Development of Semi-Intensive Fish Farming in Morogoro Region, Tanzania

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Development of Semi-Intensive Fish Farming in Morogoro Region, Tanzania

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Preface

This report presents the results of the pilot project "Development of semi-intensive aquaculture for small scale farmers". This project was executed by ALCOM in collaboration with the Fisheries Division of the Ministry of Natural Resources and Tourism in Morogoro Region, Tanzania. It started in 1993 and had a duration of three years.

The report describes the region, the extension approach used, and the various extension methods tested during the project. It analyses the results and proposes recommendations for the development of aquaculture in Tanzania.

ALCOM is a regional aquatic resource management programme of the FAO (Food and Agriculture Organization of the United Nations), with its head office in Harare, Zimbabwe. It cover the SADC countries: Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

The aim of ALCOM is to assist member countries improve the living standards of rural populations through the practice of improved water resource management. Towards this end, pilot projects are executed in member countries to demonstrate new techniques, technologies or methodologies. Successes achieved, ideas derived, and lessons learned are applied on a wider scale by member governments.

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EXECUTIVE SUMMARY

The pilot project "Development of semi-intensive aquaculture for small scale farmers" was executed by the Aquatic Resource Management for Local Community Development Programme (ALCOM) in collaboration with the Fisheries Division of the Ministry of Natural Resources and Tourism in Morogoro region, Tanzania. The project started in November 1993 and had a duration of three years.

The objective of the pilot project was to develop suitable semi-intensive fish farming techniques and extension packages for small scale farmers and to incorporate these into the rural extension system. Initially, it was intended to work with practicing fish farmers. However, during the initial stage of the project it was realised that very few fish farmers existed in the project area. Therefore the objectives were revised and emphasis was given to study the introduction process of fish farming under local conditions. Further, it aimed to demonstrate the possibilities for farmers to practice semi-intensive management, using management options acceptable to the farmers and to determine why a certain system was adopted as the most suitable.

Out of a total of 19 surveyed areas, four areas were selected for on-farm trials. These were Malolo in Kilosa District, and Mgeta, Matombo and Pemba in Morogoro Rural District. Extension activities in Pemba were stopped after it was found that water availability was insufficient during the dry season. Tangeni and Kinole, both located in Morogoro Rural District, were added during the beginning of 1996. The technical criteria used to select the above areas were; water availability, temperature, soil and topography. The socio-economic criteria were; input availability, access to market, taboos related to fish and fish farming, willingness to accept new technologies, labour availability and access for regular monitoring.

The target group consisted of small scale farmers, who formed the majority of the region's population. The farmers that participated with the project had the following characteristics in common: they owned on average three acres of land and crop farming was their main activity while they kept few animals like chicken, goats, cows, pigs and rabbits. Family labour was the main source of labour used. Crop production was for both home consumption as well as for generating cash. They were risk evaders and used locally available tools for farming.

The project followed a participatory and problem solving approach. Before starting the extension work a survey was conducted to study the existing communication channels and to describe the socio-economic whereabouts of the rural communities in the selected areas. During the survey, discussions were conducted with farmers and the findings were used to formulate an extension message.

The extension message comprised of basic technical fish farming information and background information to increase the awareness about the risks involved in undertaking fish farming. The project provided knowledge, and assisted farmers only in securing fingerlings, as it was anticipated that all tools and materials and inputs would locally available. A minimum surface area of one are was suggested to enable fish production for both home consumption and sale. Ponds were preferred to be located on a gentle slope. The species used for fish farming was *Oreochromis niloticus* with a stocking density of at most two fingerlings per m^2. Locally available farm yard manure and agricultural by-products were suggested as fertilizers and feeds. The yield per are was expected to be around 18.5 Kg after 6-8 months (3700 Kg/ha/y).

Communication media used to arouse the interest of farmers for fish farming were; the village authorities, the village announcer, posters and letters. Although tested only few times, village announcers and posters turned out to be good media to create interest of the farmers. Agriculture Extension Officers (AEO), slide shows, pamphlets, group discussions, field visits by the team, newsletters and farmer-to-farmer extension and field visits were methods tested to deliver knowledge. Of all methods, farmer-to-farmer extension, group discussions and AEO were the most effective to deliver knowledge. It was noted that when two or more methods were used together they became more effective than when one single method was used.

Fish farmers in Malolo had the highest average income per year followed by Tangeni, Mgeta and Kinole. In all areas a large proportion of the income of the farmers was generated by agriculture followed by sale of livestock and trading, handicraft and casual labour. The contribution of cash generated by the fish sale in the total income was limited (6-8%). The low contribution of fish farming to the total income of the farmers was explained by the fact that most farmers consumed most fish themselves, and many farmers did not like to harvest the fish once they were big.

During the two year trial period 40 farmers participated with the project and constructed a total of 47 fish ponds with an average of 154 m^2 per pond. In total 43 % of all the ponds were smaller than one are. Reasons limiting pond size were lack of land, slope of the terrain, unavailability of water and lack of cash to hire labour for the construction. Ponds constructed with hired labour, though generally bigger in size, often had leaks due to poor compaction of the dikes . Ponds in Mgeta, Tangeni and Matombo were constructed near the homestead while in Malolo and Kinole most ponds were constructed within 100 to 1000 m. distance. Tools used for pond construction were possessed by the farmers themselves or locally borrowed from others.

A large variety of animal manure was used to fertilise the ponds, usually obtained from the own or neighbouring farms. These varied from pig manure, which was commonly used in Mgeta, a mix of goat droppings and cow dung widely available in Malolo, to goat, chicken and duck droppings used in Tangeni, Matombo and Kinole. Only farmers in Malolo had access to sufficient manure, while in the other areas animal manure was scarce or was in high demand for other farming activities. Especially, in Tangeni, Matombo and Kinole, where animal husbandry was not widely spread and the use of manure in gardening was not commonly practiced, the quantity of animal manure was limited. In Mgeta where pig manure was available, the demand for animal manure for other farming activities was very high. The largest amount of animal manure in terms of nutrient input was applied in Mgeta, being 25 Kg of nitrogen, 12 Kg of phosphate and 20 Kg of potassium oxide per are per year. In the other areas only 10 % to 20 % of these input levels were realised. The level of integration of aquaculture and animal husbandry was generally low, however, some farmers in Mgeta had constructed their pig pens above or near the fish ponds. After it became clear that some farmers did not have enough animal manure to develop a plankton bloom the team advised to fertilise the ponds with green compost in extended enclosures. At the time of the report writing, not enough data had been collected to draw conclusions about the fish production under these conditions.

The main feeds used by the farmers to feed their fish were rice bran, kitchen leftovers, leaves from a variety of food plants, local brew leftovers and maize bran. All feeds were locally available and only maize bran was occasionally paid for. As for manure, there was high

competition for the local available feeds, which were commonly used to feed livestock or to produce local brew.

On average only 186 fingerlings could be stocked per are due to lack of fingerlings. Although most farmers initially agreed to harvest the fish by drainage of their ponds, many farmers did not do so. Instead they preferred continued production and harvested the fish by using nets. Reasons for not draining their ponds were identified as; lack of understanding why and how to drain a fish pond, preference to use less time consuming harvesting techniques, lack or high price of fingerlings and insufficient water to refill the ponds. Further, it was thought to be a waste to drain the fertile water and some farmers did not drain the ponds as it was assumed that a dry pond would show less status. The above reasons were strengthened by the fact that some farmers already owned nets and the few farmers who drained their ponds had disappointing yields. Recognising the above problems the following measures were taken: more emphasis was put on why and how to drain ponds; to avoid farmers dependency on the team for harvest, the project sampling net was replaced by a cast net; and lift nets were introduced to facilitate the harvest of fingerlings.

Production from total harvests ranged between 1.7-39 Kg/are/y, while yields from partial harvest ranged between 9.6-33.1 Kg/are/y. Due to fact that only limited data could be collected it was difficult to draw conclusions which of the two methods attained the highest production. Fish farmers who partial harvested their ponds did this 3-5 times a year. Farmers drained their pond for total harvest when they wanted to market the fish, while most of the fish from partial harvests was consumed.

Predation of fish was generally not a big problem, however, in Malolo and Matombo several ponds were severely predated by otters causing some farmers to abandon the activity. The advice to fence the pond, preferably using locally available materials, was followed, while the advice to put an otter barrier inside the pond was not followed.

Most fingerlings used for stocking were taken from production ponds. No farmers specialised in fingerling production, although this was given considerable attention by the team. Fingerlings were initially harvested by a seine net, which often resulted in a high post-stocking mortality. To improve fingerling harvest techniques the team introduced lift nets. These showed to be effective as long as they were not used too frequently.

The objectives for farmers to undertake fish farming were to obtain fish as a source of relish and for the purpose of income generation while some farmers particularly aimed at prestige. Lack of time, long distances to the pond site, lack of means to carry inputs to the ponds and unavailability of inputs were the main reasons for farmers not to manage their ponds intensively.

Fish farmers incurred both capital and opportunity costs. A considerable amount of cash was spent on pond construction and purchase of fingerlings and feeds. Farmers who hired labour to construct a pond spent on average TSh. 19,935 per are while their colleagues who made the pond themselves incurred on average TSh. 15,229, including opportunity cost, for a similar pond. Feed costs were on average TSh. 8,142 per are and per year.

The average annual profit for a one are fish pond was TSh. 12,727 which was considerably higher than net return's of other crops (TSh. 120-2,885). Assuming that these crops would have been marketed locally just after the harvest. Even if two or three crops were rotated,

profits remained lower than for fish farming.

Although fish farming had shown to be profitable it was found that the target group gave it low priority. In this respect it has to be reminded that fish farming was a completely new activity in Morogoro Region and totally different from traditional crops. In addition, it competed highly for land, water, labour and inputs.

1 INTRODUCTION

The pilot project "Development of semi-intensive aquaculture for small scale farmers" was launched in Tanzania in 1993, and had a duration of three years. The project was executed by the Aquatic Resource Management for Local Community Development Programme (ALCOM) in collaboration with the Ministry of Natural Resources and Tourism.

As a preparation for the project, a study was carried out in Mbeya and Ruvuma regions to identify adoption and viability criteria for semi-intensive fish farming[1]. Mbeya and Ruvuma regions were selected for the study as these were among the most developed regions in terms of the number of fish farmers. The purpose of the study was to assist the pilot project in the identification of criteria for adoption and viability of fish farming. The following were identifies: regular access to extension services, access to feeds and fertilizer, a sufficient market for fresh fish, interest in fish farming by the farmers, profitability of the activity, and in the long run access to good quality fingerlings.

1.1 Objective

The objective of the pilot project was to develop viable semi-intensive fish farming techniques and extension packages for small scale farmers in Tanzanian and to incorporate these into the rural extension systems.

Although the Morogoro Region Fisheries Office reported more than 300 active fish farmers in the region in 1993, not much was known about their location and the status of their ponds. Therefore, a back ground survey was carried out in 1994 to collect technical and socio-economic information to enable the team to select suitable areas for fish farming trials. Field trips were made to nineteen different villages in the region by the pilot project team[2]. These field visits revealed that only a few farmers practiced fish farming and that semi-intensive management of fish ponds was almost non-existent.

For this reason it was decided to revise the objectives. The revised objectives were:

- To introduce fish farming in selected areas of Morogoro Region and to monitor the introduction process for future application in other regions of the country. The selected areas were those with potential for semi-intensive management.
- To demonstrate the possibilities for farmers to practice semi-intensive fish farming, using management options acceptable to the farmers and to determine reasons why a certain system was adopted as the most suitable system under local conditions.

Out of the nineteen areas surveyed, Malolo, Mgeta, Turiani, Pemba, Changa and Matombo were chosen for a detailed study. Only Malolo, Matombo, Mgeta and Pemba (see Figure 1) were found potentially suitable for on farm trials. Criteria used for the selection of the trial areas contained both technical as well as socio-economic aspects. The most important technical criteria were water availability, temperature, soil and topography. Socio-economic criteria covered; availability of inputs, access to market, availability of animal protein, taboos related to fish and fish farming, willingness of the farmers to accept new technology, availability of labour

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[1] Nilsson, H. and K. Wetengere, 1994. ALCOM Field document No. 28. Adoption and Viability Criteria for Semi-Intensive Fish Farming: A report on a socio-economic study in Ruvuma and Mbeya regions, Tanzania.

[2] The team comprised of an Aquaculturist, a Fisheries Biologist and a Socio-Economist.

and easy access of the trial areas by road for regular monitoring. Extension activities in Pemba stopped after it was found that water was insufficient for fish farming during the dry season. Tangeni and Kinole were added to the pilot sites in the beginning of 1996.

1.2 Description of the project area

Description of the region

Morogoro Region is located in the South Eastern part of Tanzania and lies between longitude 37 to 39° east and latitude 6 to 10° south (See Figure 1). The region has a total surface area of 70,799 Km^2. Out of the total area 39% is suitable for agriculture of which less than 20% is cultivated.

Physical features

The region can be divided into three physical zones;

1. Plains and valley zone. These are areas lying below 500 m. and include: the valleys of Kilombero river, Wami, Duthumi, Malinyi and Lupero in Ulanga District and Kilangali and Mkamba in Kilosa District.
2. Highland zone. These areas lay between 500-1000 m. above sea level. This zone covers a large part of Kilosa District, central and south of Morogoro Rural District.
3. Mountain zone. These are areas located between 1000-3000 m. above sea level. The areas in this zone include: Uluguru mountains, Nguru, Mahenge, Mwega, Mangalisa and Rubeho.

Climate

The rainfall in Morogoro Region varies from 400 to 3500 mm. per year. The amount of the rainfall varies greatly per location, altitude and season. The eastern side of the Uluguru Mountains (windward side), receives mean annual rainfall ranging between 1500-2900 mm. Peaks above 1800 m. receive more than 3000 mm. per year. The western side (leeward side) on the other hand has a mean annual rainfall of less than 2000 mm. Both areas have two rainy seasons, a short rainy season from November to December and long rainy season form March to May. The amount of rainfall in the region decreases as one goes westwards. The mean annual rainfall in Malolo area, which has only one rainy season from November to December, ranges between 400-500 mm. per year.

Mean annual temperature varies from 12 °C (above 2500 m.) to 30 °C (in the low lands). Highlands above 1500 m. have a mean temperature range between 12 °C and 25 °C. The mean annual temperature in the low land zone ranges between 25 °C and 30 °C.

Demographic characteristics

The region has a total population of 1,220,564 (National census, 1988), has an average population density of 17 people per Km^2 compared with 27 people per Km^2 for the whole of Tanzania. Fifty one percent of the total population is female and over 77% of the population live in the rural areas.

