A CASE STUDY OF SMALL-SCALE RURAL AQUACULTURE IN NAMPULA PROVINCE, MOZAMBIQUE

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ABSTRACT

The Nampula province is in the northern part of Mozambique. The climate is sub-tropical and suits well for development of fresh water fish culture. Small-scale rural aquaculture can play an important role in providing nutrition, income, food security, employment, social benefits and reduced poverty. The survey was conducted on a group of 19 associations and 39 private fish farms with 218 ponds, stocked with *Oreochromis niloticus*. The fish farms are 200-600 m^2. The production of about 4.000 kg/year was achieved from small seasonal homestead ponds through integrated use of locally available biological resources.

Keywords: Aquaculture, small scale, rural

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1 INTRODUCTION

1.1 Background

The Republic of Mozambique is located on the southeastern coast of Africa bordered by Tanzania to the north, South Africa and Swaziland to the south, Zimbabwe to the west, and Zambia and Malawi to the northwest (Figure 1). The total area of the country is about 801,590 km^2. The average temperature ranges from 15.5 to 33.9ºC. There are two seasons; summer/dry (October to March) and winter/wet/cold season (April to September). The total population is about 22 million, with 70% living in rural areas and depend on subsistence agriculture, livestock and fisheries. Mozambique has a coastline of about 2,780 km (Indian Ocean), 13,000 km^2 of inland waters, which include a large number of rivers (Zambeze, Rovuma, Lugenda, Lurio, Save, Pungue, Buzi, Limpopo, Incomati and Maputo), lakes, reservoirs and streams. The total registered aquaculture production in 2010 was 667 tonnes. The estimated per capita consumption of fish is 9 kg/year in urban and 2-3 kg in rural areas (MAE 2005).

Figure 1: Mozambique geographic location (maps.google.com).

1.2 Rationale

Small-scale aquaculture offers a significant potential for income generation, as well as contributing to improvement of food security and the alleviation of poverty among rural communities. More than seventy per cent of the population in Mozambique lives in rural areas and over 3 million families or 89 % of population are involved in small-scale farming.
In these areas, low levels of education, high dependency rates, low productivity and poor infrastructure to contribute poverty (Modadugu *et al*. 2005). Studies to assess small-scale aquaculture production in Mozambique are needed in order to get a good overview of the current status and as a basis for future development of the sector. The goal of this study is to assess small-scale tilapia production in Nampula province, Mozambique.

1.3 Objective of study

The overall objective of the survey was to collect information on small-scale (subsistence) aquaculture activities in Nampula province. This information is needed for monitoring and evaluating the development of aquaculture and to develop strategies and plans for future development of the sector.

1.4 Specific objectives

The specific objectives of this study were to:

1. Collect information on small hold fish farms in Nampula province including:
    a) Background information on fish farmers.
    b) Ownership and running form of farms.
    c) The number of women involved in activity.
2. Collect information on farm management practices.
4. Quantify harvest and destination of harvested fish.
5. Estimate level of assistance and advice sought by farmers.
6. Estimate harvest yield and factors affecting harvest yield.

1.5 Research questions

- What is the number of ponds in Nampula province?
- What is the volume of tilapia production in each district?
- How many fish farmers and association exist in Nampula province?
- What are the main constrains the farmers face?
- Which conditions are associated with high harvest yield?

2 LITERATURE REVIEW

2.1 State of word aquaculture

Aquaculture is a growing food production sector, which provides high protein food. The global production of food fish from aquaculture, including finfish, crustaceans, molluscs and other aquatic animals for human consumption reached 52.5 million tonnes in 2008 (FAO 2010).

Contribution of aquaculture to the total word fish production continued to grow from 34.5% in 2006 to 36.9% in 2008. From 1970-2008, the production of food fish from aquaculture increased at an average annual rate of 8.3%, while the world population grew at an average annual rate of 1.6 % per year (FAO 2010). The combined result of development in aquaculture worldwide and the expansion in global population has caused the average annual per capita supply of food fish from aquaculture for human consumption to increase from 0.7 kg in 1970 to 7.8 kg in 2008, at an average rate of 6.6% per year (FAO 2010).

The value of the aquaculture harvest, excluding aquatic plants, was estimated at US$98.4 billion in 2008. The actual total output value from the entire aquaculture sector is significantly higher than this because the value of aquaculture hatchery and nursery production and that of breeding of ornamental fish are yet to be estimated and included.

Including aquatic plants, world aquaculture production in 2008 was 68.3 million tonnes, with an estimated value of US$106 billion (FAO 2010).

2.2 Status of aquaculture in Africa

In Africa, aquaculture production has increased by 56% in volume and more than 100% in value between 2003 and 2007. This growth was driven partly by increasing prices for aquatic products along with the emergence and spread of small and medium scale aquaculture enterprises, and due to a significant investment in cage culture accompanied with the expansion of larger commercial ventures, some producing high-value commodities for overseas markets (FAO 2010).

