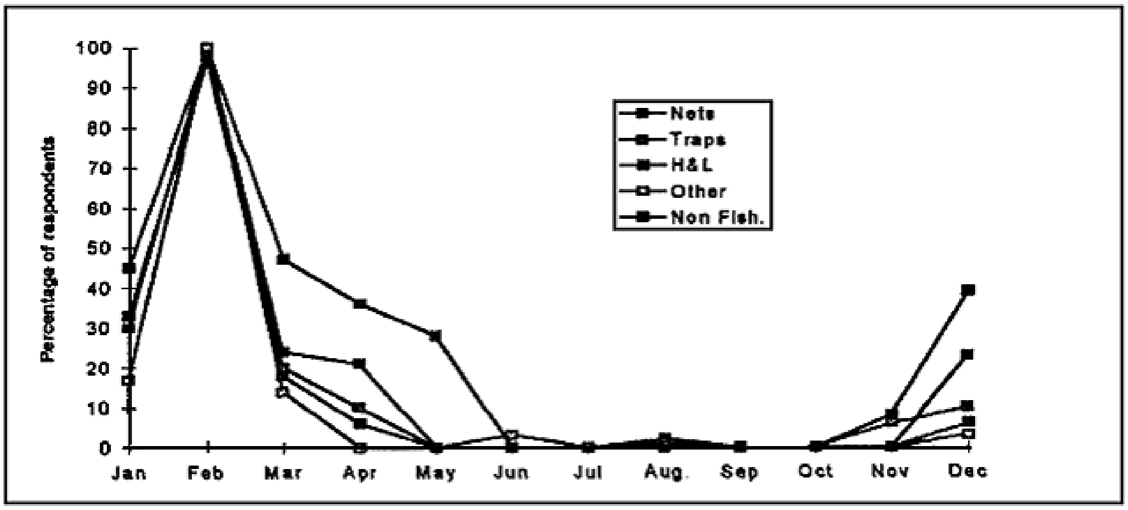
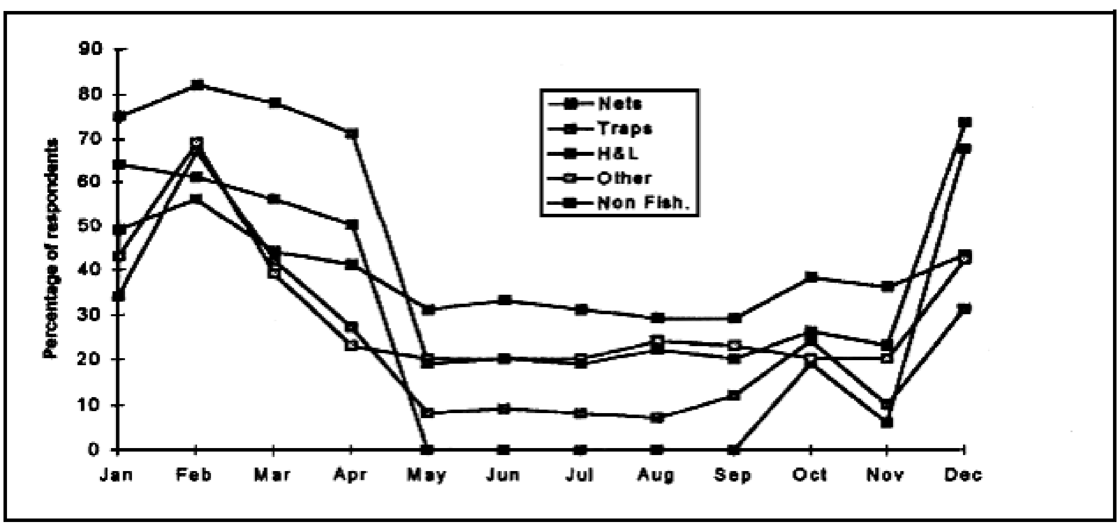


Figure 10: Percentage of respondents reporting lack of animal protein during certain months of the year, by gear



The household food security for the different categories was measured by the availability of the staple food nshima (Figure 9), a thick porridge made of maize meal, as well as the abundance of animal protein (Figure 10).

The hungry season, February, hit all household categories equally. It was remarkable that net fishers experienced a higher lack of the staple food (see Table 18), especially since they were relatively well-off and they were also active in fanning. It is possible that they concentrated more on the cultivation of cash crops and thereby neglected food crops, which is a common feature in Zambia.

An index[8], combining the availability of the staple food and animal protein, was developed. The results are given in Table 18 in percentages of the total possible score (24). The results were significantly different between categories at all dams.