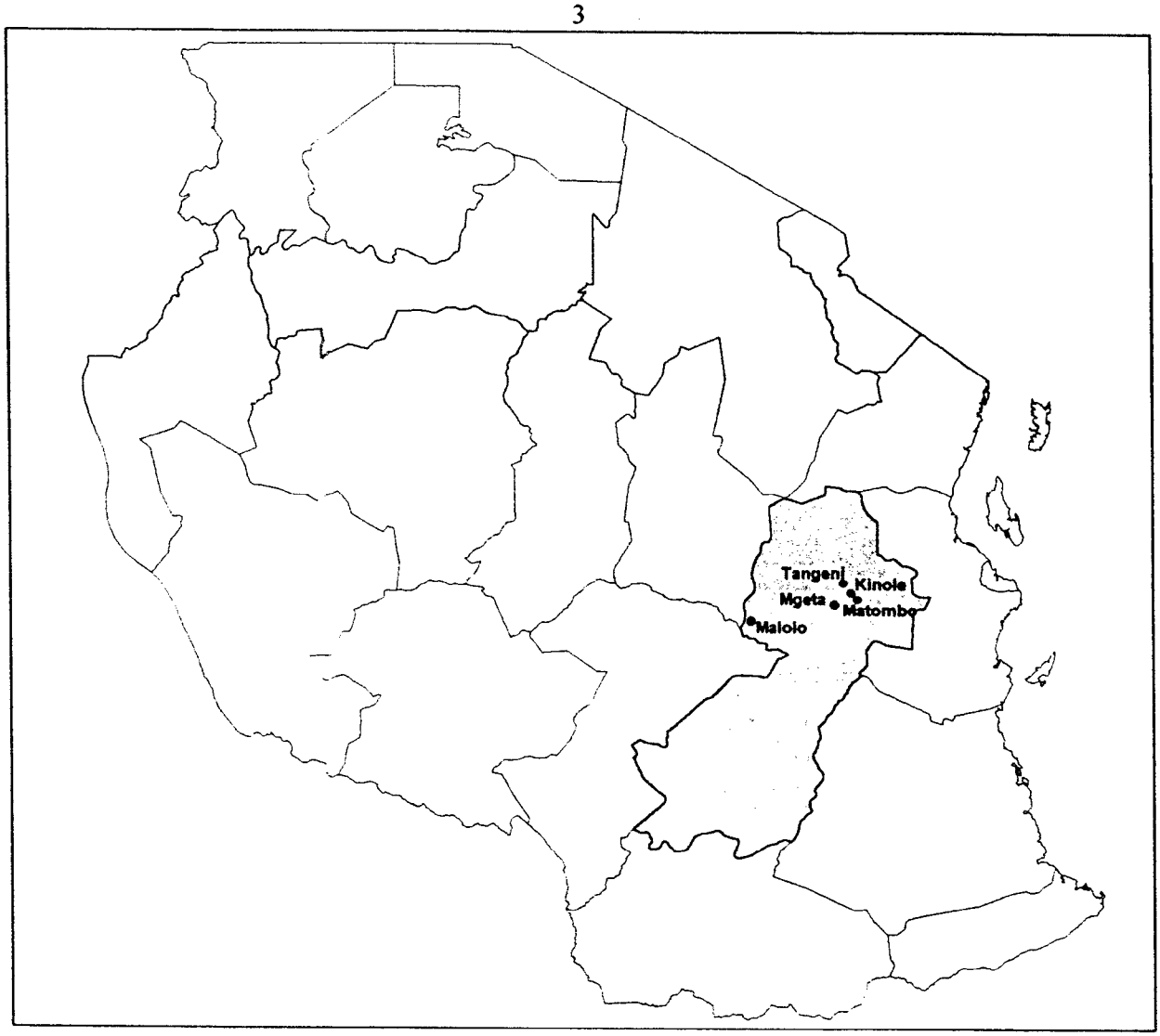

Figure 1. The position of Morogoro region and the project areas in Tanzania.

The region has five districts; Kilosa, Morogoro Rural and Urban, Kilombero, and Ulanga. The annual population growth rate in the 1978-88 census period was 2.6%, slightly less than National growth rate (2.8%).

In 1988 the region had a total number of 227705 households (National Census, 1988) with an average of 5.3 people per household. Forty five percent of the people were literate[3]. Around 55% of the literate population was male. According to the National Census, 1988, the infant mortality rate (IMR) and under five mortality rate (U5MR) was 115 and 191 per 1000, respectively.

[3] People able to read and write in Kiswahili.

Description of the trial areas

Mgeta area

Mgeta area is situated 45 Km by road from Morogoro town in Morogoro Rural District. The area, located on the steep slopes of the Uluguru Mountains, has an altitude of 1500-1800 m. above sea. The area had an estimated population of just over 5000 people and was for Tanzanian standards densely populated. Christianity was the most widespread religion in the area.

Rainfall in Mgeta varies from 1000 to 3000 mm. per year, concentrated in a short rainy season from November to December and the long rainy season from March to May. The mean annual temperatures vary from 25 °C in the valley to 12 °C in the forest reserve on the top of the mountain.

There are four rivers which are utilised for irrigation purposes. While clay soils dominate the area, there are few places where sandy loam soils occur.

Crops grown in the area include vegetables (cabbage, Chinese cabbage, lettuce, carrots, cauliflower etc.), beans, maize, and various fruits such as bananas. Most farmers in Mgeta kept pigs and chickens while few kept goats, sheep and rabbits. Various inputs which could be used for fish farming were available:

- Maize bran. This could be obtained from farmers' own sources or alternatively from the local market. Maize bran from farmers' own sources was insufficient but maize bran from Morogoro town and Dar-es-Salaam was readily available on the local market. Currently maize bran was used to feed pigs and to make local brew.
- Vegetable by-products. These were available from farmers' own sources and also free from the market. Vegetable wastes were used to feed pigs.
- Local brew leftovers. These were available in small amounts and were used to feed pigs.
- Kitchen leftovers. These were available in small amounts and were used to feed pigs.
- Animal manure. This was available in small quantities and was used in vegetable gardens.

There were government extension officers dealing with forestry, agriculture, livestock and community development. In addition, there was a project titled "Uluguru Mountains Agriculture Development Project (UMADEP)" which provided education on the importance of afforestation in the area and sold tree seedlings. The project had encouraged farmers to form farmers groups as a way to mobilise their resource (particularly labour and cash) for their own development.

Malolo area

Malolo area is located in Kilosa District, 213 Km south west from Morogoro town by road. The area had a total population of just over 4,000 people. There were more Muslims than Christians. Over 30% of the population originally came from Iringa and Mbeya Regions.

Malolo area lies in a low plain surrounded by Msimba Mountains. The area is semi-arid and unsuitable for crop farming without irrigation. It has only one short rainy season, from November to February. The annual temperature ranges from 25 °C to 30 °C. In the valley close to the perennial river more than 4000 acres had been developed for irrigation.

The area is dominated by sandy loam soils with some of the temporarily flooded areas having clay soils. Crops grown in the irrigated fields included: onions, rice, beans, maize and vegetables. Very few farmers kept animals, however, those who did, kept between 20-50 cows and up to 100 goats. Most farmers kept chickens while few kept pigs.

The farming system provided the following inputs which could be used in fish farming:

- Maize bran could be obtained from farmers' own sources, from neighbours and from local hulling machines for TSh 100-150 per 18 litres. Maize bran was used to feed pigs, chickens and making local brew. Maize bran was widely available after harvest while it was scarce just before the planting season.
- Rice bran was available in large quantities both from farmers' sources and from the hulling machines free of charge. Only small amounts of rice bran were used to feed chickens.
- Sorghum bran was available in small quantities and a small amount was used to feed chickens.
- Local brew leftovers were available and was used to feed pigs.
- Plant leaves, vegetables by-products and fruits were available in small amounts and were used to feed pigs.
- Animal manure was available in large quantities but only a small amount was used in gardening.

A number of government extension officers serviced the area. In addition, there was a project called "Traditional Irrigation Improvement Programme (TIP)", financed by the Dutch Development Organisation SNV. The project provided knowledge on irrigation channel construction and transported construction materials. Farmers on the other hand provided labour.

Matombo area

Matombo area is situated on the eastern side of the Uluguru Mountains, 58 Km by road from Morogoro town. At the time of the 1988 National Census the area had just over 3,900 people. Muslims comprised of more than 60% of the population. Areas suitable for agriculture are situated along the valley which is crossed by one permanent river. Water from the river was occasionally used for irrigation. Clay and clay loam soils are found in the area.

The mean annual rainfall in the area is between 2000-2500 mm. Most rain falls from March to May and from November to December. Temperature ranges from 23 to 30 °C.

The main crops in the area were bananas, oranges, mandarins, coconuts and rice. Few farmers kept goats, chickens and ducks. There was one butcher who kept cattle for slaughtering.

The following inputs which could be used in fish farming were available in the area:

- Maize and sorghum bran was available in small amounts from farmers' own sources and from hulling machines. The brans were used to feed chicken.
- Rice bran was available but was not utilised.
- Only small amounts of animal manure was available as the domestic animals were freely grazed in the field. The manure was rarely collected and used to fertilise the gardens.
- Plant leaves and vegetable wastes were rarely used to feed animals.

Agriculture extension was provided by an agriculture extension officer.

In the 1980's there was a FAO executed project which promoted the planting of oranges in the area. The project provided orange seedlings, knowledge, chemical fertiliser and arranged farmers visit in other areas.

Kinole

Kinole area is located just north of Matombo on the Eastern side of the Uluguru Mountains, 50 Km by road from Morogoro town. The area is situated on an altitude of 1000-1500 m. above sea level and is mountainous. More than 80% of the population were Muslims. There is one permanent river but due to the fact that the river bed is far below the surrounding land, the water could not be used for irrigation without using pumps or dams. There are some streams which were occasionally used for irrigation purposes. Soils found in the area are sandy clay and sandy loam.

Crops grown were banana, coconut, green pepper, mango, sugar cane and yams. Farmers from Kinole also cultivate rice on the lower areas. Very few animals were kept in the area (only goats and chickens).

The following inputs which could be used for fish farming were available in the area:

- Rice bran was scarce and often had no use.
- Very little maize bran was available after the harvest time and was used to feed chickens.
- Very little animal manure was available and was rarely used in the garden.
- Plant leaves were available but were currently not used.

There was project called "Kilimo Milima ya Uluguru (KIMU)" meaning farming in the Uluguru Mountains. The project promoted adoption of improved farming techniques. It provided technical knowledge on various crops, had demonstration farms and encouraged farmers to form groups as a way to mobilise their resource.

The agriculture extension officer who was also in charge of the above project in the area was interested in diversifying the farming system with fish farming.

Tangeni

Tangeni area is situated on the north western side on the foot hills of the Uluguru Mountains, 22 Km by road from Morogoro town. More than 90% of the total population was Christian. The area is crossed by a river and a few streams which were used for irrigation. Like in Mgeta there are two rainy seasons; November-December and March-June. Clay, sandy loam and sandy clay are soils found in the area. The main crops grown were banana, mango, rice, sugar cane, yam, maize, pepper and cassava. Like in Kinole very few farmers kept goats or chickens.

The following inputs which could be used for fish farming were available in the area:

- Very little maize bran was available and was used to feed chickens. Maize bran could be purchased from hulling machines in Morogoro town.
- A lot of rice bran was available but was not used.
- Plant leaves and fruits were available and were not used.
- Very little animal manure was available.

Like in the other areas there were agricultural extension officers stationed in the area. No projects were identified in the area.

1.3 The target group

The project aimed at introducing improved fish farming techniques to small scale farmers, the majority of the region's population. These farmers depended mainly on agricultural activities besides on trading and animal husbandry. The main consideration of the farmers interested to adopt fish farming was to raise fish as a way to improve their diet and to supplement their income through selling of surplus fish. During the first fish farming introductory meetings, which were open to all interested villagers, it was found that 80% of the participants had following characteristics:

- Crop farming was their main activity. By-products from cultivation found their way in traditional farm activities or were occasionally sold.
- Few animals like chickens, goats, sheep, cows, pigs and rabbits were kept. The excreta of these animals were used in vegetable gardens.
- Family labour was the main source of labour used in farming.
- Production of crops and animals was for home consumption as well as to generate cash.
- On average three acres of land was owned by the farmers.
- They did not like to involve themselves in economic risky businesses.
- They used locally available tools for crop farming like hoes, bush knifes and spades.

Villagers with the above characteristics were found to comply with the group targeted. It was anticipated that this group could utilize readily available resources in fish production at limited additional cost.

1.4 Extension approach

The project followed a problem solving or participatory approach rather than a directive approach. As most farmers had no experience with fish farming the team initially gave them a set of guidelines as described in section 2.1.1. Using this approach it was expected that farmers would more easily and successfully adopt the new technology and that it would give the best guarantees for sustainability of the introduction in the long term. In order to do so, a preliminary survey in the region was carried out to study the existing farming systems and the socio-economics of the rural population, with emphasis on communication channels. For the specific topics covered in this survey see Appendix 1.

2 METHODOLOGY

At the start of the project only ten fish farmers with a total of twelve ponds were culturing fish in the five selected areas. The majority of these ponds were stocked with riverine fish species while some ponds in Kinole were stocked with *Oreochromis urolepis* formerly introduced for fish farming by the Agricultural University of Sokoine. Seven out of the ten fish farmers were interested to participate in the project while other interested farmers had to be identified to achieve revised project objectives. A discussion was held with experienced fish farmers and interested individuals to asses constraints and to be able to formulate an effective extension message and extension activities, the methods of which are given in the following sections.

2.1 On farm trials

2.1.1 Extension message

Farmers interested in fish farming were initially given basic technical information and the risks involved were explained , in order to assist them in making a balanced decision whether to start fish farming or not. Participating farmers were given technical assistance and assistance in securing fingerlings. Assistance to secure fingerlings was only given during the initial stage of the project. No materials, cash, or credit were provided by the project. During the introduction process ample time was given to explain why certain techniques were advised. Depending on the specific physical and socio-economic situation of the participants, farmers where free to deviate from these guidelines.

It was the intention of the project that ponds should be constructed and operated without any initial capital investments. Tools and materials needed for these processes were expected to be locally available. Only in a later stage when the activity would prove to be economically viable, farmers could decide to improve the fish farming system using financial inputs.

Field observations revealed that under local conditions the following minimum requirements for ponds could be expected to give good results. The team advised farmers to construct ponds with a surface area of at least 100 m^2. Ponds were preferred to be located on gently sloping terrain with a depth at shallow end of 0.5-0.8 m., and at the deep end 0.8-1.2 m. Freeboard was advised to be 0.2 m. Further, the ponds should have a control mechanism on the water inlet and spillway if required by physical conditions, in addition it should be possible to drain the pond by cutting the dike. Information and explanations how to construct a fish pond with such requirements were described in ALCOM Extension pamphlet No. 1.

The species introduced for fish farming was *Oreochromis niloticus*. The guideline for the initial stocking density was maximum two fingerlings per m^2. Initially, the project had assisted the participating farmers in securing fingerlings at cost price, but it was anticipated that after some time farmers would produce their own fingerlings or obtain them from other fish farmers without assistance of the project.

As farmers had stated that animal manure was available, they were initially advised to add animal manure to their ponds in a compost enclosure using a quantity sufficient to develop a plankton bloom. However, after it became clear that a number of farmers in some areas did not have enough animal manure, these farmers were advised to apply green compost in an extended compost enclosure to enable fertilisation. It was recommended that the farmers fed the fish at least once a day

with maize or rice bran, in quantities to be increased as long the fish showed feeding behaviour.

Guidelines used for fertilisation and feeding were derived from The ALCOM Extension Pamphlet No. 2, "How to Feed Your Fish." ALCOM Extension Pamphlet No. 3 gave guidelines how to maintain the pond.

The farmers were initially advised to drain their ponds and harvest the fish after 6 to 8 months. The yield, using the above described management strategies for a 100 m^2 pond stocked with the maximum number 200 fingerlings, was expected to be 18.5 Kg (i.e. 3700 Kg/ha/y). This figure was based on a 75 percent survival rate at the end of the cycle, an average fish weight at harvest of 115 grams and approximately 500 fingerlings of 4 grams being produced.

After one cycle period it became clear that most farmers were not willing to drain their ponds completely for total harvest and restocking although in initial discussions they had agreed to do so. Reasons why they changed their minds are discussed in section 3.2.4. As an alternative the project introduced several harvesting methods (cast net, lift net, fyke, seine net) which could be used by these farmers for partial harvests.

2.1.2 Monitoring of the adoption of aquaculture technology

Group discussion between fish farmers and the team were carried out to retrieve information about farming activities. Different activities in fish farming such as; site selection, pond management, control of predation, fingerlings production and distribution and harvest methods were discussed as well as a variety of socio-economic issues (see Appendix 1).

In 1995 all farmers who had started fish culture were requested to record the type, amount and frequency of feeding and fertilisation in order to measure adoption of fish farming. In addition, they were requested to record the date and number of fish harvested as well as other experiences like predation and fish mortality. Data was received from six farmers, unfortunately the data given for the amount and frequency of fertilisation and feeding was found incomplete or unreliable. Therefore, in September 1996 the team prepared five questionnaires (see Appendix 2) to collect more data and information on the fish farmers and the different aspects of fish farming.

The five questionnaires covered the following topics:

General information of the fish farmer

The farmers were asked to give information about the household composition, farm size and their sources of income with special attention to agriculture and animal husbandry. In total nineteen farmers were interviewed.

Pond construction

Farmers were interviewed about different aspects of the construction process. This included the labour and materials used and their cost, and a variety of data related to the physical situation of the pond. In total fifteen farmers were interviewed.

Pond management

This questionnaire was made to obtain more information about fertilisation, feeding and water management. Of each topic the source, frequency, quantity and labour aspects were documented. In total nineteen farmers were interviewed.

Fish production

With this questionnaire information was collected from thirteen farmers. Questions were asked about the last time the farmer harvested his/her fish pond. This involved the harvest method and number of fish collected, the labour investment and the disposal of the fish. To be able to estimate the quantity of fish harvested the farmers were shown a sheet displaying pictures of seven different sizes of fish ranging from 3.9 g. to 441 g. Farmers had to point to the size of fish they collected and give their number. The average weights for the seven sizes of fish were calculated from the length-weight relationship $W = a L^b$ in which $a = 1.32*10^{-4}$ and $b = 2.63$. The given relationship was computed using length and weight recorded from 582 tilapia.