Egypt dominates the aquaculture production in Africa. In the near East and North Africa, some countries have invested heavily in capacity building and infrastructure development for aquaculture. Several countries in sub-Saharan Africa, including Angola, Ghana, Mozambique, Nigeria, Uganda and United Republic of Tanzania, have also experienced good growth in aquaculture (FAO 2010).

In other countries in sub-Saharan Africa, growth has been held back by persistent bottlenecks such as access to good-quality feed, seeds and markets. However, Africa governments have demonstrated increasing support for aquaculture, presumably anticipating benefits for economic growth, food supply and security as well as in the form of poverty alleviation (FAO 2010).

2.3 Status of aquaculture in Mozambique

Aquaculture in Mozambique is a relatively new venture. Fish culture in Mozambique started in the 1950s with the construction of embankment ponds for fish culture for farm workers in the provinces of Nampula, Zambézia, and Manica. In the early 1960s, three research and demonstration centres were built by the colonial government in Umbeluzi (0.5 ha), Sussundenga (20 ha), and Chokwé (1.6 ha). The main goal was to restock dams, lakes, and natural reservoirs. These facilities were abandoned during the civil war and are currently degraded (Mapfumo *et al.* 2009, FAO 2010).

The Mozambican government has adopted a strategic plan to reduce extreme poverty and hunger by developing aquaculture to minimize the dependence on fish from capture fisheries. By developing aquaculture, the government expects to increase the supply of cheap and affordable fish as source of protein, improve diet, create jobs, generate income and promote regional development (Modadugu *et al.* 2005).

Currently, there are two types of aquaculture in Mozambique (MIPE 2007), which include culture of marine prawns in semi-intensive systems (with annual production of 1000 tonnes) and small-scale freshwater aquaculture in ponds. Around 5500 people are involved in subsistence aquaculture in ponds as a part time activity, of which 3500 are in extensive tilapia farming and 2000 in seaweed farming (FAO 2010).

The potential for freshwater aquaculture in Mozambique is very high (Modadugu *et al.* 2005). It is estimated that 258,000 ha of land are suitable for aquaculture. At present there are only about 3500 aquaculture ponds in Mozambique with an average area of 400-500 m^2. The species cultured in the ponds are mostly Mozambican tilapia (*Oreochromis mossambicus*),

Nile tilapia (*O. niloticus*) and red-breasted tilapia (*Tilapia rendalli*) (INAQUA 2010). The culture of tilapia in cages installed in reservoirs has only begun in recent years.

The subsistence aquaculture in Mozambique contributes to the alleviation of poverty through the farming of aquatic organisms for domestic consumption and/or income. Furthermore, aquaculture contributes to economic development through employment (Edwards 2002). The small-scale aquaculture in Mozambique is extensively characterised by low external inputs and low-cost technologies accessible to the poor, without the use of mechanical aeration, fertilizers or industrial feed. It is mostly based on family labour (Demaine 2009). The Ministry of Fisheries of Mozambique has promoted small-scale aquaculture for decades through provision of subsidized inputs for ponds construction, seed, lime and extension services (Modadugu *et al.* 2005).

Most of small-scale fish farms in Mozambique grow tilapia. It is practiced as extensive aquaculture in earthen ponds, ranging in size from small backyard ponds (200-400 m^2) to larger ponds (1.5 ha). Seeds are either collected from the wild or from other farmers' ponds and stocking density is 2-5 fish/m^2. The fish grow to maximum of 150 grams over a period of six months (FAO 2005).

The ponds additionally provide water for household use, watering vegetables and livestock and trapping wild fish, functioning essentially as a farm reservoir. The fish ponds can increase aquaculture diversity by supporting the production of crops, leading to increased sustainability in social as well as in environmental terms. Nile tilapia is a favoured species for extensive systems because of its high tolerance of poor water quality. These fish farm are owned either by small families or organized in groups or associations (Carballo *et al.* 2008).
Formulated feed for fish is not available in Mozambique. Fish are fed agricultural by-products such as rice, maize, millet, sorghum bran and cassava leaves. Farmers use manure from cow and other livestock for fertilizer depending on availability. Yields are low, estimated at 0.8 tonnes/ha/year. Grow-out time is from six months to a year depending on the feeding regime (FAO 2005).

Poverty is a multidimensional concept that includes (i) deprivation or lack of access to capital assets essential to livelihoods; and (ii) vulnerability to physical and economic shocks, and to various attributes of seasonality. Poverty is reflected in low standards of living, deprivation of income and non-income assets, shortfalls in consumption, nutrition and access to services and limited means to cope with crisis situation. Poverty also reflects lack of employment opportunities (FAO 2006). Poverty exists when people do not have the capacity required to attain adequate levels of income, health, education, security, self-confidence and free expression, among others (Sen *et al.* 2000).