Table 18: Average number of months per year households lack animal protein and nshima

	Dam	Nets	Traps	H & L	Other Gear	Non Fishers
Lack Animal Protein	Chadewa		2.6	6.2	3.1	5.0
	Makungwa	2.3	3.3	3.1	4.0	5.4
	Kangombe	4.0	2.5	4.5	4.5	5.5
Lack Nshima	Chadewa	2.2	1.5	1.4	1.3	2.0
	Makungwa		2.0	1.7	1.2	1.3
	Kangombe	3.3	1.4	2.9	1.5	1.5
Average Food Security Index	All Three Dams	74%	73%	66%	74%	62%

During the rainy season (December until April), the non-fishers felt a higher lack of animal protein than all the other categories of fishers. The main contributions to animal protein were fish, meat and eggs. No significant differences were found between the five categories with regard to the consumption of meat and eggs during the rainy season (see Table 19). The difference in consumption of animal protein was determined by the consumption of fish. Obviously the non-fishers had less access to fish and consequently experienced a higher lack of animal protein. The fact that the fish catches were available at the time when there was a shortage of animal protein in the area is an important factor to recognise in all types of reservoir fisheries. However, it was surprising that fishers perceived a high lack of animal protein during the month of February (also for those fishers who mainly fished during the rainy season). It is possible that this lack was related to the shortage of the staple food (if there is no nshima, the accompanying relish is not eaten). Another possibility is that a relatively large portion of the fish is being sold during that period in order to pay for the labour needed for weeding the crops, purchase of fertilizer or school fees and uniforms for the children.

Table 19: Consumption of meat, fish and eggs for the different household categories (in number of times per month)

Household category	RAINY SEASON			DRY SEASON		
	Fish	Meat	Eggs	Fish	Meat	Eggs
Nets	5.6	4.5	3.0	5.0	6.6	3.2
Traps	7.0	4.6	1.8	5.6	5.7	3.2
Hook & Line	4.6	3.3	2.9	4.2	4.6	2.8
Other Gear	4.1	3.6	1.8	4.8	5.2	2.8
Non-fish.	1.7	3.3	1.7	1.7	3.9	1.8

During the dry season the non-fishers did not only consume less fish, they also ate less meat and less eggs than the other household categories. The household food security for this group was thus more precarious than for the other groups.

It was striking that apparently the fish catches did not alleviate problems of animal protein in Kangombe like it did in the other areas (see Table 18). Even net fishers felt they lacked animal protein during 4 months of the year. There are several possible explanations for this fact:

- the net fishers here did not fish as often as those in other dams because they gave priority to farming;
- the trap fishery, which was not very time consuming, was not affected by this labour and time constraint;
- there were indications that the dam was overfished (fish caught were relatively small);
- because of the stumps and vegetation, it was more difficult to catch the fish.

[7]Dependency ratio = ((No. persons less than 14 yrs) + (No. persons 60 yrs and over)) / (No. persons 15 - 59 yrs)

[8] Food security index is composed of the following indicators: number of months household has nshima, number of months household has animal protein, number of times household consumes fish, meat and eggs in rainy and dry season. A higher figure indicates a better food security sutation.

8. DISCUSSION

8.1. Findings

There are approximately 200 reservoirs in Eastern Province of Zambia with a total surface area of nearly 1000 hectares. The studies did not produce exact production figures for these reservoirs, but the fish production does not appear to have a great impact on the food situation of the whole population of the Province, which is estimated at around one million people. It showed, however that fish from the reservoirs is an important source of protein for the local population.

The study looked at the fishery of five reservoirs in the Province and it is dangerous to generalize its findings. However, the fish species composition of the five reservoirs studied corresponds well with the composition of the total 15 reservoirs sampled. These reservoirs are also located in the same river system as most of the other reservoirs in the Province and can, from the point of view of species composition, be considered representative.

At the start of the pilot project it was believed that the reservoirs were generally under-exploited. The dominance of *B. paludinosus* in the stock sampling, and the fact that this species is hardly ever caught in the nets of fishers, contributed to the idea that the fish stocks were not efficiently exploited. Especially the information obtained with the socio-economic study revealed that gears other than nets did catch a much wider range of fish species, and that the trap fishers and the hook and line fishers, as well as the fisheries using grass bundles caught *B. paludinosus* effectively.

From the data presented in this report it can be concluded that the fish stocks in the reservoirs are not underexploited, but are intensively exploited, and most likely in many cases overexploited.

The study showed however, that fishing pressure is not constant and varies with the seasons, nets more intensively used during the dry season, while hook and line and trap fishing practiced mainly during the rainy season.

The perceived lack of animal protein is not constant throughout the year and is most severe during the rainy season. Fish from reservoirs did not replace meat or eggs, but was an additional source of animal protein available at a time when there was a shortage of animal protein in the area. As has been shown in other studies in Eastern Province, people with access to reservoir fisheries consumed significantly more fish than people who had no access. Another important factor is that fishing was a way of making surplus labour productive through capturing fish for home consumption and/or selling it to obtain an additional income. This was particular helpful for the lower income groups, like the anglers and to a lesser degree for trap fishers and those using other gear. The non-fishers often bought or received fish from local fishers, which was a valuable contribution to ease their precarious food situation.

At present there is little management of the reservoir fishery. Most gear can be used without a permit. Nets do require a permit from the District Council. The Department of Fisheries is supposed to advise on the licensing of net fishers, but in most cases is not consulted. Moreover, the District Council and the Department of Fisheries do not communicate with the majority of the fishers. Thus the two authorities responsible for the issuing of permits for gillnets and checking of the nets, do so without having any idea on the fish stocks and the fishery on the reservoirs. This means that permits are not issued on the basis of potential to increase the fishing pressure on a particular reservoir.