Fingerling production and distribution

In this questionnaire farmers were asked about fingerling production, the last time they bought or sold fingerlings and their experiences concerning transportation of fingerlings. In addition, farmers were asked about their experiences with predation and theft. Five farmers were interviewed using this questionnaire.

As it was too time consuming to do all five questionnaires at one time it was decided to conduct only questionnaires which were most applicable to the fish farmers current situation. That meant, a questionnaire of a certain topic was only used if the farmer just had experienced the activities the questionnaire was dealing with.

In addition, the team documented observations made in the field. These direct observations were an important way to triangulate the information of the questionnaires and farmer records.

2.2 Extension Activities

A variety of communication channels was used in the extension process. In the following paragraphs a distinction was made between channels to arouse the interest of the target group for fish farming and channels to deliver knowledge about fish farming.

2.2.1 Communication channels used to arouse interest of the farmers

Few rural farmers actively sought for information about new technologies that could be useful for them. As a consequence any extension agent had to first find ways to arouse interest of the farmers before actual knowledge was delivered. The channels used to arouse farmers interest included:

The village authorities

In each area the project team first visited the village-, ward- or division authorities to inform them about the project objectives, the approach and the intended target group. The authorities concerned were requested to assist the project to make a first contact with the target group. The usual way to

arouse the interest of the farmers by the village authority was to address the subject during a large gathering in the market or church or during a village meeting. Another way to reach the target group was to inform the settlement leaders who called for a meeting about the subject in their respective settlements. The settlement leaders informed the individual farmers directly or through ten cell[4] leaders. Following the announcements, interested villagers could meet the team to hear more about the project and to discuss fish farming in more detail.

Village announcer using drum

Some villages in Morogoro region had one or more persons responsible for delivering announcements to the people. During the process this person walked around in the village, particularly during the evening or early morning (when most villagers were at home), beating a drum to attract the attention of the villagers. After alerting the farmers the announcement was given. Drum beating was successfully done in one village which was not selected for on-farm trials. Due to the fact that this village was only visited in the latter stages of the project this positive experience could not be applied in the other areas.

Poster

A poster was used to arouse the interest of the farmers. It was placed at different meeting centres or places where many people passed, and informed farmers about the introduction meeting. For easy understanding, the language, information and pictures on the poster were kept simple. Posters were only used in Tangeni, the last area were the project started working.

Letters

After fish farming had taken off, fish farmers in some villages formed a farmers group. A typical group consisted of the fish farmers in an area, a chairman and a secretary, One of the responsibilities of the group secretary was to inform members about a scheduled meeting by sending a letter or by transferring the message orally.

2.2.2 Communication channels used to deliver knowledge to the fish farmers

Different communication channels were used to deliver fish farming knowledge to the interested farmers. When such a channel was used for the first time an introduction was given on what ALCOM was doing, its objective and the main idea of the project. This was to give a clear picture about the project and to enable farmers to decide whether to participate. The following channels were used to deliver knowledge to the farmers.

Agriculture Extension Officers (AEO)

The AEO's working in the respective areas were requested to assist in delivering fish farming knowledge and to help farmers to make decision whether or not to adopt fish farming. All AEO's in the farmer trial areas attended a two week training course organised by ALCOM which familiarised them with fish farming and extension methodologies. It was thought that since AEO's, unlike

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[4] A ten cell was the lowest administrative level, comprising of at least ten households. A settlement comprise of several ten cells.

Fisheries Officers, were found in almost all villages, it would be useful to train them so they could assist in fish farming extension.

Slide show

During the first village meetings a slide show was conducted to improve the understanding of fish farming. Since some farmers had practised fish farming before or had seen or heard about it from other farmers, the discussion was participatory and active. The team introduced knowledge using the slides and facilitated the discussion by asking questions.

Pamphlets

These were manuals in booklet form explaining different aspects of fish farming using both text and pictures. ALCOM extension pamphlet No's. 1, 2, and 3 developed in Eastern Province, Zambia were translated into Kiswahili. Pamphlet No. 1 provided information on "How to construct your fish pond", No. 2 "How to feed your fish" and No. 3 "How to take care of your fish pond".

Group discussion

In each area fish farmer groups were organised to discuss issues related to fish farming. These groups started in most cases from either farmers' own initiative and in some cases with minimal assistance from the team. In Mgeta and Kinole areas farmer groups already existed for other agricultural activities and transport of crops.

Team's field visit

The team visited each trial area once every two weeks during the first stages of the introduction process, in later stages this frequency was reduced to once per month. This enabled the team to follow up what farmers were doing. A typical field visit included;

- introduction with the farmer;
- interviewing the farmer on his experiences over the passed period;
- reviewing the status of pond, occasionally using a seine net or cast net to monitor fish growth;
- taking records using farmers data sheet (see Appendix 3);
- discussing with the farmer the problems encountered during the passed period;
- educating (informing) the farmer about specific issues;
- giving advice on how to the improve fish farming system.

Farmer-to-farmer extension

All farmers who adopted fish farming got technical training on fish farming through group meetings, group discussions and frequent field visits by the ALCOM team. It was anticipated that farmers would pass this information through to other farmers.

Field visit or farmer-to-farmer visit

In each area a day was organised for interested fish farmers to visit ponds of colleague fish farmers together with the team. At the pond side different aspects were discussed and demonstrated, for instance colour of the water, construction of dikes, the use of compost enclosures, integrated farming system etc. This was followed by identification of ponds where this new knowledge could

be introduced. Together with the owners and the other farmers these ponds were visited and the situation reviewed in respect to the new knowledge.

Newsletter

In mid 1995 a newsletter was launched. It aimed at delivering specific information to the farmers. The newsletter was of two pages having pictures, data from the trial areas and new technical information. By the end of 1996 five newsletters had been issued. Subjects covered in the newsletters were; fish farming in Mgeta and Malolo, harvest by draining, control of predation and high quality fingerlings production and management. After each newsletter a follow up was made to see whether farmers read and understood the newsletter. If farmers had questions about subjects covered in the Newsletter then these were discussed individually with the farmer or in the next group discussion.

3 FINDINGS AND DISCUSSION

During the course of the extension work the work plan and extension message were changed several times. Initially it was anticipated to work closely with ten established semi-intensive fish farmers. When there only appeared to be few of them, the project objectives had to be revised as discussed in the first chapter. In addition, the collection of production data from farmers became complicated and fragmentary when many farmers decided not to drain their ponds for complete harvests. Further, two years of extension work were judged by the team as insufficient to do a proper research under the conditions mentioned. Due to the above reasons only little data could be collected which in most cases was insufficient conduct a proper statistical analyses.

The information in section 3.2.4 about fish production was compiled from data collected in 1995 while most of the other data in this chapter was based on interviews executed in September 1997 and experience gained during the course of the extension work.

3.1 General information of the participating farmers

In September 1996 in total nineteen farmers were interviewed; seven from Mgeta, three from Malolo, five from Tangeni, and four from Kinole. No farmers were interviewed from Matombo. Eighteen were male including one boy, and one was female. The average household size was higher in Mgeta than in all other villages and was closely followed by Malolo and Kinole. Data for household size were not available for Tangeni and Matombo. The average farm size was larger in Malolo (2.7 ha) followed by Tangeni (2.2 ha) and Kinole (1.3 ha). Mgeta had the smallest average farm size (0.9 ha) (see Table 1).

Table 1: Total number of farmers interview, average household and farm size of the trial.

Village	Male	Female	Farmers interviewed	Average no of adults in household	Average no of children in household	Average no of members in household	Average farm size (ha)
Mgeta	6	1	7	2.8	6.3	9.1	0.9
Malolo	3	0	3	4.3	4	8.3	2.7
Tangeni	5	0	5	-	-	-	2.2
Kinole	4	0	4	2.3	4.3	6.6	1.3
Matombo	-	-	-	-	-	-	-
Total/mean	18	1	19	2.1	5.2	8.2	1.6

Information about the cash income generated by the farmers through agriculture, animal husbandry, trade, employment, handicraft, and fish farming for the interviewees was used to calculate their yearly income. Table 2 shows the relative value of each of the income generation activities for all interviewed farmers.

Table 2: Sources of income for the farmers as a percentage of fish farmers' total income in the trial Areas, 1996.

Areas	Agriculture	Animal husbandry	Trade	Casual Labour	Employment	Handi-craft	Fish farming	Others
Mgeta (7)*	32	19	1	1	40	1	3	3
Malolo (3)	76	22	0	0	0	0	2	0
Tangeni (5)	51	2	2	6	39	0	0**	0
Kinole (3)	69	0	24	0	0	7	0	0

* The number of farmers was given in parenthesis ** Fish farmers had not yet harvested their ponds but already had sold some fingerlings.

The relative importance of fish farming in terms of cash was rather low with only 2-3 % in Mgeta and Malolo while in September, 1996, farmers in Kinole and Tangeni had not yet reached the stage to sell their fish. Because of the fact that a few economically strong farmers had a large effect on these figures, as they earned large sums of money through permanent employment, and some farmers had not yet had the opportunity to harvest their ponds, an alternative method to determine the importance of fish farming was used. Table 3 gives the relative importance per activity for the interviewees who were involved in this cash earning activity.

Table 3: Sources of income for the farmers involved in the activity as a percentage of fish farmers' total income in the trial areas, 1996.

Areas	Agriculture	Animal husbandry	Trade	Casual Labour	Employment	Handicraft	Fish farming	Others
Mgeta (7)*	46 (7)	20 (3)	22 (2)	4 (1)	67 (2)	29 (1)	8 (6)	20 (2)
Malolo (3)	83 (3)	46 (1)	-	-	-	-	6 (1)	-
Tangeni (5)	72 (5)	17 (1)	16 (1)	11 (2)	87 (1)	-	1** (1)	-
Kinole (3)	62 (3)	-	48 (2)	-	-	16 (1)	-	-

* The number of farmers was given in parenthesis. ** Fish farmer involved had not yet harvested his pond but already sold some fingerlings.

The relative importance for cash generation for the fish farmers who had sold fish was between 6 and 8 % of the total income. The explanation of why these figures were low was that a rather big share of the fish harvested was consumed by the farmers themselves as will be discussed in section 3.2.4, and because of the fact that only a few of the farmers harvested the fish from their pond.

Fish farmers in Malolo had the highest average income per farmer per year (TSh. 695,000)[5] followed by Tangeni (TSh. 305,300), Mgeta (TSh. 281,513) and finally Kinole (TSh. 137,333). In Table 3 the percentile contribution of the sources of income for the five areas is given.

Table 4: The most important cash crops and their relative value (%) of the total cash earned out of agriculture for the different areas.

Area	Cabbages	Beans	Banana	Maize	Tree seedlings	Onion	Rice	Mango	Sugar cane	Coconut	Green Pepper	Oth
Mgeta	36	14	11	11	7							21
Malolo		9	3	2		51	31		1			4
Tangeni			28	4			18	13	11		5	21
Kinole			7				34	18		14	11	16

In all areas a large proportion of the farmers income was generated by agriculture activities[6]. The crops grown and their contribution to farmers total income differs from one village to another. The relative importance of the most important cash crops for each of the areas was given in Table 4. Cash earned from animal sales was also an important source of farmers income. In Malolo the number of cattle and goats was high. Most of these were owned by a few wealthy farmers who kept between 20-50 head of cattle and up to 100 goats. Pig husbandry was a popular activity in Mgeta where most farmers kept one to three pigs. In Kinole and Tangeni very few animals were raised. Income was generated through the sale of cattle, goats and chickens in Malolo through sales of pigs, goats and chickens in Mgeta while farmers in Tangeni only generated income by selling chickens. No cash was earned from animal sale in Kinole. Trading of household articles also featured as an important cash earning activity in Kinole, Mgeta and Tangeni.

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[5] At the time of study US$ 1 = Tsh 600.

[6] Except for two farmers in Mgeta who were employed as agriculture officers and one farmer in Tangeni employed as a watchman.

3.2 Adoption of aquaculture technology

3.2.2 Pond construction

During 1994-96 the project had worked with 40 farmers who adopted fish farming and constructed 47 fish ponds. The total pond surface was 6440 m^2, the average 154 m^2. The number of farmers participating in the project, the number ponds and average pond sizes for the five areas are given in Table 5. The average pond surface of 90 m^2 applies to Matombo if the biggest pond with a surface of 806 m^2 was disregarded.

Table 5: Number of farmers participating in the project, number ponds and average pond sizes for the five areas (September 1996).

Area	Number of farmers	Number of ponds	Average pond size (m^2)
Mgeta	15	19	100
Malolo	7	9	200
Tangeni	8	9	106
Kinole	5	5	138
Matombo	5	6	201
Total/mean	40	47	154

Although farmers were advised to construct ponds with a minimum size of one are (100 m^2) a considerable number (43 %) constructed was found to be smaller. Some of these however, were farmers' second pond, not meant for production but for storage of fingerlings. The main reasons limiting the pond size were lack of sufficient land close to the homestead, and in the villages surrounding the Uluguru Mountains, the slope of the terrain. Further limiting factors were availability of water and cash to hire labour for construction.

Ponds made by hired labour, generally bigger in size, often had leaks due to poor compaction of the dikes. Although the owners were advised to emphasise good compaction, this was not done by their labourers. Reasons were:

- Labourers did not attend meetings organised by the team and often were not instructed properly by the owner of the pond.
- Compaction of dikes was usually not included in the contracts. After the team had identified problems relating to this subject labourers were usually not willing to change the work plan.
- Hired labourers were generally less committed to the work than family labour as they did not benefit from the results of their work.

The owners with leaking ponds had to make considerable effort to improve the dikes afterwards. Often this included compaction and adding clay soil in combination with an excessive supply of water to clog the leaks. Lack of suitable land forced some farmers to construct their pond in areas with many stones and rocks. Instead of removing small stones from the pond site, they were added to the dike to speed up the construction process. Big rocks were sometimes ground with a hammer and integrated into the dike as were old tree trunks and banana stems for the reason mentioned above. In most cases these materials caused leaks which were difficult to repair and gave the farmer continuous problems to maintain the desired water level.

Ponds in Mgeta and Tangeni and Matombo were constructed next to the homestead while in Malolo and Kinole most ponds were constructed within 1000 m. of the family compound.

Tools used for pond construction such as a hoe, a spade and buckets were usually already possessed by the farmer while a pick and a hammer (used for crushing big stones) could be borrowed locally. The wooden poles to compact the dikes, used by the majority of starting farmers were home made. Materials used the pond itself were usually limited to inputs which were directly locally available i.e. bamboo stems and banana leaves for the water inlet and overflow, bush rope or alternatively sisal rope and sticks for the construction of the compost enclosure. Three farmers however had made an investment which required financial inputs. These pertained to two farmers installing PVC pipes of which price varied from just TSh 300 to 8000 and one farmer who used iron sheet to guide pig excreta from the pig pen into the pond.

When ponds were drained, less than one hour was spent on pond maintenance. This activity was carried out by the whole family. Only one farmer stated he hired labour to maintain the pond after total drainage. In this case TSh 3000 was paid for the work. After the first cycle a few farmers decided to add new structures to the pond like pipes for drainage and a fence for security. The participating farmers doing so spent on average TSh 10125.

Water supply

The availability of water dominated the selection of the areas. In many parts of Morogoro Region water was not available in sufficient quantities for aquaculture. Irrigation schemes were few in number, limiting the area suitable for aquaculture to the higher mountain ranges. In the areas surrounding the Uluguru Mountains water was utilised from mountain streams which was channelled to the farms, in Malolo the water supply was taken from an irrigation channel.

3.2.3 Pond management

Fertilisation

Initially the project had encouraged the use of animal manure to fertilise ponds. Nearly all farmers constructed a compost enclosure inside the pond with a surface of between 1 and 2 m^2 regardless of the pond size. After it became clear that animal manure was often not available in sufficient quantities this strategy was changed and farmers were advised to increase their enclosures to about ten percent of the pond area. This was to allow larger quantities of plant matter to be composted inside the enclosures for optimal fertilisation. Nineteen farmers were interviewed about their fertilisation activities. All farmers stated the used animal manure with an average application of nearly one time per week. Manure was applied by farmers in Tangeni most frequently (2 times per week) followed by Mgeta farmers (1.1), while fish farmers in Kinole applied animal manure only once in four weeks, and in Malolo the activity was repeated every one and a half weeks. To cross check the answers, the farmers were asked when they last put manure and when was the last time before that. Based on these data different frequencies where found, i.e. for Kinole 15.6, Mgeta 13.3, Malolo 13.3 and Tangeni 5 days between each application of manure. In Table 6 the frequency and quantity for each type of animal manure used are given using the answer of the cross-check.

