A survey study on freshwater fish farming in Tanzania

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Summary

In a literature review, the national status of aquaculture in Tanzania is discussed. Through own investigations, the status of freshwater fish farming is investigated in more detail. A questionnaire study, concerning fish farming practices, fish production and socio-economic aspects, has been conducted. A total of 30 fish farmers from the regions Mbeya, Arusha and Ruvuma were interviewed. A market investigation and harvesting of a small number of ponds were also conducted.

Despite the efforts made in the 1950's and 60's in introducing fish farming to Tanzania, aquaculture has not developed to any extent. The total aquaculture production have increased the last years, but was in 1990 estimated to be only 375 t. There is a great demand for fish in Tanzania, and there are areas well suited for fish farming activity.

The dominating aquaculture practice, is semi-intensive freshwater farming of tilapia in ponds, and *Oreochromis niloticus* is the most common species used. Common pond size is 150-500m^2. The ponds are fertilized with manure, and as supplementary feeding, maize bran, leaves and kitchen leftover are common. Most common is to harvest the ponds once a year without totally drainage. Intermediate harvests between the main harvests are practised.

In this study, an average productivity in the ponds of 1400 kg/ha/year was found. The generally low production can be explained by unproper drainage of the ponds, little or no fertilizing and feeding, and lack of seine nets, which results in overcrowded ponds and stunted fish.

Most of the people having fish ponds, are small-scale farmers. The fish produced is mainly for own consumption. For about half of the farmers interviewed, it is also a source of income.

Among the main constraints to a fish farming development in Tanzania, is: low priority given to aquaculture by the government, unproper extension service due to lack of transport and extension workers trained in fish farming, lack of trained personnel for education and research, and lack of quality fish seed.

Strategies for a aquaculture development are discussed for Sub-Saharan African countries in general, and some recommendations for Tanzania are given.

Sammendrag

I en litteraturdel er det sett på status når det gjelder akvakultur i Tanzania. Gjennom egne undersøkelser, er fiskeoppdrett i ferskvann studert mer i detalj. En spørreundersøkelse som omhandlet både driftsmåter, produksjon og sosioøkonomiske aspekt, ble foretatt. Totalt 30 fiskeoppdrettere fra regionene Mbeya, Arusha og Ruvuma, ble intervjuet. En markedsundersøkelse and høsting av et mindre antall dammer ble også foretatt.

Til tross for forsøkene som ble gjort i 1950 og -60 årene på å introdusere fiskeoppdrett til Tanzania, har det ikke funnet sted noen betydelig utvikling innen akvakultur. Den totale produksjonen fra akvakultur har økt de senere år, men var dog bare på 375 tonn i 1990. Det er stort behov for fisk i Tanzania, og det finnes områder som er vel egnet for fiskeoppdrett.

Semi-intensivt oppdrett av tilapia i dammer er den dominerende oppdrettsformen. Den vanligste arten er *Oreochromis niloticus*. Vanlig damstørrelse er 150-500m². Dammene er vanligvis gjødslet med husdyrgjødsel, og maiskli, husholdningsavfall og blader brukes som tilleggs fôring. Dammene høstes vanligvis en gang i året, og de høstes vanligvis uten å tørrlegges. Noe fisk høstes også mellom hver hovedhøsting.

Den gjennomsnittlige produktiviteten i dammene ble i denne undersøkelsen funnet til å være 1400 kg/ha/år. Den generelt lave produksjonen kan forklares med utilfredsstillende tørrlegging av dammene, liten eller ingen gjødsling/fôring, og mangel på nøter til å høste dammene med. Dette resulterer i dårlig vekst hos fisken, og dammer med altfor høy fisketetthet.

De fleste som har fiskedammer, er småbønder som produserer fisk til eget konsum i familien. Halvparten av de som ble intervjuet hadde i tillegg inntekter fra fiskedammene.

Lav prioritet fra myndighetenes side, utilfredsstillende veiledningsapparat pga. mangel på transportmidler og trenet personell innen fiskeoppdrett, mangel på utdannede folk til forskning og undervisning, og dårlig tilgjengelighet på yngel av god kvalitet, er alle faktorer som hindrer utviklingen av fiskeoppdrett i Tanzania.

Hvilke strategier som bør følges i en utviklingen av akvakultur er diskutert for afrikanske land generelt. Til slutt er det gitt noen anbefalinger som gjelder Tanzania.

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5.0 MATERIALS AND METHODS

List of abbreviations

ADCP	Aquaculture Development and Coordination Programme
AKVAFORSK	Institute of Aquaculture Research
ALCOM	Aquaculture for Local Community Development Programme
ARAC	African Regional Aquaculture Center
DO	Dissolved Oxygen
EIFAC	European Inland Fisheries Advisory Commission
ELCT	The Evangelical Lutheran Church
FAO	Food and Agriculture Organisation of the United Nations
ha	hectare
ICLARM	International Center for Living Aquatic Resources Management
KFI	Kunduchi Fisheries Institute
MBDC	Mbegani Fisheries Development Center
NFFI	Nyegezi Freshwater Fisheries Institute
NGO	Non Governmental Organisations
NLVF	Agricultural Research Council of Norway
NORAD	Norwegian Agency for International Development
NORAGRIC	Norwegian Center for International Agricultural Development
PCV	US Peace Corp Volunteers
SADCC	Southern African Development Coordination Conference
SIDA	Swedish International Development Authority
SUA	Sokoine University of Agriculture
TAFIRI	Tanzania Fisheries Research Institute
UN	United Nations
UNDP	United Nations Development Program

List of appendices

1.0 INTRODUCTION

The total world fish catches had a steady increase from 84 million tonnes (t) in 1984 to 95 mill. t in 1987. The few last years however, the increase in total catches have declined. In fact, from 1989 to 1990, there was a 3 mill. t reduction in the world's fish catches (FAO 1992a). The world's population is growing, and to cover the demand for fish products, there is need for a increased fish production. Aquaculture play, and could play an even more important role, by filling the gap between the increasing demand for fish, and the production obtained from the catches (Pillay 1990). The world's aquaculture production increased from 10 mill. t in 1984, to 15 mill. t in 1990, and made in 1990 up 13-14% of the total production from the fisheries (1992b).

With a population growth of 3.3% per year, there is need for a increased food production in Tanzania. The economic situation, also indicates need for a stimulation of the country's commercial activity (World Bank 1991).

In Tanzania, as in most of the other African countries, aquaculture has not yet developed to any extent. However, a further fish farming development could help to satisfy Tanzania's need for food, and to increase the income for small scale farmers.

In the development of fish farming, proper information about present status, constraints, and prospects are of importance. For Tanzania, this was felt lacking, and hence, studied here.

The aims of this study was to:

i) identify the current status of fresh water fish farming in Tanzania,

ii) describe the potential for, and constraints to, a fish farming development in the country,

iii) discuss approaches for a development of fresh water fish farming in Tanzania.

The study is divided into three parts: a literature review, own investigations, and concluding discussion/ recommendations.

The specific objectives for the literature review was to:

a) describe the status of aquaculture in Tanzania at a national level,
b) give background information about tilapias, due to the important role this species play in fish farming in Africa,
c) discuss actual strategies for a development of fish farming in Sub-Saharan African countries.

The specific objectives for own investigations was to:

d) identify the status of fish farming practices and socio-economic aspects of the fish farming activity,
e) identify the demand for fish and the prospects for commercial production,
f) estimate the productivity in the fish ponds.

The concluding discussion is based on both the literature review and own investigations.

It is the hope that this study will contribute to a further development of fish farming in Tanzania.

Based at Sokoine University of Agriculture, Department of Animal Science in Morogoro, the field work for this study was carried out during the period from January to May 1992. The study was made possible through a scholarship donated by the Norwegian Centre for International Agriculture Development (NORAGRIC), and by financial support from the Agricultural Research Council of Norway (NLVF). The study was a part of a pre-investigation conducted by AKVAFORSK, in connection with an application to EC, for research funds.

2.0 AQUACULTURE IN TANZANIA

2.1 General background

2.1.1 Physical geography

Tanzania is located on the east coast of Africa, south of equator, within 12°latitude. The total area is 945 200 km^2, see Figure 2.1[1].

The altitude in Tanzania range from sea level up to mountains more than 5500 meter above sea level. Figure 2.2 shows the reliefs. Only a narrow belt along the 800 km long coast is under 200 m above sea level. Most of the country, including the Central Plateau, range from 1000 to 1500 m above sea level. The highland / mountain areas with altitudes above 2000 m are found mainly in north around the Kilimanjaro - complex, and in south near the northern part of Lake Nyasa. The Great Rift Valley runs through the country, divided in an eastern- and a western rift. Lake Tanganyika is a part of the western rift, while the Manyara and Natron lakes are found in the eastern rift. The two arms of the Rift join into one at the northern end of Lake Nyasa, which is a part of the Rift going further south (S.M.D. 1976).

Woodland, bushland and wooden grasslands are the predominant types of vegetation.

About 54% of the soils, dominated by loamy sand and sandy loam, are of good drainage and hence well suited for agriculture purposes. Almost 29% of the soils, mainly heavy clays, clay loams and sandy clay loams are, because of poor or imperfect drainage, of low agricultural value (Figure 2.3). However, these areas could be well suited for fish farming development. Generally, the soils are low on fertility. Most places fertilizer is therefor needed for agricultural and for eventually fish farming purposes.

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[1] The first number indicate in what chapter the figure/table is found.

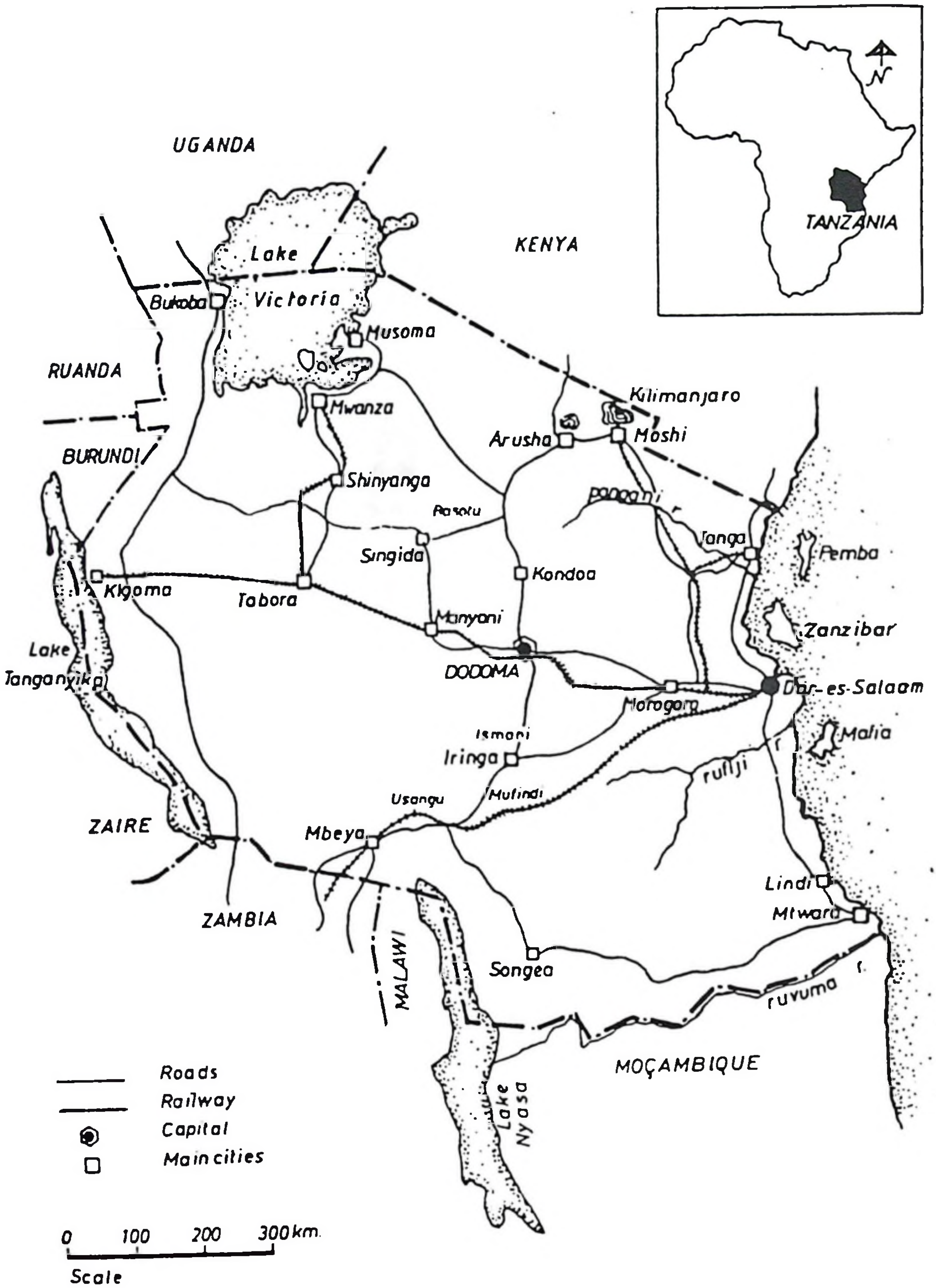


Figure 2.1 Map of Tanzania; roads, railways and cities (Source: Boesen et al. 1986).

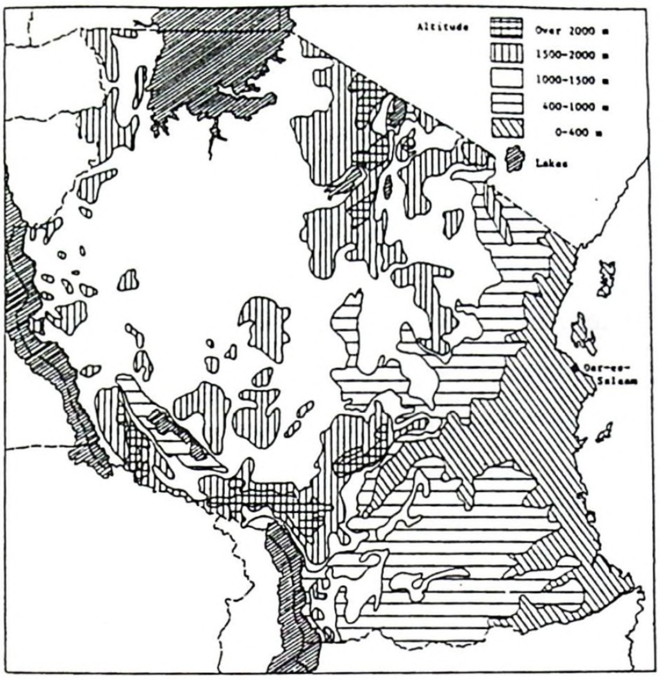


Figure 2.2 Relief map of Tanzania (after Philip 1980 in Balarin 1985).

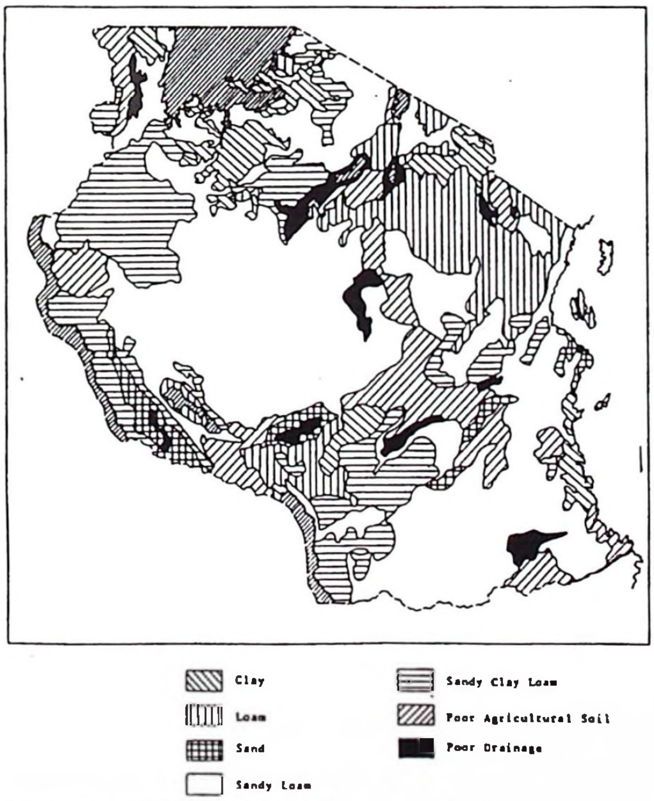


Figure 2.3 Soil map of Tanzania (after Philip 1980 and S.M.D.1976 in Balarin 1985).

2.1.2 Climate

The climate is tropical, with generally high temperatures, concentrated rainy periods and no cold seasons. July is the coolest month all over the country, while the hottest period is varying, but everywhere between October and February. Mean daily temperature fluctuations can be up to 12°C, while seasonal mean fluctuations are not greater than 6°C. The temperatures are more or less uniform all over the country (S.M.D. 1976). Therefor the temperature is closely related to altitude. With a degrease in temperature of 0.6°C per 100 m elevation, the general temperature regime is shown in Table 2.1.

Table 2.1 Temperature regimes of Tanzania (after DePaw 1984 in Balarin 1985).

Temperature regime	Physiography	Altitude range (m)	Temperature ranges, centigrades (1)	(2)	(3)	Major field crops requiring tempera-ture/altitude range	Crops tolerant of temperature/alti-tude range
T1	Lowlands	0-750	29-31	19-23	9	Cashew, cocoa, co-conuts, rubber	Cotton, rice, sugarcane, groundnuts, cowpeas, cassava, bananas, citrus, soya, sisal, maize, sorghum, sweet patatoes, bulrush and finger millet
T2	Medium altitude plateau	750-1 500	27-30	15-18	12	Flue cured tobacco	Cotton, rice (lower level), sugar-cane, sesame, groundnuts, cowpeas, cassava, bananas, pineapple, citrus, soya, sisal, sorghum, beans, coffee (higher level), maize, bulrush and finger millet, wheat (higher level), sweet patatoes
T3	High altitude plateaux and mountains	1 500-2 300	22-25	10-15	11	Tea	Maize, finger millet, wheat, pyre-thrum (higher level), apples, pea-ches, plums, grapes, potatoes, wattle (higher level), sweet pota-toes, beans (lower level)
T4	Very high alti-tude plateau and mountains	2 300	16-19 Note: night frost common in dry season	5-10	10	Temperate grasses and clovers	Apples, plums, peaches, grapes, apricots, potatoes, pyrethrum, wattle

Notes

(1) Mean annual maximum temperature

(2) Mean annual minimum temperature

(3) Range: Tmax - Tmin

The water temperatures follow the air temperatures, and the mean air temperature approximate the mean minimum water temperature condition (Balarin 1985). This gives the zonation of fish farming as shown in Table 2.2 and Figure 2.4.

Table 2.2 Fish farming zonation in Tanzania (after Balarin 1985).

Region (Refer to Fig. 20)	Altitude (m)	Temperature (°C)		Fish farming potential[a/]					
				Cold water (trout)		Temperate (carp)		Warm water (tilapia)	
		Min.	Max.	GP (month)	System	GP (month)	System	GP (month)	System
A. Coastal, Lowlands, and Lake shore	Below 500	Above 25	-	-	-	All year	1-6	All year	1-6
B. Plateau	500-1 500	20	25	-	-	9-12	1-6	6-9	1-5
C. Highlands	1 500-2 500	15	20	5-6	3, 4, 5,	9-12	1-5	4-6	1-4
D. Mountain Range	Above 2 500	-	15	All year	1-6	6-9	1-4	-	-

a/ GP: : Growth period, potential duration of season favouring optimum performance, in months;

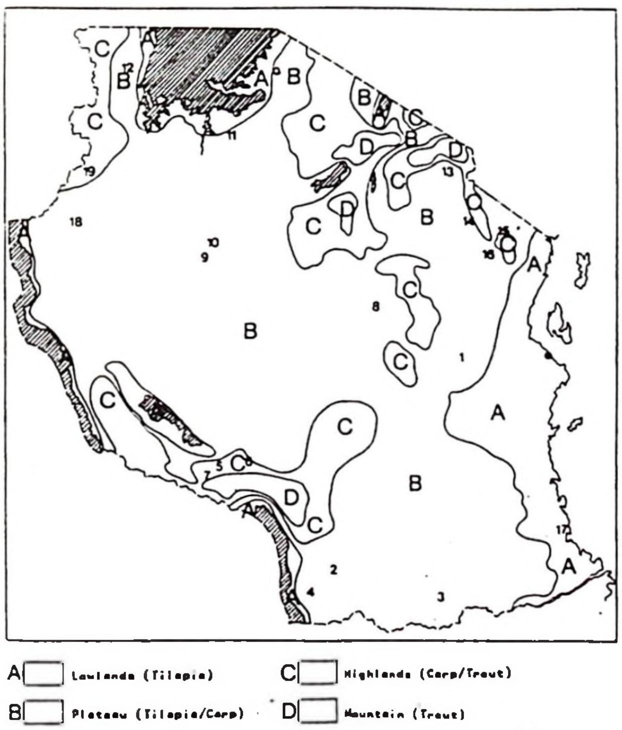


Figure 2.4 Fish farming zonation map of Tanzania (after Balarin 1985).

The annual rainfall, presented in Figure 2.5, is high in the mountainous areas. Central areas are dry, with annual rainfalls under 750 mm. Generally there are two peaks in the annual rainfall; "the short rain" in the period from October to December, and "the long rains" in the period from December to June. This varies however, and in the southern and central areas, a unimodal rainfall regime is common, with the peak usually in the period from December to March (S.M.D. 1976).