After the issuing of gillnet licenses, there is no system in place to ensure that the nets are used according to the regulations. This study showed that most nets are used as seine nets, which is officially not allowed. From the average size of the fish caught in these nets, it is obvious that the mesh sizes used are much smaller than the legal minimum of 3.5 inch. Since most reservoirs are too small to sustain a full time net fishery in combination with an intensive fishery using other gears, most net fishers move from one dam to another when the catches decrease, using the same license.

These migrant net fishers catch a large portion of the total yield, while they represent less than 1% of the fishing population. This phenomenon is especially striking in Makungwa dam where six "migrant" fishers catch, according to the information of the catch monitoring survey, up to 92% of the total yield. This means the benefits of the fish resource are not distributed on an equitable basis.

In order to identify the most suitable management strategy for the reservoir fishery, these findings have to be reviewed taking the development policy and the possible management options into consideration.

8.2. Development policy

The management strategies for the reservoir fishery have to harmonize with the development policy of the Zambian Government. The current government policies for the fisheries sector place great emphasis on job creation without taking into consideration the capacity of the resource to withstand the increased fishing pressure. The newly proposed fishery policies (1996) aim at reversing this trend and are designed to enhance fisheries growth based on rational management practices. The policies, as described in the fisheries sub-programme of Agricultural Structural Investment Programme (ASIP), include:

- to encourage the use of available labour to eliminate rural poverty and increase gainful employment;
- to encourage increased but sustainable use of the available natural resource base;
- to promote conservation of all aquatic resources based on sound ecological principles;
- to encourage greater participation by the private sector, traditional institutions, and NGO's in resource management,
- to create a legal framework conducive to greater involvement by the private sector in fisheries related activities;
- to improve the technical capability and conditions of service of DoF staff, in view of the ongoing Public Service reform programme aimed at improving efficiency.

These policies are designed to lead to an increase in fish production in the country.

8.3. Management options

Three general options to enhance the reservoir fishery exist:

- increase the productivity of the reservoirs;
- increase the total revenue of the fishery;
- maximize the yield through optimizing the fishing effort.

The productivity of the reservoirs can be increased through stocking of species that would fill unoccupied or under utilized niches. Since reservoirs are created by obstructing a river, the original species composition is riverine. The construction of the reservoir changed the aquatic environment and it may be that the riverine species are not adapted to fill all the vacant niches. This was one of the reasons why the Department of Fisheries stocked several reservoirs with *O. andersonii, O, macrochir* and *T. rendalli.* When stocking other species, care should be taken not to introduce species that do not originate from the same riversystem. Introductions from other riversystems can only be conducted after careful study of alternative species and investigation of possible effects of the introduction. The stock sampling showed that many reservoirs hold a limited number of fish species. It is obvious that the production of many reservoirs can be enhanced through the introduction of additional species.

The productivity can also be increased through fertilization of the dam or feeding of the fish. This option is not possible in the context of the reservoirs in Eastern Province since the water from the reservoirs is also used for domestic consumption and fertilization can be seen as polluting the water. Production increase through the introduction of aquaculture techniques like cage culture is not practical in the context where inputs for fish feeds are scarce. Besides, the economic situation of the local community living around reservoirs does not justify the introduction of capital intensive culture systems.

The total revenue of a fishery can be improved through a change in catch composition towards the more valuable species. The fisheries assessment gave data concerning the gear selectivity while stock sampling results gave the relative abundance of the different species. This information, together with the prices of the fish can be used to formulate a strategy which can augment the Maximum Economic Yield. Seasonal variation in catches, gear effectiveness, prices and labour availability have to be taken into account. Distinct price differences for different fish species or sizes, mainly exist in urban areas. Implementation of this option would mean that the fish will be sold outside the community, and benefits will be restricted to only few specialized fishers. Fishing will become a source of income for few, rather than a source of animal protein for the community, and a little extra income for many. Seen the importance of the fish for local food security, this management option is not in line with the development policies.

To regulate the fishing effort in such a way that the maximum yield is obtained requires control. Legally, only the net fishery can be controlled, but this report demonstrated that licensing of fishing permits is not done on the basis of attaining the optimal fishing pressure on the reservoirs, neither is the use of the nets controlled. Under the cover of a permit, nets are used as seine nets, increasing the efficiency of the net, smaller mesh sizes than allowed are used, and nets are used on various dams. This has led to overfishing of the fish stocks.

The lack of communication between the Department of Fisheries and the District Council on the one hand, and user groups on the other, concerning the issuing of net licenses has resulted in an unsustainable and inequitable use of the common resources. Co-operation of all villages around a reservoir is essential to establish secure user rights which is a prerequisite for sustainable management. ASIP encourages greater participation by the private sector, traditional institutions, and NGO's in resource management. Community surveys and meetings show that reservoir communities and their leaders are concerned about perceived overfishing, lack of control over fishing activities, and benefits from fishing which flow out of the community.

9. CONCLUSIONS AND RECOMMENDATIONS

The pilot project was meant to develop a cost effective method for collecting and analyzing information regarding the fishery on reservoirs, identify suitable management strategies and test and demonstrate these strategies. The first phase of this pilot project focused on data collection. This report analyzed the data collection methods, as well as the data in order to identify suitable management strategies. The pilot project sampled fish stocks in fifteen reservoirs, conducted a socio-economic study around four reservoirs and carried out a catch monitoring survey at two. Unfortunately these activities were not synchronized, as they were not all carried out on the same reservoirs, nor during the same period. This has had a negative effect on the analysis of the information collected.