A development plan will be implemented in Mozambique, to improve productivity and production in small-scale aquaculture. A SWOT analysis performed by INFOSA (Intergovernmental Organization for Marketing Information and Technical Advisory Services for the Fisheries Industry in Southern Africa) identified strengths, weakness, and opportunities for small-scale aquaculture in Mozambican (Mapfumo *et al.* 2009).

The main results of the SWOT analysis (Table 1) indicated that Mozambique has access to land and good quality water for aquaculture, a stable business environment and aquaculture is a Government priority. The main constrains to aquaculture development are poor

infrastructures, lack of good quality fingerlings, fish feed, weak technical assistance and limited access to credit.

Table 1: SWOT analysis of the development of the small-scale aquaculture in Mozambique (Mapfumo *et al.* 2009).

Strengths	Wide range of potential suitable endemic freshwater species; Stable political and business environment; Species diversity; Unpolluted environmental; Government priority; Willingness of small scale farmers to produce crops for fish feed; Availability of land and good quality water for aquaculture.
Weaknesses / Limitations	Technical knowledge of suitable species specific to aquaculture practices is limited; Lack of infrastructures and logistic; Lack hatchery capacity for seed-stock supply; Few incentives for development in aquaculture; Expensive fish feed; Lack of local inputs; Poor knowledge of market requirements.
Opportunities	Build necessary infrastructure; Build capacity and train stakeholders; Encourage investors and FDI; Encourage fish feed production/ feed formulation; Encourage applied research and development; Introduction of new species.
Threats	Low technical level of fish farmers; Lack of institutional Infrastructure to facilitate aquaculture; Lack of finance; High fuel cost; Natural catastrophes (cyclones, floods)

3 METHODOLOGY

3.1 First phase, start in Mozambique

The survey was conducted in June 2011 a by team of technicians from the National Institute for Aquaculture Development, the provincial fisheries office, and extension officers of the District Service for Economic Activities (SDAEs), in seven districts of Nampula province, namely Rapale, Murrupula, Ribaue, Mogovolas, Lalaua, Mecuburi e Malema.

Four technicians carried out the survey over a period of 4 days in each district. They obtained information from provincial directorates of fisheries on the number of ponds in operation in each district and identified fish farms in the districts where the survey was performed with the assistance of SDAEs. They also visited fish farms, offering extension services and suggestions for management practices, evaluating water quality in ponds, fish size, size of ponds, soil type, source of water and allow recommendations of dissemination of good practice for aquaculture. Finally, they conducted structured interviews with thirty-nine family fish farms and nineteen associations of fish farmers to collect data.

3.2 Second phase, in Holar University College, Iceland

In Holar the data were analysed using Microsoft Excel. The data were entered into a spreadsheet and analysed using pivot tables for descriptive statistics (average, frequency and variation). The results were written up as a part of the project.

4 RESULTS

4.1 Location of fish farm

Most of the fish farms were in the district of Murrupula, Mecúburi and Ribaue (Table 2). They all produced tilapia in earthen ponds. The water was taken from a lake, river, well or other natural source and channelled into the ponds.

Table 2: Number of ponds in different districts (Stocked and not stocked).

Districts	Number of ponds	Stocked	Not stocked	Production (Kg) per ponds/year	Estimated Production (Kg/Ano)	Specie cultured
Rapale	27	10	17	38.43	384.3	Tilapia
Murrupula	380	90	290	7.83	705	
Ribaue	65	35	30	46.23	1618.3	
Lalaua	49	22	27	10.91	240.5	
Mecuburi	76	45	31	7.75	349.4	
Mogovolas	17	7	10	19.71	138	
Malema	15	9	6	63.67	573	
Total	629	218	411	194.53	4008.5	

4.2 Ownership and organization of fish farm

Most of fish farms (39) were privately owned (Table 3). Furthermore, 19 farms were organized in associations, which are a group of fish farmers who have joined to develop aquaculture activities in individual or common ponds in the same area (Table 3). Most of associations were in Murrupula district. Rapale district has the largest number of fish farms.

The government and NGOs play an important role in development of the associations in Murrupula district.

Table 3: Number of associations and family farms.

Districts	Number of Family owned fish farm	Number of Associations	Family %	Association %	Total number of fish farms
Rapale	11	1 association with 19 members	28.2	5.3	30
Murrupula	8	13 association with 354 members	20.5	68.4	362
Mecúburi	5	1 association with 27 members	12.8	5.3	32
Mogovolas	0	1 association with 16 members	0	5.3	16
Lalaua	6	1 association with 10 members	15.4	5.3	16
Ribaué	6	2 association with 41 members	15.4	10.5	47
Malema	3	0	7.7	0	3
Total	39	19 associations with 467 members	100	100	506

4.3 Involvement of women in small-scale farm association

The participation of women is more common in associations. About 48.2 % of women who were in the survey are involved in fish farm associations with most them in Murrupula district. Women play an important role both as workers in the fisheries and aquaculture sector in ensuring household food security (Satia 1989). It is easy for women to engage in activities such as feeding and harvest of fish and collection of fish fry and fingerlings from the wild environment (ADB 2005).