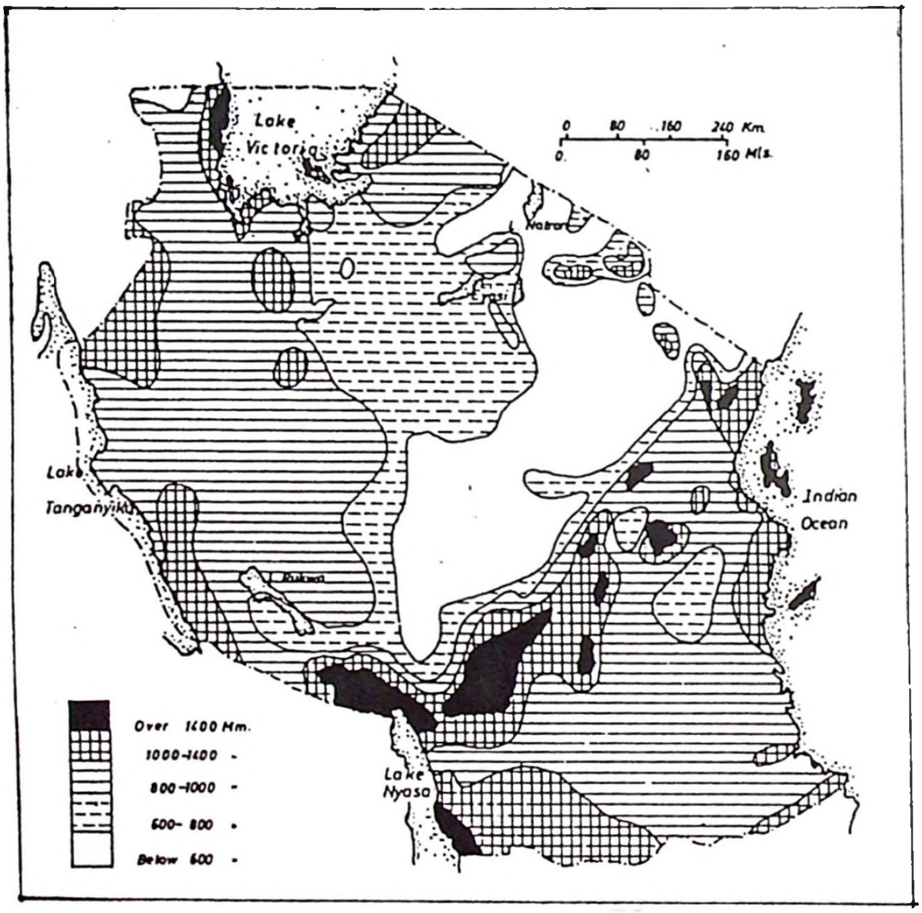
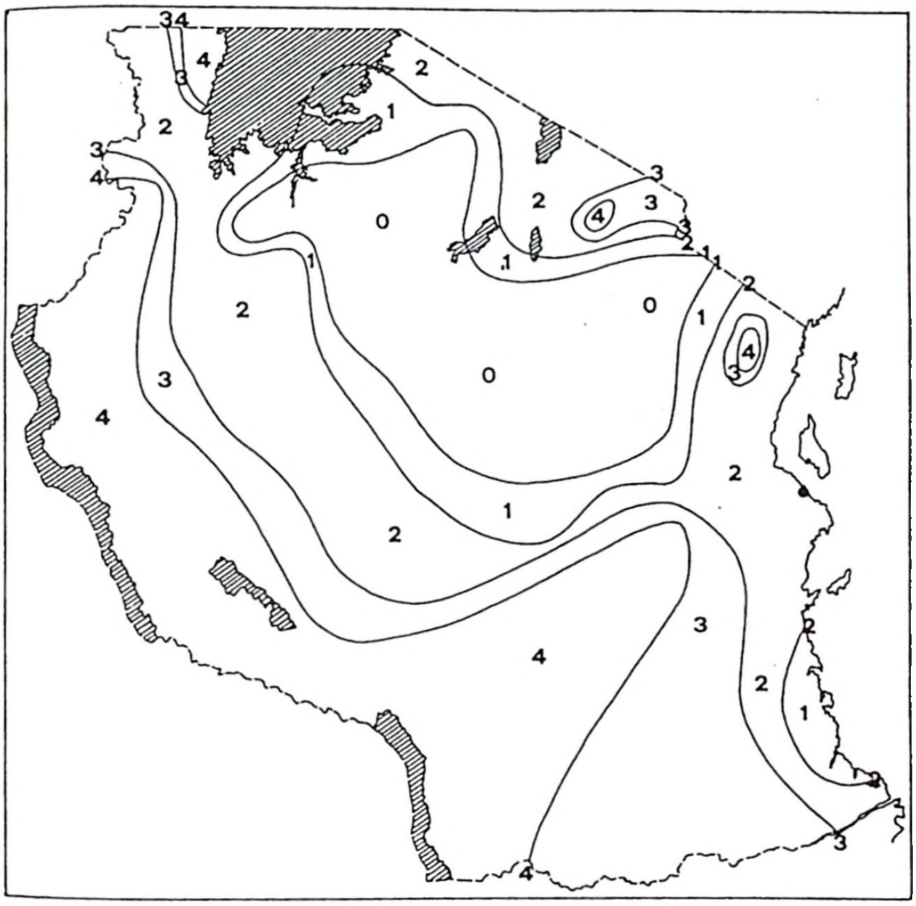


Figure 2.5 Average annual rainfall in Tanzania (after Boesen et al. 1986).

The relative humidity increases during the rainy seasons. It is high on the coast and near the lakes, and decreases generally with distance from the ocean.

Figure 2.6 shows number of months which have a surplus of rainfall over potential evaporation. Concerning fish farming, this wet months indicate a pond filling period. The rest of the year, water has to be added if evaporation losses shall be replaced. Evaporation losses are generally less in highland areas.



NB: Numbers refer to months with surplus of rainfall over potential evaporation.

Figure 2.6 Rainfall / evaporation surplus in Tanzania (after S.M.D. 1976 in Balarin 1985).

2.1.3 Water sources

The total water area covers almost 61 500 km², which is 6.5% of the country's total area. 88% of this area is made up by the three big lakes; Lake Victoria, Lake Tanganyika and Lake Nyasa. Four other lakes, from 500 to 5 600 km² in size, also included in the rift - system, are more saline (S.M.D. 1976).

Water reservoirs have been constructed especially in the drier areas including Eastern rift, the Masai steppe, the Western - and the Central Plateau. In 1966 490 reservoirs had been constructed, about 50 % of them less than 0,5 ha (Bailey 1966). The two largest reservoirs are Mtera reservoir in Great Ruaha river south of Dodoma (580 km^2), and Nyumba ya Mungu dam near Moshi (180 km^2).

There are four river drainage basins. The rivers in the southern and eastern regions, including the largest Rufiji river, are drained into the Indian Ocean. Rivers in northwest are drained through Lake Tanganyika to the Atlantic Ocean, while the area in north is drained through Lake Victoria to the Mediterranean Sea. Central areas have an interior drainage. Generally, the rivers flow for 5 - 6 months of the year, varying with the rainfall. In the mountainous areas however, the stream flow pattern is usually perennial (S.M.D. 1976).

Appendix 1 shows hydrological zones, major river systems, lakes and swamps/floodplains in Tanzania.

2.1.4 Agriculture and livestock

Agriculture is dominating Tanzania's economy. In 1989 72% of the export earnings (FAO 1992a), and 66% of the gross domestic production (GDP) came from agriculture (FAO 1991a). Not included in the GDP, however central in the people's nutrition, is the food produced for own consumption. Most of the farmers are small holders, and about 83% of the holdings are less than 2 hectare (ha) (Balarin 1985).

Kilimanjaro, Iringa, Mbeya, Kagera, Zanzibar and parts of Arusha make up most of the high potential agro-economical zone. This zone is characterized by intensive agriculture, altitudes above 1500 m above sea level, a high population density and limited land available (Table 2.3).

The western and coastal areas make up the intermediate agro-economical zone with extensive agriculture producing a wide variety of food- and cash crops. Both this zone and the dry, low potential zone in the central area are low populated (Balarin 1985).

Table 2.3 Agro-economic zones in Tanzania (Balarin 1985).

	ZONE 1	ZONE 2	ZONE 3	ZONE 4
Name	HIGHLAND AND ZANZIBAR	WESTERN	COASTAL	CENTRAL
Description	(high potential zone)	(intermediate potential zones)		(low and erratic rainfall zone)
Type of Agriculture	Intensive agriculture densely populated	Extensive agriculture and livestock, with wide variety of food and export crops		extensive agriculture and livestock large subsistence component
90% R" probability (mm)	Above 1500	500–100	500–1000	under 500
Altitude (m)	Above 1500 (highland)	500–1500	0–1250	300–1500
Representative Areas	Kilimanjaro/ Arusha, Mbeya, W.Lake, Iringa plus Zanzibar	Mwanja, Mara, Shinyanga. Kigoma	Tanga, Coast, Morogoro, Lindi Mtwara	Dodoma, Singida, parts of Arusha, Iringa
Dominant food crops	Plantain, hybrid maize, beans, irish potatoes	Composite maize cassava, peas sweet potatoes	Composite maize Rice, groundnuts cassava	Sorghum, millet
Export crops	Coffee, tea, pyrethrum. Cloves in Zanzibar	Cotton, Tobacco	Cashewnuts, coconuts, oilseeds	no major export crops
Livestock and Fish	Dairy cattle, pigs, fishing off Zanzibar	Fishing in inland lakes	Poultry, coastal fishing	
		3,340		
Effective area cultivated ('000 ha)	910	1,820	1,520	910
		8.8		
Total rural population (mn)	3.5	5.0	3.8	2.7
Total income per holding (Shs p.a)	2 500	1,700	1,350	450
Equivalent monthly wage of holding (Shs p.m)	870	300	370	120

Nearly 30% of the 161 000 km^2 arable land is cultivated (FAO 1982 in Balarin 1985). According to FAO (1991a), about 10% of the cultivated land is under irrigation. The main food crops are maize, cassava, sweetpotatoe, sorghum/millet, bananas, beans and rice. Further are potatoes, groundnuts, sesame, soyabeans, copra, sugar, sunflower, fruits and vegetables cultivated. Main cash crops are coffee, cotton, cloves, tea, tobacco, sisal and cashewnuts.

The herds of livestock are uneven distributed. Because of poor water distribution, tsetse fly occurrence, inadequate economic and social infrastructure and conflicting objectives of land use, some areas are under stocked with animals, and there is a lack of animal protein for human consumption. Other areas are overstocked. Over grassing and pressure from livestock is especially high in the semi-arid areas with mixed farming activities.

Regions with generally high density of cattle, goat, sheep and/or pigs are Arusha, Kilimanjaro, Shinyaga, Tabora, Mwansa, Mbeya, Mara and Dodoma. Poultry is found all over the country (Balarin 1985). FAO (1991a) estimated the meat production in 1990 to be 9.0 kg per caput. Balarin (1985) refers to Donald et al. (1981), who estimate that there will be a shortfall in meat production of 94 660 t in year 2000.

2.1.5 Fishery

Total fish landings in 1989 and in 1990 were 377 000 t, a decrease from 1988 of about 15 000 t (FAO 1992b). While there were no increase in total fish landings from 1977 to 1984 (Balarin 1985), this increased from about 277 000 t in 1984 to almost 393 000 t in 1988 (FAO 1991b).

More than 85% of the total fish landings come from freshwater fishery. Of this, the majority come from the major waters; the lakes Victoria, Tanganyika and Nyasa, and the Mtera and Nyumba ya Mungu dams. Only about 3% of the freshwater landings come from minor waters; small lakes, rivers, reservoirs, swamps and floodplains (Fisheries Division 1987, 1988 and 1989).

Of the total fish landings, 95% is taken by small scale fishermen, usually using canoes or small boats, and nets, hooks or traps (Lema and Angwazi 1988).

The freshwater landings include several species, and are dominated by Nile perch (*Lates niloticus*), tilapias (mainly *Oreochromis niloticus, Tilapia variabilis, T. zillii* and *T. esculenta*), *Stolothrissa spp* and *Limnothrissa spp* ("dagaa"[2]), *Bagrus spp.*, *Clarias spp.* and *Haplochromis spp.* In the marine landings there is a great variety of species, mainly fish, but also some shrimp and lobster (FAO 1991b).

There is a wide range in the estimates of the maximum sustainable yield (MSY) in the Tanzanian water sources. A MSY ranging from 300 000 to 730 000 t for both marine and freshwater is estimated by different authors (Balarin 1985).

The fish market

The main constraint to fish availability in Tanzania, is lack of infrastructure; roads, transport and processing facilities. This gives regional differences in both supply and individual fish consumption. Almost all the transported fish is sold in the main towns, and only small amounts are transported from the major fishery sources and sold to other rural areas. The roads in the rural areas are unproper and transport takes a long time. Hence, the fish available in rural areas without local fishery activity, is either usually very expensive or it is spoilt.

However, Balarin (1985) refers to Rupamoorthy (1982), who reports that most of the fish landings are sold locally by the landing areas. Only 5 - 10 % of the total fish production is considered to be commercially marketed.

Though two parastatal fish sale organizations exist, the wholesale and the retail trade are both dominated by private traders (Balarin 1985). The marine fish is generally sold fresh or frozen, while the freshwater fish is sold either fresh, dried, fried or smoked.

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[2] Swahili name

Fish prices have, as other food prices, have increased dramatically during the last years (Balarin 1985). In Table 2.4, some food prices during the last 10 years are shown. FAO (1988) concludes that; "overall, the demand for fish appears to be much greater than the supply".

Table 2.4

Consumer prices in Dar es Salaam (TSh[3]/kg).

Commodity	1982/83	1986	1990	1992
Maize meal	2.5	24	54	.
Meat (beef)	36	99	450	300-400[a)]
Dried fish	134	375	546	.
Fresh fish	.	.	.	450-700[b)]

a) and b) Consumer prices for fresh/frozen fish in Mbeya, Arusha, Morogoro and Ruvuma (information from staff at the Fisheries Offices)

Only small amounts of fish products are exported or imported. FAO (1991c) estimated a total export of fish products on less than 900 t, dominated by prawns and other crustaceans. The low import was estimated to 180 t fish, of this, 130 t were canned fish.

2.1.6 People and their nutritional status

The total population of Tanzania was according to FAO (1991a) 27.3 million (mill) in 1990. The yearly growth rate is 3.3 %. This will give an estimated population of 34 mill in year 2000 (World Bank 1991). According to Lema and Angwazi (1988), about 90 % of the population live in the rural areas, in some 8 400 villages. FAO (1991a) estimated that the agricultural population make up about 80 % of the total population. Today there is a net migration from the rural to the urban areas, and the urban population was in the period 1980 - 89 growing with 10.8 % per year

[3] 290 Tanzanian Shilling (TSh) = 1 US$, 45 TSh = 1 NOK (in April 1992). In 1982, the value was about 1 TSh=1 NOK.

(World Bank 1991).

The average daily calorie supply in the period 1987 - 89 was 2209 kcal per caput, or about 95% of the requirement. Of the total energy intake, 6.4% came from animal products (FAO 1991a).

The average daily protein intake for the same period was 55.0 g per caput. Of this, 20.4% (11.2 g) came from animal products. The total protein intake per caput has increased the last 30 years, only as a result of a increase in the consumption of vegetable protein (FAO 1991a). The per caput intake of animal protein has been stable on about 10 - 11 g per day. About 30% of the animal protein came from fish products in the period from 1967 to 1984 (FAO 1988).

From the period from 1970 to 1987, the fish production indicated an average annual fish consumption fluctuating from 10.2 to 15.7 kg per caput (Balarin 1985; FAO 1991b). In 1989, this was about 16 kg per caput (World Bank 1991; FAO 1991b).

Balarin (1985) refers to Rupamoorthy (1982), who suggests a minimum annual fish consumption of 15 kg per caput to cover the protein demand. The Government wants to increase the annual per caput fish consumption to 20 kg (Balarin 1985). A fish production similar to 15 kg per caput and a population growth on 3.3 % gives a production of 510 000 t in year 2000, while a 20 kg per caput consumption would demand a total annual production of 680 000 t in year 2000. This is an increase of about 300 000 t from today's level.

Though the average daily protein intake is near the requirements, several people get insufficient amounts of protein because of the regional differences in both meat- and fish supply.

The regions with high concentrations of livestock have a relatively high meat consumption, while per caput protein intake from livestock production in the regions Lindi, Mtwara, Kigoma and Ruvuma range from 0.9 to 2.1 g (Donald et al. 1981 in Balarin 1985). Fish consumption varies widely, from 1 to 50 kg per caput per year (FAO 1988).

2.1.7 National economic status

With a gross national product (GNP) of 130 $ per caput in 1989, Tanzania is among those with lowest GNP of the low income economics - countries in the world. The per caput GNP had a annual decrease of 0.1% in the period from 1965 to 1989. During the 80's there was a 8.2% annual decrease in the total export. This gave an export of 260 mill $ in 1989, while the import was 840 mill $. The total external debt has increased the last years, and in 1989, it was 4918 mill $. The total net disbursement of official development assistance was in 1989 918 mill $, which was 32% of the GDP (World Bank 1991).

2.2 History of aquaculture in Tanzania

The first attempts to cultivate tilapia in Central-East Africa in recent time, was made in Kenya in 1924. Other East-African countries followed, and in 1942 the first trials of fishpond culture were done in this part of the world (Maar et al. 1974).

The beginning of fish culture in Tanzania is not well documented (Balarin 1985). However, Balarin (1985) referee to Meshkat (1967), who set 1949 as a start for fish culture in Tanzania. In Korogwe in Tanga region and in Malaya on the Central Plateau, experimental work with tilapia in ponds was started during the early 1950's (Bailey 1966).

During the 1950's about 10 000 fish ponds of a total surface area approximately 1000 ha were constructed. Due to lack of proper management and use of unproper technology, these ponds turned to be mostly non productive (Balarin 1985).

Balarin (1985) referee to Dibbs (1964) who reported that in 1964, there were 5000 fish ponds in Ruvuma region only. According to reports from FAO (1968), 8000 fish ponds had been constructed in Tanzania by 1968. Both these reports documented unproper management, too small ponds (even 20 m^2) and very low production.

In spite of people's interest constructing fish ponds, the development priorities were given to the exploitation of natural waters including reservoir stocking, rather than to pond fish farming. This can be explained by the fact that there still were cheap fish available from the fish landings (Balarin 1985).

Bailey (1966) reports that water reservoirs constructed for domestic, stock, irrigation and factory purposes or for flood control purposes, were stocked with tilapia. This started in 1950. By 1966, 50% of the reservoirs in the country had been stocked by the Fishery Division. The ponds in Korogwe and Malaya established for experimental studies, became important distribution centres for fish stocks.

In 1972, aquaculture was for the first time paid any attention in the national development policy (Singh 1975). After that, aquaculture was included in the fishery policy, however always as a low priority sector (FAO/SIDA 1988).

Foreign aid, both from official development assistance through UN organisations (mainly FAO and UNDP) and different nations, and from non governmental organisations (NGO), have played an important role in introducing fish farming to Tanzania.

However, in 1981 FAO/UNDP stopped the development programme initiated two years before, because of budget limitations (Lema pers. comm. 1992). Included in this programme was a national fish farming centre in Morogoro, for research, training, seed production and demonstration of integrated farming systems.

The 1980's were characterized by several small aquaculture aid projects (Balarin 1985). Despite this efforts, the aid generally have not had the expected success. However, the interest for fish farming is growing.

2.3 Total aquaculture production

In a composite of aquaculture statistics from 1965 to 1985, Balarin (1988a) estimated that there were 8 000 - 10 000 fish ponds in Tanzania, covering a total area of 1000 ha. The annual production from these ponds was estimated to be 500 - 1800 tonnes (t). UNDP (1981) suggests however in Balarin (1985) that in 1981, the production from the 600 - 1000 believed functional fish ponds was 8 - 13 t.

Bwathondi (1986) estimated that in 1985 there were 3000 fish ponds of an average size of 0.25 ha. 80% of the ponds were supposed to be unmanaged, and the annual yield was estimated to 150 t. Lema (1987) estimated that in 1987, there were 5000 fish ponds with an average pond size of 0.1 ha. The annual yield from these ponds was estimated to be 375 t.

According to FAO (1992b), Tanzania's aquaculture production had a steady increase from 15 t in 1984 to 40 t in 1989. In 1990 the production raised to 375 t, all from freshwater fish farming of Oreochromis niloticus. It seems however that the total production include not only O. niloticus, but also other ciclides (Lema and Angwazi 1988).

Even though research has been done on both marine species of fishes, crustaceans, molluscs and algae (Bwathondi 1986), marine aquaculture is not developed to any extent in Tanzania.
Lema and Angwazi (1988) reports that no efforts have been done to establish brackish water or marine farms. However, some sea weed ranching is found on the coast near Tanga (Nhwani pers. comm. 1992), and around the Zanzibar and Mafia islands (Lema pers. comm. 1992).

On the coast, prawn culture in tide ponds has been tried unsuccessfully because of unproper management. However, new prawn farming projects are planned, and in the areas south of Dar es Salaam and near Bagamoyo, some projects are in the initial stage (Tamatamah pers. comm. 1992).

Marine aquaculture will not be further discussed here.

2.4 Fish farming practices

The freshwater fish culture activity in Tanzania can be divided into two categories; reservoir stocking and pond fish farming (Balarin 1985). The reservoirs are usually stocked only once, there is no inputs of any kind, and the fish is harvested with fishing gears similar to those used by the fishermen in the lakes. Hence, this practice is not included in the definition of fish farming, and will not be discussed further.

Even though the differentiation between fish ponds and reservoirs can be diffuse according to both size, management and techniques used, those water bodies which main aim is to produce fish, can be characterized as fish ponds. Water bodies where fish production comes as an additional purpose, can be characterized as water reservoirs.

2.4.1 Species farmed

Several species, both indigenous and introduced, are used or have been used in fish farming in Tanzania (Appendix 2). However, the fish farming activity is totally dominated by farming of tilapia, and species belonging to genera *Tilapia* and *Oreochromis* are the most common (Lema and Angwazi 1988). *Oreochromis niloticus* has become the dominating species, after stocks were introduced from Baobab Farm, Mombasa (Kenya) in the early 1980's.

However, the purity of the stocks is not known, and in rural tilapia farming in general, hybrids often occur due to wild spawning (Pillay 1990). Often also *Clarias spp.* is harvested together with the stocked fish, though not originally stocked (Balarin 1985).

Common carp (*Cyprinius carpio*) was introduced from Hungary in 1982 into some Governmental ponds (Balarin 1985). However, this introduction has not been any success, due to lack of knowledge and facilities for reproduction. One trout farm is found in Arusha (Lema and Angwazi 1988).

A list of cultivable aquatic organisms available in Tanzania is presented by Ibrahim (1976), see Appendix 3.

2.4.2 Management methods

The common method of freshwater fish farming, is farming in earthen ponds with stagnant water (Lema and Angwazi 1988). Pond sizes vary a lot. In e.g. Mbeya region, pond sizes varying from 24 m^2 to 30 000 m^2 were found. Common sizes ranged from 100 - 400 m^2 (Msuya 1992). The ponds are usually 0.3 to 1 m deep.

Common feedstuffs used in the fishponds are locally available maize- and rice bran, kitchen leftover (Bwathondi 1986), leaves and fruit, both wild and from the garden (Ibrahim 1976). According to Balarin (1985), generally little or no feeding is practised. To fertilize the ponds, locally available manure is used. Use of artificial fertilizer is rare.

The management of the fishponds varies a lot. Bwathondi (1986) divides the practices into managed and unmanaged pond culture. He considers 80 % of the ponds in Tanzania as unmanaged. These ponds are harvested after 1 - 2 years, nothing is done with the ponds between stocking and harvesting, and the production is low.

After a survey made, Ibrahim (1976) reports of generally lack of systematically pond management. The ponds had not been drained, treated or manured for several years. Stunted tilapia was found in most of the ponds, and these were distributed as fingerlings and stocked in new ponds.

From field work done in Mbeya region in 1990, Msuya (1992) reports about limited feeding and fertilization, stunted fish, unproper harvesting and management.