Nevertheless, the information as presented in this document, clearly supports the identification of a suitable management strategy for the reservoirs in Eastern Province of Zambia.

In the current situation in the rural areas in Eastern Province, there are not many alternative sources of animal protein, the majority of the households rarely has cash to buy fish or meat and there are few possibilities to use surplus labour to earn an additional income. Professional fishers tend to sell their fish for higher prices than local fishers, and consequently their fish does not reach the local markets. The local community thus tries to make surplus labour productive by going out fishing in the reservoirs.

Restriction of access to the dam to a few fishers who fish on a commercial basis would worsen the food security situation for the majority of the community, limit their possibilities for additional sources of income, and in short lead to undesirable social problems. Moreover, results from Makungwa indicate that full-time commercial fishery is not sustainable on the reservoirs.

A fair distribution of the communal fish resource is in line with the objectives of ASIP, and can be achieved by the promotion of labour intensive and capital extensive fishing methods since less privileged target groups often do have labour available at a low cost during certain times of the year, but capital is scarce. This would plead in favour of a ban of the net fishery in the reservoirs in Eastern Province and a control over the fishery by the local community. This would mean a loss of income for the full-time fishers as well as a minor loss of income for the District Councils from the licensing fees, which also means a loss in their power to control the issuing of fishing licenses.

This strategy can be tested on a limited number of reservoirs, although it is likely that complete implementation would only have beneficial effects for the fishery and the local communities.

The initiation of the following activities to improve the management and increase the production of the reservoirs are therefore advised:

Determination of which fish species are most suitable for stocking the reservoirs to increase the production by filling vacant niches. The practical workability, as well as the financial feasibility of such a stocking exercise has to be considered.

Investigation of how a ban on net fishing on reservoirs in Eastern Province can be implemented, and how the local communities can be empowered to control the other fishing activities on the reservoirs. It may be necessary to test this management strategy on a few selected reservoirs and monitor the effect of it. The monitoring should include practical implications of the management, the satisfaction of the community, the overall production of the fishery, the seasonality of the catches, but also the distribution of the fish among the community members.

APPENDIX 1: METHODOLOGY SOCIO-ECONOMIC STUDY

1 Study Design

The research goal had to be reworded and broken up into a few confined research questions. The research propositions had to be made specific. The study focused on four problems:

description of the actual fishing effort in the three dams, to supplement the data on the fishing effort required to obtain the Maximum Sustainable Yield (MSY) from the test fishing;

- description of access to resources for each target group surrounding the reservoirs;
- financial evaluation of different fishing methods employed in the reservoirs;
- description of the standard of living of the target groups surrounding the reservoirs.

The primary aim of this descriptive study was to describe a specific group and to put together generalizations based on observational data.

Since there were no primary sources available to answer these questions, the data had to be gathered by the project.

2 Tools of Research

A one-moment sample survey was chosen to generate the necessary data. Two interview schedules were designed. One for interviews with fishermen, and one for interviews with households whose members did not fish in the reservoirs. The interviews with fishermen were aimed at building up as complete a picture as possible of the different fishing methods encountered in the survey areas as well as the situation of the fishermen. It focused on four problems:

- description of the actual fishing effort. This should supplement the data on the fishing effort required to obtain the Maximum Sustainable Yield from the test fishing. Although observations of fishermen and registration of their catches is a more accurate technique than asking questions, it was included because at that time no other data collection method catered for this information;
- description of access to resources, like, access to fishing grounds, gear and skill to operate the gear;
- financial evaluation of different fishing methods;
- description of the standard of living of fishermen.

The interviews with the non-fishing community members were carried out to study three problems:

- distribution of fish within the community;
- other uses of the dam;
- description of standard of living of community members compared to fishermen.

The interviews with community members were not carried out in communities around Lutembwe dam. This reservoir is used to provide drinking water for Chipata, the capital of Eastern Province. The implementation of fisheries management or development strategies would not have been allowed. The dam was included for the test fishing exercise because of certain interesting characteristics (deepest and largest reservoir in the Province). The interviews with fishermen complement the data obtained from the test fishing.

3 Sample Frame

In every community surrounding the reservoirs, a meeting was held with the village elders during which the purpose of the survey was explained and information was gathered with regard to the number of fishermen in that village stratified according to the type of gear used. The sample for the first survey was based on this inventory. The selection of the sample also took the gear effectiveness into account. For example, it was assumed that someone fishing with a net will catch more fish than someone who is angling and hence the effect on the fish stock will be more important. Moreover, it was expected that there would be far fewer people fishing with nets than hook and line. Therefore, the recommendation was to interview all net fishermen and a sample of the other fishermen. In total 26 net fishermen were interviewed, 69 trap fishermen, 72 anglers and 42 fishing with other gear.

During the same village meeting, the number of households not fishing in the dam were also recorded. Ideally this information had to be gathered for male- and female-headed households separately, In practice, it was found to be difficult to obtain accurate information on the head of the households. The following sample plan was used: if the number of remaining households (households who do catch fish were excluded) in a village is less than 50, a 25% sample was taken and a 20% sample for those with more than 50 households. In total 97 non-fishermen were interviewed.