Although efforts are in place in Mozambique to eliminate inequalities between men and women through promotion of women human rights and the introduction of laws and regulations that guarantee a formal equality of rights, much work still remains in this field.

4.4 Labour (People involved in the care of fish)

Most of the fish farms (52.8%) rely on family members for aquaculture activities (Figure 2). Some farms (32.1%) rely on other members of the association. Few farms (15.1%) in Ribaue districts use personnel hired for pond construction.

Figure 2: Labour (People involved in the care of fish).

4.5 Other sources of income than fish farming

Most of fish farms have other sources of income than aquaculture. These include agriculture at 75% and livestock at 22% (Figure 3).

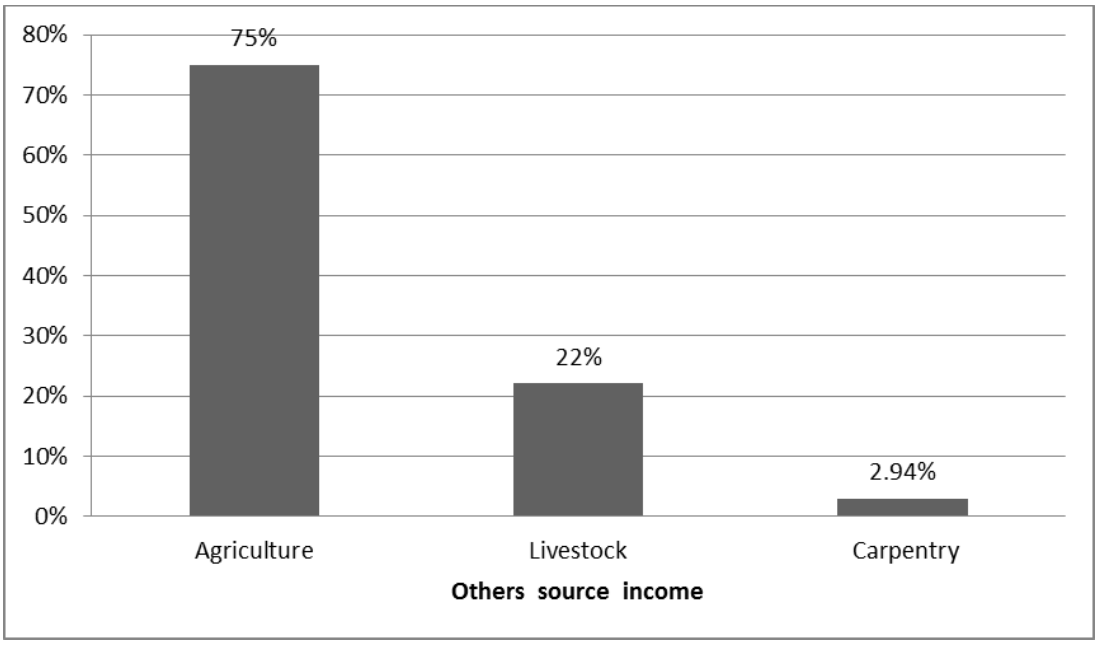

Figure 3: Other sources of income than fish farming.

4.6 Size of farms (m^2)

Most of the fish farms (27.3 %) are 201- 400 m^2 (Figure 4). Less than 10% range from 600 and 1200 m^2. The largest farms (>1600 m^2) were in the Ribaue districts. All of the fish farmers in the survey used earthen ponds to grow Nile tilapia. About 20% of the farms were above 1600 m^2.