It has to be noted that three of the four farmers interviewed in Malolo who stopped applying manure for a while, started to apply manure again just before the farmers were interviewed. Because of this the applications of cow manure recorded were rather high. Based upon the data given above

the average quantity of animal manure and nutrients applied per are per year were estimated. The results are given in Table 7. In terms of quantity and nutritional input ponds in Mgeta were best fertilised where nine out of ten farmers used pig manure and seven out of ten used goat droppings. Kinole farmers fertilised as much as Malolo farmers but the nutrient inputs were higher because of the type of manure applied, i.e. goat droppings vs. cow dung. In all areas the manure used was taken from the farmer's own farm or from a neighbouring farm. Three of the interviewed farmers stated they have bought manure from other farmers.

Table 6: Frequency and quantity of animal fertiliser used by the farmers applying in the different areas.

Area	Source of animal manure	% of farmers applying	Integrated with pond**	Frequency (days) (STD)		Quantity (l/are) (STD)	
Mgeta (9)	pig	89	50 % of farms	9	9	21	19.3
	goat	67	-	17	16	16	11.8
	chicken	33	-	21.8	28.8	6	21.2
	duck	11	-	1	-	0.27	-
	sheep	11	-	14	-	40	-
Malolo (4)	cow & goat mix	75	-	13.3	2	130*	120
Tangeni (2)	goat	50	-	4	-	10	-
	chicken	50	-	6	-	4	-
Kinole (4)	goat	75	-	15.6	11	45.6	28.4

* Malolo fish farmers had only restarted applying manure shortly before the interviews were taken. ** Livestock housing located on top or near of the fish pond..

Table 7: Total quantity of manure and nutrients applied per are per year.

Area	Quantity (m^3/are/y)	N (Kg/are/y)	P_2O_5 (Kg/are/y)	K_2O (Kg/are/y)
Mgeta	1.9	24.8	11.7	20.3
Malolo	0.4	2.1	1.7	1.8
Tangeni	0.2	3.8	3.5	2.3
Kinole	0.4	10.0	3.6	8.6

Levels of P_2O_5, which is often the most limiting factor in pond culture, estimated for Mgeta were higher than recommended by Auburn University. Auburn University recommended[7] a weekly application of 1.25 -1.75 g P_2O_5 per square metre which was 6.5-9.1 P_2O_5 Kg/are/y. The estimated levels for P_2O_5 applied in Malolo, Tangeni and Kinole were considerably lower.

Fertilisation was generally good during the first year of extension, creating a good plankton bloom in many ponds. Despite large quantities of cow dung freely available in Malolo, ponds were slightly less well fertilised than the ponds in Mgeta where there was a high demand for pig manure. Reasons for the better performance in Mgeta were firstly the short distance between the pond and the homestead which eased management and secondly, it was stated by Mgeta farmers that due to diseases their cabbage production had been reduced in the last few years which forced them to deviate their time and effort to other activities like fish farming.

In Kinole and Malolo none of the farmers kept animals in the immediate vicinity of the pond. In Mgeta half of the fish farmers kept one or more pigs close to the pond site, some farmers shifted the pig pen to the dikes for an easier supply of excreta to the ponds. The integration of pigs was however not complete as the excreta and manure do not automatically drop into the pond but still need to be carried to the pond. These farmers decided not to put the pen above the pond because this was technically difficult and it ruled out the possibility to use the manure for other activities.

[7] Chemical Fertilizers for Fish Ponds. International Center for Aquaculture and Aquatic Environments, Auburn University.

Farmers in Mgeta and Malolo had at least periodical access to sufficient quantities of animal manure, while their colleagues in Tangeni, Kinole and Matombo had only limited access. Over three quarters of the farmers in Kinole and Mgeta said fish farming competes for the manure with other farming activities. Here animal manure was used in gardening. During and just before the preparation of the fields animal manure was temporarily not or less available for fish farming. In addition, Kinole fish farmers had less access to manure as animal husbandry was not widely practised. Farmers here indicated that it was not possible to increase the application of animal manure while their Mgeta colleagues felt this was a minor problem. Only half of the Malolo farmers experienced competition for the animal manure they were using. Those who did, utilised the manure in their gardening activities. Most of the farmers, however, thought that they had access to enough manure and were able to increase the quantity of cow dung used to fertilise the pond when needed.

Availability of animal manure not only differed strongly between the different areas but also between the farmers in the areas. It may be obvious that the fertilisation strategy to be adopted had to be fine tuned with the local situation of the farmer. That meant that where animal manure was available it could be used pure or with addition of 'green' compost. In this case the compost enclosure only needed to be small in size, 1-2 m^2 for a one are pond. To avoid clogging and to enable the free flow of nutrients released into the pond the animal manure added needed to be stirred with a stick daily. During farm visits by the team it was often observed that farmers took considerable effort to fill the compost enclosure but failed to turn it on a daily basis. This resulted sometimes in sub-optimal plankton bloom.

In case animal manure was not available or not sufficient other sources of fertiliser needed to be utilised. Although animal excreta were commonly preferred above green compost, fertilisation through compostation of plant matter could also improve fish production considerably. Compostation of plant matter however requires a larger compost enclosure (10 % of the pond surface) for comparable nutrient application. Since the second half of 1996 farmers were therefore advised to increase the compost enclosure and to increase the application of larger quantities of green compost. Many farmers followed the idea and enlarged the compost enclosure and started applying plant matter. Although the exact effect of these measures has not been quantified. The following were preliminary experiences derived from the interviews. Seven out of the nineteen farmers started putting plant matter in the enclosure which was done on average about once in nine days. Whetherfarmers put green compost in their enclosure depends strongly on the distance between their homestead and the pond and the availability of animal manure.

In general farmers tended to put only very little plant matter into the compost enclosure, usually this was less than ten percent of the enclosure volume while locally available unused agricultural by-products or vegetation and grasses were abundant. In Kinole, however, farmers tended to fill the compost enclosure totally and noticed that the fish thereafter stopped eating yams leaves usually fed to the fish. It was argued by these farmers that the fish were already satisfied by the green compost they had found inside the enclosure.

The plant matter which was freely available to all farmers was usually collected in the direct vicinity of the pond either on the same or neighbouring plots. Despite its wide availability, about a quarter of the farmers felt that there was competition for the plant matter used with other farming activities. In these cases the material was also used for the feeding of the animals, pigs in Mgeta, goats in Kinole, while the sweet potato shoots used for this purpose in Tangeni were seasonally used for planting. Just over one third of the farmers stated that they had enough access to plant matter and

were able to increase the quantity to fertilise the pond if needed.

It was important for all types of enclosures to be installed that the fish should be allowed to move freely in and out to be able to forage on it's contents. The spaces between the sticks forming the enclosure should be therefore at least 10 cm. and the enclosure should be loosely filled.

Improvement of pond fertilisation not only can be accomplished by optimal use of the sources available but also by stimulating the adoption of animal husbandry to increase manure production. In this respect ,after introducing fish farming several farmers in Mgeta and in the other areas surrounding the Uluguru Mountains started raising extra animals for the sake of manure production. In this way the project had not only boosted protein production in the form of fish but also in the form of domestic animals.

Feeding

All participating farmers fed their fish. The most preferred feed was maize bran, (defined here as the bran coating and the maize germ) followed by rice bran. Few farmers fed the leftovers from the kitchen, mainly from the staple feeds (rice, stiff porridge, yam, potato etc.) and leaves from cabbage, papaya, yams, potato and cassava. In Table 8 the source and the percentage of farmers using these types of food sources are given. The fish were fed between once per week and three times per day with an average of twelve times per week and the quantity given varied from 1 to 2 litres per are per feeding time.

Table 8: Type of the fish feeds used in the trial areas, September 1996.

Area	Type of feed	Percentage of farmers using
Mgeta (9)	maize bran	89
	kitchen leftovers	22
	leaves (papaya, yam, cabbage)	22
Malolo (4)	maize bran	100
	rice bran	25
	brewery left over (maize bran)	25
Tangeni (2)	maize bran	50
	rice bran	100
	leaves (sweet potato)	100
	fruits (local mango)	50
Kinole (4)	maize bran	75
	rice bran	75
	leaves (yam, cassava)	25

Most farmers (95 %) experienced competition for the use of feeds with other farming activities. Maize bran was most commonly used to feed livestock or in local brew production. Despite this, maize bran was the preferred fish feed, mainly because farmers thought it was more nutritious than other feeds. Several farmers indicated they had purchased the maize bran in periods of the year when it was less available on the farm (November-May) for prices varying between 8-15 TSh/l, resulting in relatively high feed costs (i.e. TSh 5,220-11,160 per year). Reduction of feeding cost and competition with other farm activities could easily be accomplished by replacing the maize bran in times of shortage with other feeds such as rice bran which was always freely available and only difficult to obtain during the months of February to May. Relatively little use was made of other alternative feeds, like local brew waist and plant leaves.

Further, the team had noted that a number of farmers fed their fish properly but paid little attention to fertilization, even when manure was available. Feeding in absence of fertilization

had only limited effect on the growth of fish as the feeds used were usually nutritional deficient and only supplemental fo natural food. Addition of manure to develop the natural food production increased the effect of feeding and was therefore recommended.

Water management

Just over 25 percent of the farmers added water to the ponds continuously and one farmer did not have to add any during the wet season because the pond was automatically refilled by the high water table. Farmers who had to refill did this on average every 2.6 days. Farmers in Tangeni and Kinole added water most frequently, once every day (in Kinole three quarters of the ponds get water continuously). Farmers in Malolo added water on average only once in 5.5 days and Mgeta (2.6). Close to three quarters of the farmers reported to experience competition for water. Water shortage occurred during the dry season when especially gardening demanded a large amount of water.

3.2.4 Fish harvesting

From the beginning the team had discouraged farmers from installing outlet structures, such as PVC pipes, as these often require financial inputs and can cause leaks if not properly installed. Alternatively, farmers were advised to simply cut the dike and drain the pond to collect the fish. Many farmers however did not follow this advice and decided to harvest the fish using nets. The intention of both harvest methods was rather similar i.e. to harvest as much fish as possible regardless of the number of fish left in the pond. Due to this, most of them lost track of the number of fish in their pond.

In discussions with the farmers the following reasons were found to explain this behaviour:

- Lack of understanding of why and how to drain a fish pond. Many farmers stated that they did not like to drain the pond because they thought they would lose the fertile water undoing all their fertilisation efforts. In reality this was not the case as most nutrients were bound to the pond bottom and can be released at a later stage. This was clearly demonstrated by a farmer in Matombo, after he had drained, harvested, maintained and refilled the pond his pond developed a plankton bloom within three weeks with only minimal fertilisation efforts. Two neighbouring fish farmers were apparently impressed by the results and followed his good example.
- Another reason for not draining the pond was lack of time.. Farmers gave their first priority to the traditional crops.
- Some farmers had their own nets to harvest, others used the net from colleague fish farmers (although these were usually reluctant toloan them) or had used the project seine. The project net was not used with the intention of harvesting the fish for consumption, but to check the growth of the fish. In many cases however the owner decided to keep the fish. Harvesting fish this way had taken away the incentive to do total harvest by draining.
- Lack of fingerlings or a high price of fingerlings to restock the pond. For unknown reasons several farmers were not able to reproduce their tilapia, others were not able to store the fingerlings for the short time they had to dry the pond. Generally, fish farmers preferred to rely solely on their own fingerlings and avoided buying from colleagues as prices usually were very high (TSh. 30-100 a piece while initially they had bought the fingerlings for TSh 8 only). Even when fingerlings were available and reasonable prices could be negotiated the harvest posed a problem as many farmers did not have the means to harvest these

fingerlings in good condition.

- Insufficient water to refill the pond immediately after draining and therfore a loss of valuable culture time.
- Some farmers who had drained their pond faced disappointing yields (due to predation), which demotivated other fish farmers to follow their example.
- For some farmers it was apparent that they kept the pond as a status symbol which according to them ought to contain many fish rather than lying dry in the sun.

Recognising these problems the team modified their extension message and activities in the following ways:

- More emphasis had to be given how and why to drain ponds. Explanations had to be given step by step at the pond side following, for example, an indicative test fishing. Information exchanged in the discussion with the farmer included; where to cut the dike, what material to use, at what day and time, how long to dry the pond etc. It was expected that once few farmers had practised a total drainage others would follow.
- To avoid farmers becoming dependent on the team for harvesting, the project seine net was replaced by a cast net. This way farmers only could take small amounts of fish leaving the incentive to adopt total drainage or alternatively to adopt or develop partial harvest methods which were more sustainable.
- To enable farmers to collect the fingerlings from their ponds the project introduced lift nets which can easily be made using locally available materials. After the lift nets were introduced this problem was solved. No measures were taken by the team to reduce the price of fingerlings as it was expected the price would drop automatically after more farmers market excess fingerlings.
- Discussions were held with farmers who faced a disappointing harvest, the reasons of the low yield were identified and the farmers encouraged to continue. The team stressed that in their case it was a better decision to start over than to continue in the same manner.

First results of the above revised extension strategies initially showed promising results but require more time to study their effectiveness.

Farmers not able to drain their pond or farmers facing, for example, serious problems such as lack of sufficient water to refill the pond, were advised to make more frequent partial harvests. This production system was expected to suit the demands of these small scale farmers better because:

- Fish would become more frequently available for home consumption and in this way improvethe diet of the farmers.
- Fish would become more frequently available for marketing and provide the farmer a small but regular income.
- The culture system was relatively easy and required less planning and labour.
- Farmers would be independent for fingerlings from others as they continuously produced fingerlings themselves.
- Frequent harvests rather than complete harvests after longer periods might stimulate the farmer to good management. This effect was already demonstrated by the team using a cast net during test fishing. Some farmers who had dropped good management picked it up again after being surprised by the size and number of fish in their pond.

Disadvantages of this system were expected to be the development of a stunted fish stock

which would result in sub-optimal production. Further, it was expected that this strategy would be less productive than a strategy which included a total drainage and restocking. Whether this is indeed true remains to be investigated.

During the first production cycle all farmers were requested to record their management activities and the fish yields. The production figures received from ten farmers were given in Table 9.

From the 10 farmers of which the team collected production data three (farmers 8-10) had actually harvested their pond totally while the others decided not to do so. From the information of the on farm trials it was difficult to draw conclusions which of the two systems was the best in terms of production as it was not known which part of the fish remained behind in the partially harvested ponds. These ponds might have been harvested below or beyond their carrying capacity and so have given a misleading picture. Follow up of the ponds after the cycle showed that some extent of stunting of fish had occurred in the ponds of farmers 1, 3, 6, and 7 while the ponds of the farmers 5 and 6 had to be drained and restocked after it became clear that too few adult fish remained and fry appeared to be predated by aquatic frogs. Also was it difficult to draw conclusions about the effect of feeding and fertilisation as no quantitative recordings were made. Two of the totally harvested ponds (8 and 9) which were managed well had an estimated annual production per are which comes close or even exceeds the expected production of 37 Kg/are/y. These results were very promising. Unfortunately these farmers were not able to repeat these results in the next cycle as farmer 8 wasdiscouraged by the results and delayed restocking due to unavailability of fingerlings, while farmer 9 did not properly restock his pond resulting in poor performance.Moreover, due to the small sample size and the large variation in the data no statistical difference between the two methods could be shown.

Table 9: Yields per are per year for 10 fish farmers following different strategies in the trial areas.