4 Training Enumerators

Three Fish Scouts working at the Chipata Fish Farm were used as enumerators. They received a one day training during which;

- the introduction of the questionnaire to the headman as well as respondents was discussed and practised, and
- the purpose of each question was explained and rehearsed in Nyanja and Tumbuka, the two local languages mainly used in the survey area.

5 Data Analysis

Simple describing statistics were used in most of the cases. Frequencies and percentages were tabulated, averages and medians to measure the central tendency of the data and variances and standard deviations to measure dispersion.

Analysis of frequencies in One and Two-Way Classifications were used to test hypotheses like the probability of having cows is equal among all five household categories'. For this analysis the percentage of households owning cows was used. Even if the null hypothesis was confirmed, another analysis has to be carried out, namely whether the average number of cows owned is the same for the 5 populations.

Nonparametric methods[9] (Mann-Whitney Rank Sum test and Kruskal-Wallis One-Way Analysis by Ranks) were used to test the difference between the medians of independent samples, like the consumption of fish or the scores on the resource index for the five household categories. Correlation coefficients (Spearman rank correlation) were used to measure the closeness of relationships between two variables, like the consumption of fish during the rainy season and the felt lack of animal protein during that same season.

Tests of statistical significance (Chi-square Goodness of Fit) were used to determine whether sample results support hypotheses like 'there is no difference in sources of cash between the five household categories!.

Regression analysis was used to determine whether there was a relationship of one or more dependent variable(s) to an independent variable. For example, the strength of the relationship between the number of dependants, number of people of working age, the age of the respondent and the resources a household owned. However, the results can not be interpreted as if the change in the independent variable (resources) is caused by an increase or decrease in the dependent variable(s). The reason is that in socio-economic surveys it is hard to prove that a certain variable is a causal factor (e.g. number of dependants, number of people of working age, age: household head) and it is impossible to exclude all underlying factors which may influence the independent variable as well.

[9] Nonparametric methods are statistical procedures which do not rely on the assumption that the data conform to a normal distribution.

APPENDIX 2: ANNUAL INCOME DIFFERENT TYPES OF GEAR

I. NET FISHERY

Capital Costs

Canoe	ZK	500
Gill net (1 of 3.5" and 1 of 2.5") mounting	ZK	2 265
TOTAL	ZK	2 765

Table 20: Annual income net fishery (ZK)

ITEM	MAKUNGWA	KANGOMBE	LUTEMBWE
Fixed Costs:			
- Depreciation			
* Net	906	906	906
* Canoe	66	200	72
- License Fee	200	200	200
Total Fixed Costs	**1172**	**1306**	**1178**
Variable Costs:			
- Repairs			
* Net	41	41	41
* Canoe	0	0	0
- Payment Helpers	18 803	875	1332
Total Variable Costs	**18 844**	**916**	**1373**
Revenues: Fish for			
- Home Consumption	9 401	1220	1673
- Distribution	3 761	186	496
- Barter	I 504	292	0
- Sale	22 939	954	929
TOTAL COSTS	**20 016**	**2 222**	**2 551**
TOTAL REVENUES	**37 605**	**2 652**	**3 098**
PROFIT	**17 589**	**430**	**547**

Assumptions

1. Number of fishing days in a year is based on the average number of fishing days obtained from the questionnaire (time of the year they fish times fishing frequency).

2. Total annual catch is based on the number of fishing days times the average number of fish caught per fishing day.

3. Depreciation periods: Canoe 2-3 years
   Net 2-3 years

   The technical lifespan[10] was used to calculate the depreciation period. The current replacement cost of the asset divided by the expected years of technical life gives the depreciation. The annual depreciation is thus constant and it assumes that there is no salvage value at the end of its technical life.

4. Repair costs: Canoe 0%
   Net 2% (ZK 41 per year)

5. Payment helpers:
   Number of regular workers: Makungwa 2 persons
   Kangombe 1 person
   Lutembwe 1.5 person

   Payment as part of catch: 2 shares for the owner, regular workers each 1 share. For seining casual helpers are used.

6. Selling price of fish; the size distribution for each species caught as well as the species composition of the catch was calculated for the different types of gear and for each reservoir. Estimates were thus obtained for the weighted price of 1 fish at May 1990 prices. The catch composition was as follows:
   Kangombe
   Bream: 60% Catfish: 33% Other: 7%
   Average price for 1 fish estimated at ZK 5
   Makungwa
   Bream: 60% Catfish: 30% Other: 10%
   Average price for 1 fish estimated at ZK 9
   Lutembwe
   Bream: 55% Catfish: 28% Other: 17%
   Average price for 1 fish estimated at ZK 4

7. Revenues were divided into fish for home consumption, for distribution, for barter and fish for sale. For comparative purposes even the fish for the first 3 categories was assigned a market value.

   Kangombe Home consumption: 46% Distribution: 7% Barter. 11% Sale: 36%
   Makungwa Home consumption: 26% Distribution: 11% Barter: 4% Sale: 59%
   Lutembwe Home consumption: 54% Distribution: 16% Barter: 0%Sale: 30%

8. Not all fishermen use a canoe. The following represent the percentages of fishermen who do use it:
   Makungwa: 33%, Kangombe: 100%, and Lutembwe: 36%

[10] Technical life span means the time up to when the equipment is technically impossible to use.