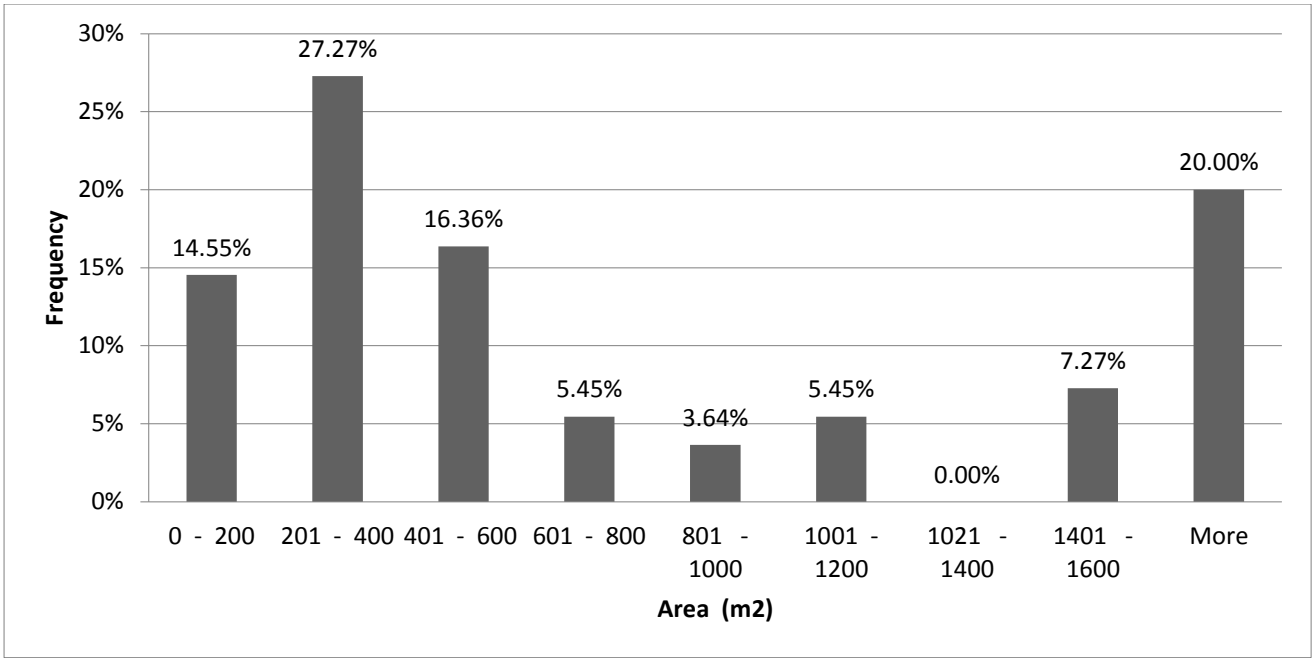

Figure 4: The area of ponds in fish farms (m^2).

4.7 Conservation status of aquaculture

The conservation status in most of fish farms was considered to be acceptable with some good (Figure 5). Although the conservation status of the fish farms was considered acceptable in general, the following irregularities were commonly observed, degraded levees and too much grass growing on banks and in the ponds, lack of fertilization and poor water quality, and irregular shapes of ponds.

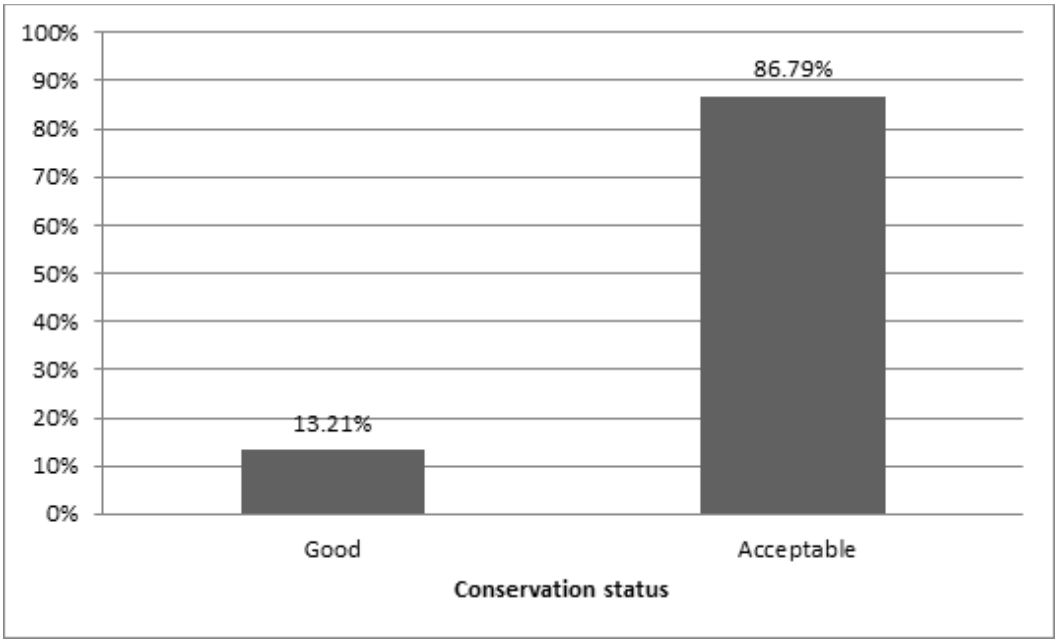

Figure 5: Conservation status of aquaculture.