2.4.3 Fish yields

Systematically records of production in ponds with different management are scarce. Some production records from 1979 was collected by FAO (1982) and presented by Kisaka (1982), and showed annual yields varying from 50 to 1010 kg per ha.

Balarin (1985) referee to UNDP (1981), who suggested the average annual yield in Tanzanian fish ponds to be 130 kg per ha. Lema (1987) estimated the average to be 750 kg per ha, with variations from 200 to 1000 kg per ha.

2.4.4 Structure and distribution of the fish farming activity

There has not been any development on large scale fish farming in Tanzania (Balarin 1985). According to Lema and Angwazi (1988), rural individual family ponds and communal fish ponds are totally dominating. The communal ponds are usually village-, school-, prison-, or church ponds. For this systems, both land, labour, feed and fertilizer are generally free, which mean only a minimum of investments used. The fish production from the ponds are used mainly for own consumption. If something is sold, this is done by the pond or in the village.

Only a few artisanal fish farms exist. Mbarali rice farm in Mbeya region started in 1989 a fish farming project. In 1991 a hatchery and 11 ponds of a size of about 1 ha each had been constructed. The production was in 1990 about 4 t tilapia, mainly O. niloticus (Byakwaga and Sahini 1991). Another fish farm, farming tilapias, catfish (*Clarias spp.*) and Nile perch (*Lates niloticus*), in both concrete ponds and earthen ponds, is found near Dar es Salaam. Here, the total pond area is about 5 ha: 10 concrete ponds, and one 2.5 ha and several smaller earthen ponds. The first fish were stocked in the beginning of 1990. The fish is harvested by net and hook, and the ponds have not yet been drained (Nkondoa pers. comm. 1992).

Ibrahim (1976) reported that in the 1970's, more fish ponds had been constructed in Ruvuma and West Lake (now Kagera) regions, than in other areas. According to

Bwathondi (1986), the fish farming activity in Tanzania is concentrated in the southern zone; Lindi, Mtwara, Ruvuma and Mbeya regions, and in the north-east; Kilimanjaro, Arusha and Tanga regions.

According to Lema (pers. comm. 1992), most of the fish farming activity today is found in the Ruvuma, Mbeya, Arusha and Iringa regions.

2.5 Institutions for fish farming development

2.5.1 Governmental institutions

Extension service, research and education are main tasks for the governmental institutions in the development of fish farming. However, no special education on aquaculture exists at any level, and the demand for knowledge on aquaculture is great. Both the Division of fisheries and the institutions lack resources like operating funds, transport and basic equipment (Balarin 1985), which limit their activity.

The Division of Fisheries under the Ministry of Natural Resources and Tourism has the primary responsibility for developing fisheries and fish farming at the national level. Balarin (1985) reported that out of a total staff of 946 people, 29 were based at the head quarter in Dar es Salaam or at the research institutes. The majority of the staff, based at region or district level, are administrated by the Regional Development Directors and Regional Natural Resources Officers, according to the decentralization policy. This often gives fish farming a low priority in the districts, and it makes the communication between the headquarter and the region/district staff difficult. The main tasks for the staff in the regions and the districts are extension work for both fishermen and fish farmers and collection of fisheries statistics (Balarin 1985).

Balarin (1985) reported about 15 Government or District fish farming stations, with a total of about 58 ponds. However, "few of this if any are in operation"

(FAO/SIDA 1988).

Tanzania Fisheries Research Institute (TAFIRI) is a parastatal organisation established for fisheries research, including aquaculture. In addition to the head quarter in Dar es Salaam, there are three other centres in other parts of the country; in Mwanza, Kigoma and Kyela. Due to lack of facilities and funds, there is no ongoing research projects in the field of aquaculture (Nhwani pers. comm. 1992).

At the **University of Dar es Salaam**, Master of Science (M.Sc.) degree in marine biology can be taken by the University's Department of zoology and marine science. Included in this study, is minor amounts of aquaculture, and no specialization is possible. Aquaculture, which not has been given any priority in the research work, will now be included in the work. Among the staff, one is a aquaculture specialist (Nikundiwe pers. comm. 1992). At the **Institute of Marine Science** at Zanzibar, also belonging to the University, there is also one aquaculture specialist (Msuya pers. comm. 1992).

Sokione University of Agriculture (SUA) in Morogoro has from the academic year 1992/93 included aquaculture in the curriculum. At the Faculty of Agriculture, Department of Animal Science, a 60 hours (h) course in fish and non-conventional animal farming is included in the Bachelor of Science course (SUA 1991). In the five year study at the Faculty of Veterinary, 30 lecture hours in aquaculture is included.

At **Kunduchi Fisheries Institute (KFI)**, about 20 - 25 students are each year examined from the 2 years' Diploma course in fisheries. The course include 50 h with mariculture and 50 h with freshwater fish culture (KFI 1989). Little research is done, and nothing on aquaculture. Of the scientific staff, two persons are specialized on aquaculture.

Nyegezi Freshwater Fisheries Institute (NFFI) in Mwanza gives a 2 year Certificate course in fisheries, which include 40 h of fish farming. 20 - 30 students are examined each year. Of the staff of more than 20, four have a university degree (Mahatane pers. comm. 1992).

Mbegani Fisheries Development Centre (MBDC) work with both education, development and extension. Both Certificate and Diploma courses are given, and about 30 Diploma students are examined each year. However, no subjects cover the field of aquaculture (Foyn pers.comm. 1992).

2.5.2 Fish farming programmes and projects

A number of foreign aid programmes have been initiated in the field of fish farming.

The Hombolo hatchery near Dodoma, is run by the **Anglican Church** and is a part of their Fish Farming Development Programme. *O. niloticus* were introduced from Baobab Farm in Kenya, and the hatchery plays an important role in the distribution of fingerlings in Tanzania. The site in Hombolo also includes production ponds. Integrated farming is practised, and it is also a site for extension and training (Fowler pers. comm. 1992). Through the programme, demonstration ponds have been established in 3-4 other regions, and also in Morogoro region, some demonstration ponds are planned.

The Evangelical Lutheran Church (ELCT) started in 1984 a fish farming project in Arusha region. Farmers are trained on seminars in fish farming, and after the training, they are ment to be "motivators" for their villagers. The aim for the volunteer "motivators" is to increase the interest of fish farming among people, to help people starting with fish farming, and to teach them how to farm fish. The project is still going, and a result of this, is about 600 constructed ponds and a yield of about 5 - 6 t in 1991 in Arusha region. There is a cooperation between the Fisheries Office in Arusha and the ELCT - project. In 1991 the project expanded to also other regions, including areas in Mbeya, Iringa, Mara and Singida regions (Murnyak pers comm 1992).

US Peace Corp Volunteers (PCV) have been working with fish farming through the whole 1980's. In 1991 they were withdrawn because of political reasons. However, they are expected to be back during 1992 (Lema pers. comm. 1992). Their work, concentrated in the Mbeya, Ruvuma, Tanga and Iringa regions (Balarin 1985), has been extension service and fingerling distribution.

Also other smaller NGO projects, like an Irish project in Mbulu (Arusha region), is found, which main aim is to initiate fish farming in local communities.

Some countries, including Scotland, Finland and Norway have education programmes for foreign students. Some Tanzanian students have taken their M.Sc. degree in aquaculture abroad through such programmes.

The Aquaculture for Community Development Programme (ALCOM) was started in 1986, funded by SIDA and executed by FAO. The programme has a long term, implementation phase going to 1995 (Goppers and Miller 1989), and focuses its activities in the SADCC countries, including Tanzania. " The overall objective is to develop, test, and demonstrate methods for assisting rural people to improve their quality of life through the development of aquaculture in association with other community activities" (FAO 1988b). In order to learn more about the socio-economics of small-scale farmer involvement in aquaculture, and about the technical, biological and environmental aspects of aquaculture, both research, surveys and pilot projects are conducted (Goppers and Miller 1989).

At the **African Regional Aquaculture Centre (ARAC)** in Nigeria 4 Tanzanians have completed the one year training course for aquaculturists (post-graduate level). This course started in 1980, funded by several donors. However, in 1988 the activity stopped because of economical reasons (Lema pers. comm. 1992).

Aquaculture Development and Coordination Programme (ADCP) is a long term programme run by FAO and UNDP. The programme is international, and have a major role in UN's activity on aquaculture development in the third world countries.

International Centre for Living Aquatic Resources Management (ICLARM) has established a base in Malawi. This is ment to be a research and training centre for the African countries (Edwards, Pullin and Gartner 1988).

2.6 Constraints to fish farming development

Lema and Angwezi (1988) considers the following as main constraints for aquaculture development: "aquaculture is given a lower priority than agriculture and animal husbandry, no loans are provided for an aquaculture project and lack of quality fish seed of the correct species".

Because of the low priority given, the Fisheries Division lack both facilities, transport and funds. There is also a lack of trained personnel at all levels from researchers to field extension workers (Coche and Demoulin 1986). Hence, the extension service, including fingerling distribution, is unproper. A result of this is unproper management of the fish ponds, stunted fish and low production (Balarin 1985). This in turn, makes the farmers loosing interest for fish farming.

3.0 THE BIOLOGY OF TILAPIA WITH RESPECT TO AQUACULTURE PURPOSES

3.1 Classification and distribution

The tilapias, belonging to the family Ciclidae, are tropical fish species, and are naturally found in fresh and brackish water. They are mainly herbivorous, and of shape generally deep bodied and bilaterally compressed.

About 100 species of tilapia are known (Balarin 1984), and they have been classified in different ways. Fishelson and Yaron (1983) characterize all the tilapias as one genus, with seven sub-genera. By Trewavas (1982), the tilapias are divided into the three genera *Tilapia, Sarotherodon and Oreochromis,* according to their reproduction habits. This classification will be used here. The species in the genus *Tilapia* are substrate spawners, species of *Oreochromis* are maternal mouth brooders, while the species in the genus *Sarotherodon* are paternal or biparental mouth brooders.

The tilapias originate from Africa. It is believed that the speciation of the genus *Tilapia* took place in West Africa, while the two other genera developed mostly in East and Central Africa (Trewavas 1982).

During the last 40-50 years, the tilapia has been introduced to a number of countries outside Africa, as well as to areas in Africa where not originally found (Phillipart and Ruwet 1982). It has become an important fish for aquaculture purposes, especially in South East Asia and China. Of the total world aquaculture fish production in 1990 of about 8.4 million t, almost 400 000 t came from tilapia (FAO 1992c). Of these, more than 200 000 t came from farming of *Oreochromis niloticus* (Nile tilapia). The total world fish catches of tilapia, was in 1990 estimated to be about 803 000 t (FAO 1992b).

According to Pillay (1990), the more important species of tilapia for commercial aquaculture are: *Tilapia rendalli, T. zillii, Oreochromis mossambicus, O. hornorum, O. niloticus, O. aureus, Sarotherodon melanotheron*, while

O. andersonii and *O. spilurus* are of some importance.

In Appendix 4, information about availability of the species, food habits, growth, salinity and temperature tolerances, and reproduction is collected for some of the most commonly farmed tilapia species.

3.2 Environmental requirements

Tolerance of temperature and salinity are the major determinants of the geographical spread of tilapia (Balarin and Hatton 1979).

Tilapia are essentially tropical lowland fish, but some species and strains withstand low water temperatures much better than others (Bardach et al. 1972). Generally, tilapia stop growing between 15 and 20°C, start spawning at 20-23°C, and do best within temperatures ranging from 25 to 35°C (Balarin and Hatton 1979; Balarin 1988b). Lower lethal temperature varies between the species from about 6 to 12°C, while common upper lethal temperatures are 37-43°C.

Most tilapias are tolerant to brackish waters, while species like *O. mossambicus, O. aureus, O. spilurus* and *S. melanotheron* may thrive and reproduce in sea water (Bardach et al. 1972; Balarin and Hatton 1979; Balarin 1988b).

Compared with other fish genera, the tilapias tolerate poor water quality. This makes it possible to rear fish in ponds with stagnant water, rich on nutrients and organic matter. Dissolved oxygen (DO) as low as 1 ppm is tolerated, and below this level, they may utilize atmospheric oxygen (Chervinski 1982).

The toxity of ammonia (NH^3) depends on the level of DO in the water. NH^3 is toxic at a lower concentration when the DO is low, and the toxity will besides be decreased with increased levels of CO^2. *S. aureus* tolerated in experimental ponds a maximum of 2.4 mg/l NH^3 (Chervinski 1982).

Generally, tilapias tolerate a pH range of 5 to 11 (Chervinski 1982). Huet (1971) recommends pH of 7 to 8 for culture of tilapia.

3.3 Reproduction

The tilapia is generally highly prolific. Under tropical conditions, the female may lay batches of eggs every 4-6 weeks, and may spawn continuously throughout the year (Lowe-McConnell 1955; Pillay 1990).

Number of eggs per spawning depends on the species, and varies from about 150 to 6000. The fecundity is generally higher among the substrate spawners than the mouth brooders. *O. niloticus* mature in ponds at 4-5 months, spawn at least 3 times per year. Number of eggs produced per spawning depends on the size of the females. While a 100g *O. niloticus* spawns about 100 eggs, a 600-1000g female will spawn about 1000-1500 eggs per spawning (Balarin and Hatton 1979).

All the tilapias exhibit a high degree of parental care. The substrate spawners guard the eggs, and also the fry the 45-50 first days after hatching. The mouth brooders keep the eggs in the mouth, and after hatching the young fry are hidden in the mouth when threatened (Balarin and Hatton 1979).

At what age and size the tilapia reach maturity, seems to be effected by factors like food availability, water quality, presence of predators, space available, size of the water body and water depth. Though the mechanism behind the maturity is not fully understood, it seems that adverse conditions promote maturity at an early stage (Pullin 1982).

Populations of fish with low weight for length seems to switch to reproduction at a smaller size than populations in which the fish are in better condition (Lowe-McConnell 1982). Hence, the importance of fingerlings of good condition for pond stocking is highlighted by Pillay (1990).

It is obvious that tilapia reach maturity at an earlier stage in small water bodies like ponds, than in natural lakes and other large water bodies (Lowe-McConnell 1955;

Balarin 1979; Lowe-McConnell 1982). Common ages of maturity are for wild tilapia one to two years, while the same species reach maturity 3-6 months old in ponds (Balarin 1979; Hepher and Pruginin 1982). The size at first spawning can then be 8-10 cm.

A result of this early prolific breeding habit in pond culture, is stunted fish. This can be explained by i) the fish use the energy for reproduction rather than to growth, and ii) the ponds become overcrowded due to the uncontrolled spawning, and food and space become limiting (Hepher and Pruginin 1982).

To overcome the problem of stunted fish, several methods have been developed. Most common is the all-male culture by manual sexing. The sexes are distinguished by examination of the genital papilla. The size of the fish have to be 20-50g when manually sexed (Pillay 1990). However, it seems difficult to achieve greater than 90% accuracy (Hepher and Pruginin 1982).

All-male culture can also be obtained by hormonal sex reversal (Mair and Little 1991) or development of all-male or predominantly male hybrids (Lovshin 1982). Due to high costs and need for well developed technology these methods are only used in countries with well developed and intensive tilapia culture industries, like e.g. Israel and Taiwan (Mair and Little 1991).

Hepher and Pruginin (1982) recommend practising of "young-of the year" culture, i.e. harvest before the fish reach maturity, and complete drainage between the production cycles. Low stocking density, proper fertilization and additional feeding is recommended because of the short production period.

Predator fish in the ponds have been used to cull the fish population. However, it has been difficult to find the optimal predator/pray stocking rates (Mair and Little 1991).

Despite this methods developed, overcrowded ponds and stunted fish caused by early sexual maturity and frequent breeding, is still the greatest problem in tilapia farming (Pillay 1990).

Langholz et al. (1987) found that for *O. niloticus*, the age of maturity were genetically controlled and of high genetic variability. This indicate good selection prospects for late maturity, which could give a longer production period before first maturity.

Several methods for fry production in ponds, tanks and hapas are described (Pillay 1990). Fertile eggs can also be taken from incubating females, and be hatched and rared in separate containers. Artificial fertilization is also possible (Balarin and Hatton 1979).

3.4 Nutrition

In general, the mouth brooders (genera *Oreochromis* and *Sarotherodon*) are microphagous omnivores, taking phytoplankton like blue-green algae, green algae and diatoms, and detritus. The species of genus Tilapia are mainly macrophagous herbivores (Bowen 1982; Jauncey and Ross 1982).

Some species, like *O. niloticus, O. mossambicus* and *O. aureus* are versatile feeders, and feed also on macrophytes, in addition to the micro organisms (Bardach et al. 1972; Pullin 1983). The species feeding on macrophytes, can be used in weed control. Some weeds are habitats for mosquito larvae, and this can consequently reduce the spread of human diseases like malaria. *O. niloticus* also predate on the mosquito larvae (Bardach et al. 1972). Under culture conditions, tilapia generally have flexible feeding habits (Pillay 1990).

The juveniles of all the three genera usually feed on phytoplankton and zooplankton, until they reach a size of about 5 cm (Balarin and Hatton 1979).

The food habits can be predicted by examination of the gillrakers. Plankton feeders usually have numerous long, thin closely spaced gill rakers (*O. niloticus*: 19-28 rakers), while the macrophytes have fewer and larger gill rakers (*T. zillii*: 8-12 rakers) (Lowe-McConnell 1955; Bardach et al. 1972).

Two types of teeth are found at tilapia; the teeth of the jaws, and the pharyngeal teeth. The degree of coarseness and mobility of the teeth varies between the species due to their different diets (Trewavas 1982). The teeth are used to prepare the food by shredding coarser materials and breaking some of the cell walls before passing it on to the stomach.

Very low pH in the stomach is typical for tilapia. Common gastric pH on actively digesting tilapia is 1.25 (Jauncey and Ross 1982), and values as low as 1.0 have been recorded (Payne 1978 in Janucey and Ross 1982). Among other fish species, a gastric pH of more than 2 is common.

Janucey and Ross (1982) refer to Moriarty (1973), and say that: "The acid in the stomach decomposes chlorophyll and lyses blue-green algal cell walls which makes subsequent intestinal digestion possible by allowing enzymes access to the algal cell contents".

The intestine where the assimilation take place, is long and coiled; adapted to the herbivorous diet (Trewavas 1982).

The natural food available for tilapia in ponds can be increased by fertilization (Bandach et al. 1972; Balarin and Hatton 1979; Pillay 1990). In 250m^2 ponds in Thailand, Diana et al. (1988) found that ponds receiving high fertilizer inputs exhibited higher nutrient levels in water, higher primary production, and higher fish production than ponds treated with low inputs of fertilizer. By using manure, increased production of protein rich bacteria and protozoa can also be obtained, in addition to the increase of primary production (Hepher and Pruginin 1981). Parts of the manure can also be utilized as fish food directly.

To increase the production in the ponds, supplementary feeding can be used. In well manured ponds, the protein demand will be covered by the bacteria and the protozoa produced, hence the supplementary feed can be rich on carbohydrates (Hepher and Pruginin 1981). Common feeds used supplementary, include rice and maize bran, oil seed and oil cakes, copra and brewery wastes, plant leaves, rotten fruit and kitchen leftover (Bardach et al. 1972; Pillay 1990).

In Jauncey and Ross (1982), the nutritional requirements of tilapias are summarized as shown in Table 3.1.

Table 3.1

A summary of the major nutrient requirements of tilapias (after Jauncey and Ross 1982).

Nutrient	Size group				
	First feeding to 0.5g	0.5-10g	10-35g	35g to market size	Brood stock
Crude protein	50%	35-40%	30-35%	25-30%	30%
Crude lipid	10%	10%	6-10%	6%	8%
Digestible carbohydrate	25%	25%	25%	25%	25%
Fibre	8%	8%	8-10%	8-10%	8-10%

According to the Table 3.1, and if all requirements shall be covered by the feed composed, they suggest the following feeding diets:

1. First feed fry - 0.5g; 50% protein, 10% lipid
2. 0.5 - 35g; 35% protein, 8% lipid
3. 35g to market size; 30% protein, 6% lipid

Vitamin and mineral supplements needed, are also suggested (Jauncey and Ross 1982).

3.5 Growth

Growth rates vary with species and conditions. In natural waters various tilapia species grow at different rates within a water body, and the faster-growing species reach a larger size. "But the same species will grow at different rates in different water bodies, suggesting that environmental differences are more potent than genetic ones in determining maturation and maximum size" (Lowe-McConnell 1982).

O. andersonii has been caught at a size of 3.2 kg (Lowe-McConnell 1982), while maximum size is about 3 kg (35 cm) for *T. zillii*, and 2.5 kg (50 cm) for *O. niloticus*. Other tilapia species reach a maximum size of 1 - 1.5 kg (Balarin and Hatton 1979).

In freshwater ponds, *O. niloticus, S. mossambicus, T. rendalli* and *O. spilurus* are among the fastest growing species, while *S. aureus* and *T. zillii* seems to be the fastest growing species in sea water pond culture (Balarin and Hatton 1979; Pullin 1983). Oreochromis monosex male hybrids and so called red tilapias (various *Oreochromis* hybrids) have also shown good growth.

The yields achieved in culture of tilapia varies a lot, depending on nutritional status in the pond, and kind of farming system practised.

According to Bardach et al. (1979) the yearly natural production in a tilapia pond can be 0.5 t/ha, with a common fish size of 85 - 140 g. If fertilization and/or supplementary feed is used, the production can be 1 - 2.5 t/ha.

Yields of about 2 t/ha in a five month production period is reported from Philippines (Pillay 1990). This ponds had been stocked with 20 000 - 30 000 fingerlings per ha, fertilized with chicken manure and ammonium phosphate, and rice bran had been used as supplementary feed.

In more intensive systems, higher yields can be obtained. Lovshin (1982) reports about annual yields ranging from 5.6 to 12 t/ha, when ponds had been stocked with 13 000 - 31 000 hybrids (*O. niloticus* x *O.hornorum*) per ha. Size of the fingerlings were 22-25g, and average size of harvested fish varied between different ponds from 353 to 495 g.

Polyculture systems with common carp (*Cyprinus carpio*), mullet (*Mugil spp.*), silver carp (*Hypophthalimichthys molitrix*) and tilapia is common in Israel. These systems give high yields, because of the maximum utilization of feeds and improvement of the chemical regime. Common annual yields are 7.5-10.7 t/ha, and the tilapia account usually for about 1/4 of the yield (Pillay 1990).

Increased production is obtained when fish culture is combined with animal husbandry, in e.g. fish-cum-pig culture or fish-cum-duck culture. Continual supplies of fresh organic fertilizers have positive effects on the production in the ponds (Vincke 1988a).

In Philippines, growth rate was compared in 8 strains of *O. niloticus*. There was found a significant variation between the strains, tested in 11 test environments and farming systems (Bentsen 1992). A mixed population was made by crossing the 8 strains together. In the mixed population, a heritability of 0.2-0.3 was found for body weight at harvest, when 120 full-sib and 50 half-sib groups were tested. The effect of selection seemed to be as high as 20% increase in body weight at harvest after one generation.