II. TRAP FISHERY

Table 21: Annual income tran fishery (*ZK)*

ITEM	MAKUNGWA	KANGOMBE	CHADEWA
Costs:			
- Trap	0	0	0
- Bait	0	0	0
- Repairs	0	0	0
Total Costs	**0**	**0**	**0**
Revenues: Fish for			
- Home Consumption	9 403	9 047	8 553
- Distribution	1 194	1938	978
- Barter	597	517	244
- Sale	3 731	1422	2 444
TOTAL COSTS	**0**	**0**	**0**
TOTAL REVENUES	**14925**	**12 925**	**12 219**
PROFIT	**14 925**	**12 925**	**12 219**

Assumptions

1. The number of fishing days, total annual catch and the selling price of fish has been calculated as described under net fishing. The outcome, however, is different.
2. Average number of traps set per fisherman:
   Kangombe: 2.5
   Chadewa: 2.4
   Makungwa: 2.2
3. No money was needed to make traps. There were no financial expenses for repairs, natural fibres were used. No expenses for bait, used mostly nshima leftovers to attract fish.
4. Catch composition:
   Kangombe Bream: 11% Catfish: 31% Barbus:58% Other: 0%
   Chadewa Bream: 22% Catfish: 29% Barbus: 37% Other: 12%
   Makungwa Bream: 19% Catfish: 45% Barbus: 29% Other: 7%
5. Weighted price for one fish:
   Kangombe: ZK 3.2
   Chadewa: ZK3.0
   Makungwa: ZK 7.8

III. HOOK AND LINE FISHERY

Table 22: Annual income book and line fishery (ZK)

ITEM	MAKUNGWA	KANGOMBE	CHADEWA
Costs:			
- Line	12	13	8
- Hooks	5	3	8
- Bait	0	0	0
Totals Costs	17	16	16
Revenues: Fish for			
- Home Consumption	4 401	1 832	5 653
- Distribution	419	297	1087
- Barter	70	155	72
- Sale	2 096	297	436
TOTAL COSTS	**17**	**16**	**16**
TOTAL REVENUES	**6 986**	**2 581**	**7 248**
PROFIT	**6 969**	**2 565**	**7 232**

Assumptions

1. The number of fishing days, total annual catch and the selling price of fish has been calculated as described under net fishing. The outcome, however, is different.
2. Average number of lines bought per fisherman per year:
   Makungwa: 1.8, Kangombe: 1.4, and Chadewa; 2.6
3. Average price per line; when it was bought (some people made their own twine):
   Makungwa: ZK 6.8, Kangombe: ZK 9.0, and Chadewa: ZK 2.9
4. Average number of hooks bought per fisherman per year:
   Makungwa: 3.5, Kangombe. 2.0, and Chadewa: 5.4
5. Average price per hook:
   Makungwa: ZK 1.4, Kangombe: ZK 1.7, and Chadewa: ZK 1.4
6. Catch composition Hook and Line Fishery:
   Makungwa Bream: 38% Catfish: 27% Barbus: 24% Other: 11%
   Kangombe Bream. 48% Catfish. H% Barbus: *42%* Other: 0%
   Chadewa Bream: 27% Catfish: 27% Barbus: 36% Other: 11%
7. Weighted price for one fish:
   Makungwa: ZK 6.5, Kangombe: ZK 2.8, and Chadewa: ZK 3.0

IV FISHERY WITH OTHER GEAR

Table 23: Annual income fishery with other gear (ZK)

ITEM	MAKUNGWA	KANGOMBE	CHADEWA
Costs:			
- Gear	0	0	0
- Repairs	0	0	0
Total Costs	**0**	**0**	**0**
Revenues: Fish for			
- Home Consumption	10 914	10 775	5 130
- Distribution	0	862	837
- Barter	475	0	0
- Sale	475	677	0
TOTAL COSTS	**0**	**0**	**0**
TOTAL REVENUES	**11864**	**12 314**	**5 976**
PROFIT	**11864**	**12 314**	**5 976**

Assumptions

1. The number of fishing days, total annual catch and the selling price of fish has been calculated as described under net fishing. The outcome, however, is different.
2. No financial expenses for gear nor repairs.
3. No bait was used for these methods.
4. Catch composition;
   Kangombe Bream: 14% Catfish: 57% Barbus: 29% Other: 0%
   Makungwa Bream: 16% Catfish; 58% Barbus: 21% Other: 5%
   Chadewa Bream: 18% Catfish: 52% Barbus: 23% Other: 7%
5. Weighted price for one fish;
   Kangombe: ZK 5.4, Makungwa: ZK 9.2, and Chadewa: ZK 4.0

APPENDIX 3: SENSITIVITY ANALYSIS ON INCOMES

Table 24: Sensitivitv analysis net fishery (ZK)