4.8 Species farmed

The species most commonly used in small-scale aquaculture in Mozambique is Nile tilapia (Figure 6). It is well suited for fish farming because it grows well, is able to survive in poor water conditions and eats a wide range of foods (Mapfumo *et al.* 2009). They all require warm water (25 – 29 ºC) for optimum growth, pH 6.0 – 8.0, dissolved oxygen recommended range is from 4 mg/l, water turbidity moderate green with an average secchi disc reading of 30–45 cm, alkalinity major than 20 ppm, ammonia less 0.1 and nitrite less than 0.3.

In terms of rapid growth tilapia males grow faster than females. Nile tilapia weighing 75 to 500 grams can deposit 50 to 2000 eggs per spawning and can breed easily with no need for special hatchery technology. The adult tilapia prefers vegetarian diets, varying from macrophytic to phytoplanktivorous. In ponds with supplementary feeding, natural food contributes 30 to 50% of tilapia growth. Tilapia becomes sexually mature at a size of about 10 cm (about 30 grams body weight). This early maturity and frequent breeding causes overpopulation of the ponds with young fish and will lead to fierce competition for food between the stocked tilapia and the newborn recruits (Carballo *et al.* 2008).

Figure 6: Nile Tilapia (*Oreochromis niloticus*) freshwater fish aquaculture.

4.9 Feeding and Fertilization

The most common supplementary feeds used (Figure 7) were millet bran (35.2%,) vegetables (28.8%) and sorghum bran (21.6%). Less than 10% of respondents used rice bran, food scrap and locusts. For fertilizing the ponds, chicken, pig, and cattle manure were commonly use as well as, leaves, rice bran and other farm by-products. In some cases, farmers composted this material before fertilizing the ponds.

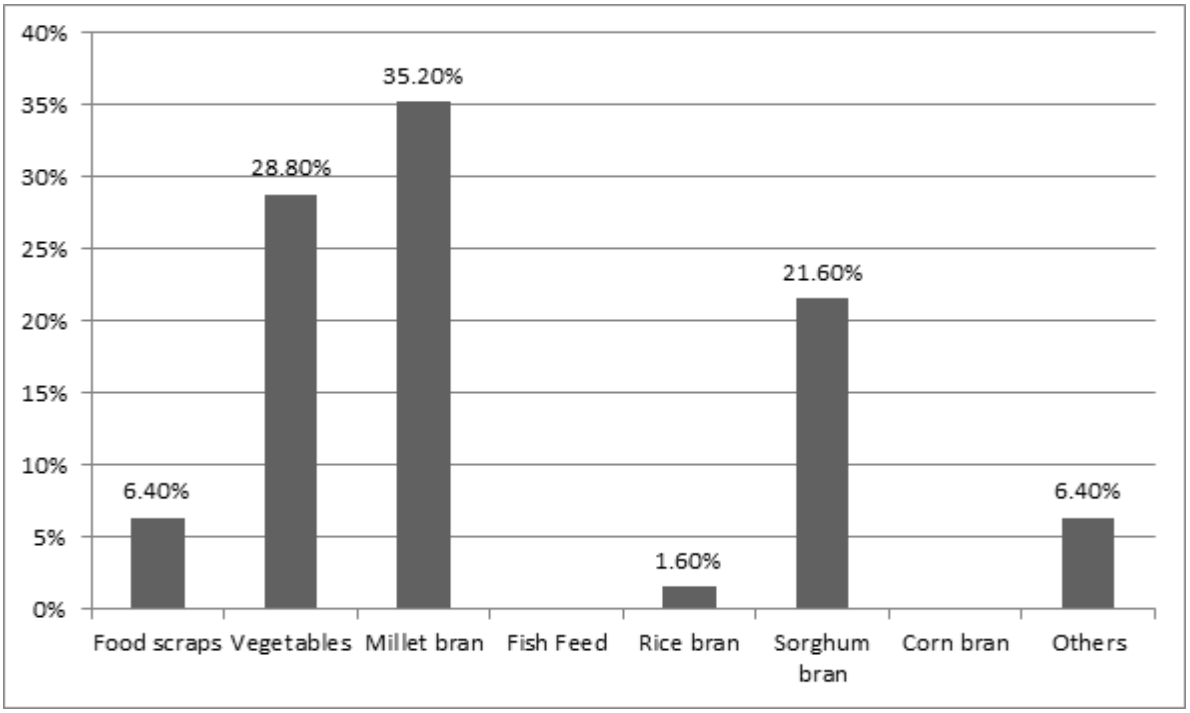

Figure 7: Feeding and Fertilization.

4.10 The age of the fish farms

The number of small hold fish farms increased from 2004 to 2006 (Figure 8). However, slightly fewer were found the following two years; this was because of drought, lack of fingerlings and low technical assistance.