3.6 Diseases and mortality

In tropical extensive and semi-intensive tilapia farming, few diseases and mortalities due to infection have been reported (Pillay 1990). Natural resistance to disease and low fish densities can be parts of the explanation for this.

Most common mortalities caused by environmental factors, are sudden lowering of the temperature below the tolerance level, and anoxia following blooms of algae such as Michrocystis, Anabaena and Oscillatoria (Pillay 1990).

In intensive tilapia farming, a number of diseases and mortalities are found. Roberts and Sommerville (1982) and Lightner et al. (1988) describe viral, bacterial, fungal, parasitic, nutritional and environmental diseases found in intensive culture.

By Lightner et al. (1988), gill hyperplasia was found, presumably due principally to chronic ammonia and nitrite toxity.

According to Roberts and Sommerville (1982) nutritional problems are a major difficulty in intensive culture. Aflatoxicosis, which is caused by mycotoxines, often occur as a result of losses associated with poor quality storage of food ingredients.

4.0 STRATEGIES FOR AQUACULTURE DEVELOPMENT IN SUB-SAHARAN AFRICAN COUNTRIES

4.1 Introduction

Despite the important role tilapia farming was thought to play in the African food production strategy (Maar et al. 1974), fish farming has not developed to any extent on this continent. It has been estimated that in 1985, only 0.1% of the worlds aquaculture production came from Africa. The African aquaculture products, mainly tilapia, cover only about 0.3% of the continents fish consumption (Huisman 1986). From 1975 to 1980, African aquaculture production decreased at an average rate of about 13% per year (FAO 1984a). In view of this, and despite large efforts in funding and assistance during the last 30 - 40 years, aquaculture must, according to Huisman (1986), still be seen upon as a new practice in Africa.

The constraints to aquaculture development in African countries, and thereby also the reasons why the aquaculture development failed to come, are described by several authors (Pillay 1983; Pruginin 1983; Balarin 1984; Kutty 1986; FAO 1987; Balarin 1988; Vincke 1988b; Goppers and Miller 1989; World Bank 1991a), and can be summarised as followed:

1. Aquaculture has not been given any priority by the governments, and an overall national aquaculture plan and policy is lacking.
2. Too little attention is paid to socio-economic and socio-cultural conditions, when aquaculture is introduced into new areas.
3. Lack of personnel trained in aquaculture at all levels, from field extension workers up to senior researchers.
4. The research done, is often of an impractical manner. There is a lack of pilot production facilities, both for experiments in adaptive research and for demonstration and training.
5. Poor extension service, due to lack of well trained personnel, facilities, transport and funds.
6. The projects have been of a too short duration, and farmers have been left by their own before they have got the knowledge and the real understanding of fish

farming.
7. The prolific reproduction habit of tilapia.

Other constraints, which have occurred partly or fully as a consequence of one or more of the above mentioned points, are;
8. Unproper project sites and farming methods chosen, and poorly constructed ponds.
9. Unsuited fish species, lack of knowledge about their biology, and lack of high quality seed.
10. Unproper amounts of fertilizer and feed used because of lack of knowledge, and in some areas because of competition of these resources with other crops or stocks.
11. Difficult to get credit for people who want to start with fish farming.
12. Lack of equipment and technology needed for proper fish farming activity.

4.2 National aquaculture plan and policy

In the development of aquaculture in most of the African countries, there is a strong need for establishment of a clearly defined national aquaculture plan and policy (FAO 1976; Coche and Demoulin 1986; Pillai 1988). Today, strategies for a national aquaculture development are lacking, and from the SADCC countries, including Tanzania, it is reported that aquaculture is given a low priority compared to other food- and cash-generating sectors. Therefore there is need to increase the awareness among the decision makers, on the importance of the fishery sector, including aquaculture (Coche and Demoulin 1986).

Only when an aquaculture development plan is included as a component of the national economic development plan, this sector can be evaluated together with agriculture and other sectors for its potential. Then, resources can be allocated to aquaculture in proportion to its economic worth (Maine and Nash 1987). The national needs which aquaculture can help to satisfy, are domestic production of food and nutritional health, commercial profit, job creation and foreign trade.

Basic data collection is needed for further planning. This should include determination of i) the requirements for aquaculture products, ii) environment suitability and resources available for aquaculture; land, water, inputs, manpower and infrastructure, and iii) the potential for aquaculture production. Then a strategy should be worked out, including the aspects: level of aquaculture production and development, selection of production systems and species, requirements for manpower and how to cover this, need for legislation and level of government assistance in research, training, extension, finance and credit (Pillai 1988).

ADCP has worked out a guideline for the preparation of a aquaculture national plan, useful for developing countries (Maine and Nash 1987). Here it is suggested that the plan should be prepared by a multi-disciplinary team. From a workshop on aquaculture planning in the SADCC-countries (Coche and Demoulin 1986), it is recommended that in the aquaculture development planning, should be clear practical priority ratings based on future development prospects more than on earlier results in the aquaculture sector. There should be plans on long, middle and short term bases.

High priority should be given to collection of social, economic and biological fishery data. Because of the low degree of aquaculture development in the SADCC-countries, the workshop highlights the need for positive government action on two levels; i) direct intervention, including general promotion of aquaculture, research, training, seed production and extension service, and ii) positive policy making to create a suitable socio-economic environment for fish farmers, like credit facilities and invest funds (Coche and Demoulin 1986).

4.3 Biological, technological and environmental aspects

4.3.1 Selection of species

When selecting species for aquaculture purposes, there are several considerations to be aware of. Balarin (1988c) divides these into four:

a) Biological criteria. "The optimum environmental requirements of a species for maximum growth must be matched up to the prevailing environmental conditions". Generally *O. niloticus* and all male tilapia hybrids are considered as most favourable for fish farming purposes. If the local species are unsuited for farming in a zone, introductions should be considered.

b) Technological criteria. The tilapia is relative easy to cultivate, the technology of farming is widely known in Africa, and well documented. For other species, farming technology is either not developed, or the knowledge of this is limited to a few people.

c) Bio-economical criteria. The economic viability of fish farm production depends on a good growth rate on the fish under local conditions, the fish must be able to convert low grade protein into high quality flesh, it must reproduce easily in captivity and be a fish suited to the market. For the small-scale farmers, it is necessary to achieve maximum benefit for minimum input.

d) Pathological criteria. In small-scale projects, were inputs have to be minimized, a hardy, high resistant fish like tilapia is best suited. Large-scale commercial farms can put more inputs on optimal environment for, and treatment of the fish.

Of the about 25 species which are actively cultured in Africa, the tilapia are the most common, with ten species commonly cultured (Balarin 1988c). According to the above mentioned criteria, tilapia is ideal for low technology culture. However the prolific breeding nature causes problems, if this is not controlled in one way or another (Balarin 1984). New species should not be introduced, unless all aspects of the introduction has been considered. Codes of practice and a manual of procedures for this consideration is developed by the European Inland Fisheries Advisory Commission (EIFAC) (Turner 1988), and also ICLARM intend to adopt this practice (ICLARM 1992).

4.3.2 System selection

What kind of aquaculture systems which shall be developed, have to be selected according to local conditions, existing and potential infrastructure and government policy (Coche and Demoulin 1986). The intensity of the farming systems depends on what role aquaculture is meant to play, either being a way of feeding the rural poor, a way of getting foreign exchange, or something in between this extremes. The needs for infrastructure, inputs, qualified manpower and extension service depend on wether the system to develop is extensive, semi-intensive or intensive[4] (Pruginin 1983; Pillai 1988).

For small scale farmers in the tropics, the best way of farming fish would be through integrated crop-livestock-fish farming systems (Balarin 1984; Coche and Demoulin 1986; Edwards, Pullin and Gartner 1988). This systems utilize the available resources in an optimal way, and the demand for capital input is limited. According to Edwards et al. (1988), this systems will "improve the diet, spread the risk, provide employment and generate surplus produce for sale".

However, not all integrated systems are appropriate for African countries, something which must be taken into consideration. General aspects that influence the development of integrated farming in Africa, are according to Balarin (1988b); fertilizing the ponds with human excreta is taboo, few farmers keep large number of livestock, the livestock and chicken often range freely, manure is used on crops and vegetables, ducks and pigs are not widely farmed, the major crop residues are of low nutrient value as fish feeds and pond fertilizer, and the more nutrient crop residues like maize bran are used in livestock feeds.

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[4] Extensive systems are characterized by no inputs, and are nutritional requirements derived from natural sources. In semi-intensive systems, fertilization and supplementary feeding is used. In intensive systems, the energy input is high, and the nutritional requirements are met from external sources.

4.3.3 Site selection and environmental aspects

Pruginin (1983) stresses the importance of proper selection of site and environmental conditions when planning aquaculture projects. Criteria for such a site selection should include i) water; availability, quality, physical and chemical properties, ii) soil; water-holding capacity, other physical and chemical properties and topography of the selected area, and iii) climatic criteria like maximum and minimum temperatures, rainfall and radiation. Balarin (1988b) see upon temperature as the single most important environmental factor determining tilapia production in ponds.

A negative environmental impact of aquaculture, can be higher frequency of human water-born diseases like malaria, bilharzia, sleeping sickness and river blindness. This because of the increasing area of open water. However, the negative impacts can be limited by clearing the vegetation in and around the ponds. This unfavour both the snail carrying bilharzia, the larvae of the malaria-carrying mosquito and the tsetse fly which transmits sleeping sickness. Fish larvas feed on mosquito larvas, and some species like *Oreochromis macrochir* predate on snails. The larvae of black flies which transmit river blindness, are associated with rapidly running water. Hence, this can be a problem in e.g. channels, but not in ponds with stagnant water (Nyman 1988).

4.4 Socio-economic aspects

In the development of aquaculture in Africa, the approach has till now mainly been concentrating on the technical aspects. However, there is need for a multi-disciplinary approach in the development, where the social and the economical aspects are given a much higher priority (FAO 1987; World Bank et al. 1991a). "In the development of small-scale aquaculture in particular, it is the ecological and socio-economic conditions that determine the choice of technological solution, and not the reverse" (World Bank et al. 1991a).

The key target group for aquaculture development in Africa has till now been the subsistence farmers. However, Huisman (1986) is of the opinion that it should be focused more on the commercialisation of aquaculture, and not only on the aspect of family nutrition. Priority should, according to Huisman, be given on the basis of projects' commercial feasibility within the target area. Then, artisanal fish farmers and cooperatives might form a better target group.

Balarin (1984) is of the same opinion; the assistance given, including infrastructural costs and all the aspects of extension service, is very expensive, compared with the benefits obtained. He believes that a new strategy of intensive fish farming has to be adopted. Intensive large scale tilapia farming, though dependent on more direct capital, could be a way of producing more fish to a total lower cost. However, the intensive farming depend on qualified personnel, proper infrastructure and availability of cheap artificial feed. To cover the costs of this production, the market price has to be rather high. This will be too expensive for the majority of the rural population. However the introduction of intensive tilapia farming will have positive effects also on the development of the rural fish farming sector, "in the form of successful demonstration, a source of seed, and a centre for extension and demonstration".

A FAO/UNDP/NORAD evaluating team (1987) see it as unrealistic that the industrial aquaculture can solve the nutritional problems among the urban and rural poor in the developing countries, because of the high prices needed to cover the capital costs.

Weeks (1990) put the emphasize on the negative effects of commercial aquaculture programmes on the rural people. Resources earlier available for production of local consumed products, can be used for products exported from the area. This can cause local malnutrition. Commercial aquaculture is not labour intensive, something which can cause unemployment, especially among the unskilled. Also the subsistence aquaculture activity can lead to a negative development among the rural poor, if not the resources and labour available are considered regarding alternative use in agriculture, animal husbandry or other sectors.

4.5 Education

Development of skilled manpower and extension service is by the workshop on aquaculture planning in the SADCC-countries, seen upon as the most important components of aquaculture development in these countries (Coche and Demoulin 1986). Education is strongly required for both aquaculturists at research level, for technicians and for field extension workers, but because of low priority and lack of facilities, staff and funds, proper education is lacking.

The field extension workers need a training of a highly practical nature through local courses, but trained and experienced trainers to lead such courses is lacking. Technicians could get their education at national institutions or at a regional aquaculture centre. Researchers should get specialized training through participation in research under a senior scientist after basic training in the universities (FAO 1976; Coche and Demoulin 1986).

On the FAO World Conference on Fisheries and Development in 1984, establishment of national aquaculture centres is recommended. In addition to training of technicians and extension workers, their main tasks should be pilot production with research, technology testing and adaptation, and distribution of information (FAO 1984b). Further, it is recommended that the African regional aquaculture centre (ARAC) and the other regional centres established by ADCP, are linked to the countries in the region through the national centres (FAO 1984b).

4.6 Research

Due to the limited resources available, the research activity should be limited to a few proven species (King and Ibrahim 1988), and both the basic and the applied research has to be relevant and useful for the development of the country (FAO 1976; World Bank et al. 1991a). Research and development should be of the low-technology kind (UNDP/FAO 1987).

Further, cooperation in the education and research is important. Close national cooperation between the institutions conducting research, especially between the universities and the fishery research institute within the Department of Fisheries, is needed (World Bank et al. 1991b).

A sub-regional (e.g. the SADCC-countries) or a regional (Africa) cooperation could include identification of research priorities, joint regional research programmes and common services like information, publications and meetings (Coche and Demoulin 1986; World Bank et al. 1991a). Establishment of an African fellowship for individual aquaculture and fishery researchers, parallel to e.g. the Asian Fisheries Society Research Fellowship Awards could, according to World Bank et al. (1991b), be valuable. More attention should be paid to the individual scientists, and they should be given incentives in the research-work. Professional development of young researchers should be given a special priority.

International cooperation, where both developing and developed countries participate, will strengthen the research capacities in the developing countries, both directly and indirectly by upgrading of their own scientists (King and Ibrahim 1988; World Bank et al. 1991a; World Bank et al. 1991b). Research oriented projects initiated by foreign agencies should be planned and formulated in close association with the national research institutes. This would benefit both the projects and the institutes (Coche and Demoulin 1986). To utilize the resources in an optimal way, there is also need for a greater cooperation in research and training between the different funding agencies operating in the same region (FAO 1976).

The research conducted, should be system-oriented and multi-disciplinary, including biological, technological, social and economical aspects (FAO 1976; World Bank et al. 1991a). High priority should be given to the socio-economic research.

According to the World Bank (1991b), priority-areas for freshwater aquaculture research in Southeastern Africa are; i) integrated agriculture-aquaculture farming, where the farmers is the ultimate target group, ii) investigations on fish nutrition and feeding and iii) choice of suitable species and strains, species selection and genetics. In addition to development of small scale aquaculture in new rural areas, research should also include development of culture based fishing and stock enhancement (World Bank 1991a).

4.7 Extension work

Extension activities can be divided into i) training, ii) services like e.g. seed distribution, technical assistance and economical assistance, and iii) being a link between government and private institutions, researchers and farmers (Engle and Stone 1989).

The importance of a proper extension service is generally accepted. In ADCP's review of extension methodologies in aquaculture, it is recommended that the major emphasis of aquaculture development programmes should be on field extension, more than on developing "seed production, demonstration, and research infrastructure" which have been the priorities till now (Engle and Stone 1989). By others, also hatchery-facilities and production of quality seed are given a high priority (Balarin 1984; King and Ibrahim 1988).

"The extension programmes are justified by the fact that economic development resulting from extension activities should more than compensate for the national investment required to provide these services" (Engle and Stone 1989).

According to the ADCP-review, successful extension efforts depend on use of a sound technology adapted to the local conditions, careful selection and training of motivated extension workers, support from the Government and the producers and trust and confidence between the farmers and the extension workers. Engle and Stone (1989) conclude that success or failure in aquaculture development depends on "attitudes towards extension and extension agents" rather than the structures of the extension service.

The links between research and extension service have to be strengthened because i) the researchers need the feedback from the farmers to conduct useful research, and ii) useful technological innovations conducted by the researchers should become available for the farmers. This can effectively contribute to the development of aquaculture industries (Engle and Stone 1989).

4.8 Marketing and financial support

At the FAO technical conference on aquaculture in 1976, lack of adequate financing and appropriate credit facilities was seen upon as main constraints on aquaculture development in many countries (FAO 1976). These financial problems are still existing, and to support the aquaculture development in Africa, available investment-funds, inputs and credit facilities are needed (Coche and Demoulin 1986; King and Ibrahim 1988).

Because of the high risk of starting a new activity like fish farming, subsistence farmers need, according to Huisman (1986), financial and marketing support as well as technical support. This is "needed until the local aquaculture industry has reached a stage of autonomous growth" (Huisman 1986).

According to Pruginin (1983) and Engle and Stone (1989), subsidies should be limited to a transition period. To create incentives among the farmers, the projects have to be economically feasible. Further, supplying production inputs other than seed stocks, can result in dependency on government and impede potential development of local business producing or manufacturing equipment, or providing other services. However, the transfering of responsibilities from the public to the private sector, requires that the private sector have the means and motivation to manage this. For the SADCC-countries, this is considered as a long- or middle-term objective (Coche and Demoulin 1986).

4.9 Aspects of assistance through foreign aid

The aquaculture projects initiated should be multi-disciplinary, and of a long term duration, pioneering projects lasting at least 10 years (UNDP/NORAD/FAO 1987).

Till now, foreign aid projects often have been of a short duration, and projects have been terminated before being completed. (World Bank 1991a).

From the workshop on aquaculture planning in the SADCC-countries, the importance of programme- and project-coordination is stressed. There should be a close cooperation within the SADCC sub-region, between the SADCC-countries and the rest of the African region through institutions like CIFA and ARAC, and an overall international cooperation in particular through ADCP (Coche and Demoulin 1986).

According to Huisman (1986), "private initiative and incentive-based entrepreneurship" should be part of the receiving counterpart when assistance is given. This is important in the development of feasible aquaculture activity. Governments, having a regulatory role, should provide a suitable environment for development, more than being the active counterpart as it is today.

The importance of project monitoring, evaluation and post implementation of aquaculture projects is stressed by King and Ibrahim (1988). This have been lacking till now, but should be included in all future projects and programmes.

4.9.1 Priority areas

In a future economic outlook for aquaculture and related assistance needs, it is concluded that with the current economic situation and the level of technology, capital and technical assistance to aquaculture development in African countries should be directed towards freshwater pond culture and integrated farming. Policy making and planning, production and marketing should be given priority, and attention should be paid to socio-economic aspects (UNDP/FAO 1987).

In the UNDP/NORAD/FAO thematic evaluation of aquaculture (1987), recommended priority-areas for assistance to aquaculture in Africa are; extensive and semi-intensive tilapia culture, culture-based fisheries, education and training.

Aquaculture training, applied research and establishment of national aquaculture centres are priority-areas for assistance to the SADCC-countries (Coche and Demoulin 1986).

Photo 1. *Oreochromis niloticus* of about 20 cm length.

Photo 2. Low production and stunted fish; a result of overcrowded ponds (the ruler is 15 cm).

5.0 MATERIALS AND METHODS

The study was conducted during the period from February to May 1992. Information was collected from fish farmers[5] by using a questionnaire. A market investigation and harvesting of fish ponds were also done in the same period.

5.1 The questionnaire study

The questionnaire study was carried out in the three regions Mbeya, Arusha and Ruvuma. The regions were selected because of the relative high fish farming activity found in these areas. Three different areas were selected, to see if there were regional differences in the fish farming activity.

In consultation with the Region Fisheries Officer, two districts were selected in each region[6] (Table 5.1). The selection of the interviewed fish farmers was done in consultation with the District Fisheries Officers in each district. In Arusha, the consultation also included representatives from the ELCT Fish Farming Project (see chapter 2.5.2). A total of 30 fish farmers were interviewed, 10 from each region. The areas investigated, are shown in Figure 5.1.

Table 5.1

Number of fish farmers interviewed in each district and each region.

Mbeya region		Arusha region		Ruvuma region	
Mbozi	5	Hanang	7	Songea rural	7
Rungwe	5	Arusha/Arumeru	3	Songea urban	3
Total	10		10		10

[5] Fish farmer is in this study defined as a person who farm fish in one or more ponds, regardless the economical importance of this activity.

[6] In Ruvuma region, the two areas selected (Songea rural and Songea urban) are both found in Songea district.

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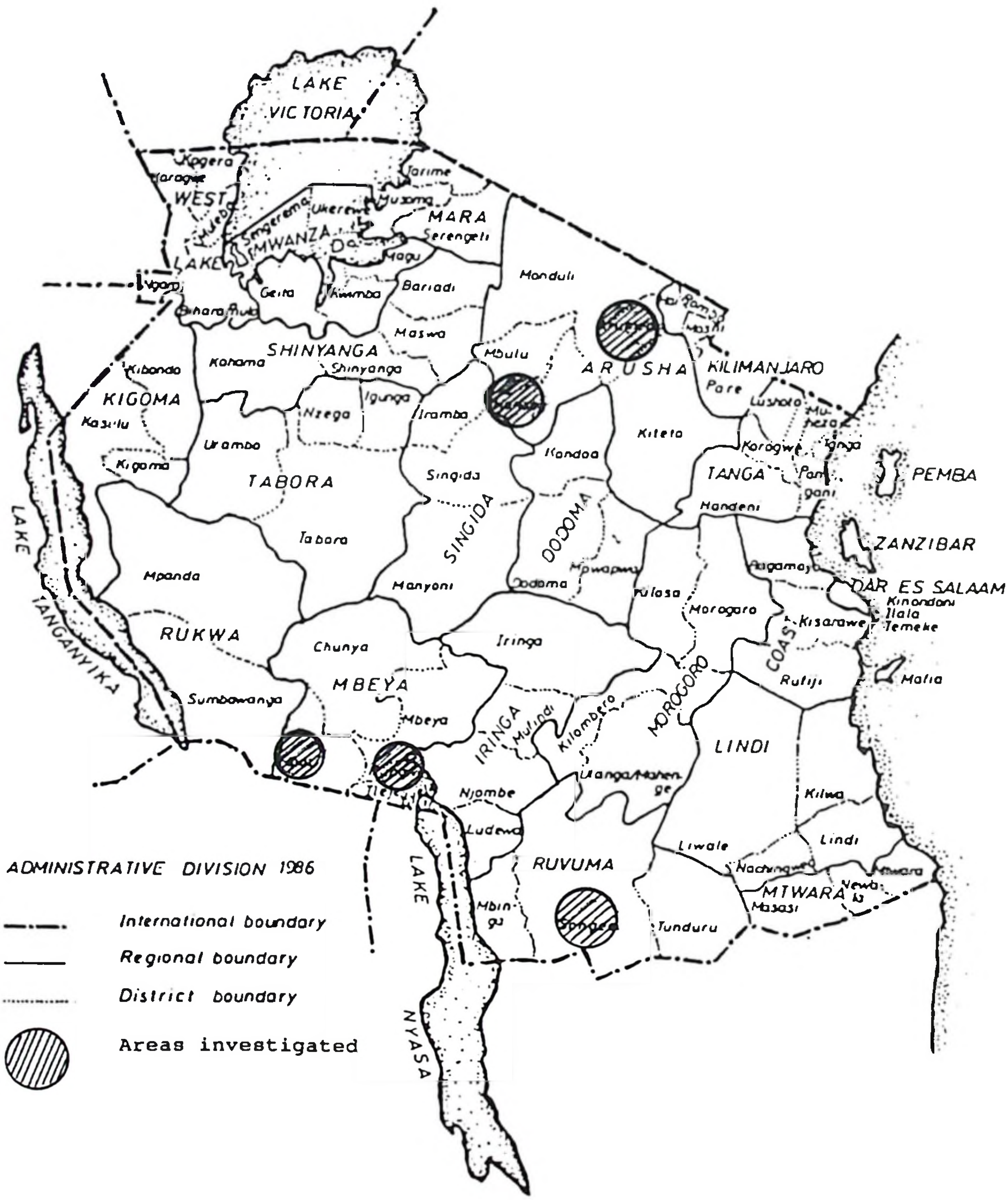

Figure 5.1 The areas investigated in the questionnaire study.