Harvesting strategy:	Partial harvesting							Total harvesting		
Farmer	1	2	3	4	5	6	7	8	9	10
Area	Malolo	Malolo	Mgeta	Mgeta	Mgeta	Mgeta	Mgeta	Mgeta	Mgeta	Mgeta
Distance from homestead	Close	Far	Close	Close	Close	Close	Close	Close	Close	Close
Stocking density (no/are)	200	192	189	133	163	171	200	220	200	220
Stocking date	01/12/94	01 12/94	29/12/94	29/29 94	22/12/94	22/12/94	05 05 95	28/08/95	28 08 95	06/02/96
Number of harvests	5	4	5	3	3	3	3	3	1	1
Feed type	maize	maize	maize	maize	maize	maize	maize, leaves	maize, leaves	maize, leaves	maize
Feeding*	+	+	+	+	0	-	0	+	+	0
Fertilisation*	0	0	0	+	-	-	0	+	+	0
Manure type	cow	cow	pig	pig, goat	pig, goat	pig	pig**	pig, market waste	pig**	pig
Duration (year or no. days)	Year	Year	Year	Year	Year	Year	216	217	192	240
Yield (Kg/are/y)	33.1***	13.8***	18.8***	10.0***	9.6***	20.6***	29.1***	33.2	39	1.7

* Based on teams observation, + = Good, 0 = Fair, - = Poor. ** Pig farming integrated with fish culture. *** Unknown what part of the fish remained in the pond.

In addition to the pond data in Table 10, twelve farmers were interviewed about the last time they harvested fish from their ponds, either by total harvest by draining (5) or partial harvest (7). Partial harvests yielded on average 3.8Kg/are while 6.0 Kg/are was harvest bycomplete harvest. The latter

figure was rather low as often partial harvests had preceded the total harvest. Fish farmers who partially harvested their pond did so three to five times per year, with an average of 3.7 as was calculated from Table 9. The average fish weight from partially harvested ponds was 108 grams. Nearly 65 % of the number of the fish partially harvested weighed between 70 and 151 grams). Fifty percent of the harvested fish was given away within the extended family (Figure 2). As all fish including the juveniles were collected in a total harvest the average fish weight (59.6 g) was less than in the partial harvests. The majority of the fish harvested during total draining was sold (Figure 3).

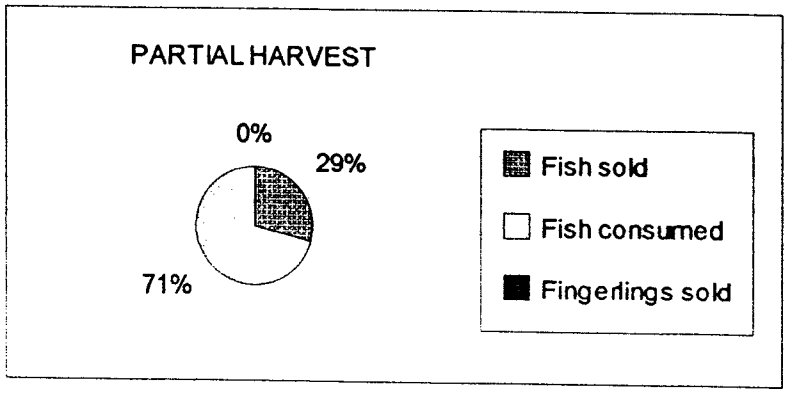

Figure 2: Uses of fish of partially harvested fish ponds.

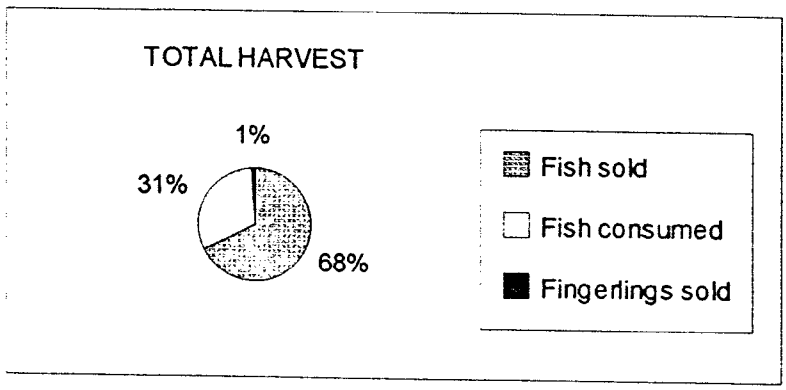

Figure 3: Uses of fish of totally harvested fish ponds.

The difference between the proportions of the yield could be explained by the fact that the amount of fish from partial harvests only met the family's needs and did not allow for sales. The main purpose of a total harvest was to generate cash income through the sale of fish, hence less fish could be given away.

During the interviews the team could not detect any favouritism regarding the size of fish consumed by the family. i.e. small and big fish were equally distributed between family members. The duration of time needed to harvest the pond was 1 hour for a partial harvest and 6 hours for total harvest.

3.2.5 Predators

Some farmers in Malolo and Matombo faced unexpected problems with predators, especially otters. Otters were in fact reported to exist in all five areas. Five ponds in Malolo and one pond in Matombo, all located far from the homesteads, were severely predated by these animals.

Because of this, some of the farmers affected became demotivated and one even abandonedfish farming . Solutions given to the farmers by the team were to fence the pond with locally available material such as bamboo or putting a otter barrier[8] inside the pond. In Malolo the problem was solved by the farmers after they built fences while the fish farmer in Matombo, after unsuccessful attempts to eliminate the animal(s) using traps, also intended to construct a fence. Although special attention was given to the advantages of the otter barrier, none of the farmers was willing to introduce the barrier as, according to them, it restricted them from harvesting the fish by using nets. Ponds were also predated by other animals such as birds and aquatic frogs but never to an extent that this caused serious problems. Monitor lizards were commonly blamed for predating on fish although it was doubted by the team that this animal predated on live fish. To find out, one farmer caught nine monitor lizards but never found fish remains in their stomachs.

3.2.6 Fingerling production

to restock ponds, fingerlings had been taken from farmers' production ponds. Initially, this was done using seine nets, which often resulted in high mortality just after fishing and during transport or after stocking. To improve the fingerling harvest methods the team introduced lift nets. One lift net in each village was used to demonstrate its use and to give the farmers an opportunity to get experience with this method of harvesting. When successful, it was expected that the farmers would construct their own lift nets from locally available materials. The lift nets introduced proved to be very effective catching fingerlings and the survival rates while transporting in fish buckets over short distances and after stocking in new ponds were improved . It was however noted by farmers that the lift net lost it's effectiveness when the net was used too frequently and that it was not successful in catching larger fish. This is because larger fish easier escape the net, and fish demonstrate an avoidance behaviour when the net is used to often.

To avoid problems connected with stunting it was important that only young fingerlings were used for stocking. Young fingerlings could be selected from old ones by experienced fish farmers or be produced by the farmers if they collected the first generation fingerlings from a pond two to three months after these ponds had been stocked with fingerlings. For this purpose it was also possible to construct a small breeding pond where selected breeders could reproduce.

3.3 Effectiveness of extension activities

3.3.1 Methods used to arouse interest of the farmers

Extension methods used to organise village meetings were non discriminatory. People who were not targetted also joined the project. This group included progressive farmers, division, ward or village authorities and extension officers. They were prepared to purchase materials like cement, plastic pipes etc. even when it was not necessary or even when alternative materials were locally available. Due to this attitude, they had delayed the adoption of the activity in some areas. For instance one farmer did not accept the project idea of providing solely knowledge instead of other

[8] A otter barrier was a fence contructed inside the pond dividing it into several parts and allowing the fish but not the otter to move from one part to the other.

assistance such as cash. He managed to convince other farmers that the project was not worthy. Further, it created the impression that fish farming could only be adopted by wealthy farmers. To some extent, this was an obstacle for the intended target group to adopt fish farming.

Out of the 40 people who adopted fish farming only four were female. Reasons behind low adoption rate from women were:

- most women did not attend fish farming education meetings, therefore were not informed.
- even when they were informed, they did not own land, they had to ask for it from their husband or somebody else, and
- women were not decision makers regarding the farming activities and innovations.

Village Meeting

The village meeting was a very effective way to arouse farmers' interest as a majority of the target group could be reached easily. This method however, had the following disadvantages:

- In some cases the village or settlement authorities were not interested so they did not deliver the message. This was a good channel only when the village leaders were committed to their work.
- Sometimes the message was delivered to few farmers, mainly friends, relatives and well-to-do farmers thinking that they would benefit from the assistance in one way or another. Only few (1-2) women attended these meeting most likely because they were not informed.
- Several times the message was changed by village authorities and therefore created problems. The village authorities failed to tell the farmers the idea of the project especially when it came to inform them that no assistance in cash or kind would be provided. They also failed to explain what a slide show was instead they said it was a video show. Some farmers who came to see a video but saw slides instead were discouraged and went away.

Village Announcer

Drum beating, although a rare practice, turned out to be a very effective way of mobilising and arousing farmers interest as most people heard the announcement. This medium attracted many farmers including women to come to the introductory meeting.

Poster

The poster was also an effective way of arousing interest and inviting farmers to a meeting as many people could see it and read its message. Fifty five percent of the farmers interviewed, saw and read the poster (Michielsens, 1998[9]) and 36% of the second generation farmers remembered the poster. Posters had the advantage that they did not discriminate against certain groups.

Letters

Letters were another good way of arousing interest and inviting farmers to attend a meeting as it assured that the message reached the intended farmer. This channel was effective during the early stage of the project when few farmers needed to be informed. At the later stage however, it may become difficult to reach large groups of farmers by letters.

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[9] Michielsens, C., 1998. Study Of Semi-Intensive Fish Farming Extension In Morogoro Region, Tanzania. Universiteit Gent, Faculteit landbouwkundige en toegepaste biologische wetenschappen, 1998. p. @@.

3.3.2 Methods used to deliver knowledge to the fish farmers

Agriculture Extension Officers (AEO's)

AEO's provide agriculture extension support to farmers. Because of their country-wide coverage and location in villages, fish farming extension was thought to be improved by the use of AEO's. However, the AEO's were not co-operative for the following reasons:

- In Tanzania the sectors of fisheries and agriculture were the responsibility of two separate Ministries., No agreement for collaboration for aquaculture extension had been established between these two departments, and hence fish farming extension was not within the official responsibilities of the AEO's
- AEO's not only considered fish farming as an extra job, but also a different subject which was not their responsibility unless extra payment was made.
- Other projects in Malolo and Tangeni provided extra payment to AEO's. Since the ALCOM project was aimed at sustainability of the activity, the team refused to offer payment. Whether the AEO worked with the project or not depended mainly on AEO's' own committment .

As ALCOM did not provide extra payment, only two AEO's continued working with the project after fish farming was introduced in their areas. If AEO's were doing their job properly, this was a good channel to communicate with the farmers. Partly because the AEO's were based in the villages and also because they visit the same farmers for other crops. For this to be successful, fish had to be considered as a crop just like any other crop within the existing farming system. In the two villages where the team worked with the AEO's, extension work progressed easily and most farmers had a better understanding of what fish farming was than in other villages.

Slide show

Showing slides during meetings was a good way to deliver messages to farmers. Michielsens (1998) reported that farmers seemed to remember very well what they saw during the slide show two years before. However, to be effective slides had to be shown 2-3 times as the first show was mainly attended by children. It was also important what time of the day the slides were performed. Slides conducted during the morning were more effective than those conducted during the afternoon and evening hours when most of the farmers lost concentration due to intake of alcohol. Farmers who attended slide shows during the morning were more serious as they had to forgo their other farming activities.

Advantages of slide shows:

- Slide shows were a good way to communicate with literate and illiterate farmers.
- Slide shows can be shown in the rural areas where women and children can attend.
- Slides like photographs show real situations.
- Slides facilitate group discussion.

Disadvantages:

- Slides may give irrelevant details which may distract the attention of the audience.
- It was not very attractive to the rural people, particularly amongst the young generation, as they were now days familiar with television and video.

Pamphlets

Pamphlets helped the farmers to solve some of their problems on their own. Some farmers selected sites and started pond construction with only the assistance of these pamphlets. Although pamphlets were prepared in a way that they could be read easily, their weakness was that they were not useful to the few farmers who did not know how to read and write. Michielsens (1998) reported that this extension channel was not utilised to the optimum by ALCOM as only 42% of the farmers working with ALCOM received all three parts. It was anticipated that farmers would exchange pamphlets among each other but apparently many farmers who had received the pamphlets were not willing to do so. During the project the extension pamphlets were upgraded and subjects that were not covered in the former versions such as, transport of fingerlings, stocking, harvesting methodologies, and protection against predators, were included.

Group discussion

Group discussions among fish farmers themselves and the team increased the knowledge of the farmers through questions, answers and discussions. It also created a bond between the farmers, when they became aware that they were not the only ones to face a specific problem. The team only facilitated the discussion by sometimes asking questions and inviting farmers to give answers according to their experiences. In case new knowledge was introduced, the team played a more dominant role.

Disadvantages:

- Few farmers (2-3) dominated the discussion leaving others as listeners for whom it was difficult to keep their attention for long time.
- Most farmers preferred to hear solutions of their problems from the team rather than from other farmers.
- Most farmers seemed to prefer assistance in cash or kind from the project as a solution to most of their problems. Discussion on this issue took more time than the problems themselves and how to solve them.

In Mgeta and Kinole group meetings were organised without the participation of ALCOM. Although new initiatives were discussed in these groups, action was rarely taken (Michielsens, 1998). According to farmers, this was due to lack of unanimity and commitment of the members and lack of good leadership. However, Michielsens (1998) suggested that for farmers who only received fish farming knowledge from other farmers these group meetings could be of importance to help them solve their problems.

Team field visit

Team visits were an effective way of delivering messages to the farmers for of the following reasons:

- At the early stage of project implementation it was important for the team to visit the farmers frequently to avoid doing things wrong as most farmers were not knowledgeableabout specific aspects of aquaculture .
- Discussion between the farmers and the team at the site gave a clear picture and therefore it was easy to find solutions.
- Direct observation by the Team gave an opportunity to cross check what farmers were saying or

recording.

Disadvantages:

- Field visits were expensive to maintain as the team had to visit the trial areas frequently.
- Discussion with an individual farmer at the site was time consuming making it difficult to cover many farmers in a day.
- Some farmers managed their ponds better when they knew that the team was visiting or were already in their village.

Farmer-to-farmer extension

During the two years of extension work no farmers had emerged as motivators[10]. Although a number of attempts was made by the team to encourage fish farmers to identify a motivator, these were not successful due to power struggles amongst the farmers and because most of them felt they had no time to do extension. There was a number of farmers however, who did adopt fish farming because of other farmers efforts. Most of the farmers (58 %) who received farmer-to-farmer extension had an age less than 35 years (Michielsens, 1998). Farmers tended to adopt fish farming more easily when they were advised by other experienced fish farmers. This applied especially when they were within the same income class and social order. If a motivator could be identified and accepted by all fish farmers and was willing to do the work, the farmer-to-farmer system would be a very good way to sustain fish farming extension.

Farmer to farmer extension had the following disadvantages:

- Wrong information was seldom corrected. One farmer in Mgeta, for instance, was telling other farmers that manure in the crib should not be totally submerged by water. Another farmer in Malolo spread news among other fish farmers that application of manure lead to death of fish.
- Most farmers were busy on their own business and did not have time for extension.
- Some farmers who showed interest to become motivators were not accepted by other fish farmers, for reasons of jealousy.

These disadvantages indicated the characteristics of an ideal motivator: a motivator had to be accepted as knowledgeable, should be willing to spend time advising farmers, be well trained and/or experienced, and have gained the confidence of the other farmers.

Farmer-to-farmer extension was very prominent in Mgeta, Tangeni and Kinole. In Matombo the farmers were not willing to teach other farmers while farmers in Malolo got demotivated after seeing other farmers fail in their fish farming activities.

The advice of good fish farmers was followed more frequently than the advice of farmers who did not do well (Michielsens, 1998). The farmers who provided fingerlings to other farmers were very important for farmer-to-farmer extension and were good fish farmers (Michielsens, 1998). Many fish farmers older than 60 years gave advice to other people (Michielsens, 1998). Seventy one percent of these older farmers had farmed fish before ALCOM started working in their area. This increased their credibility as advisors. However, younger people (≤ 60) also gave advise to a larger

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[10] These were farmers who had been selected by other farmers to assist in the extension work.

number of people. This can be explained by the fact that younger people had a more active social life and met more people. Farmer-to-farmer extension was mainly provided by farmers who were also engaged in side-activities like business, construction or had a job with a fixed salary (Michielsens, 1998). Whether or not a farmer gave extension support to other farmers did not depend much on their education (Michielsens, 1998). However, those with a lower education (standard 7 or 8) gave advice to more farmers than those with an higher education. Even though farmer-to-farmer extensionists were good fish farmers themselves, the average farmer they taught was not farming well (Michielsens, 1998). Apparently, the information provided through this channel was not sufficient on its own. Not only did these farmers have only a few contacts with their extensionist, the farmers also lacked extension aids.