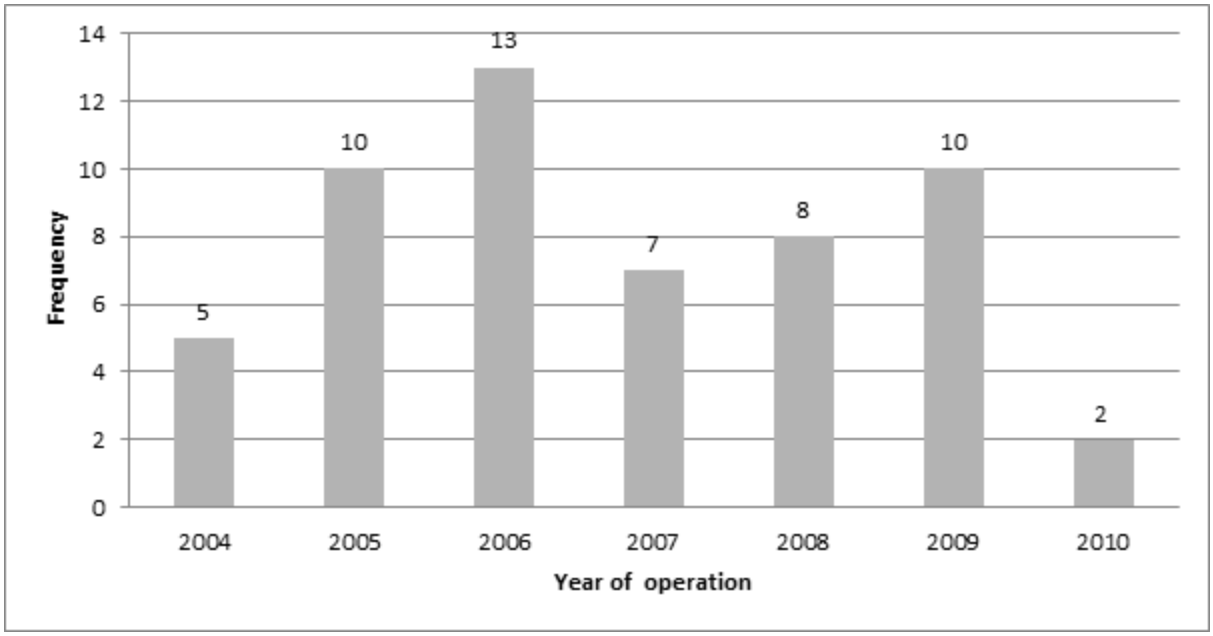

Figure 8: The year in which the fish farms started operation.

4.11 Harvest

Most commonly the fish were harvested with frequent partial harvests (Figure 9) on average of 3 partial harvests per year. Most fish farmers harvested with fishing nets (56.9%); while other farmers harvested with mosquito nets (35.3%). Few of them harvested with hooks (7.84%). Due the low production, the fish farmers harvested only as much as can be consumed or sold within a day. The most common method of harvesting was by using fishing nets, capturing larger fish while leaving the smaller fish in the ponds.

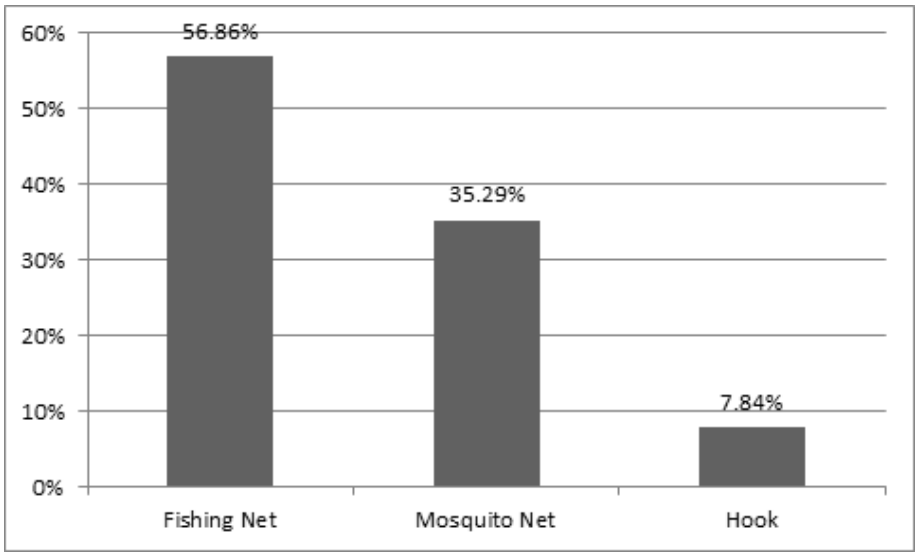

Figure 9: Harvest method for farm cultured Nile Tilapia.

4.12 Aquaculture production

The total production in the 218 ponds stocked was about 4000 kg/year (Figure 10). The greatest production was in Ribaue district at 1618 kg/year. Two others districts Murrupula and Malema had 705 and 573 kg/year respectively.