The selection was made among fish farmers having active ponds. A criteria for the selection was that not only fish farmers from one category (either those with good ponds, or those with bad ponds etc.) were selected.

5.1.1 Geographical areas studied

Mbeya region

Mbeya region is found in the south west of the country, and for most of the region, the altitude range from 1 000 to 2 000 m above sea level (Figure 2.2). The total area is 62 420 km^2, including 2 070 km^2 of water area, mainly made up by Lake Nyasa and Lake Rukwa. The annual rainfall range from 600 to more than 1 400 mm (Figure 2.6), and the minimum temperatures in Mbeya can be relatively low (Table 2.1 and Appendix 5).

About 1.6 million people live in the region. Fish farming activity is found in four of the six districts. According to reports from Mbeya Regional Fisheries Office, the total number of fish ponds is 600-650. Of the two districts without fish farming activity, one is dominated by sandy soil and heavy floods during rainy season. The other district receive little rainfall, and large areas are included in a forest reserve (Mwang'onda pers. comm. 1992).

Arusha region

Arusha region in the north east of the country, cover a total area 84 567 km^2. Of these, 2 261 km^2 are water areas. Most of the area is found within an altitude ranging from 1 000 to 2 000 m above sea level (Figure 2.2). For most of the area in the region, the annual rainfall is less than 600 mm or 600 - 800 mm (Figure 2.6).

Total number of inhabitants is about 1.4 million. In five of the seven districts, fish farming is practised, while two districts are too dry for such activity. Total number of fish ponds were in 1991 about 600 (Mafwenga pers. comm. 1992).

Ruvuma

Ruvuma region in the south of Tanzania is made up by the three regions Mbinga, Songea and Tunduru. The total land area is 63 498 km². Expect Lake Nyasa, no bigger water areas exist. Most of the region is a part of the Southeast Plateau, and range from 400 to 1 500 m above sea level (Figure 2.2). The annual rainfall is usually high, ranging from 800 to more than 1 400 mm (Figure 2.6).

Ruvuma is the region in Tanzania with highest number of fish ponds. According to reports from Ruvuma Fisheries Office, the total number was in 1988 about 4 900 ponds. The fish farming activity is highest in Songea district with about 3 000 ponds. Songea urban alone, is estimated to have about 2 000 fish ponds (Chiwangu pers. comm. 1992).

5.1.2 Interview and registrations

The fish farmers were interviewed by using a modified questionnaire from Misamfu Fish Culture Station (Zambia) which had been used in the Northern Province of Zambia. It contained 82 questions (Appendix 6). It covered information about socio-economy and total farming activity, fish ponds and water, fish species, fish farming management methods, fish production, problems the fish farmers were faced with, economy of the fish farming activity and use of resources.

All interviews were carried out by the author. The interviewer spoke English, hence a interpreter translating English/Swahili was used. Often also staff from the Fishery Office listened to the interview. Each interview lasted for about two hours.

Water flow through the pond, kind of inlet and outlet, the physical condition and the fertility of the ponds were registered for most of the fish farmers.

Information about what kind of fish species farmed, was based on information from the fish farmers and the staff from the Fisheries Offices.

Amounts of feeds and fertilizer used were for the majority of the farmers, rough estimates.

The fish production was estimated on the basis of information about number and size of harvested fish and how often the harvests were made.

On some questions, information from some fish farmers is lacking. Then, the actual number behind the information is given.

5.2 Market investigation

A marketing investigation was conducted in the Arusha, Mbeya, Ruvuma and Morogoro regions (Figure 5.1).

The information was collected through i) unstructured interviews of Region and District Fishery Officers in the actual areas, and ii) interviews of people selling fish in fish shops and at market places.

People from a total of eight fish shops were interviewed; 5 from Arusha town and 3 from Morogoro town. Total number of existing fish shops is for Arusha 7-8, and for Morogoro 5-6 shops.

Five market places were visited; two in Arusha town (Arusha region), one in Morogoro town (Morogoro region), one in Songea town (Ruvuma region) and one in Vwawa town (Mbozi district, Mbeya region).

The information collected was: what kind of fish species which was sold, where the fish came from, and common fish prices.

5.3 Harvesting of fish ponds

During March 1992, seven fish ponds were harvested in Arusha region; 6 from Hanang district (altitude 1500-1700 m) and one from Arumeru district (altitude 1300 m). One pond was a school pond, one was owned by 3 people in a cooperation, and 5 ponds were individually owned.

The pond sizes ranged from 100 - 320 m^2. All ponds were stocked with Oreochromis niloticus, with a stocking density of about 2 fingerlings per m^2. The ponds had been manured with cow manure, and feeds which had been used, were maize bran, kitchen left-over, and leaves from wild plants and plants grown in the garden. Amounts used, had not been registered. There had not been any registration on mortality in the ponds through the production period. In one pond, pond no. 6, also two individuals of catfish (*Clarias spp.*) were harvested.

Six ponds were totally drained, while one pond was almost totally drained. For this pond, number of fish left in the pond was unknown but estimated to be minor.

All the harvested fish were counted, and the total harvest was weighed for each pond. The fish were divided into three size groups. For each of six ponds, individually length and weight measurements were done on 50 - 76 fish, representing all the three size groups. In the ponds where fingerlings were taken out for stocking of other ponds, also this number was counted.

On the basis of the harvestings carried out, and of information collected about earlier intermediate harvests after last stocking, total harvest from each pond was estimated.

6.0 RESULTS

6.1 The questionnaire study

6.1.1 Socio-economic background

The average age of the 30 interviewed fish farmers[7] are 41 years (std=13.0), the youngest is 18 and the oldest 72 years old.

Number of people living in the household are at an average 9.1 (N=29, min=2, max=28, std=5.6).

60% characterize themselves as peasants. Of the interviewed, 5 farmers (17%) have no formal education, and 15 (50%) have only primary school. 8 (26%) have secondary school, and only 2 farmers (7%) have higher education.

<u>Means of living</u>

Table 6.1 shows that agriculture, including livestock, is generally the most important life sustaining activity; 90% have it as the main means of living, while the others characterize it as an important second activity. Fish farming is mainly an additional activity. Only 2 of the farmers (7%), both in Ruvuma region, have fish farming as a main means of living (Table 6.1).

Most of the interviewed fish farmers are small-scale farmers (Table 6.2). 57% own less than 4 ha, and only 10% own more than 20 ha. 70% farm an area of less than 4 ha.

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[7] All the people interviewed are in the text called fish farmers and farmers.

Table 6.1

The importance of different means of living.

Means of living	Importance of different means				
	Main means	Second means	Minor importance	No importance	Total
Agriculture[a]	90	10	0	0	100
Fish farming	7	56	20	17	100
Waged work	3	13	7	77	100
Business	3	0	3	94	100
Handicraft	0	13	0	87	100
Other	0	0	3	97	100

[a] Including livestock.

Table 6.2

Percentage distribution by size group for total area owned and total area farmed per farmer.

Size group	Area owned	Area farmed
0-2 ha	20	27
2-4 ha	37	43
4-10 ha	27	20
10-20 ha	6	0
> 20 ha	10	10
Total	100	100

All the farmers cultivate maize and beans, while bananas and coffee are the second most common crops, cultivated by 50% of the farmers.

All the interviewed farmers in Mbeya and Arusha keep cattle, while only one of the 10 farmers in Ruvuma does. Totally 60% of the farmers keep goats, and 73% keep chicken, both evenly distributed. 7% (2 farmers, both in Ruvuma) do not keep any kind of animals.

Income and investments

The majority of the farmers (83%) belong to the low-income group. In the middle-income group, there is only one farmer, while four farmers (13%) belong to the high-income group.

Table 6.3 shows that the farmers belonging to the low-income group, have an average annual net income of less than 58 000 Tanzanian Shilling (TSh)[8]. Ten farmers of the low income group (40%), had for 1991 an annual net income of less than 42 000 TSh, which is the lowest legal paid salary. The middle-income farmer, representing a cooperative of three families, had a net annual income of 450 000 TSh. Information about income and investments for the high-income group is lacking.

Table 6.3

Income from and investments on different sectors in 1991, among the farmers belonging to the low income group.

Income and investments (TSh)	Sector			
	Agriculture	Livestock	Fish-farming	Total
Gross income				
N	24	20	24	24
mean	54 475	21 355	10 879	92 150
min	0	0	0	16 000
max	245 700	113 000	150 000	245 800
std	57 415	34 936	30 490	60 350
Investments				
N	23	23	24	24
mean	22 330	9 204	3 646	34 283
min	3 700	0	0	3 700
max	62 500	89 700	30 400	141 600
std	17 041	23 025	7 543	31 004
Net income				
N	23	18	24	24
mean	**34 200**	**8 805**	**7 233**	**57 867**
min	-29 200	-52 600	-7 200	-19 000
max	199 800	98 000	119 600	198 800
std	50 805	31 191	24 471	51 162

[8] 290 TSh = 1 US$, 45 TSh = 1 NOK (in April 1992).

68% grow their own staple food, and do not buy anything of this. 20% experience food shortage during the year. This usually occur in the period before harvesting.

Initiation of fish farming

Most of the farmers started with fish farming during the 1980's (Table 6.4).

Table 6.4

Period of time when the farmers started their fish farming activity.

Period	No.	%
1964 - 75	4	14
1976 - 82	0	0
1983 - 87	16	55
1988 - 91	9	31
Total	29	100

6.1.2 Ponds and water

Ponds

Most common, is to have 1-3 ponds (Table 6.5). Half of the farmers have only one pond, while only 10% (3 farmers, all from Ruvuma) have more than 4 ponds. 33% have other ponds under construction, and 52% have planned to construct 1-3 ponds in the near future.

Table 6.6 shows that the average total pond area is about 1100 m^2. However 21 farmers (70%) have a total pond area of less than 600 m^2. Average pond size is about 350 m^2, and varies from 85 m^2 to 2025m^2, estimated as total pond area divided by number of ponds for each farmer. The actual variation in pond sizes range from 50 m^2 to 2400 m^2. There are regional differences in both total pond area and average pond sizes. The ponds are usually 0.3 - 1 m deep.

Table 6.5

Actual number of ponds, number of ponds under construction and ponds planned in the near future per farmer; distribution by pond number per farmer.

Number of ponds	Ponds					
	Actual number		Under construction		Planned in near future	
	No.	%	No.	%	No.	%
0	0	0	20	67	14	48
1	15	50	6	20	7	24
2	6	20	2	7	4	14
3	4	13	1	3	4	14
4	2	7	0	0	0	0
>4	3	10	1	3	0	0
Total	30	100	30	100	29	100

Table 6.6

Total pond area per farmer and average pond size per farmer; by region and total.

Region	Total pond area (m^2)				Average pond size (m^2)			
	mean	min	max	std	mean	min	max	std
Mbeya	575	105	2025	620	418	105	2025	579
Arusha	262	88	600	151	163	88	390	83
Ruvuma	2480	170	7200	2574	474	85	738	205
Total	1105	88	7200	1782	351	85	2025	372

All ponds are excavated by hand, and no ponds are sealed. Under the construction, 47% hired labour for some of the work, while 53% had no costs on the pond construction.

Time spent on the pond construction is at an average of 20 mandays per 100 m^2 excavated pond (Table 6.7), with regional average variations from 12 to 26 mandays.

Table 6.7

Amount of labour used on the pond construction; by region and total.

Region	Mandays per 100 m² excavated pond				
	N	mean	min	max	std
Mbeya	9	26.4	2.9	94.3	29.0
Arusha	9	12.0	2.7	40.0	10.8
Ruvuma	8	23.0	3.2	108.5	36.9
Total	26	20.4	2.7	108.5	26.9

Water

The most common water source is river/stream, occurring at 21 farms (72%), while 8 farmers (28%) get their ponds filled from ground water.

The water availability is by 87% characterized as very good, 10% as good and 3% as bad.

Most common are ponds with stagnant water. For 20 of the 26 farmers (77%) this was observed. Waterflow was observed in the ponds at 6 farmers (23%), however there was usually only a low degree of water replacement. In the rainy season this increases.

The majority have a kind of water inlet and outlet (Table 6.8). Of those who have a kind of inlet, the majority do not have any protection preventing fish entering the pond with the inlet water (Table 6.9). More common is to have protection on the outlet, preventing fish escapement.

Table 6.8

Kind of water inlet and outlet in the ponds; percentage distribution (N=28).

Water transport	Kind of inlet	Kind of outlet
No inlet/outlet	18	32
Dug channel	22	14
Pipe of organic matter	17	18
Pipe, plastic/metal/concrete	43	36
Total	100	100

Table 6.9

Protection on inlet and outlet in ponds; distribution by protection status.

Status	On inlet		On outlet	
	No.	%	No.	%
Protection	2	9	10	52
No protection	13	57	3	16
Information lacking	8	34	6	32
Total	23	100	19	100

6.1.3 Fish

Species

Most common fish species, farmed by 70% of the farmers, is *Oreochromis niloticus* (Table 6.10). All the farmers in Arusha stock their ponds with *O. niloticus*, while mixed species are farmed in Mbeya and Ruvuma.

Table 6.10

Distribution of fish species farmed; by regions and total.

Fish species	Mbeya		Arusha		Ruvuma		Total	
	No.	%	No.	%	No.	%	No.	%
Oreochromis niloticus	6	60	10	100	4	44	20	70
Tilapia melanopleura	1	10	0		0		1	3
T. ruvuma	0		0		1	12	1	3
T. variabilis	1	10	0		0		1	3
Mixes of species[a)]	2	20	0		4	44	6	21
Total	10	100	10	100	9	100	29	100

[a)] Includes two or more of: the species mentioned above, Haplochromis spp. or T. zillii.

Fingerling distribution

In Mbeya and Ruvuma, the most common is to get fingerlings from natural breeding in their own production ponds (Table 6.11). In Ruvuma, 2 of 9 farmers get their fingerlings from the extension service. All the farmers in Arusha, and about half of the total number of farmers, restock the ponds with fingerlings from either own nursery pond or from other fish farmers.

Table 6.11

Source of fingerlings for the fish farmers; distribution by region and total.

Source of fingerlings	Mbeya		Arusha		Ruvuma		Total	
	No.	%	No.	%	No.	%	No.	%
Own nursery pond	1	10	4	40	2	22	7	24
Other fish farmers	1	10	6	60	0	0	7	24
The extension service	1	10	0	0	2	22	3	10
Breeding in the pond	7	70	0	0	5	56	12	42
Total number	10	100	10	100	9	100	29	100

16 farmers (57%) regularly distribute fingerlings to other farmers, 11% (3 farmers) do this rarely, and 32% (9 farmers) do not distribute fingerlings to other farmers.

The fingerlings are usually distributed free to the villagers, and to others, a price of 2-5 TSh per fingerling is common.

Wild fish species in the ponds

In addition to the above mentioned fish species, catfish (*Clarias spp.*) and "dagaa" (small fish species of the genera *Engraulicypris, Stolothrissa and Limnothrissa*) occur in some ponds. These species have entered the ponds, and are seen upon as a problem. The catfish predate on the fish stocked, while the "dagaa" compete with the stocked fish about some of the food. Problem with unwanted fish species in the ponds is mentioned by 53% (10 farmers), while 47% (9 farmers) do not have this problem.

6.1.4 Management methods

Fertilizer

Pond fertilization by manure is practised by totally 83% of the farmers; 50% use cow manure, 13% use goat manure, and 20% use a mix including cow-, goat-, pig- or poultry manure. The manure used is usually dried. 17% do not manure the ponds at all.

Among the farmers who manure the ponds, the average amount used per 100 m^2 [9] pond is 46 litre monthly (Table 6.12). For Mbeya and Arusha, the amounts used is about 70 kg, while 10 kg is used in Ruvuma.

Among those who manure their ponds, the frequency of manuring is on an average 2.9 times per month (N=23, min=0.3, max=8.0, std=2.9).

At two farms (7%), the ponds had been fertilized with smaller amounts of artificial

[9] For pond area, the unit 100 m^2 is used, and not ha. This is due to the common pond sizes.

fertilizer (2.2 and 2.4 kg per 100 m^2) last year in addition to manure.

Of the 22 farmers who manure the ponds, only 18% (4 farmers) have any costs on the manure, ranging from 400 - 1 800 TSh yearly. The majority (86% of all the farmers), have no costs on the manure used in the fish ponds.

Table 6.12

Amounts of manure added in the fish ponds among farmers who manure their ponds; by region and total.

Region	Litre manure per 100 m^2 pond and month				
	N	mean	min	max	std
Mbeya	6	70	18	175	56
Arusha	8	68	27	182	54
Ruvuma	9	10	1	41	14
Total	23	46	1	182	46

Feed

Type of feed used in the fish pond, is shown in Table 6.13. This varies through the year, depending on the feeds' availability. Each farmer usually use several different kind of feeds. Most common feeds are maize bran, leaves/fruit from the garden, kitchen leftover and wild plants .

By the majority, maizebran is characterized as the most important feed (Table 6.14). In Ruvuma, all farmers put bran as the most important, while 3 out of 10 farmers in Arusha put kitchen leftover as the most important feed.

All farmers say they feed the fish. Table 6.15 shows that 45% feed 1-2 times per day, while the rest feed from once every fortnight to 3 times per week. On an average, the fish is fed 4.8 times per week (N=27, min=0.5, max=14, std=3.8).

Amounts of feed used is registered only for maizebran. Of the farmers using maizebran, an average of 4.0 kg per 100 m^2 pond is used weekly (N=26, min=0.1, max=28.9, std=5.9).

46% (13 farmers) have no costs on fish feed, while 54 % (15 farmers) have an average feed cost, mainly on maize bran, on 7 371 TSh, ranging from 1 200 to 26 700 TSh per year (std = 8 982).

Table 6.13

Feeds used in the fish ponds; distribution by region and total.

Kind of feed	Mbeya	Arusha	Ruvuma	Total	
	No.	No.	No.	No.	% [a]
Maizebran	10	7	10	27	90
Rice/wheatbran	0	1	3	4	13
Sunflower/soyabean	0	0	1	1	3
Kitchen leftover	7	8	4	19	63
Brew leftover[b]	2	1	0	3	10
Wastes, garden[c]	6	7	9	22	73
Wild plants	7	8	2	17	57
Termites	0	0	4	4	13

[a] Per cent of all the 30 farmers.
[b] Mainly maize and millet products.
[c] Leaves and/or rotten fruit from the garden.

Table 6.14

The most important feed used in the fish ponds; distribution by region and total.

Kind of feed	Mbeya	Arusha	Ruvuma	Total	
	No.	No.	No.	No.	%
Bran[a]	4	3	10	17	57
Kitchen leftover	0	3	0	3	10
Leaves	1	0	0	1	3
Other[b]	5	4	0	9	30
Total	10	10	10	30	100

[a] Mainly maize bran, see Table 6.13.
[b] Other "priority" or feeds equal in importance.

Table 6.15

Feeding frequency (times pr. week); distribution by region and total.

Times per week	Mbeya	Arusha	Ruvuma	Total	
	No.	No.	No.	No.	%
0.5[a] - 1	1	0	5	6	22
2 - 3	4	2	3	9	33
7 - 14	3	7	2	12	45
Total	8	9	10	27	100

[a] Feeding once per 14 days.

Physical condition and fertility of the ponds

The physical condition of the ponds, registered for each farmer interviewed and given a score from 1-5, is shown in Table 6.16. Ruvuma and Arusha have generally higher score than Mbeya.

Table 6.16

Physical condition of the ponds; distribution by score within regions and total.

Region	Physical condition (score)[a]										Total	
	1		2		3		4		5			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Mbeya	2	20	4	40	2	20	2	20	0	0	10	100
Arusha	0	0	1	13	3	37	3	37	1	13	8	100
Ruvuma	0	0	3	33	3	33	0	0	3	33	9	100
Total	2	7	8	30	8	30	5	18	4	15	27	100

[a] 1=not maintained, 2=bad maintained, 3=ordinary maintained, 4=well maintained, 5=excellent maintained.

The fertility of the ponds was registered optically, and given a score from 1-4. Table 6.17 shows that 59% of the farmers have, according to this registration, ponds with low or no fertility. 24% have ponds with high fertility.

Table 6.17

Fertility in the ponds (registered optically).

Score	No.	%
1: No/very low fertility	5	21
2: Low fertility	9	38
3: Medium fertility	4	17
4: High fertility	6	24
Total	24	100

Drainage of the ponds

Drainage of the ponds about once a year is practised by 37%, while the majority (63%) either never dry their ponds or do this irregularly, with more than two years between each drainage.

Most of the farmers (78%) drain the ponds by digging/breaking the pond wall, while 22% drain the ponds by either bottom-pipe or munk.

Harvesting methods

In Arusha, all the interviewed farmers (33%) harvest the fish by totally drainage of the ponds combined with use of seine net. The rest of the farmers interviewed (67%), harvest usually without totally drainage. This is divided between 57% reducing the water level, and 10% harvesting without any reduction of the water in the pond.

Record keeping

The majority of the farmers (80%) do not keep any kind of production records. The records kept, are usually on income from the fish ponds.

6.1.5 Fish production

Main harvest from the ponds is on an average taken once a year. However, time between every main harvest vary a lot, ranging from 3 to 48 months.

The majority (77%) practice intermediate harvests in between the main harvests, while 23% (7 farmers, all from Mbeya) do not. In Ruvuma, intermediate harvests are usually taken from once per month to 2-3 times per week. In Arusha, the intermediate harvests are not taken that often, common is 3-4 times per year.

Table 6.18 shows the harvests from the fish ponds, estimated from information collected through the interviews. The total harvest per farmer is on an average about 100 kg per year, which gives 14 kg per 100 m^2 pond yearly. However, there are great variations in total harvest both by region and within the regions, with a total range from 5 - 499 kg. Ruvuma has an average total harvest on 234 kg, while Mbeya and Arusha have much lower harvests.