	Total Costs	Total revenues	Profit	% Change
Base Case **Makungwa dam**	20 016	37 605	17 589	
10% increase variable costs	21 900	37 605	15 705	-11.0
10% increase fixed costs	20 133	37 605	17 472	-0.5
10% increase catch	20 016	41 366	21 350	+21.0
10% increase selling price offish	20 016	39 899	19 883	+13.0
Base Case **Kangombe dam**	2 222	2 652	430	
10% increase variable costs	2 314	2 652	338	-21.0
10% increase fixed costs	2 353	2 652	299	-30.5
10% increase catch	2 222	2 917	695	+61.5
10% increase selling price of fish	2 222	2 747	525	+22.0
Base Case **Lutembwe dam**	2 551	3 098	547	
10% increase variable costs	2 688	3 098	410	-25.0
10% increase fixed costs	2 669	3 098	429	-21.5
10% increase catch	2551	3 408	857	+56.5
10% increase selling price of fish	2 551	3 191	640	+17.0

Table 25: Sensitivity analysis trap fishery (ZK)

	Total Costs	Total revenues	Profit	% Change
Base Case Makungwa dam	0	14 925	14 925	
10% increase costs	0	14 925	14 925	0.0
10% increase catch	0	16418	16418	+10.0
10% increase selling price of fish	0	15 298	15 298	+2.5
Base Case Kangombe dam	0	12 925	12 925	
10% increase costs	0	12 925	12 925	0.0
10% increase catch	0	14218	14218	+10.0
10% increase selling price of fish	0	13 066	13 066	+ 1.0
Base Case Chadewa dam	0	12219	12219	
10% increase costs	0	12 219	12 219	0.0
10% increase catch	0	13 441	13 441	+10.0
10% increase selling price of fish	0	12 463	12 463	+ 2.0

Table 26: Sensitivity analysis hook and line fishery (ZK)

	Total Costs	Total revenues	Profit	% Change
Base Case Makungwa dam	17	6 986	6 969	
10% increase costs	19	6 986	6 967	0.0
10% increase catch	17	7 685	7 668	+10.0
10% increase selling price of fish	17	7 196	7 179	+ 3.0
Base Case Kangombe dam	16	2 581	2 565	
10% increase costs	18	2 581	2 563	00
10% increase catch	16	2 839	2 823	+10.0
10% increase selling price of fish	16	2611	2 595	+ 1.0
Base Case Chadewa dam	16	7 248	7 232	
10% increase costs	18	7 248	7 230	0.0
10% increase catch	16	7 923	7 957	+10.0
10% increase selling price of fish	16	7 292	7 276	+ 0.5

Table 27: Sensitivity analysis fishery with other gear (ZK)

	Total Costs	Total revenues	Profit	% Change
Base Case Makungwa dam	0	11 864	11864	0.0
10% increase costs	0	11864	11864	
10% increase catch	0	13 050	13 050	+10.0
10% increase selling price of fish	0	11912	11912	+0.5
Base Case Kangombe dam	0	12 314	12 314	0.0
10% increase costs	0	12 314	12 314	
10% increase catch	0	13 545	13 545	+10.0
10% increase selling price of fish	0	12 382	12 382	+0.5
Base Case Chadewa dam	0	5 976	5 976	0.0
10% increase costs	0	5 976	5 976	
10% increase catch	0	6 574	6 574	+10.0
10% increase selling price of fish		5 976	5 976	0.0

APPENDIX 4: CATCH MONITORING SURVEY

A catch monitoring survey was carried out at Makungwa and Rukuzye dam between March 199] and March 1992 to estimate the total yield from these reservoirs.

All fish catches at these reservoirs were to be measured during 5 days per month. Since it was anticipated that there was a difference in fishing effort between week days and weekend days, 2 weekend days and 3 weekdays per month were randomly chosen. The recording took place 12 hours per recording date, starting at 12.00 hours or at 0.00 hours.

In total 28 different men and Rukuzye and 99 at Makungwa were interviewed. No women were met during the survey. Catches were recorded for the rod and line and net fishery, and on one occasion for a trap fisherman. The nets were in all cases used as seine nets.

The number of records was limited, and changes to the original monitoring schedule were made for unclear reasons. During some months no weekend days were monitored, and the stratification of the monitoring schedule was therefore lost. This, plus the limited number of records, made it necessary to group the data per 3 month periods for the analysis. The number of days recorded and the number of records per period, per dam and gear are given in table 1.

The reliability of the data can be questioned. The enumerator should only have recorded catches from fishermen who stopped fishing during the recording period. In some cases it was clear that also people who continued fishing were recorded, but in other cases this was not obvious. It is of course difficult to meet people just when they stop fishing, especially around a large dam. This may have resulted in the underrecording of the hook and line catches. Zero catches were apparently not always recorded, which resulted in an underestimation of the number of fishermen and an overestimation of the catches per hour.

There was a significant difference in fishing effort between week days and weekend days. Therefore the effort was kept separate for the different days. There was no difference in length of fishing session or catch per hour between week and weekend days. These data were grouped. The fishing effort, length of fishing sessions, catch per hour and estimated total catch per period and per dam and gear are given in table 2.