Field day visit or farmer-to-farmer visit

Field day visits were found to be very effective in disseminating information. Farmers could see and get explanation from the owner of the pond visited. The only disadvantage was that some farmers did not want to participate because the activity was time consuming.

Farmers also visited other farmers individually. The provider of fingerlings was often visited. 73 % of the farmers who never received information from ALCOM visited this pond (Michielsens, 1998).

Newsletter

Michielsens (1998) found that the knowledge presented in the newsletters was far less understood than the knowledge given in the extension pamphlets. Farmers reported that the news letters were not to the point, complicated as they contained a lot of text and only few illustrations.

3.4 Socio-economic aspects of fish farming

3.4.1 Social aspects of fish farming

Objectives for undertaking fish farming

The main objective for undertaking fish farming was to obtain fish as a source of relish, and to be able to eat fish whenever the farmer wanted ., income generation was mentioned as another important reason for undertaking fish farming. These reasons were mentioned by most farmers.

Although no one said they had adopted fish farming because of prestige, it was revealed that in fact some farmers adopted the activity for prestige in addition to the above reasons. One farmer for instance showed clearly that he was fertilising properly because he expected recognition from some government officials who might offer him a higher position in the village. On the other hand, some farmers managed (fed, fertilised and cleared grass) their ponds just to please the team. Most of these farmers fed and fertilised when they knew that the team was coming or when the team was in the village. Doing so they tried get praise from the team, other farmers and other visitors in the village. For the purpose of prestige the number of ponds and their size were deemed much more important than management or production of fish.

A successful fish farmer

Most farmers indicated that a successful fish farmer was someone who could harvest many

marketable sized fish (i.e. 120-150 g) after a short period (4-5 months). They also realised the importance of proper management of the pond. Further investigations revealed that a successful fish farmer was the one who could earn a lot of cash from fish sales,

Investing money earned from fish farming into other activities was also perceived as an indicator of success. Some fish farmers purchased fertiliser for crop farming, others used the income to pay school fees and or purchaseclothes.

These indicators were however not supported by all fish farmers, some expressed totally different views, such as; "a successful fish farmer is someone who harvests many fish regardless of size and time taken before harvest". This group's main concern was to obtain fish for consumption and sale whenever they wanted. Other farmers thought a successful fish farmer was the one owning big or many ponds. This group focused mainly on prestige and status rather than on management.

Farmers who indicated that a successful fish farmer was somebody who harvested many marketable sized fish after a shorter period, managed their ponds better than other farmers.

Constraining factors for farmers wishing to become successful fish farmers

Most farmers knew how to manage their pond properly. Reasons why ponds were not optimally managed were mentioned in group discussions.

For all five areas:

- **Low production of crops and animals led to low availability of inputs for fish farming.** It was therefore difficult to improve fish farming independently from other farming activities.

For Mgeta, Tangeni, Kinole and Matombo:

- **Unavailability of inputs.** Good management of ponds required inputs which were not always forthcoming. Inputs could be purchased locally, but not all farmers had money to purchase them. The solution to this problem could be to use alternative free inputs which were readily available in the areas. For instance, farmers could use rice bran instead of maize brain and compost mixed with little animal dung instead of using animal manure alone. Most farmers thought that maize bran was more nutritious than rice bran and animal manure better to use than green manure, as a consequence alternative inputs were not used. Due to short duration of the project it was not possible to identify all suitable alternative inputs.

For Mgeta:

- **High opportunity cost of inputs.** Maize bran widely used as feed in fish farming, was also used to feed pigs and to make local brew. Animal manure was used in vegetable garden. Both activities generated considerable cash for farmers. Since raising fish was still a new activity and its profitability not fully demonstrated, it was difficult for the farmers to allocate these resources to fish farming. Although this was a problem in all areas, it was a big problem in Mgeta where many inputs were intensively used in other activities.

For Malolo:

- **Lack of time to follow up management.** Fish farming was just one of many activities carried out by the farmers. Time constraints were a problem in Malolo as most ponds were approximately a kilometre away from farmers homestead, and management therefore required more time. Most ponds in other villages were less than ten metres from the homesteads and

generally required very little time to manage.

- **Long distances and lack of means to carry manure to the ponds.** Due to the long distance between homestead and fish ponds in Malolo, animal manure and rice bran were unutilised while most ponds lacked inputs. The situation became worse during busy periods when most ponds in the village looked abandoned.

Taboos and attitudes related to fish farming

No taboos connected with consumption of certain species of fish could be identified. Farmers of Muslim faith were restricted from handling pig manure to fertilise their ponds. This was a minor problem in Mgeta, where pig manure was the main source of pond fertilisation, as there were very few Muslims. In Malolo and Matombo areas where there were many Muslims cow, goat and chicken manure was used and in Kinole and Tangeni they use chicken and green manure. Muslims did indicate that it was no problem to consume fish from ponds which where fertilised by pig manure.

Although most respondents mentioned that peoples attitudes toward adoption of improved technology was positive, this was difficult to demonstrate. Often more than thirty farmers attended introductory meetings and, even though sometimes more than twenty of them showed initial interest, only 2-5 farmers finally adopted fish farming. Even after some farmers had started, the adoption rate was still low due to the following reasons:

- Some farmers did not accept the project idea of providing technical advise and transport of fingerlings only. In fact they did not consider these two as assistance at all, to most farmers these were regarded as standard government responsibilities. They expected assistance in cash or kind as several other projects were doing in their area, i.e. provide cash to construct ponds, buy feeds and nets. When the team explained the project's approach was not to provide inputs which were locally available, this was a minor problem to those farmers who were really interested in fish farming. However, a large group of farmers was not really interested in fish farming but more in donations, and continued to create problems Some AEO's also advised farmers not to adopt fish farming because they themselves did not accept the project idea
- Some interested farmers did not have land suitable for fish farming.
- Some farmers delayed adopting fish farming waiting to see the profitability and risks involved in fish farming. In Malolo for instance, a large number of farmers initially showed interest, but after farmers lost fishh due to predation their interest faded. In addition, in the same area a few ponds harvested did not prove to be profitable as other farming activities. In other areas profit was not high enough to attract farmers.

3.4.2 Economic analysis of fish farming

Semi-intensive fish farming was assumed to bear little or no capital investment to the farmer. This assumption was based on the fact that most activities in fish farming were carried out by family labour, using on-farm inputs obtained from the farmer's own sources or free from neighbours. However, in reality most farmers incurred some capital expenses (i.e. real cash spent) as well as opportunity costs (i.e. the cost of diverting inputs from their present uses to fish farming). The capital and opportunity costs in the present trials differed from one area to another depending on availability of the inputs and their alternative uses. Malolo area for instance, had a lot of manure,

maize bran and rice bran that was unused. Maize bran was sold but was cheaper and had a lower opportunity cost than in the other areas. In Mgeta, the supply of these inputs was limited and opportunity costs were high. In all other areas the supply as well as the opportunity cost of inputs was low.

Capital expenses

The few farmers who hired labour for pond construction allocated a large part of total cash investment to this activity. The cost for construction of a one are pond ranged from TSh. 14727 to 25000 and was lower in Malolo than in Mgeta (see Table 11, and Table 14 in Appendix 4). The average capital cost for ponds constructed by hired labour was generally higher than the opportunity costs involved for those farmers who did the construction themselves (TSh 19935 and TSh. 15229 respectively).

Cash spent to purchase fingerlings was a one time expenditure as most farmers used their own fingerlings after the initial stocking. Cost for stocking one are ranged from TSh 1040 to 4167 with an average of TSh 1825 (see Table 11, and Table 14 in Appendix 4). The price of fingerlings depended on the source. Fingerlings purchased from other fish farmers were more expensive than those purchased from the project. The actual number of fingerlings stocked depended on availability and cash.

Cash was used to purchase feeds, manure and other materials (See Table 11, and Table 16 in Appendix). Although different feeds were used, only maize bran was bought. The price of maize bran varied according to availability and alternative uses. In Mgeta, Tangeni and Kinole maize bran was sold at TSh. 15 per litre and in Malolo at approximately TSh. 9 per litre. For a pond of 100 m^2 farmers' expenditure on maize bran ranged between TSh. 3704 to 15273 and averaged TSh. 8142 (see Table 11).

Table 10: The costs and revenue of fish farming in trial areas 1996.

Activity	Maximum	Minimum	Average	Standard deviation
Capital cost for labour (TSh/are)	25000	14727	19935	5850
Opportunity cost for labour (TSh/are) *	16000	14000	15229	834
Fingerling cost (TSh)	4167	1040	1825	938
Feed cost (TSh/are/y)	15273	3704	8142	4167
Manure cost (TSh/are/y)	-	-	-	-
Material cost (TSh/are/y)	-	-	-	-
Total cost (TSh/are/y)	15273	3704	8142	4167
Revenue from fish sale (TSh/are/y)	37273	9877	18891	9826
Revenue from fingerling sale (TSh/are/y)	9229	2858	6144	4646
Total revenue (TSh/are/y)	37273	9877	20939	10335
Net return (TSh/are/y)	22000	1333	12797	8213

* Calculated from opportunity cost (number of working days * estimated wage).

Only two of the interviewed farmers mentioned they purchased goat and chicken manure. The price of both goat and chicken manure was approximately TSh. 8 per litre. These costs were not included in Table 10 because these farmers had not reached a stage of harvesting their fish.

Opportunity cost

Fish farming used the existing resources which in many cases had alternative uses.

Land

Suitable sites for fish ponds were often also suitable for other farming activities and therefore had an opportunity cost. Land suitable for fish farming was scarce in the five areasMany interested farmers could not adopt fish farming, not only because they did not possess suitable land but also because they could not get extra land. Another important factor, and also related to land, was that fish (like other valuable crops) needed protection against theft or predation. This meant that fish ponds competed with other valuable crops for land located near the homestead. The decision whether or not to use valuable land for fish farming was mainly influenced by the immediacy of reward, risks involved, cash earned and the role the crop played in the household food security.

Labour time

Although family labour was often regarded as cheaper than hired labour it had an opportunity cost. Men and boys were the main contributors of family labour used for pond construction. Women rarely participated in this activity. An average of two hours of labour was spent to construct one m^2. This meant that a farmer who worked on average eight hours per day needed 25 days to construct a 100 m^2 pond.

Feeding and fertilisation was done by all members of the household but mainly by women and children. Time spent to collect manure and fertilise ponds varied between 15-70 minutes. The distance between pond and homestead greatly influenced this. More time was taken in Malolo (70 minutes) followed by Kinole and generally less in Mgeta (not more than 30 minutes). Time taken to collect plant matter and put it in the compost enclosure was twenty minutes in both Mgeta and Kinole but less in Tangeni likely due to limited application. Time spend for feeding fish was more or less the same as for fertilising the pond.

Harvesting of fish, whether by net or by draining the pond, repairing of the dikes and refilling water was mainly done by men and boys. Marketing of fish was done at the pond site by the owner. In those cases where they were sold away from the pond site, women and children played an important role.

Inputs

In Mgeta area, maize bran was used for feeding pigs and as an ingredient in local brew industry. Animal manure was intensively used in vegetable gardens. The above activities were the main cash earning activities for majority farmers in the area. In other areas maize bran was used to feed chickens and making local brew, while very little manure was used in the gardens as most farmers were traditionally non-manure users. With the exception of manure in few areas, the opportunity cost of diverting these inputs from their current use to fish farming was considerably high.

Water

In all areas water was used for irrigating of valuable crops. Access to water particularly during dry season was difficult as crops competed with fish ponds. Often fish farmers were blamed by other farmers for using too much water. This was sometimes justified, particularly for ponds with high seepage losses, but sometimes also due to jealousy. In rare cases ponds were half filled because

water was not available. In Mgeta, during periods of limited water supply ponds had to be filled during the night, when the demand for water was relatively low,

Profit

Cost of pond construction, purchase of materials and fingerlings were one time investments which were written off by the farmers almost immediately. Profitability therefore increased during the next production cycles. The profitability of fish farming and several crops competing with fish farming for land, labour, water and cash were computed and compared (see Table 11). The data for Mgeta and Malolo were collected from the trial farmers (see Table 16 Appendix 4) while the data from Iringa were derived from the FAO Fertilizer Project [11] (see Table 17 Appendix 5). The data from Iringa included costs for labour and to some extent for improved technologies. These costs were estimated, while the data collected by the team involved real costs. The average profit per cycle for a plot of one are of rice (Malolo) and cabbage (Mgeta) was TSh 2885 and TSh 2334, respectively. In Malolo most farmers grew one crop of rice on the same plot per year, while in Mgeta some farmers rotated cabbage with beans and Irish potatoes or tomatoes. However, the annual returns from trial farmers who rotated two or three crops were not available.

Table 11: Comparison of average production cost and average net returns per are for various crops competing with fish farming for land, water, labour and capital, 1996.

Crops	Area	Average total cost	Average total return		Average net return		Value cost ratio (VCR)	
			Low price	High price	Low price	High price	Low price	High price
Rice	Malolo	2053	4938		2885		2.4	
Cabbage	Mgeta	1430	3764		2334		2.6	
Fish	Mgeta & Malolo	8142	20939		12797		2.5	
Maize	Iringa *	2373	2500	5000	127	2627	1.0	2.1
Bean	Iringa *	1819	3240	5400	1421	3581	1.7	2.9
Tomatoes	Iringa *	4939	6000	37500	1061	32561	1.2	7.5
Irish Potatoes	Iringa *	3480	3600	11700	120	8220	1.0	3.3

* FAO Fertilizer Project - Dar es salaam

In case only one crop per cycle was cultured, annual average profit per are varied between TSh 120 to 2885 at low price[12] and between TSh. 2627 to 32561 at high price. If two or in rare occasions three crops were rotated per year, profit per are at low price was estimated to be between TSh. 1181 and 4800[13]. The annual average profits at low price from crop farming, was considerably lower than the average profit (TSh. 12797) from aquaculture. Even when two or three crops were rotated. However, at high prices, the average profit per are from one crop (tomatoes) or two or three crop cycles was higher than from aquaculture. Most small scale farmers sold most of their produce immediately after harvest, which means that the

11 End of assignment report: Income generetion improvement for farmers in southern regions, GCP/URT/106/NET, D. Montange.

12 Low price was a price prevailing immediately after harvest and within farmers locality while high price was price prevailing few months prior harvest and at distant markets i.e. Dar es Salaam.

13 TSh 1181 was the lowest (tomatoes and Irish potatoes) and Tsh 4816 highest (tomatoes, beans and Tomatoes) profit obtained if two and three crops were rotated respectively.

situation at low prices was more appropriate than at high prices.

Total return/cost ratio

The culture of cabbages had the highest Value Cost Ratio (VCR)[14] (2.6), followed by fish farming (2.5) and rice farming (2.4). The higher VCR in Malolo and Mgeta areas than in Iringa at low price was caused by the fact that in the first areas labour costs were not included. At the high price estimates, tomatoes had the highest VCR (7.5), followed by Irish potatoes (3.3), beans (2.9) and maize (2.1).

Since fish farming was more profitable than alternative crops, it was expected that fish farming would not only have high adoption rate but also would be given a high priority by the farmers. This was not the case. The following reasons were mentioned by the farmers:

- Food security. Crops like rice, maize, sweat potatoes, bananas etc. had low profits but they were farmers' staple food. They directly contribute to the household food security. Fish as a source of relish and had less direct impact on the household food security.
- The profit from fish farming was obtained from 3-5 intermittent harvests. Each intermittent harvest normally contributed between TSh 3000-8000. Crop sale on the other hand may contribute between TSh 20000-50000 per sale. Most farmers indicated that contribution from each intermittent harvest was too small to show any significant impact on development.
- The volume of the fish harvest was low, although the net returns per areas were high the overall area in production was small compaired to other crops.
- Immediacy of reward. The production of crops like beans and vegetables took 3-4 months, while the production cycle in fish farming was 6-8 months. Rewards of vegetable growing were thus more immediate. With intermittent harvests fish could be harvested earlier, but the harvest was considered too small.
- Risk involved. Most farmers indicated that in areas where irrigation was possible fish farming was more risky than crop farming. High mortality rate of fingerlings, due to poor method of harvest and transport, theft and predation were mentioned as reasons leading to high risk in fish farming. In crop farming, lack of or excess rain was considered an important risk although the former was not a problem in irrigated areas. Some farmers who harvested their ponds by total draining were disappointed when as much as 40% of the of the number of fish originally stocked was found to be missing at harvest. Related to above was the fact that crops in the field were seen while fish were difficult to monitor.
- Crops like maize, beans and rice could be stored for few months and sold later when high prices prevailed. Similarly, most crops could be transported easily to distant markets to fetch higher prices. Fresh fish was difficult to store and could not be transported easily to distant markets. It was unlikely that the profit of fish farming could be increased by storage and transportation as it could be done for other crops (see Table 17 in Appendix 5).