The productivity, as total harvest per 100 m^2 pond, is however higher in Arusha (19 kg) than in Ruvuma (14 kg), and lowest in Mbeya (5 kg). Highest productivity obtained in Arusha is 39 kg/100m^2, and in Ruvuma 27 kg/100m^2.

There was not found any significant effect on the productivity of the following effects: amounts of manure added in the pond, amounts of maizebran used, size of the pond area, time spent per pond area. The variables were investigated separately.

The average size of the fish at harvest is 86 g (N=21, std=51). There are great variations among the farmers, and average size ranges from 17 to 200 g (estimated from information about fish length). There is no significant variation between the regions.

Table 6.18

Annual main-, intermediate- and total fish harvests from ponds and total annual fish harvest per 100 m² pond per farmer; by region and total.[a]

Region	Annual harvests (kg)			
	Main harvest	Intermediate harvest	Total harvest[b]	Total harvest per 100 m² pond
<u>Mbeya</u>				
N	6	8	4	4
mean	46	1	29	5
min	1	0	5	4
max	156	11	80	7
std	62	4	35	1
<u>Arusha</u>				
N	9	9	9	9
mean	37	7	44	19
min	3	2	13	9
max	112	16	116	39
std	35	5	33	10
<u>Ruvuma</u>				
N	6	7	6	6
mean	153	83	234	14
min	27	3	27	3
max	499	216	499	27
std	178	92	166	9
<u>Total</u>				
N	21	24	19	19
mean	72	28	101	14
min	1	0	5	3
max	499	216	499	39
std	110	60	131	10

[a] Estimated from information collected through the interview, all to the nearest kg.

[b] Due to lack of information, the results on main, intermediate and total harvests are not necessarily based on information from the exact same farmers. For Mbeya, this has given a mean main harvest higher than the mean total harvest.

6.1.6 Problems fish farmers are faced with

Predator animals, lack of equipment/tools and lack of knowledge are by about the half of the farmers characterized as problems in their fish farming activity (Table 6.19). Breeding/stunting, feed availability, funds and theft are mentioned as problems by about 1/3 of the farmers.

Table 6.19

Problems the farmers are faced with concerning their fish farming activity.[a]

Problem	Part of the farmers who have the actual problem	
	No.	%
No problems	1	3
Breeding/stunted fish	9	30
Predator animals[b]	17	57
Weed in the ponds	4	13
Feed availability	10	33
Water supply	5	17
Fingerling support	5	17
Transport	4	13
Funds	10	33
Theft	9	30
Manpower	4	13
Equipment/tools[c]	17	57
Lack of knowledge	14	48
Other problems[d]	7	23

[a] Most of the farmers mention more than one problem.
[b] Mainly otter, lizard and heron.
[c] Mainly seine net for harvesting, and shovel and wheelbarrow for pond construction.
[d] Include long distance from house, land availability, marketing, maintenance of the ponds, fish diseases, drought and seepage.

Twelve farmers (43%) answer that they try to solve the problems, while 16 farmers (57%) do not.

85% (23 farmers) are satisfied with the support given by the extension service, while 15% (4 farmers) are not satisfied. To improve their offer, 54% (13 farmers) suggest that they should visit the farmers more often.

6.1.7 Fish farming economy and use of resources

Capital

For 45% of the farmers, the fish harvested during 1991 was used for only own consumption. 38% say they sold about half of the harvested fish, while almost all fish was sold by 17% of the farmers.

In Mbeya and Arusha, none of the farmers find any marketing problems if they want to sell fish. In Ruvuma, 3 out of 9 farmers say that there are marketing problems. Most common is to sell the fish fresh by the pond side or in the village.

Prices depend on fish size, and is paid per fish rather than per kg. In Arusha, common prices are 10-40 TSh per fish when the size is 20-100 g. In Ruvuma the price range from 10-60 TSh for fish of this size. Higher prices per fish are obtained for bigger fish. According to the above mentioned prices, estimated prices per kg fish are 300 - 500 TSh/kg.

Among the farmers in the low-income group, the average annual net income from fish farming is 7 233 TSh (Table 6.3). However, this varies a lot. 9 farmers have a negative or no net income from fish farming. Among 12 of the farmers the average net income from fish farming is 5 575 TSh (min= 200, max= 18 700, std= 5 162), while one farmer in Ruvuma have a net income from fish farming on 119 600 TSh.

Average gross income from fish farming as percentage of average total gross income is 11.8% (calculated from Table 6.3). The average investments on fish farming is 10.6% of the average total investments. The same percent for net income is 12.5%.

15 out of 25 farmers (60%) say that they need loan for their fish farming activity, while 40% do not. However only one farmer know where to get credit.

Labour

Table 6.20 shows that 41% of the farmers on an average work from 10 to 30 minutes each day at the fish ponds. 33% spend from 0.5 to 2 hours per day, while 18% are at the ponds only irregularly.

Table 6.20

Time spent at the fish ponds (one person per day); distribution by time group.

Time group (hours per day)	No.	%
Irregularly[a)]	5	18
Up to 0.5 h[b)]	11	41
0.5 - 1 h	4	15
1 - 2 h	5	18
2 - 3 h	1	4
> 3 h	1	4
Total	27	100

a) Irregularly or max 5 minutes per day.
b) From 10 to 30 minutes per day.

The construction and renovation of the ponds are mainly done by either the man in the family or by hired labour (Table 6.21). The daily work is mainly done by the whole family, while the family get assistance from relatives and friends for harvesting and stocking.

On the question if the fish farming activity has led to neglect of other kind of work, 97% answer no, while only one person says it has.

Land

The area now used for fish farming, could for 83% of the farmers been used for cultivating purposes, while 17% of the farmers say that their fish pond area could not be used for any such purposes. 19 farmers (70%) have used the pond area for other purposes earlier, while the area not has been used before for 8 farmers

(30%).

Table 6.21

Different kind of work at the fish ponds; distribution by kind of labour used.

Labour	Construction/renovation		Daily/weekly[a] work		Harvest and stocking	
	No.	%	No.	%	No.	%
Mainly the man	8	42	6	22	0	0
Mainly the wife	0	0	0	0	0	0
Whole family	3	16	18	64	4	14
Family, friends/relatives	3	16	2	7	22	79
Hired labour	5	26	2	7	2	7
Total	19	100	28	100	28	100

[a] Manuring, feeding etc.

<u>Manure</u>

Among those farmers who have animals, the majority (73%) use the manure in both the fish ponds and in agriculture and/or horticulture. 15% use the manure only in the agriculture/horticulture, while for 12% of the farmers, the manure is used only in the fish ponds.

6.1.8 Socio-environmental aspects of the fish farming activity

<u>Attitudes to fish farming</u>

On the question how the villagers see upon their fish farming activity, 41% of the farmers answer that they are generally positive to their fish farming activity. 45% answer that the general trend is that the villagers want to start with fish farming themselves. No dominating attitude is answered by 14%, while no one has experienced generally negative attitudes to fish farming among their villagers.

Benefits by being a fish farmer

Food production for own consumption is by all the farmers seen upon as a main benefit by being a fish farmer. 80% see it as also a way of getting income, and by 27% the prestige by being a fish farmer is also added as a benefit.

Expansion of the fish farming activity

The majority (90%) want to expand their fish farm, while only 10% do not.

Main problems with fish farming expansion are shown in Table 6.22. 72% of the farmers say that there are problems with expansion, and dominating problems are lack of funds and suitable area. However, 10 out of 14 farmers have figured out how to solve this problems.

Table 6.22

Problems the farmers have with expansion of the fish farm.

Problem	No.	%
No problem	7	28
Labour	1	4
Time	1	4
Funds	7	28
Suitable area	6	24
Equipment	2	8
Other problems	1	4
Total	25	100

Environmental changes

Minor environmental changes have occurred as a result of fish farming activity (Table 6.23). Increased number of predators like otter, lizard and birds is observed by 33% of the farmers. A positive effect on the vegetation, observed by 10%, is the drainage of water logged areas through fish pond construction. 10% of the farmers have observed an increased number of insects after the construction of ponds.

Table 6.23

Environmental changes observed by the farmer in the surrounding area after fish farming activity has been initiated; percentage distribution by environmental effect within environment class.

Environment classes	Environmental changes			
	Positive	Negative	No change	Total
Vegetation	10	0	90	100
Fauna	0	33	67	100
Insects	0	10	90	100
Human diseases	0	0	100	100
Other	3	0	97	100

6.2 Market investigation

In the bigger towns, like Arusha and Morogoro, fish is sold frozen in fish shops, and at the market places and "on the street", it is sold smoked, dried or fried. However, in the majority of the towns and in the villages, all fish is sold at the market place or "on the street". Here, fresh or frozen fish is usually not available, unless the fish-landing area is near by.

In neither Arusha, Morogoro, Mbeya nor Ruvuma region, the demand for fish is covered, and the demand is by the Region and District Fishery Officers characterized as great in both the rural and the urban areas.

Meat prices reported are in Morogoro and Arusha about 300 TSh/kg (Table 6.24). The same meat price is found in Mbeya, and in Songea, common meat prices are 300-400 TSh/kg.

6.2.1 Fish shops

Of the total of eight shops investigated in Morogoro and Arusha, 4 shops sell both marine and freshwater fish species, 3 sell only marine species, while one shop sells only freshwater fish species.

The marine fish come from Tanga or Dar es Salaam, while most of the freshwater fish come from Lake Victoria, and are transported from Mwanza. The fish is mainly transported by trucks (6 of 8 shops), while two shops also get some fish by plane. The distance between the towns, can be seen in Figure 2.1.

All the fish is sold frozen. At all the shops, it is reported that the demand for fish is not covered. Achieved prices are shown in Table 6.24. The average price for tilapia is 470 TSh/kg, while common prices on marine fish are 500-700 TSh/kg.

The main problem for the fish shops, is the unreliable transportation. Often, the shop owners do not know when they get the fish, and the fish is often of reduced quality due to a long period of transportation and unproper storage before it reaches the fish shops. Freezing plants are lacking, especially near the landing areas at the big lakes.

Table 6.24

Fish prices from fish shops in Morogoro and Arusha towns, and common meat prices (TSh per kg).

Fish species	Town									
	Morogoro				Arusha				Total	
	N	mean	min	max	N	mean	min	max	N	mean
Freshwater fish:										
Tilapia spp.	1	400	.	.	2	500	450	550	3	470
Tilapia, filets	0	.	.	.	1	1300	.	.	1	1300
Nile perch	0	.	.	.	2	400	300	500	2	400
Marine fish:										
King fish	3	600	500	700	4	710	450	1000	7	670
Tuna fish	0	.	.	.	3	650	450	1000	3	650
Other ocean fish	3	470	400	500	4	540	450	700	7	510
Meat(fresh):										
Beef		300				300	250	350		300
Pork						350				

6.2.2 Market places

The fish sold at the investigated market places are all freshwater fish, and is sold either dried, smoked or fried. The most common species are tilapias, catfish (*Clarias spp.*), Nile perch (*Lates niloticus*) and "dagaa" (*Stolothrissa* and *Limnothrissa*).

In Morogoro, large quantities of the fish come from Mtera Dam, Lake Victoria, Lake Tanganyika, and from the swamps near Dodoma. Fish landings from Mindu Dam, a water reservoir near Morogoro town, are also sold.

In Arusha town, most of the fish sold on market places come from either Lake Victoria or from Nyumba ya Mungu Dam.

Most of the fish sold at the market places in Mbeya town and in Vwawa town (Mbozi district), come from Mtera Dam, Lake Rukwa and Ruaha river. The "dagaa" sold, is from Lake Tanganyika and Lake Victoria.

In Songea town, most of the fish sold at the market place come from Mtera Dam, Lake Rukwa, Kilombero river and floodplain, Lake Victoria and Lake Nyasa.

Most common when people buy fish, is to pay per fish rather than per kg fish. The prices for tilapia are per fish or eventually per group of a small number of fish. The prices varies depending on fish size, rather than on what species of tilapia it is, where it comes from or how it is processed. Common market size on tilapia is 15-25 cm, or about 70-200 g, but both smaller and bigger tilapia occur.

Table 6.25 shows common prices on tilapia at different market places. The price for tilapia of about 15 cm length is 10-15 TSh per fish, for fish measuring 20-25 cm about 30 TSh, and the common price for big tilapia of about 30 cm is 80-100 TSh per fish.

By using the prices shown in Table 6.25, price per kg live fish weight can be roughly estimated to about 200 TSh per kg, independent of fish size.

From all the towns shown in Table 6.25, it is reported that people pay more for fresh fish if this is offered, than for processed fish.

Table 6.25

Prices for tilapia sold at market places in towns in the Morogoro, Arusha, Mbeya and Ruvuma regions.

Approximate size of the fish (length)	Town	Processing	Fish price	
			per group of fish[a]	per fish
15 cm	Morogoro[b]	fried/salted	.	16-20 TSh
15 cm	Vwawa[c]	dried	50 TSh /5	10 TSh
15 cm	Arusha[d]	fried	50 TSh /5	10 TSh
15 cm	Songea[e]	smoked	50 TSh /4	13 TSh
15-20 cm	Morogoro	smoked	.	50 TSh
15-20 cm	Songea	smoked	100 TSh /5	20 TSh
20 cm	Arusha	fried	100 TSh /4	25 TSh
20 cm	Arusha,K[f]	fried	90 TSh /3	30 TSh
20 cm	Songea	smoked	100 TSh /4	25 TSh
20-22 cm	Songea	smoked	.	45-60 TSh
20-25 cm	Arusha	fried	100 TSh /3	33 TSh
25-30 cm	Arusha	fried	.	80 TSh
30 cm	Vwawa	dried	.	100 TSh
30 cm	Arusha	fried	.	100 TSh
30 cm	Arusha,K	fried	.	70 TSh

[a] /5 indicates that the actual price is for 5 fish etc.
[b] Morogoro region.
[c] Mbozi district, Mbeya region.
[d] The main market in centre of Arusha town, Arusha region.
[e] Ruvuma region.
[f] Kilombero market, Arusha town.

6.3 Harvesting of fish ponds

Total amounts of harvested fish are shown in Table 6.26. The total harvests range from 13.3 to 48.9 kg, and the average is 24.3 kg. Total annual harvest per $100m^2$ is on an average 13.9 kg, ranging from 9.3 to 19.6 kg per $100m^2$.

The final harvest, i.e. the harvest carried out by the author, is on an average 13.9 kg per pond, varying from 8.3 to 22.7 kg per pond.

Amounts of fish from the intermediate harvests varies a lot, from nothing to 32 kg. At three farms, the yields from the intermediate harvests make up more of the total harvest, than the yields from the final harvest. On an average, about half of the total harvest had been harvested before the final harvest. In all ponds, number of fish harvested is higher than number of fingerlings stocked.

As shown in Table 6.27, average individual fish weight is 24 g, when based on the average fish size from all fish in the final harvest at six farms.

The average weight from the measurements on individual fish weights, range from 27 to 56 g among the farms. Actual fish weights range from 2 to 158 g. Average fish length is about 12-14 cm and about 40 g. The smallest fish is about 4-8 cm, and 3-8 g, while the biggest fish is usually 18-20 cm, weighing 90 to 150 g. In all the ponds harvested, there are great variations in fish size (Table 6.27).

Most of the harvested fish is of a small size (Table 6.28). Fish on an average size of about 70 g to 90 g make up only 25% of the harvest.

Table 6.27

Size of fish at final harvest from farms in Arusha region (same farms as in Table 6.26); based on all fish harvested and a sample of fish.

Farm	All fish[a]		A sample of fish (individual measurements)								
	Weight (g)		N	Weight (g)				Length (cm)			
	N	mean		mean	min	max	std	mean	min	max	std
1	1636	6	0								
2[b]	.	.	76	56	25	110	26	15	10	20	2.6
3	459	37	50	39	3	158	26	13	6	20	3.3
4	459	29	60	37	3	90	23	13	4	18	3.5
5	736	20	65	27	8	100	19	11	8	17	2.6
6	561	41	51	48	15	90	21	14	9	18	2.2
7	909	9	60	33	2	113	33	12	2	21	5.6
Mean		24		40				13			

[a] Total weight of final harvest, see Table 6.26.
[b] The smallest fish were not included in the measurements.

Table 6.28

Distribution of fish weight from the same final harvests as in Table 6.26; in percent of the total amount (kg) harvested (divided into three weight groups).

Farm	Weight group			
	Small size[a]	Medium size[b]	Big size[c]	Total
1	95	5	0	100
2	64	15	21	100
3	26	40	34	100
4	35	30	35	100
5	68	21	11	100
6	.	.	.	.
7	15	39	46	100
Mean	50	25	25	100

The average within each size group range among the farms between: [a] 2 to 18 g , [b] 37 to 51 g and [c] 67 to 87 g.

Table 6.26

Fish harvests from farms in the Arusha region (Hanang and Arumeru districts[a]).

Farm	Pond size (m^2)	Number of finger-lings stocked	Produc-tion time (month)	Harvests (kg)				Number of fish from final harvest	Live finger-lings produced
				Mid-harvest[b]	Final harvest[c]	Total harv.[d]	Annual harv. pr.100m²[e]		
1	136	260	13	19	9.4	28.4	19.6	1636	520
2	150	300	18	13	12.2	25.2	11.2	.	619
3	280	572	12	32	16.9	48.9	17.5	459	0
4	190	380	9	0	13.2	13.2	9.3	459	0
5	100	200	16	2	14.9	16.9	12.7	736	703
6	320	.	6	.	22.7	.	.	561	800
7	150	250	8	5	8.3	13.3	13.3	909	0
<u>Total</u>									
mean	189	327	12	12	13.9	24.3	13.9	793	377
std	81	134	4	12	4.9	13.6	3.9	448	362

[a] Farm no.7 was in Arumeru district, the others in Hanang district.
[b] Information about intermediate harvests collected from the farmers.
[c] The harvest carried out by the author
[d] Estimated from information about intermediate harvests and the final harvest.
[e] Estimated from information about production time, pond size and total amounts of fish harvested.

7.0 SUMMARY AND DISCUSSION OF RESULTS

7.1 Social background, economics and use of resources

Most of the people interviewed, belong to the low income group. They are small scale farmers, owning less than 4 ha of land, and produce most of their food themselves. Agriculture is generally the most important means of living, while fish farming usually is an additional activity. The majority are peasants, and about 2/3 of the farmers have either no formal education or only primary school.

The results from the questionnaire study show that only a minority have their main income from fish farming. However, one of the low income farmers in Ruvuma, having fish farming as a main means of living, had a net income from fish farming of almost 120 000 TSh in 1991.

For the majority of the farmers, fish farming is an important second activity, after agriculture. This is also reported by Lema and Angwazi (1988). Almost half of the farmers produced in 1991 fish only for own consumption. However, as many as 80% of the farmers, consider income as a benefit from fish farming. This indicate that more farmers want to make the fish farming activity to a source of income. Most of the farmers want to expand their fish farm.

In the low income group, the average net income from fish farming make up 12.5% of the total net income, and capital costs on fish farming make up 10.6% of the total capital costs. This indicates that investments on fish farming can compete with investments on other activities. Among the farmers in the low income group however, production for own consumption is even more important than production for income.

According to both the questionnaire study and the market investigation, there is a great demand for fish, and generally no marketing problems.

The questionnaire study show that for fresh tilapia sold by the pond or in the village, common prices range from 10 to 60 TSh per fish, which mean 300 - 500

TSh per kg fish.

The market investigation indicate the same prices for fresh tilapia sold in the fish shops, while processed tilapia sold at the market places is cheaper. The processed fish is often of reduced quality, as a result of too long transportation and unproper storage.

The high prices for tilapia, and the facts that people pay more for fresh than processed tilapia, indicate good prospects for fish farming as a source of income, in addition to being a source of animal protein for the family.

The questionnaire study show that generally, the fish farming activity do not interrupt other kind of work. Most of the daily work is done by the family members, while about half of the farmers hire labour for pond construction.

For the majority of the farmers interviewed, the land used for fish farming has been or could have been used for other purposes, like agriculture and horticulture purposes.

The results show that the capital costs on fish farming range widely, from 0 to about 30 000 TSh/year per farm, and was on an average about 3600 TSh for 1991.

The capital costs on fish farming is dominated by the feed costs. However, about half of the farmers have no costs on the feed, and hence, almost no capital costs at all on fish farming.

The manure used in the fish ponds is usually from their own farm, or they get it free from neighbours. The majority combine the use of the manure, by using some of it in the crop/garden, and some of it in the fish ponds.

7.2 Fish farming practices

Ponds and water

The results from the questionnaire study show that for fish farmers, it is most common to have only one or two ponds. The usual pond size range from 150 to 500 m^2. About the same pond sizes are reported from Mbeya, by Msuya (1992). In Ruvuma, the total pond area is generally higher than in Arusha and Mbeya. This is a result of both bigger ponds and higher number of ponds.

The ponds are constructed in areas with good water availability, and most common is ponds with stagnant water. This is also reported by Lema and Angwazi (1988).

About 2/3 of the ponds are more or less maintained, while the physical condition of the ponds at the rest of the farms visited, is bad.

Fish

Nile tilapia (O. niloticus) is the dominating species farmed. Due to its high growth rate and suitability for pond farming, this species has been chosen by both foreign fish farming projects and by the Fisheries Division.

However, the accuracy of the determination of fish species farmed is not known. Though the ponds have been stocked with pure strains, wild fish may enter the pond through the inlet which is usually not protected. Hybridisation as a result of this, is quite common in tilapia farming (Pillay 1990).

The majority of the farmers interviewed, harvest the ponds without totally drainage, and drain the ponds only irregularly. Hence, the new fingerlings are produced through uncontrolled spawning in the production ponds. In Arusha, the farmers drain their ponds totally when they take the main harvest. When stocking the ponds, they get fingerlings from other farmers or from own nursery pond. This practice was introduced in Arusha region through the ELCT fish farming project.

Only a few farmers get their fingerlings from the extension service. This can be explained by both the Fisheries Division's unproper facilities for fingerling production and their lack of transport.

Management

Most of the farmers interviewed practice a system which can be characterized as semi-intensive, with manuring and supplementary feeding.

The results from the questionnaire study show that the majority of the farmers fertilize the ponds with manure. The manure is on an average added in the pond three times per month, however both frequency of manuring, and amounts of manure used, varies widely. Most common is cow manure, but also goat-, pig-, and chicken manure are used. The manure is often dried before added in the fish pond.

According to the registrations of fertility in the ponds, ponds with low fertility dominate. This was also registered by Msuya (1992).

According to Hepher and Pruginin (1981), some manure should be added every day rather than on monthly or weekly basis. Then, higher amounts of organic matter can be added, without reducing dissolved O_2 to critical levels. By using fresh manure in stead of dried manure, more feed will be available for the fish, due to greater production of microorganisms obtained when the manure added is fresh (Hepher and Pruginin 1981).

The generally much lower amounts of manure used in Ruvuma, can be explained by the lower concentration of livestock in this region, than in Mbeya and Arusha.

Supplementary feeding is practised by all the farmers interviewed. About half of the farmers feed the fish at least once per day, while the rest feeds more rare. In 1985, Balarin reported in a review that the generally practice was little or no feeding of the fish.