The total yield from the rod and line and net fishery is estimated at *6000* kg/yr*,* for Makungwa dam (94% for *net* fishery and 6% for rod and line) and at 2200 kg/yr. for Rukuzye dam (79 and 21% for nets and rod and line, respectively). Yields per hectare per year are respectively 600 and 100 kg. The monitoring of catches was done during a year of extreme drought and especially the water level in Makungwa dam went very low. It was easy for the net fishermen to reach all areas with their seine nets, and as a consequence they fished out most of the fish. The high catches at Makungwa were probably unique for that year only and can not be considered sustainable. The yield is therefore more related to the biomass of the reservoir than to its production.

Catches are always effected by annual fluctuations and the monitoring of catches during one year does not recognise these fluctuations. However, one year of records could give an indication of the average annual yield in those cases where fluctuations are not too great. Small Water Bodies are often affected by strong water level fluctuations that influence both the production and the catches. The catch monitoring survey was carried out during the driest year recorded in southern Africa, and water levels were exceptionally low. Especially for Makungwa dam the yield during the year of monitoring probably does not even give an indication of the average annual yield.

Table.30 gives the species composition of the catches in the two reservoirs by gear. It is obvious that the net fishery concentrated on the tilapia species, while the rod and line fishery targets a wider *variety of species.* The average sizes of the tilapia species in the seine nets are 43 and 20 gr. The minimum mesh size for nets in Zambia is 3.5 inch (89 mm.) stretched mesh, which would catch tilapias above 150 grammes. The catches indicate that the fishermen used much Smaller mesh sizes.

Table 28: Number of records collected during creel survey per day. dam and gear

Period	Total number of days recorded	Total number of week end days	Total number of week days	Total number of records	Total number of records for weekend days	Total number of records for week days
Makungwa seine netting						
Mar–May	8	3	5	1	0	1
Jun–Aug	7	3	4	8	3	5
Sep–Nov	10	2	8	12	2	10
Dec–Feb	4	2	2	4	2	2
total	29	10	19	25	7	18
Makungwa rod and line						
Mar–May	8	3	5	21	8	13
Jun–Aug	7	3	4	0	0	0
Sep–Nov	10	2	8	3	1	2
Dec–Feb	4	2	2	9	9	0
total	29	10	19	33	18	15
Rukuzye seine netting						
Mar–May	11	5	6	3	2	1
Jun–Aug	13	5	8	7	2	5
Sep–Nov	10	4	6	9	3	6
Dec–Feb	15	4	9	7	0	7
total	49	18	29	26	7	19
Rukuzye rod and line						
Mar–May	11	5	6	51	36	15
Jun–Aug	13	5	8	6	1	5
Sep–Nov	10	4	6	11	0	11
Dec–Feb	15	4	9	32	6	26
total	49	18	29	100	43	57

Table 29: Fishing effort, catch per hour and estimated total catch per dam and gear

Period	Fishermen per half weekend day	Fishermen per half week day	Length of fishing session (hours)	Total fishing effort (hours)	Catch per hour(kg)	Total catch (kg)
Makungwa seine netting						
Mar–May	0.00	0.20	0.50	13.00	1.01	13.13
Jun–Aug	1.00	0.80	2.44	380.64	8.99	3420.05
Sep–Nov	1.00	1.25	2.85	611.33	3.15	1923.84
Dec–Feb	1.00	1.00	2.19	398.58	0.74	294.95
total						5651.97
Makungwa rod and line						
Mar–May	2.67	2.60	4.39	2092.57	0.12	242.74
Jun–Aug	0.00	0.00		0.00		0.00
Sep–Nov	0.50	0.25	4.83	282.56	0.32	89.57
Dec–Feb	4.50	0.00	4.53	1060,02	0.04	42.40
total						374.71
Total estimated harvest in Makungwa						**6026.68**
Rukuzye seine netting						
Mar–May	0.40	0.17	2.08	88.33	0.89	78.17
Jun–Aug	0.40	0.63	1.54	157.16	3.21	504.85
Sep–Nov	0.75	1.00	2.65	447.85	2.13	953.02
Dec–Feb	0.00	0.78	3.36	339.73	0.63	214.98
total						**1751.13**
Rukuzye rod and line						
Mar–May	7.20	2.50	3.65	2552.81	0.06	156.56
Jun–Aug	0.20	0.63	1.93	176.88	0.19	33.15
Sep–Nov	0.00	1.83	3.47	827.02	0.09	75.04
Dec–Feb	1.50	2.89	4.68	2122.64	0.09	187.43
total						452.17
Total estimated harvest in Rukuzye						**2203.30**

Table 30: Species composition in percentage in number and weight per dam and per gear

Species:	O. macr.	T. ren.	C. gar.	B pal	L.cyl.	O. and	Other
Makungwa seine netting							
% number	77	8	0	2	2	10	
% weight	79	11	2	0	2	6	
aver. weight (gr.)	43	56	394	5	54	27	
Makungwa rod and line							
% number	16	28	4	31	0	12	8
% weight	12	26	47	7	0	4	4
aver, weight (gr.)	16	21	241	5	48	7	10
Rukuzye seine netting							
% number	88	2	0	4	5	0	
% weight	91	7	1	1	1	0	
aver, weight (gr.)	20	56	140	28	5		
Rukuzye rod and line							
% number	38	52	1	8	0	0	
% weight	41	45	10	4	0	0	
aver, weight (gr.)	8	7	78	4	35		