The following measures were mentioned by farmers to reduce costs:

- Replacement of high cost inputs by low cost ones. Rice brain which was readily available free of charge in all areas, could replace maize bran as feed. Tree leaves, grass and various other vegetable leaves can also be used as feeds.

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[14] the returns compared to the investment made.

- Reduction of feeding through intensive fertilisation. Growth of natural food in the pond was stimulated by application of manure which was often freely available. Use of optimal levels of manure would result in a reduction of necessary feed. Small amounts of animal manure could be mixed with a large quantity of plant matter in areas with shortage of available animal manure.
- Increased manure production. Some farmers had started keeping animals as a way to get manure to fertilise their ponds.
- Integrated fish farming with animal husbandry would improve the use of waste feed and animal excreta.

Marketing of fish

Most fish were sold at the pond site, few were sold elsewhere in the village. Fish sold at the pond site were not scaled or gutted. Fish sold in the village or in the market were scaled and gutted and sometimes fried. Specialised fish traders were not present in the study areas. Any member of the family, but particularly women and children, sold the fish.

The price of fish was set by the fish farmer. Although there were possibilities for negotiation, this rarely happened. Table 12 shows the average prices of the different sizes of fish, as identified by the questionnaire. The categories 1 and 2 concern mainly live fingerlings, which usually were not sold for consumption.

Table 12: Weight, average price per fish and Kilogram for the seven size categories (September, 1996).

Size category	1	2	3	4	5	6	7
Weight (g)	3.9	11.5	24.4	71.1	151.6	272.9	441.1
Price/fish (TSh)	20	60	117	200	313	650	1000
Price/Kg (TSh)	5128	5217	4775	2813	2061	2382	2267

These were somewhat higher than observations made by the team in Mgeta and Malolo at the end of 1995 as given in Table 13.

Table 13: Prices of fresh and fried fish as observed in Mgeta and Malolo (November, 1995).

Weight (g)	110-150	180-220	300
Price/fish fresh (TSh)	200	250	500
Price/Kg fresh (TSh)	1538	1250	-
Price/Kg fried (TSh)	1923	1500	1670

Large fish were preferred above small fish which was reflected in the price per individual fish. Weight for weight however the smaller and medium sized fish were preferred above the larger fish. To increase profitability farmers could focus on the production of small fish. Fish was more expensive than meat which had prices ranging from TSh 800 to 1000 per Kg.

The demand for fish was so high that potential buyers often left the pond site without fish. The demand for fish depended on the availability of other meat and their relative prices. In most villages animal meat was available 1-3 times a week.

3.5 Independent evolution of fish farming

The ALCOM team had to interrupt aquaculture field activities in October, 1996, and fish farming had to develop independently. Michielsens (1998) returned to the project areas in August-September 1997 to carry out a study on the effectiveness of the extension channels

used by ALCOM, while the ALCOM team returned to Mgeta and Tangeni to assess the status of fish farming and its independent development in February 1998. Michielsens (1998) found that one third of the farmers who participated with ALCOM had stopped semi-intensive fish farming. This however referred to all farmers who stopped temporaryily or permanently, those who reduced their fish farming activities from two to one pond and those who turned to extensive fish farming, i.e. did not apply fertilisation and or feeding. Seventy percent of the farmers who had stopped fish farming did so because of water shortages and most of these were located in Kinole which was severely affected by the 1997 El Niño droughts. The remaining thirty percent stopped because of disappointing harvests. Field visits to Tangeni and Mgeta revealed that nearly all farmers who had participated in the project were still farming fish. In general the application of fertilisers and feed was reduced to a minimum although ponds in Mgeta showed a moderate algae bloom. In Tangeni, where animal manure was not available, ponds showed no blooms except for several ponds that were intensively fertilised with green compost (chopped trunks of banana and sugar cane). These well fertilised ponds included new ponds that had been constructed by farmers who received farmer-to-farmer extension.

During the time ALCOM was actively working with the farmers it had been difficult to persuade the farmers to harvest the fish by draining their ponds. Michielsens (1998) reported that 42% of the farmers had drained the entire pond once before the short rainy season at the end of 1997. In the beginning of 1998 it was found that nearly all farmers in Mgeta and some farmers in Tangeni had drained their ponds at least partially by cutting the dike for the purpose of harvesting. Unfortunately, none of the ponds that had been drained completely had been restocked properly. As a result it was found that most ponds were overcrowded with predominantly small fish.

4 CONCLUSIONS AND RECOMMENDATIONS

Target group

The pilot project "Development of semi-intensive aquaculture for small scale farmers" in Morogoro region clearly showed that adoption of improved fish farming technology was possible without external financial assistance. The target group (small scale farmers) was reached, although in few cases it took considerable effort by the team to convince individual farmers to accept the project's idea of providing technical advice only. All areas selected for on-farm trials met both technical and socio-economic criteria set by the project and proved to be suitable for aquaculture production.

Recommendation 1: During the initial stages of extension (i.e. the first meetings, visits etc)., the following conditions should be emphasised; suitable location, availability of water, measures to be taken to avoid predation and acceptance of extension approach. Farmers who do not comply with these conditions should be adviced not to start fish farming.

Extension methods to arouse the interest of farmers

Interest of the farmers in aquaculture was best aroused by the village authorities but only in combination with announcements made by a village drum beater and posters as village authorities sometimes changed the content and redirected the message.

Recommendation 2: To ensure that all potential fish farmers are informed about scheduled aquaculture extension activities announcements have to be made through official channels but also through posters and announcers using a drum. To reach women announcements, have to be made at places visited by women.

Extension methods to transfer knowledge to the farmers

Technical knowledge and information was found best transferred to small scale farmers through some Agriculture Extension Officers (AEO), group discussion between farmers, and farmer-to-farmer extension. These channels, showed to be sustainable, less costly and less time consuming then the other methods tested. Co-operation of AEO's largely depended on the personal interest of the officer as aquaculture extension was not a part of their official assignment.

Recommendation 3: The Fisheries Division is advised to investigate the possibilities of developing a channel for aquaculture extension. This could be within the Fisheries Division or potentially integrated into the existing agriculture extension network.

Recommendation 4: The formation of fish farmers groups should be encouraged . Group meetings and discussions among farmers should be stimulated and be attended by the extension service when new knowledge is to be transferred.

Recommendation 5: Slide shows and meetings with the farmers have to be conducted in the morning. The first slide show, meant to arouse the interest, only needs to be short, while a second show, to deliver information to the interested farmers, should be more detailed.

Recommendation 6: Field visits by the ALCOM team were found to be effective, however, time constrains made it necessary to limit the number of farm visits to once per three weeks for starting farmers and once per 1 or 2 month for experienced farmers. Advanced farmers should be less frequently visited and to a greater extent rely on other extension channels such as meetings, pamphlets and newsletters.

Recommendation 7: The development of an effective system of farmer-to-farmer extension requires special attention. Special care must be given to the identification and training of motivators.

Recommendation 8: Field day visits for fish farmers were very time consuming and only feasible when they were combined with group discussions and the introduction of new knowledge. These visits should only be organised when a short distance of travel is involved.

Farmers actively adapted the new technology during the early stages of the introduction process. After the first production cycle farmers were often less motivated to include new techniques, especially when the expectations had not been during in the first production cycle.

Recommendation 9: For an effective adoption by the farmers it is essential that the extension message is correctly and fully transferred to the participants during the early stages of introduction.

Extension message

Ponds constructed by hired labour were larger than ponds constructed by the owners themselves. However, ponds constructed by hired labour were usually poorly made.

Recommendation 10: Farmers who hire labour for pond construction are advised to instruct the labourers carefully, or alternatively to involve the labourers in pond construction education before agreeing on a contract.

Recommendation 11: Small scale farmers should be encouraged not to invest any materials needing cash.

Ponds constructed far from the homestead were generally poorly managed and often severely predated.

Recommendation 12: Farmers are advised to construct the pond close to their homestead.

The demand for animal manure was high in most areas, and the quantity available to fertilise a fish pond often insufficient. Where animal manure was available in sufficient quantities, and it was used to increase the fertility of the water, it improved fish production. Fish ponds integrated with animal production showed the best fish growth. Ingredients to produce green compost were widely available and were used to fertilise ponds. Insufficient data had been collected to draw conclusions on the fertilising abilities of green compost or on the socio-economic impact on the farming system.

Recommendation 13: Whenever available in sufficient quantities, animal manure is preferred to fertilise the fish pond. Animal manure can be applied in small compost enclosures.

Recommendation 14: Integrated fish culture and animal husbandry should be encouraged wherever possible.

Recommendation 15: In case animal manure is not available, green compost can be made using large quantities of plant matter in an enclosure that covers at least 10% of the pond surface.

Most farmers preferred to use maize bran for feeding rather than other freely available feeds. Maize bran was considered more nutritious. Maize bran, however, had high opportunity cost and often had to be purchased.

Recommendation 16: Farmers should be advised to give more priority to the use of low or no cost feeds, such as rice bran, market leftovers and edible plant leaves. Emphasis should be given to the identification of no cost feeds.

The fish production reached high levels, up to 39 kg/are/y for a pond that was drained and harvested totally. Yields were generally lower due to the fact that most farmers did not practice a total harvest but rather small partial harvests. It was not possible to determine the carrying capacity of fish ponds under different management conditions practicing intermittent harvests only, and no conclusions could be drawn about its potential production under local conditions. Many farmers preferred to harvest their ponds using a net as opposed to harvesting by draining. Reasons identified for this behaviour were; lack of understanding why and how to drain a fish pond, easy availability of nets, lack of fingerlings at reasonable prices and lack water to refill the pond.

Recommendation 17: It is advised to investigate the effectiveness and the suitability of both total and partial harvest strategies under local conditions.

Recommendation 18: The provision of nets or other harvest equipment for non-demonstration purposes should be avoided in order to encourage the independent development of harvesting methods and to ensure sustainability.

Recommendation 19: It is advised that ponds be drained at least once a year and restocked with good quality fingerlings to avoid stunting of fish stocks. This advice should also be given to farmers who practice partial harvests. Adoption of this strategy is vital when enhanced aquaculture techniques are to be introduced.

Recommendation 20: More emphasis should be given to proper planning of culture cycles according to the physical condition of the locality and the farming schedule of the farmer.

Animal predation was found to have a negative effect on the adoption and sustainability of aquaculture. As a result of fish losses due to the otters, farmers abandoned fish farming, while others lost the interest in starting the activity,

Recommendation 21: The presence of predators needs to be identified during site selection, control measures need to be implemented during the construction phase of the pond. Measures suggested at a later stage are usually not adopted.

The introducing of liftnets improved the availability and survival of fingerlings. No fish farmers

specialised in fingerling production, as a result all farmers stocked or restocked their ponds with fingerlings from their own production ponds.

Recommendation 22: The advantages of stocking ponds with quality fingerlings has to be demonstrated to the farmers. This could stimulate quality fingerling production.

Although fish farming had proven to be more profitable than other farming activities, its adoption rate and the level of priority given by the farmer were low. Reasons were: small amount of income from ponds, risks involved, immediacy of rewards, and the role of fish in the household food security.

Fish from total harvest was primarily meant for sale while fish from partial harvests was mainly used for home consumption. Fish were easily marketed and fetched a higher price than meat. Small fish were sold at higher price per Kg. than larger fish.

Recommendation 23: Farmers can increase profitability of their fish pond by producing small size fish. Small fish can be produced in a short period, and farmers are advised to shorten the production cycle.

Recommendation 24: Fish farmers should avoid harvesting and selling their fish at times when animal protein is readily available.

APPENDIX

Appendix 1 Topics covered by the background survey

Demography:
Population by district, growth rate, age and sex structure, education, infant and child mortality, no. of households, no. of farming households, female headed households (de fact and de juro), main religions/church membership.

Climate:
Temperature, rainfall, and evaporation figures per month.

Topography and soils.

Land utilisation and Tenure:
Settlement patterns, agro-ecological zones, main crops by region/area, estimated yields, tenure system.

Water supply:
Rivers and streams perennial/seasonal, reservoir, areas with high water table.

Farming systems:
Types of farming system and description, areas where these farming systems are practised, estimation of economic returns for different on-farm activities, animals integration of farming activities.

Other economic activities in the rural areas.

Community management:
Experience of community management schemes, livestock grazing, dams, forestry, possible constraining factors.

Leadership:
Importance of structures of leadership, political/traditional, roles/influences.

Agricultural Credit and Extension:
Organisation of the extension service, access to extension by farmers, with special reference to fish farming extension. Access to, and conditions for credit for different agricultural activities.

Protein availability:
Availability of other sources of protein, sources, prices.

Taboos:
especially related to consumption of fish, or certain fish species.

Labour division:
Division of labour in a farming household. Labour calendar for different farming systems.

Input availability:
Kinds, present use, amounts, source and price.

Environmental degradation:
Areas, types.

Experience with the adoption of new technologies.

Communication channels used.

Appendix 2 Questionnaires

QUESTIONNAIRE FIELD VISITS
GENERAL INFORMATION

1 Name fish farmer:_____
2 Village:_____
3 Farmers code: (Village + Initials Name) _____
4 Sex\Age Group: Male Female Boy Girl

5-8 Household composition: Male(s), Female(s), Boy(s), Girl(s)

9 Farm size: _____ Acres

Sources of income.

10 Agriculture:	TSH _____	per year
11 Animals:	TSH _____	per year
13 Trading:	TSH _____	per year
14 Labour:	TSH _____	per year
15 Employment:	TSH _____	per year
16 Handicraft:	TSH _____	per year
17 Fish farming:	TSH _____	per year
18 Other:	TSH _____	per year

AGRICULTURAL OUTPUT:

	Crop	Income		Irrigated (Y/N)
19	_____	TSH _____	per year	Y / N
20	_____	TSH _____	per year	Y / N
21	_____	TSH _____	per year	Y / N
22	_____	TSH _____	per year	Y / N
23	_____	TSH _____	per year	Y / N
24	_____	TSH _____	per year	Y / N
25	_____	TSH _____	per year	Y / N
26	_____	TSH _____	per year	Y / N

ANIMAL OUTPUT:

	Number	Income	
27 Cow:	_____	TSH _____	per year
28 Pig:	_____	TSH _____	per year
29 Chicken:	_____	TSH _____	per year
30 Duck:	_____	TSH _____	per year
31 Goat:	_____	TSH _____	per year
32 Other:	_____	TSH _____	per year

QUESTIONNAIRE FIELD VISITS
POND CONSTRUCTION

1 Farmers code: (Village + Initials Farmer) _____
2 Pond code: _____
3 Distance from house:

1 = <50m 4 = 500-1000m
2 = 50-100m 5 = >1000m
3 = 100-500m

4 Date construction (day/month/year): __/__/__

Labour inputs for construction of the pond.