Maize bran, leaves/fruit from the garden, kitchen leftover and wild plants are the most common feeds. Amounts of feed used varies a lot, however, exact information is lacking. For maize bran, the estimated amounts used ranged from 0 to 29 kg per 100 m^2 weekly.

The farmers have generally not seen the importance of totally drainage between every production cycle, which is highlighted by Hepher and Pruginin (1982). According to them, the production cycle should not be longer than 4-6 months. Then, the problems with uncontrolled spawning in the ponds will be reduced to a minimum.

A result of harvesting without drainage, is overcrowded ponds and stunted fish. Such fish, reaching maturity at an early stage, are distributed from farmer to farmer as fingerlings. Especially in the production of tilapia, the fingerlings should be of high quality and of good condition. Only then, the fish can reach a reasonable size before maturity (Pillay 1990).

When not the ponds are totally drained, and only the bigger fish are harvested, a good proportion of the unharvested stock is individuals with slow growth. This fish spawn, and hence, also an unwanted selection for slow growth is obtained by this practice (Pillay 1990).

The main problems the fish farmers feel they have in their fish farming activity, are lack of equipment and tools, especially seine nets, lack of knowledge and problems with predators in the ponds. Even though about half of the farmers feel they lack knowledge, 85% of the farmers are satisfied with the extension service. However, the majority want to be visited more regularly by the extension service.

The extension workers themselves, feel they could do a better job if transport and necessary equipment were available.

The majority of the farmers do not keep any kind of records in their fish farming activity. Due to this, it is difficult to get proper information about inputs and outputs. Such information would have been valuable, to see if use of resources for fish farming purposes can be justified, and to find the optimal way of using the available resources.

7.3 Fish production

The results from the questionnaire study show that the time between every main harvest range widely, from 3 month to 4 years. Common is about one main harvest per year.

Intermediate harvests between the main harvests are practised by the majority of the farmers, especially in Arusha and Ruvuma. This can be done from 3-4 times per year to several times per week. Then, the biggest fish are harvested, mainly for consumption in the family. The part of the total harvest made up by the intermediate harvests varies a lot. From the results of the harvesting of fish ponds, intermediate harvests make on an average up half of the total amounts harvested.

The total yearly harvests per farmer range, according to information from the questionnaire study, from 5 to 499 kg. For Arusha and Mbeya, the total yearly harvests are about 30-45 kg, while in Ruvuma it is much higher (234 kg). This is mainly due to the larger total pond area per farmer in this region.

The great variation in annual production between farmers, reflect the different role fish farming plays, from being a source of animal protein for the family to be mainly a commercial activity.

According to results from the questionnaire study, the total annual production per 100 m^2 pond is however higher in Arusha (19 kg/100m^2) than in Ruvuma (14 kg/100m^2), and lowest in Mbeya (5 kg/100m^2). Both the results from the questionnaire study and from the harvesting of fish ponds in Arusha, show an average productivity of 14 kg/100m^2. This is higher than both the suggestions from UNDP (1981) of an average annual yield from the Tanzanian fish ponds of 1.3 kg/100m^2, and of the 2-10 kg/100m^2 estimated by Lema (1988). However, from harvestings of fish ponds in Mbeya region, Msuya (1992) found an average annual yield of 22 kg/100m².

The production results from the questionnaire study is based on information from 19 of the 30 interviewed farmers. If the information from all the farmers had been available, the average productivity would probably have been even lower. This can be explained by the fact that generally, such information is lacking at the farms where the ponds are more or less abandoned, and where the productivity therefor is low.

Information from Arusha and Ruvuma, show that a productivity of about 30-40 kg/100m² can be obtained by tilapia farming in ponds with manuring and supplementary feeding.

According to Balarin (1988a), an annual production from 10 to 50 kg/100m² can be obtained in ponds under such conditions.

The positive effects of fertilization and supplementary feeding on fish growth are generally accepted (Pillay 1990). From the investigations in Mbeya region, Msuya (1992) found a significant positive correlation between amounts of fish harvested and amounts of feeds and manure used. A positive correlation was also found between amounts harvested and frequency of applying feeds and manure.

In the results from the questionnaire study however, no significant effect of amounts of manure or maize bran added in the ponds, or amounts of labour used, was found on the productivity in the ponds. This may be explained by the low number of farmers who had proper information on both productivity and the input variables mentioned above.

The questionnaire study show that the common fish size at harvest varies among the farmers from 17 to 200 g, with an average of about 90g. However, from the results from the harvesting of fish ponds in Arusha region, the fish on an average size of 70-90g make up only 25% of the total amounts of harvested fish.

For all the harvested ponds, number of fish harvested is higher than the number of fish stocked, as a result of uncontrolled spawning. Small fish (2-50g) dominate the amounts of harvested fish. This gives a total average fish size of 24g at harvest. Individual measurements gives a total average of 40g. The higher average can be explained by relatively more fish from the bigger size groups measured than from the group of small fish.

This generally small size of the fish, reflects the problem of stunting and overcrowded ponds as a result of uncontrolled spawning and too long period between each time the ponds are totally drained.

7.4 Limiting factors for the pond productivity

At most of the farms, the productivity in the ponds is low, compared with the potential productivity which can be obtained in this kind of fish farming systems.

Though none of the above mentioned effects were found to be on the productivity, the results from the questionnaire study point out some factors affecting the productivity in the ponds:

Uncontrolled breeding; Most of the ponds are not totally drained between each main harvest, and the production period between each main harvest is often too long. This results in uncontrolled spawning, overcrowded ponds and stunted fish which become mature at an early stage. Under such conditions, the total productivity will be low, and the fish harvested will be of a small size. These problems will be transformed from farmer to farmer, by the fact that fish from such ponds are distributed to other farmers as fingerlings for stocking.

Lack of seine net; characterized by more than half of the farmers interviewed as a problem, makes it difficult to harvest the ponds properly. This reinforces the problem with uncontrolled spawning and overcrowded ponds.

Lack of manure; Though manuring of the ponds is practised by the majority, the amounts used varies a lot. At the majority of the farms, the fertility of the ponds were low, as a result of unproper manuring.

Lack of supplementary feeding; Supplementary feeding varies a lot both in kind of feed, amounts used, and how often the feed is added. At some farms, the fish were fed irregularly.

Unproper pond management; At about 1/3 of the farms investigated, the physical condition of the ponds was characterized as bad.

Lack of knowledge; About half of the farmers interviewed, feel they lack knowledge on fish farming practices. This is a serious problem, and was also observed by the author during the field work. This can in many cases explain the unproper fish farming management practised, and indeed affect the pond productivity.

Other factors affecting the productivity, like temperature and the natural fertility of the soil, are not included in this study.

8.0 CONCLUDING DISCUSSION

8.1 Demand for fish production

The demand for fish in Tanzania seems to increase continuously as a result of the growing population (chapter 2.1.5 and 2.1.6). If the today's per caput consumption of fish of about 15 kg shall be kept, there is need for a 100 000 - 150 000 t increase in the fish landings, from less than 400 000 t per year in 1988-1989, to about 500 000 - 550 000 t in year 2000. A great demand for fish is also reflected in the generally high fish prices (chapter 2.1.5 and 6.2).

With the facts that most of the fish are landed by small scale fishermen with simple equipment, and that the maximum sustainable yield for the Tanzanian waters may soon be reached, it seems difficult to cover the demand for fish by a increase in the fish catches alone. Hence, parts of the demand could be covered by fish farming. Balarin (1985) suggests that to cover the increasing demand, "aquaculture will have to increase at an unrealistic rate of 9 000 - 15 000 t/year, a formidable task", compared with the today's fish farming production of about 300-400 t.

There are great regional variations in the fish consumption (chapter 2.1.5 and 2.1.6). Especially in the rural areas distant from the fisheries, fish farming could play an important role in covering the demand for fish.

8.2 Potential for fish farming

Apart from the dry areas in the central parts of Tanzania, the water availability is generally good (chapter 2.1.2 and 2.1.3). Most of the regions have areas with natural water resources suitable for fish farming production.

In the dry areas, the water from the reservoirs could be utilized for fish farming, however only in systems with low demand for water, and not competing with agriculture. This include reservoir stocking and fish farming integrated with irrigation schemes (Balarin 1985).

In some areas in the high agro-economical zone, land available is limited, due to high population density. However, in most of the country, there are areas with low population density and available land (Table 2.3). Part of this areas could be used for fish farming.

In the questionnaire study, it was found that the land used for fish farming, often had been or could have been used for other purposes. Hence, there can be a competition for land between agriculture and fish farming interests.

In areas with soil of poor drainage (Figure 2.3), there will not be any strong competition between agriculture and fish farming. Some of the land is however flooded during the rainy season, and are not suited for fish farming (Balarin 1985).

The questionnaire study showed that manure and agricultural by-products/wastes are the main inputs in the fish farming practised. These inputs are generally available, though the availability vary depending on the agricultural activity and the density of livestock.

8.3 Present status of fish farming

Despite the great demand for fish, and the relatively good potential for fish farming, the total production from fish farming in Tanzania is, though increasing, still very low (chapter 2.3).

This can be explained by several factors. As mentioned in chapter 2.6, fish farming have not been given any high priority by the government. Though there are several extension fisheries staff in all the regions (see chapter 2.5.1), the extension service is unproper. This is due to i) lack of facilities, funds and transport, and ii) lack of personnel trained in fish farming practices. This in turn, also makes the extension workers loosing their motivation.

Since there is no strong fish farming tradition in Tanzania, the lack of proper extension service results in unmanaged ponds (chapter 2.4 and 7.2), and restrict the expansion of the fish farming activity.

As mentioned earlier (chapter 2.6), credit is not available for fish farming production, and there is a lack of quality fingerlings available for the farmers.

Education at all levels is lacking, and the research is restricted by lack of trained staff, funds and facilities.

8.4 How to stimulate fish farming development

If fish farming shall be developed to any extent in Tanzania, constraints have to be removed.

As indicated in chapter 4.2, aquaculture should be given a higher priority by the government, and should be included in the country's national economic development plan. A clearly defined aquaculture strategy should be worked out.

To cover the demand for fish in the rural population, semi-intensive[10] pond farming of tilapia should be further developed, and be given priority. This is a technology which can be managed by the farmers, and has already been introduced. The need for capital is low, and local available inputs can be used.

Other fish species, like e.g the carps, require technology and facilities, which is not available to any extent in Tanzania today. Hence, farming of other species, and introduction of poly-culture, should come at a later stage.

Coche (1991) considers the potential for semi-intensive tilapia farming in Tanzania, as high. By using by-products, integrated farming systems, and utilize marginal lands, fish farming can be a way of intensifying the use of the local available resources.

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[10] Definition, see chapter 4.3.2.

The development of semi-intensive tilapia farming can make fish available for rural people lacking animal protein in their nutrition, and can also, as shown in the questionnaire study (chapter 6.0), give some valuable income.

Intensive large scale fish farming systems could also pay an important role, by producing large amounts of fish to the increasing urban population. And in areas where land become scarce, intensification is needed for a increased fish farming production. However, such systems depend on technology, trained staff and capital, which all are lacking today (Balarin 1985).

As pointed out earlier (chapter 4.7), the extension service play an important role in the dissemination of the rural fish farming activity, through assistance, training of the farmers, and demonstration. Therefor, high priority should be given to establish an adequate extension service, by making funds and transport available for the extension workers. Training of the extension staff is also needed. This is also highlighted by Balarin (1985).

The availability of quality fingerlings is very limited, and there is only one proper and well managed hatchery found in Tanzania. The stations of the Fisheries Division were meant to supply the farmers with fingerlings. However, most of these stations are more or less unmanaged, due to both lack of funds, motivation and knowledge. Hence, high priority should be given to fingerling production and distribution.

Credits and loans should be offered, also for fish farming projects, as in agriculture and fisheries.

The lack of specialized, trained personnel at all levels, from extension workers to researchers, show that if fish farming shall be developed to any extent in Tanzania, development of education in aquaculture is strongly needed. Specialized aquaculture education is needed at university level, and at Certificate/Diploma level. The extension workers need courses in fish farming practices and technology.

There is need for a strengthening of the aquaculture research activity. Today there is no proper research in the field of fish farming, due to lack of funds, facilities and researchers specialized in aquaculture. The research activity should at this stage be applied research limited to tilapia, and priority should be given to integrated farming, optimal management methods and use of inputs, and stunting/uncontrolled spawning. To produce high quality fingerlings, selective breeding should also be included.

As highlighted in chapter 4.0, there should be a cooperation between the different institutions and organisations involved in the fish farming activity in Tanzania. The cooperation should include extension work, research and education. Tanzania should also cooperate with other countries through the existing international organisations and programmes.

A national body could have been established, including the institutions and programmes involved in aquaculture development in Tanzania. By exchange of experience and knowledge, coordination, and sharing of the tasks through this body, the resources used in the development of fish farming could be utilized in an optimal way.

Sokoine University of Agriculture and the University of Dar es Salaam have valuable basic knowledge, and play an important role in education and research. However, specialization in aquaculture is needed. Also at TAFIRI and the institutes where education on Certificate/Diploma level is offered, aquaculture should be given higher priority.

A national aquaculture centre, like the one in Morogoro which never was completed, could be a centre for seed production, applied research, demonstration, and training of extension workers.

Today, support from foreign aid already play an import role in fish farming in Tanzania. However, more assistance is needed. Both financial support and trained staff are needed in the extension work. Here, the NGOs have played, and will still play, an important role.

To develop proper education and research in the field of fish farming, assistance is needed. The assistance should on this stage include both qualified personnel and financial support.

By building up competence in the country, extension workers can be trained properly, and applied research can be conducted, which is needed for a fish farming development. Today, assistance is needed for this. However in the future, this could make Tanzania independent of foreign aid in the field of fish farming.

9.0 RECOMMENDATIONS

There is a great demand for fish in Tanzania, and the potential for fish farming must be characterized as good. However, due to constraints, the production from fish farming is still low. A increased production could be obtained by a stimulation of further fish farming development.

In the light of this study, the following is recommended:

The Tanzanian government should include fish farming in the national economic development plan, and there should be a strategy for aquaculture development.

A national body should be established, for institutions and organisations involved in the development of aquaculture in Tanzania. Included in this body, should be representatives from all the institutions and programmes mentioned in chapter 2.5.1 and 2.5.2.

Financial support should be given to the governmental extension service. Today, lack of funds hamper their activity.

Specialized aquaculture education should be offered at university level and at Certificate/Diploma level. Foreign assistance is needed; both qualified personnel and financial support. Norwegian competence could here been used.

The building up of the national aquaculture centre in Morogoro should be completed. This should be realized through funds from the government, and through foreign financial support.

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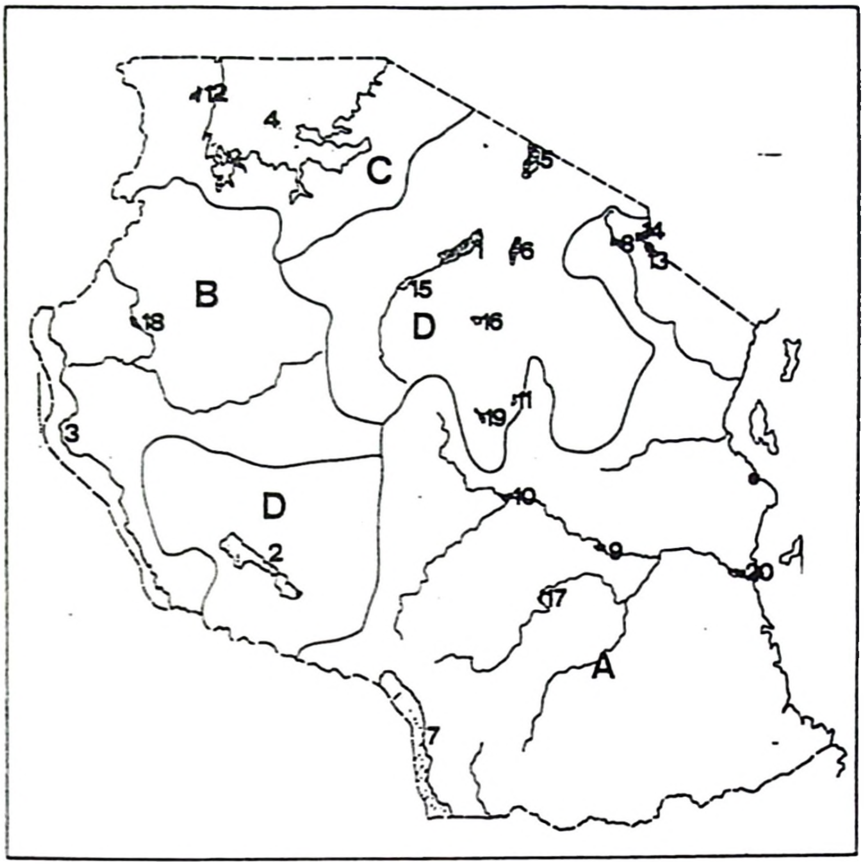
11. Appendices

Appendix 1. Hydrological zones, major river systems, main lakes and reservoirs in Tanzania (after Balarin 1985).

Drainage basin (see Fig. 8)	Major river system			
	Name	Length (km)	Catchment ('000 km²)	Flow (m/s)
A. Indian Ocean	Umba		6.7	
	Pangani (+ others)	360	29.5–42.1	
	Msangasi		4.7	
	Mligasi		2.8	
	Wami		46.4	
	Ruvu		18.4	
	Mbezi (+ others)		7.7	
	Rufiji: Ruaha Mkuu	750	177.4	10-700
	Rufiji	640		0.3-2 200.0
	Matandu		18.6	
	Mavuji		5.6	
	Mbwemkuru		13.9-16.3	
	Lukuledi		6.0	
	Lupululu		0.8	
	Mambi (+ others)		5.3	0.01
	Ruvuma	640	52.1	
	Lake Nyasa - Ruhuhu		14.0	
	Others		13.1	
B. Atlantic Ocean (L. Tanganyika)	Malagarasi	560	126.1	
	Luiche		2.6	
	Others		80.3	
C. Mediterranean Sea (L. Victoria)	Mirare		0.8	
	Mara		8.0	
	Grumeti		11.7	
	Mblageti		5.7	
	Simiyu		11.6	
	Magogo (+ others)		19.7	
D. Interior drainage	Rift Valley rivers		64.5	
	Masai Steppe		10.9	
	L. Eyasi and Kitangiri		64.4	
	Bubu River		25.6	
	L. Ikimba		1.3	
	L. Rukwa - Rungwa + others		77.4	

Appendix 2. Fish species cultured and status, Tanzania (after Balarin 1985).

Species	Introduced Indigenous	Location	System	Comment	Reference
Oreochromis esculenta	Indigenous		Ponds	Widely stocked in ponds and dams	CIFA, 1974
Sarotherodon macrocephala			Ponds, brack. water	Experimental	CIFA, 1974
O. macrochir	Introduced	Korogwe/Malya	Ponds	Experimental culture	Kambona, 1975
Tilapia rendalli	Introduced	Central Plateau	Ponds	Once widespread in Songea District	Kambona, 1975
O. mossambicus	Introduced	Korogwe	Ponds	Experimental culture	Meschkat, 1967
O. niloticus	Introduced	Korogwe	Ponds	Experimental	Meschkat, 1967
T. zillii	Introduced	L. Victoria Basin	Ponds	Introduced into many ponds and dams	Kambona, 1975
O. amphimelas	Indigenous			Recommended	Balarin and Hatton, 1979
O. jipe/girigan	Indigenous	Korogwe/Pangani	Ponds	Experimental and dam stocking	Kambona, 1975
O. manyone	Indigenous			Experimental and dam stocking	Balarin and Hatton, 1979
O. pangani	Indigenous	N. Tanzania/Dodoma	Dams	Established in dams. Experimental culture	Kambona, 1975
O. rukwaensis	Indigenous		Ponds	" " "	Kambona, 1975
O. ruvumae	Indigenous			" " "	Kambona, 1975
T. sparrmanii	Introduced			" " "	Kambona, 1975
Cyprinus carpio	Introduced			Experimental	
Siganus reticulatus	Indigenous		Brackish water	Experimental	Kambona, 1975
Signus canaliculatus	Indigenous	Kunduchi	Salt water cages	Experimental	IFS, 1980
Penaeus sp.	Indigenous	Kunduchi	Salt water tanks	Experimental	IFS, 1980
O. variabilis	Indigenous	Korogwe	Ponds	Widely stocked in ponds and dams	Kambona, 1975
O. leucostictus	Introduced	L. Victoria Basin	Ponds	Experimental culture. Stocked only in few dams	Kambona, 1975
O. tanganicae	Indigenous	L. Tanganyika	Ponds	A few recorded stockings	Kambona, 1975
O. korogwe	Indigenous	Coastal	Dams	Tanga dams stocked	Kambona, 1975
O. hornorum	Indigenous	Zanzibar		Experimental	Kambona, 1975
O. urolepis	Indigenous	Bagamoyo/Morogoro	Dams	Stocking	Kambona, 1975
Haplochromis bloyeti	Indigenous	Widespread	Dams	Transplanted with tilapia	Bailey, 1966
Astatoreochromis alluadi	Indigenous		Dams	Bilharzia snail vector control	Bailey, 1966
Crassostrea cucullata	Indigenous			Experimental	Kollberg, 1979
Chanos chanos	Indigenous			Experimental	Bwathondi, 1981



A - D and 1 -20 refer to the tables.

Ref. No see Fig. 2	Name of lake or reservoir (construction date)	Basin/ District	Description			Fishery Pot. (t/yr)	Use[a/]	Number of fish species
			Area ('000 km²)	Altitude (m)	Mean depth (m)			
15	L. Kitangiri	Eyasi	0.11	800	3		f	20
1	L. Eyasi	Eyasi	1.04	1 117	-		saline	
2	L. Rukwa	Rukwa	2.85	500	4		f	22
3	L. Tanganyika	Tanganyika	13.3	773	572		f	193
4	L. Victoria	Victoria	34.8	1 100	40	100 000	f	209
-	L. Manzi	Mbezi	0.04					
-	L. Mzoe	Mbwenkum	0.002					
-	L. Burundi	Rift	0.05					
6	L. Manyara	Rift	0.52	1 045			saline	
5	L. Natron	Rift	0.91	675			f/saline	
7	L. Nyasa	Malawi	5.6	471	273		f	245
-	L. Rutamba	Lupululu	0.002		2			
-	L. Chidya	Ruvuma	0.003					
-	L. Kitere	Mambi	0.003					
12	L. Ikimba	Ikimba	0.035					
13	L. Jipe		0.04				f	
14	L. Chala		0.01					
16	L. Balangida							
17	Kibasira Swamp	Rufiji	4.0					
18	Malagarasi Swamp		1.8					
19	Bahi Swamp		0.85					
20	Rufiji floodplain		1.45					
-	Pangani Falls Dam							
8	Nyumba ya Mundu Dam (1945)	Pangani	0.1-0.18	670	6		f/p	
11	Hombolo Reservoir	Wami	0.02		3-4			
9	Kidatu Reservoir (1974)	Rufiji	0.01					
10	Mtera Reservoir (1979)	Rufiji	0.58		5	2 000-6 000	p	
	Stieglers Gorge Reservoir (proposed)		0.88					

a/ i = irrigation; c = commercial/industrial; w = water supply; p = power generation; f = fishery

Appendix 3. List of cultivable aquatic organisms available in Tanzania (after Ibrahim 1976).

1. Fresh water

1.1 Family Cichlidae (*Tilapia = Oreochromis/Sarotherodon/Tilapia*)

Tilapia esculenta Graham
T. nilotica (Linn.)
T. zillii (Gervais)
T. rendalli (Boulenger)
T. macrochir (Boulenger)
T. variabilis (Boulenger)
T. leucosticta Trewavas
T. mossambica (Peters)
T. pangani Lowe 1955
T. jipe Lowe 1955
T. rukwaensis Hilgendorf and Pappenheim
T. andersonii (Castelnau)
T. ruvumae
T. sparrmanii A. Smith
T. heudeloti Dumeril
T. manyarae
T. amphimelas Hilgendorf

1.2 Family Lepidosirenidae

Protopterus aethiopicus Heckel

1.3 Family Claridae

Clarias mossambicus Peters

1.4 Family Bagridae

Bagrus docmac Forskal
Bagrus spp.
Auchenoglanis occidentalis Boulenger

1.5 Family Schilbeidae

Schilbe mystus Linn.

1.6 Family Cyprinidae

Labeo victorianus Boulenger
Labeo cylindricus Peters
Barbus altianalis radcliff Worthington
Barilius microcephalus

1.7 Family Anguillidae

Anguilla nebulosa labiata Peters 1852

1.8 Family Citharinidae

Citharinus spp.

1.9 Family Characidae

Alestes spp.
Hydrocynus spp.

1.10 Family Mormyridae

Gnathonemus spp.
Marcusenius spp.
Mormyrus spp.

1.11 Family Centropomidae

Lates niloticus albertianus Worthington
Lates spp.

1.12 Family Salmonidae

Salmo gairdneri-Rainbow Trout
Salmo trutta-Brown Trout

1.13 Family Centrarchidae

Micropterus salmoides-Black Bass

2. Brackish water

2.1 Fishes

Chanos chanos Forskal
Tachysurus dussumeri
Mugil cephalus Linn.
Elops saurus
Megalops cyprinoides
Trachynotus sp. (Pompano)

2.2 Shrimps

Penaeus indicus H.M. Edwards
P. monodon Fabricius
P. semisulcatus De Haan
Metapenaeus monoceros (Fabricius)

2.3 Lobsters

Palinurus ornatus
P. versicolor
P. longipes
Thenus orientalis

2.4 Molluscs

Oysters – *Crassostrea cucullata* (Born)
– *Ostrea amasa*

Mussels – *Mytilus* sp.
– *Septifer* sp.
– *Modiolus* sp.

Clams and others – *Andara antiquata* (Linn.)
– *Donax* sp.
– *Cypraea tigris* (Linn.)
– *Cypraecassis rufa* (Linn.)

2.5 Sea Cucumbers

Holothuroidea – *Holothuria scabra*

2.6 Edible Seaweeds

Brown seaweed – *Sargassum* sp.
Turbinaria sp.

Red seaweed – *Eucheuma* sp.
Hyphea sp.
Gracillaria sp.

Appendix 4. Summary of the characteristics and environmental requirements of the more important tilapia species used in fish culture (after Balarin and Hatton 1979).

SPECIES	AVAILABILITY	FOOD HABITS	LIMITS OF SALINITY TOLERANCE	TEMPERATURE RANGE	GROWTH	REPRODUCTION AND TEMPERAMENT
Oreochromis andersonii	Distributed throughout Central West Africa. Cultured in Katanga and Zambia.	Adults tend to be omnivorous, fry below 5 cm feed mainly on zooplankton at 7 cm. Also take benthic organisms.	22 - 33 ‰	Lower than that of *O. mossambicus*.	Maximum size is 0.7 kg (36 cm); generally grow 200-225 g/year in ponds but may grow as much as 120 g in 2 months.	Male constructs a 18-60 cm saucer shaped nest in 30-45 cm water. Mature at 12-15 months (15-21 cm). Female lays 300-700 eggs, spawning only at temperatures above 21°C. Broods the eggs for 2-3 weeks and cares for young for 5-6 weeks.
Oreochromis aureus	Widely distributed from Israel to Uganda and across Africa to Senegal. Experimentally cultured in Alabama, S.USA and Israel.	Adults omnivorous. Fry below 5 cm feed on cladocerons but fish larger than 2 cm eat filamentous Algae, rotifers etc. and take supplementary foods, e.g. oil cake.	Euryhaline species, normally survives at a salinity of up to 36-44 ‰ but cannot reproduce. Reproduces at 19 ‰ Can be acclimated to a salinity of 54 ‰	Lower lethal temperature about 8°C can tolerate 30°C for 3-4 h.	Male grows faster than female attaining a maximum size of 31.5 cm.	Mature at 13.5-16 cm in 2nd year in wild, at 7.6 cm in ponds. Eggs laid in strands, 300-400 incubated at a time; hatch in 7-8 days. Spawning can occur every 4-9 weeks. (aggressive).
Sarotheorodon galilaeus (Galilee cichlid)	Widespread from Galilee and Jordan R. to Senegal and throughout Central Africa to the Nile. Cultured widely in North Central Africa and Israel.	Entirely planktonophagic. Filter-feeds on Algae including epilithic Algae and make use of supplementary foods.	Generally tolerates 13-29 ‰ Found to reproduce in wild at 29 ‰	As tolerant of low temperatures as *O. aureus* surviving at 8°C for 3-4 h.	Grow between 0.5-3 g/d reaching maximum of 0.8 kg (40 cm). Male growth distinctly superior to female.	Mature at 12-16 cm (80g). Both sexes make nests and brood young. About 5000 eggs/year, 150-1100 incubated at a time. Hatched fry are carried for 10-15 days.
Oreochromis macrochir (Great headed bream)	Native to South Central Africa, Zaire to South Africa. Cultured mainly with *Tilapia rendalli* in Zaire, Rhodesia and Malagasy Republic.	Young feed on zooplankton and phytoplankton. Adults generally phytoplankto-phagous, feeding almost entirely on planktonic and epiphytic Algae. Fish above 4 cm readily take artificial feeds. At 12 cm can take 70 % of diet as artficial food.	Freshwater species but some populations tolerate salinities up to 13-20 ‰ in Lake Mwerawa - N'tipa in Zambia.	Grows well between 23-24°C. Lower lethal limit below 12-13°C.	Males grow 1.4 times faster than females, reaching 6-7 cm in 6 weeks and 14 cm in 6 months. Generally gain 150-200 g/year in ponds. Maximum size 1.2 kg (40 cm).	Matures at 10-20 cm (8-12 months). Lay 1000-1500 eggs at a time, spawning at 4-5 week intervals and 6-11 times/year. Nests 50-300 cm in diameter, raised centre, in 30-150 cm water. Egg laid in strands, fertilized and buccal incubation 5 days and cared for for 2-3 weeks. (Non-aggressive).

SPECIES	AVAILABILITY	FOOD HABITS	LIMITS OF SALINITY TOLERANCE	TEMPERATURE RANGE	GROWTH	REPRODUCTION AND TEMPERAMENT
Oreochromis mossambicus (Java tilapia)	Indigenous to East and Southern Africa as far south as Natal. Mainly confined to lower Zambezi R. and costal lagoons. Cultured widely in S. E. Asia, Near East, Southern Africa; experimentally in Japan, Latin America, USA and Russia.	Adults omnivorous though mainly feed on plankton, vegetation and bottom Algae. First feed at 6-9 mm. Juveniles (below 5 cm) feed entirely on zoo-plankton. 5-7 cm fish are plankton feeders: diatoms,green Algae, small crustaceans and readily take artificial foods.	Euryhaline and can reproduce at salinities up to 35 ‰ and can survive in ponds at salinities of 35-40 ‰	Optimum temperature is 20-35°C. Overwintered in heated tanks outside tropics, 8-10°C being lethal. Because of this does not occur wild above 1000 m. Upper lethal temperature 39°C.	Males grow faster than females; growth 150-350 g/year in freshwater and up to 450 g/year in brackish water. Maximum size in wild 1.7 kg (36 cm) but stunting occurs in ponds.	Monogamous mouth brooder. Matures at 2-3 months in ponds, 3-6 months in wild. Male constructs 30-35 cm saucer shaped nest in 30-90 cm water. Female broods eggs (extraoral -ly fertilized); hatch 2-3 days emerge 5-8 days, staying with parent 3-6 weeks. Spawn 6-11 times/year every 22-40 days. (somewhat aggressive).
Oreochromis niloticus (Nile tilapia)	In freshwater from Syria, through Egypt all East Africa to Zaire and West Africa. Also found in brackish waters. Has been as widely distributed as *O. mossambicus* and rapidly becoming one of commonly cultured species in Africa, Israel, Thailand.	Omnivorous but mainly feeds on phytoplankton; can use blue-green Algae. Feeds also on benthic fauna and soft deposits. Fish of below 6 cm generally have more diverse food spectrum.Adults readily take pelleted food.	Thrive and reproduce at salinities of 29 ‰ but less well adapted than *T. zillii*. Has survived salinities up to 35 ‰	Temperature below 12°C are lethal but tolerates 8°C for 3-4 h. Survives prolonged periods at 15°C. Spawning is induced by 22-24°C. Upper lethal temperature 42°C.	Males grow 2-5 times faster than females. Achieve 18-20 cm/year in Sudan; 120-200 g in 4 months in cages in Ivory Coast. Maximum size in wild 50 cm (2.5 kg).	Mature in ponds at 4-5 months (10-17 cm) and in wild at 20-39 cm. 2 or 3 hollow nests are made and female produces 1500-2000 eggs at a time, spawning at least 3 times/year. (somewhat aggressive to other species).
Oreochromis spilurus nigrus	Indigenous to the Athi and Tana rivers in East Africa. Introduced to various parts of Africa and cultured in Kenya,Zaire, Uganda, Mozambique but results disappointing.	Omnivorous grazer, feeds on epiphytic, epilithic and filamentous Algae and benthic organisms but not on higher plants.		8-43°C.	Grows rapidly to the early stages (4-5 cm /month for 3-4 months). Males grow faster than females and at 4-5 months (10 cm) are 2 cm longer than females. Maximum size obtain-ed is 1 kg (38 cm).	Spawn at 4 months (11-16 cm) and at 3 monthly intervals thereafter if conditions are suitable.

SPECIES	AVAILABILITY	FOOD HABITS	LIMITS OF SALINITY TOLERANCE	TEMPERATURE RANGE	GROWTH	REPRODUCTION AND TEMPERAMENT
Tilapia rondalli	Indigenous from Senegal to Natal. Successfully introduced and cultured in several Asian and American countries. Cultured in mixed culture with *O. macrochir*.	Adults feed exclusively on higher plant. Fry (below 5 cm) feed on zooplankton and phytoplankton, eat more plant material at 5-7 cm and thereafter 90 % of diet is filamentous Algae and higher plants. Fry above 4 cm take artificial feeds.	Cannot tolerate salinity above 19 ‰	Least cold tolerant of the *Tilapia*. Dies at 12-13°C therefore restricted to altitudes below 1000 m. Upper lethal limit 41°C.	Reaches 5-6 cm in 6 weeks and grows 100-150 g/year. Maximum size attained in the wild is 1.3 kg (40 cm).	Monogamous substrate spawner. Matute in 7 months (12 cm), spawning at 6-7 weeks intervals (4-8 times/year) provided temperature is above 21°C. Males make a nest of 5-10 holes of 10 cm diameter in 10-100 cm of water. 1000-6000 eggs are laid at one time in one hole and moved by female from hole to hole. Hatch in 15-20 days, cared for for 2-3 weeks. (aggressive).
Tilapia sparrmanii	Ranges from East Africa south of equator to South Africa. Cultured in South Africa and experimentally in Japan mainly as a forage fish.	Juveniles (below 6 cm) feed on zooplankton, gradually changing to eating benthic deposit and vegetation. By 10 cm are mainly phyto-phagous.	Can tolerate a salinity of 18 ‰	One of the most hardy of tilapia and can survive at temperatures as low as 7°C. Spawns at temperatures above 16-17°C.	Seldom exceed 100 g though a maximum size of 300 g (27 cm) has been recorded.	Mature at 8 cm. Lay 3300 eggs at a time in one or more saucer shaped nests. Male guards the eggs. (highly aggressive).
Tilapia zillii	Widely distributed throughout Africa north of equator and across to Jordan and Syria. Successfully introduced into south USA and Malaysia.	Strictly phytophagous, feeding on leaves and stems of rooted aquatic vegetation and their associated epiphytic Algae. Readily adapts to artificial feeding.	One of the more saline tolerant of all tilapia, found in Red Sea at salinity of 45 ‰, but does not reproduce at sali-nities of 39-44 ‰	Tolerant of low temperatures (6-8°C) but does not do well below 14°C. Prefers 28°C, spawning at 22-26°C.	Males generally grow 35% faster than females. Can grow 10 cm in 3 months and have reached 26-29 cm (300-450 g) in a year. Maximum size 3 kg (35 cm).	Mature in 2nd year (25-27 cm) in wild but in 3-5 months (20-50 g) in ponds. Saucer shaped nest 20-25 cm diameter, 5-8 cm deep. 7000 eggs laid per spawnings/year. Eggs guarded by female. Larvae are attached to substrate for 3-5 days, cared for by female.

Appendix 5. Climatic conditions in Tanzanian towns (after Balarin 1985).

References: a) Philip 1980
b) S.M.D. 1976
c) Bureau of statistics 1983

Name	Altitude (m)[a]	Min./Max. Temp. (°C)[c]	Rainfall (mm/yr)[b]	Rel. humidity (%)[c]
Dar es-Salaam	14 (58)	17.7 - 33.2	983	53 - 87
Tanga	35	16.1 - 28.3	1 337	75 - 91
Lindi	8 (41)	19.0 - 33.0	897	
Moshi	831	15.6 - 33.1	874	40 - 86
Kigoma	885	17.2 - 29.6	953	50 - 84
Dodoma	1 120	13.2 - 31.6	597 (573)	34 - 82
Bukoba	1 137	15.3 - 26.5	2 010	64 - 86
Mwanza	1 130	15.7 - 28.3	1 008	48 - 80
Songea	1 153 (1 067)	11.1 - 29.4	1 125	38 - 88
Tabora	1 265	13.7 - 32.2	899 (882)	29 - 84
Mbeya	1 736	4.7 - 26.8	868	39 - 81
Musoma	1 100	-	801	
Mbulu	1 900	-	818	
Morogoro	900	-	890	
Tukuyu	1 200	-	2 458	
Tunduru	650	-	1 036	
Arusha	1 400	12.3 - 28.5	-	46 - 91
Mtwara	-	18.4 - 31.3	-	54 - 86

Appendix 6. The questionnaire used in the questionnaire study in the Mbeya, Arusha and Ruvuma regions.

QUESTIONNAIRE FISH FARMERS HOUSEHOLD LEVEL

Interview start: Date:...............

Interview stop: Sample No. ....

A.location and structure of household

1. Name(s)................................ ....

Village :............................ District:..................

2. Respondents age:........ Sex.......... ethnicity....................

Education: grade/form .... Skil :...................

Speaks english: fluently............. fairly.......... Not:......

3. Marital status:...

4. No. of people living permanent in household:...........................

5. Other people contributing to household with food, money etc?

Yes........ no.........

Who .... How:..........................

6.

Family status	age	sex	health/ disease	educa- tion	skill	occupation

7. Where do you send your children to school?

8. Where have you got your training?

9. For how long have your family been living here?

10. Who is born here: wife husband other

12. Could you range your major means of living? (range 1-3)

Means of living	Major source	Important	neglible
agriculture	....	....	....
migrant work	....	....	....
local work, waged	....	....	....
working for food	....	....	....
business, specify	....	....	....
handicraft	....	....	....
fish farming	....	....	....
other	....	....	....

13. Estimated income from sales and work last year ....

b. Savings last year (total/fish)....

14. Investments last year (total/fish)...........

Fertilizer: .... seeds: .... equipment: ....

hired labour: .... other investments: ....

b. On what purposes do you hire labour? ....

15. Do you experience any food shortages during the year? ....

If yes; when: ....

b. Do you buy any food during the year? yes............. no............

When, and how much: ....

16. Who will inherit you? (Formulate the question properly)

....

B. Production systems

	aquaculture	agriculture	horticulture/ gardening
17. Total area owned: ....ha	18b. .....ha	......ha	.......ha
18. Total area farmed: ....ha	.....ha	......ha	.......ha
19. Area under irrigation: ....ha	how:.........................		

20. Type of soil (pond area): ....

21. Water availability: very good...... fair..... bad......

22. What kind of farming do you perform at present?

- Shifting cultivation ....
- semi-permanent cultivation with fallow periods ....
- permanent cultivation with crop rotation...............................
- permanent cultivation without crop rotation ....
- other :..

23. Animals/livestock on farm:

type	no	feed cost	est. mature	use of manure

b. Use of animals : ....

....

24. Crops and cultivated area last season:

Crop	est. area	ferti- lizer	manure	est. yield	sale	own use

b. Where do you sell the crops? 1..
2..

25. which crops, and on what area did you grow them 10 years ago?
....
....

b. If any changes today, why have you made these?
....
....

26. Use of compost/kitchen leftovers:

Type	rainy season amount	rainy season use	dry season amount	dry season use
kitchen leftovers				
compost				

b. How do you make the compost?
....
....

27. Fertilizer used in ponds:

type	amount	when/how often

28. Products from village garden outside own land (including fruits etc.):

kind	own consumption	sale	other use

C. Ponds

29. No. of ponds:........... Ponds under construction: ....
no. of ponds planned in the near future: ....

30. Area of ponds: x m2 x m2 x m2 x m2 x m2 x m2 x m2 x m2

31. Water source: ....
32. Distance from house to ponds: ....
33. Water quality from source : polluted? .... colour ....
34. Time water present:............ months/year

35. Bottoms sealed? yes ..... no...... how:..........................
36. Inlet/outlet - how? ....
37. Drainage - how and when? ....
38. Physical condition of ponds (maintenance): ....
....

39. Fertility of ponds: ....

40. Fingerlings from: - own nursery pond ....
- other fish farmers ....
- extension service ....
- breeding (only one stocking) ....

41. Supplying others with fingerlings? yes .... no........
Who............... how many .... max. distance ....
When do you get fingerlings?

D. Construction of ponds

42. Construction costs of one pond: .... size of pond:.............
man-days used:................. food for work.....................

43. Equipment used:..
44. Can you estimate how much work were done by:
........% male ....% female ....%children (below 15)

45. When did you start digging your first pond?.........................
46. When did you stock this pond for the first time? ....
47. When did you harvest this pond for the first time? ....

48. Credits for ponds: .... from .... to be paid .....

49. Species:
b. Proportions:

E. Production and maintenance

50. No. of people working with the ponds:..................
male........ female............ children................

51. Time spent on ponds: .... hours/day no. of people..........

52. Do you hire labour especially for working with ponds? ....
b. If yes; for which purposes:..
c. Who:...................... when:.........................

53. Who is normally doing the following operations:

operation	who	time spent	frequency (d/m)
feeding	....	....	....
maintenance	....	....	....
harvest/ stocking	....	....	....

54. When do you take the main harvest(s)?

b. Harvesting method:...

55. Estimated yield per main harvest:

species	av. size (fingers)	est. no. per harv.	consumpt.	sale	other use
O. Nilotica	....	....	....	....	....
	....	....	....	....	....
	....	....	....	....	....
	....	....	....	....	....

56. These numbers are from ....m2 of ponds

57. If anything is sold; where.................... distance..................

transport............................ price....................

b. Marketing:............................

58. Do you have any intermitent harvests? Yes...... No..................

If yes; how often :.................... a year.......... a month..........

Approx. no. or kg. per harvest:..

59. Ranking of problems : (rank 1 - 3)

	Most important	Important	Neglible
Breeding/stunting	....	....	....
Predation	....	....	....
Water supply	....	....	....
Water quality	....	....	....
Feed	....	....	....
Manpower	....	....	....
Money	....	....	....
Maintenance	....	....	....
Manure	....	....	....
Fingerlings support	....	....	....
Lack of knowledge	....	....	....
Theft	....	....	....
Tools	....	....	....
Drought	....	....	....
Weed	....	....	....
Diseases, fish	....	....	....
Transport	....	....	....
Selling, marketing	....	....	....
Other	....	....	....

b. What is done solving this problems?.......................................

:..

60. Feed for ponds:

Type	Source	Cost	Amount/ frequency	Seasonality
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....

61. Production control : Yes No

Growth ....

Harvesting records ....

Others ....

D. EXTENDING PONDS:

62. Do you want to extend your fish farm? Yes........No...........

Why/Why not...

63. What's the major problem of extending....................................

64. How have you figured out to solve this problem?...........................

....

....

65. Do you have any need for credits or loans? Yes.......... NO..........

b. For what purpose?...

c. Estimated amount needed:...TSHS.

66. Do you know where to get credit?...

67. Have you ever heard of integrated pig-cum-fish or duck-cum fish farming?

Yes............. No...........

68. Do you know of anyone running such pond systems?...........................

If Yes; who .... where ....

69. Do you have any concrete plans of integrated fish farming?

How:..

....

70. Could you be interested in further information and demonstration of such systems? Yes.......... No............

71. Are you satisfied with the support given by the extension services? Yes................ No. ....

72. Do you have any suggestions to improve their offer?

....

....

F: AQUACULTURE AS PART OF THE TOTAL PRODUCTION SYSTEM

73. Can you range the three busiest months on your farm?

1. .... 2. .... 3. ....

74. Can you range the months which are least busy?

1. .... 2. .... 3. ....

75. Attitudes to fish and fish farming: ....

....

....

....

....

....

....

76. Have fish farming led to neglect of other work on the farm?

Yes............ No.............. If Yes what kind of work:

....

....

....

77. Are there any particular times during the year that fish farming interrupt other work? Yes...... No............ If yes, when and

6. why: ....

....

The area which is utilized for ponds, could it be used for other purposes?

Yes........... No............ Which.................................

78. Have the area been in use be fore: Yes....... No.......................

79. Why is it utilized for fish farming? ....

....

80. Is it possible for you to point out any particular environmental changes caused bythe ponds? Yes.......... No............

6. Could you tell me if you have noticed changes in any of these?

	Which changes	No impact
VEGETATION	....	
Human diseases	....	
Fauna	....	
Insects	....	
Water quality	....	
Other		

81. What is your major benefits by being an fish farmer? ....

1. ....

2. ....

3. ....

82. Visible assets:

....

....

....

....