	Member	Number	Numbers of days	Hours per day	Cost per day
5	Males	_____	_____	_____	TSH _____
6	Females	_____	_____	_____	TSH _____
7	Boys	_____	_____	_____	TSH _____
8	Girls	_____	_____	_____	TSH _____
9	Hired	_____	_____	_____	TSH _____

10 Total Labour costs: TSH _____
11 Tools used for pond construction: _____
12 Materials used for pond construction: _____
13 Costs of these materials: TSH _____
14 Pond surface: ____ m2
15 Depth: ____ cm
16 Water source: 1 = Stream 4 = Spring
2 = Channel 5 = Water table
3 = Well 6 = Run off

17 Dikes covered with grass (Y/N): Y / N
18 Slope dikes: __ Grades

19 Type of inlet structure: _____
20 Control over inlet structure (Y/N): Y / N
21 Screen in water inlet available (Y/N): Y / N
22 Type of outlet structure: _____
23 Type of overflow structure: _____
24 Possibility to drain (Y/N): Y / N
25 If not, Why ? _____
26 Crib size: ___ m2

ACTIVITIES NEAR THE POND.
27 Do you own the plot at the outlet side of the pond (Y/N): Y / N
28 What crop do you grow near the pond: _____
29 Do you keep animals near the pond (Y/N): Y / N
30 What animals: Cow , Pig , Chicken , Duck , Goat , Other

QUESTIONNAIRE FIELD TRIPS
POND MANAGEMENT

0 Date: __/__/__
1 Farmers code: _____
2 Pond code: _____
3 Cycle code: _____

FERTILISATION ANIMAL MANURE

4 How many times per week animal manure was supplied: ____ per Week
5 When was the last time the pond was fertilised
with animal manure: ____ Days ago

Type:	Cow	Pig	Goat	Chicken	Duck	Other
6 How many litres:	___	___	___	___	___	___
7 Price (TSH):	____	____	____	____	____	____

8 Source: Own Farm Neighbours Elsewhere
9 If bought, where did you buy:_____
10 Who fertilised the pond:_____
11 How much time was spent on fertilising the pond: _____ Hours
12 When was the last time before that you fertilised the pond
with animal manure: _____ Days ago
13 Do you feel there was any competition for the manure's
used and other farming activities: Y / N
14 Describe this conflict:

_____
15 Do you had enough access to animal manure: Y / N
16 Was it possible to increase the of animal manure: Y / N
17 If not. Why. _____

FERTILISATION PLANT MATTER

18 How many times per week plant manure was supplied: _____ per Week
19 When was the last time plant wastes were used
to manure your pond: _____ Days ago
20 Type plant origin: _____ _____ _____
_____ _____ _____
_____ _____ _____
_____ _____ _____
21 How many litres in total: _____ Litre
22 Source: Own Farm Neighbours Elsewhere
23 If bought, where did you buy:_____
24 How much did you pay: TSH _____
25 Who fertilised the pond:_____
26 How much time was spent on fertilising the pond: _____ Hours
27 When was the last time before that you
fertilised the pond with plant wastes: _____ Days ago
28 was there any competition for the plant wastes used for

fish farming and other farming activities: Y / N

29 Describe this conflict:

_____

30 Do you had enough access to plant manure: Y / N

31 was it possible to increase the quantity plant matter: Y / N

32 If not. Why. _____

FEEDING

33 How many times per week the fish were fed:_____

34 When was the last time the fish were fed: _____ Days ago

Type of feed: Maize Rice Brew Kitchen Leaves Fruits bran bran l.or l.o

35 How many litres: ___ ___ ___ ___ ___ ___

36 Price (TSH): ___ ___ ___ ___ ___ ___

37 Source: Own Farm Neighbours Elsewhere

38 If bought, where did you buy:_____

39 Who fed the fish:_____

40 How much time was spent feeding the fish _____ Hours

41 When was the last time before that you fed the fish: _____ Days ago

42 Do you feel there was any competition for the feeds used and other farming activities (Y/N): Y / N

43 Describe this conflict:

_____

44 Do you had enough access to fish feeds: Y / N

45 was it possible to increase fish feed effort: Y / N

46 If not. Why. _____

WATER MANAGEMENT

47 How high was the maximum water level in your pond: _____ cm

48 When you last refilled your pond to this level: _____ Days ago

49 What was the level of the pond before you started filling: _____ cm

50 Who refilled the pond:_____

51 How much time was spend to refill the pond. _____ hours

52 When you refilled the pond before that: _____ Days ago

53 Do you feel there was any competition for the water between fish farming and other activities: Y / N

54 Describe this conflict:

_____

QUESTIONNAIRE FIELD VISITS
FISH CULTURE

0 Date: __/__/__
1 Farmers code: _____
2 Pond code: _____
3 Cycle code: _____

STOCKING.

4 Date cycle started: __/__/__
5 Number of fish stocked: _____
Size category of fish stocked:
6 Fingerling size 1 Y / N
7 Fingerling size 2 Y / N
8 Juvenile size 3 Y / N
9 Juvenile size 4 Y / N

HARVEST.:

10 When was the last time you harvested your pond: _____ days ago
11 Was this a total or a partial harvest (T/P): T / P
12 How many fish did you harvest: _____
13 How did you harvest these fish: 1 = Draining 4 = Lift net
2 = Cast net 5 = Trap
3 = Seine net
14 Who harvested the fish (Age\sex group): m. F b g
15 At what time of day these fish where harvested: _____ hrs.
16 How long did it take to harvest these fish: _____ hrs.
17 Did you spent any money to harvest the fish Y / N
18 On what items you spent money: _____
19 How much money was spend on this: TSH _____
20 What was the total weight of the fish you harvested: _____ Kg.

Size categories:	1	2	3	4	5	6	7
21 Number:	___	___	___	___	___	___	___

Fish eaten by family.

	No.	Number of fish	Size category
22 Male members	_____	_____	_____
23 Female members	_____	_____	_____
24 Childern	_____	_____	_____

25 How did you prepare these: _____
How many fish did you give away. _____

Size categories:	1	2	3	4	5	6	7
26 Number:	___	___	___	___	___	___	___

How many fish did you sell.

Size categories:	1	2	3	4	5	6	7
27 Number:	___	___	___	___	___	___	___

28 Where did you sell these fish: _____
29 Who bought these fish: _____
What was the price.

Size categories: 1 2 3 4 5 6 7

30 Price ___ ___ ___ ___ ___ ___ ___

31 Did you see any dead fish the day after you harvested: Y / N

32 How many dead fish did you see: _____

What was the size of these fish.

33 Size categories: 1 2 3 4 5 6 7

34 When was the last time before that you harvested: ____ days ago

35 Was this harvest a total harvest or a partial harvest: P / T

POND MAINTENANCE

36 How much time was spend to maintain the pond: _____ Hours

37 Who maintained the pond:_____

38 If labour was hired, how much was paid: TSH _____

39 What new materials were used:_____

40 If so, how much was paid for it: TSH _____

QUESTIONNAIRE FIELD VISITS
FINGERLING PRODUCTION

0 Date: __/__/__
1 Code Fish farmer: _____

SELLING FINGERLINGS

2 Do you produce high quality fingerlings: Y / N
3 Do you now how to produce high quality fingerlings: Y / N

4 When did you last sell fingerlings: _____ Days ago
5 How many fingerlings did you sell: _____
6 At what price these fingerlings were sold: TSH _____
How these fingerlings were harvested from the pond:

1 = Draining
2 = (Mosquito) net
3 = Trap
4 = Lift net
5 = Cast net

7 Who harvested these fingerlings:_____
8 How long did it take to harvest these fingerlings: _____ Hours
9 When was the time before that you sold fingerlings: _____ Days ago

BUYING FINGERLINGS

10 When did you last get new fingerlings: _____ Days ago
11 Where did you get these fingerlings:
1 = Fish farmer same village
2 = Fish farmer different village
3 = Government fish culture station
4 = Private fish culture station
5 = Caught from the wild
6 = Elsewhere
12 How many fingerlings did you get: _____
13 How much did you pay for these fingerlings: TSH _____ each.
14 How did you transport these fish:_____
15 How many fish you put in this container\bag etc: _____
16 What was the size of the container\bag: _____ litres
17 How long did it take to transport these fish: _____ Hours
18 How many fish died during transport: _____
19 How many fish were dead the day after you stocked: _____

PREDATION

20 were fish preyed from your pond: Y / N
21 What animals: Otter Hammerkop Mongoose Stork White heron
Monitor lizard
Kingfisher Frogs
22 Did you see these animals yourself: Y / N
23 Did you see droppings or prints of these animals: Y / N
24 What did you do to avoid this predation:

25 Was this method effective: Y / N

THEFT

26 had fish been stolen from your fish ponds: Y / N

27 How the fish were stolen:_____

28 When did it happen last: _____ Days ago

29 When did it happen the time before: _____ Days ago

Appendix 3 Farmers recording sheet.

	FARMERS CODE:	**POND NO:**
DATE CYCLE STARTED: / /	**POND SURFACE:**	**CRIB SIZE:**
NUMBER OF FISH STOCKED:	**STOCKING DENSITY:**	**POND DEPTH:**
PROPOSED DATE OF CHECKING THE FISH: / /	**PROPOSED DATE OF FINAL HARVEST: / /**	
FIELD VISITS		

DATE VISIT:	TIME VISIT:	POND FERTILIZATION		CRIB:			WATER MANAGEMENT				FISH	FINGERLINGS
		COLOUR SCALE:	SECCHI DISK:	% FILLING	MANURE TYPE:	FEEDING:	WATER LEVEL:	SEEPAGE:	FILLING:	TEMPERATURE:	VISIBLE:	AVAILABLE:

HARVEST:		NUMBER PER SIZE CATEGORY:	MAINTENANCE		
DATE:	TYPE:	1 2 3 4 5 6 7	DIKES	INLET	OUTLET
COMMENTS:					

DATE VISIT:	TIME VISIT:	POND FERTILIZATION		CRIB:			WATER MANAGEMENT				FISH	FINGERLINGS
		COLOUR SCALE:	SECCHI DISK:	% FILLING	MANURE TYPE:	FEEDING:	WATER LEVEL:	SEEPAGE:	FILLING:	TEMPERATURE:	VISIBLE:	AVAILABLE:

HARVEST:		NUMBER PER SIZE CATEGORY:	MAINTENANCE		
DATE:	TYPE:	1 2 3 4 5 6 7	DIKES	INLET	OUTLET
COMMENTS:					

DATE:	TIME VISIT:	POND FERTILIZATION		CRIB:			WATER MANAGEMENT				FISH	FINGERLINGS
		COLOUR SCALE:	SECCHI DISK:	% FILLING	MANURE TYPE:	FEEDING:	WATER LEVEL:	SEEPAGE:	FILLING:	TEMPERATURE:	VISIBLE:	AVAILABLE:

HARVEST:		NUMBER PER SIZE CATEGORY:	MAINTENANCE		
DATE:	TYPE:	1 2 3 4 5 6 7	DIKES	INLET	OUTLET
COMMENTS:					

DATE:	TIME VISIT:	POND FERTILIZATION		CRIB:			WATER MANAGEMENT				FISH	FINGERLINGS
		COLOUR SCALE:	SECCHI DISK:	% FILLING	MANURE TYPE:	FEEDING:	WATER LEVEL:	SEEPAGE:	FILLING:	TEMPERATURE:	VISIBLE:	AVAILABLE:

HARVEST:		NUMBER PER SIZE CATEGORY:	MAINTENANCE		
DATE:	TYPE:	1 2 3 4 5 6 7	DIKES	INLET	OUTLET
COMMENTS:					

DATE VISIT:	TIME VISIT:	POND FERTILIZATION		CRIB:			WATER MANAGEMENT				FISH	FINGERLINGS
		COLOUR SCALE:	SECCHI DISK:	% FILLING	MANURE TYPE:	FEEDING:	WATER LEVEL:	SEEPAGE:	FILLING:	TEMPERATURE:	VISIBLE:	AVAILABLE:

HARVEST:		NUMBER PER SIZE CATEGORY:	MAINTENANCE		
DATE:	TYPE:	1 2 3 4 5 6 7	DIKES	INLET	OUTLET
COMMENTS:					

Appendix 4 Production costs and returns in fish farming

Table 14. Initial capital and labour investments per are for pond construction and fingerlings for 10 farmers in trial areas.

Farmer No	1	2	3	4	5	6	7	8	9	10
Area	Malolo	Malolo	Mgeta	Mgeta	Mgeta	Mgeta	Mgeta	Mgeta	Mgeta	Mgeta
Capital cost (TSh/are)	14727	15012	15789*	16000*	15000*	16000*	25000	25000	14583*	14000*
Fingerlings cost (TSh/are)	1600	1542	1515	1067	1040	2628	1250	1600	4167	1840
Total Investment (TSh/are)	16327	16554	17304	17067	16040	18628	26250	26600	18750	15340

* Calculated from opportunity costs (number of working days * daily wage).

Table 15. Estimated real variable costs from selected semi-intensive fish farmers Malolo and Mgeta villages, January 1996.

Farmer No	1	2	3	4	5	6
Variable costs						
Feed cost (TSh/are/y)	15273	3704	6063	10667	6000	7143
Manure cost (TSh/are/y)	0	0	0	0	0	0
Material cost (TSh./are/y)	0	0	0	0	0	0
Total cost (TSh./are/y)	15272	3704	6063	10667	6000	7143
REVENUE						
Revenue from fish sale (TSh are/y)	37272	9877	21052	12000	16000	17143
Revenue from fingerling sale (TSh/are/y)	0	0	2858	0	0	9429
Total Revenue (TSh/are/y)	37272	9877	23910	12000	16000	26572
NET RETURN						
Net Return (TSh/are/y)	22000	6174	17847	1333	10000	19428
Net Return (TSh/y)	24200	25000	33910	1200	10000	13600

Table 16. Estimated annual net return per are from crops competing with fish farming for land, water, labour and capital for different trial areas, 1996.

Farmer No.	1	2	3	4
Area	Malolo	Malolo	Mgeta	Mgeta
Crop type	Rice	Rice	Cabbage	Cabbage
Tilling cost (TSh/are/cycle)	494	247	123	494
Planting cost (TSh/are/cycle)	0	0	0	82
Weeding cost (TSh/are/cycle)	0	0	0	494
Harvest cost (TSh/are/cycle)	0	0	0	0
Threshing cost (TSh/are/cycle)	66	111	-	-
Transport cost (TSh/are/cycle)	0	0	37	494
Bag cost (TSh/are/cycle)	237	119	247	-
Seed cost (TSh/are/cycle)	49	49	74	123
Fertiliser (TSh/are/cycle)	-	-	296	235
Insecticides (TSh/are/cycle)	-	-	30	132
Total cost (TSh/are/cycle)	846	526	807	2053
Total returns (TSh/are/cycle)	3160	3556	2590	4938
	—	—	—	—
Net returns per are (TSh/are/cycle)	2314	3030	2107	2885
Net returns (TSh/farm)	70300	122700	42650	35050

Appendix 5 Production cost and returns for different crops

Table 17. Production cost and returns in TSh for different crops per are.

Crop:	Maize[1]	Beans[1]	Tomato[1]	Irish patato[1]	Rice[1]	Rice[4]	Cabbage[4]
Location	Iringa	Iringa	Iringa	Iringa	Iringa	Malolo	Mgeta
Land preparation Plough by tractor	225	225	255	225			
Plough by animal					250		
Manual							494
Seed requirement				1050		49	123
250 g	162.5						
625 g		428.1					
6.25 g			94				
1 Kg					100		
Sort the soil & bunding					375	371	
Cleaning of bunds					250		
Fertiliser application							235
2.5 Kg Urea	400		400				
1.25 Kg TSP	375	375	375				
0.75 Kg Urea		120					
1.25 Kg DAP				375			
Planting operation	75	75	125	75	250		82
Weeding operation 1st Weeding	125	125	125	125	250		247
2nd Weeding	100		100	100			247
Pest control							132
0.1 Knapsack sprayer	60						
0.125 Knapsack sprayer		47.5					
0.25 l Bravo			1500				
0.24 l Bravo				1440			
0.06 l Thiodan 35 EC			570				
Bird control					250		
Top dressing			225				
Harvesting 1 Harvest	100	100		75	250		
4 Partial harvests			750				
Threshing (manual)					250	89	
Cleaning after beating					200		
Transportation	200	120	3000[3]	1350[3]	152		494
Shelling	100	35					
Storage Actellic Super Dust	150	60					
Packing material Bags	300	108			228	178	
Baskets			300				
Total production cost	2372.5	1818.6	4393	3480	2805	686	2053
Returns (low price)							
Immediate sale	2500[2]	3240[2]			2280	3358	4938
Dec-Jan in DSM			37500[3]				
Dec-Jan in Iringa			12000				
Iringa				3600			
Returns (high price)							
Sale after 4-5 month	5000	5400					
Feb-Mar in DSM			22500[3]				
Feb-Mar in Iringa			6000				
DSM				11700[3]			
Dec-Jan					7600		
Net returns Immediate sale	278	1481			-525	2672	2885
(low price) Dec-Jan in DSM			32561				
Dec-Jan in Iringa			7061				
Iringa				120			
Net returns Sale after 4-5 month	2628	3581.4					
(high price) Feb-Mar in DSM			17561				
Feb-Mar in Iringa			1061				
DSM				6870			
Dec-Jan					4795		

[1] From: End of Assignment Report, GCPF/URT/106 NET. D. Montagne 1996. [2] No use of Acetellic Super Dust. [3] Only when crop was transported to Dar es Salaam. [4] Based on real cost.