4.13 Destination of fish produced

Most of fish farmers produce for their own consumption (78.4%), and only 21.6% fish farmers sold their fish (Figure 11).

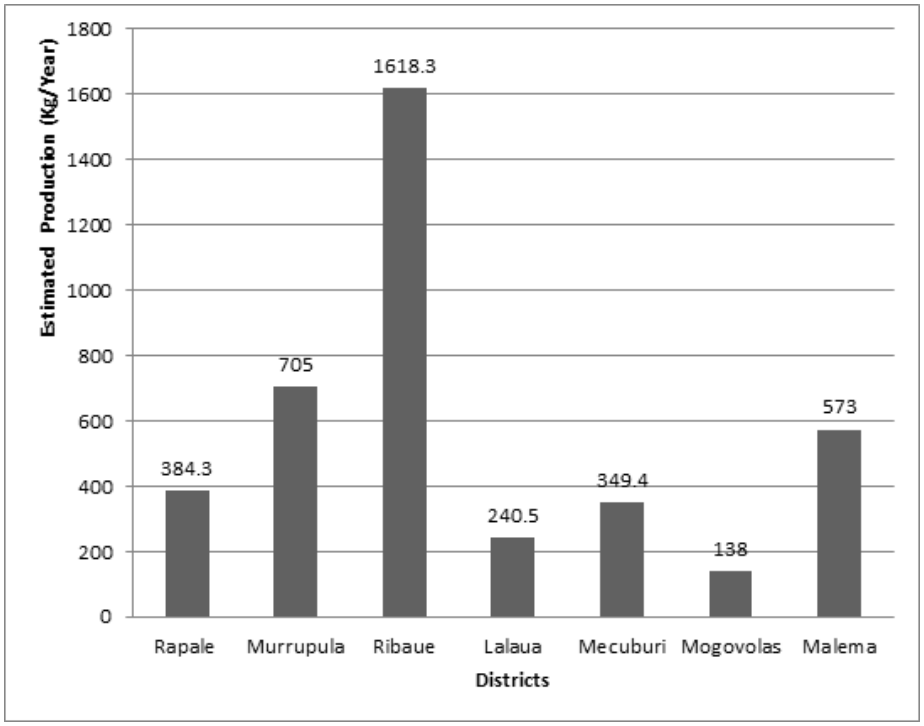

Figure 10: Aquaculture production for different farms.

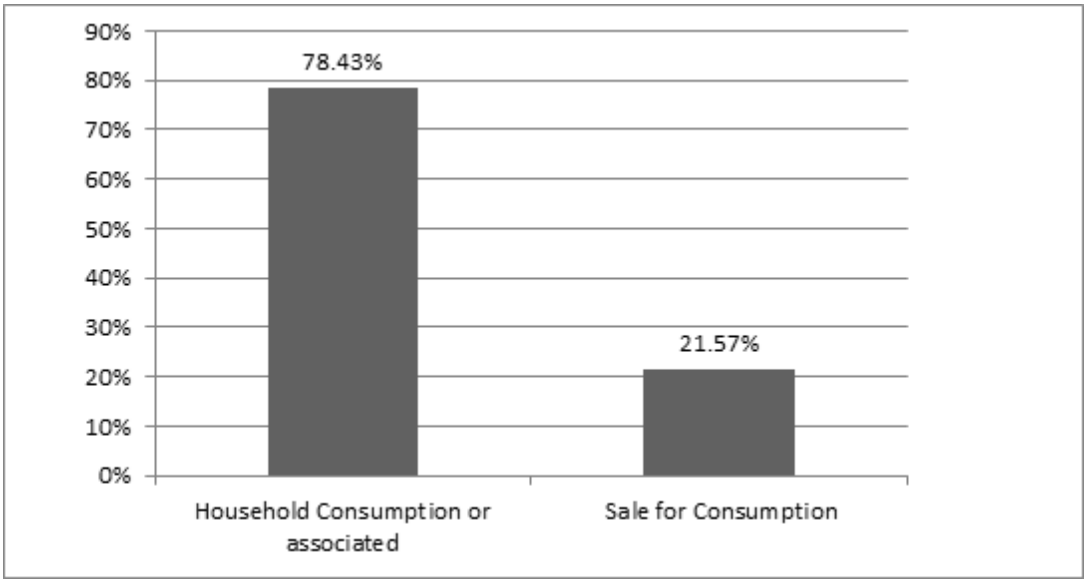

Figure 11: Destination of fish produced.

4.14 Technical assistance

All fish farms relieved technical assistance when starting pond construction. Most of the fish farmers (58%) received technical assistance from SDAEs. The Provincial Directorate of Fisheries also provided technical assistance in 22% of farms and 20% of farms received assistance from NGOs (Figure 12).

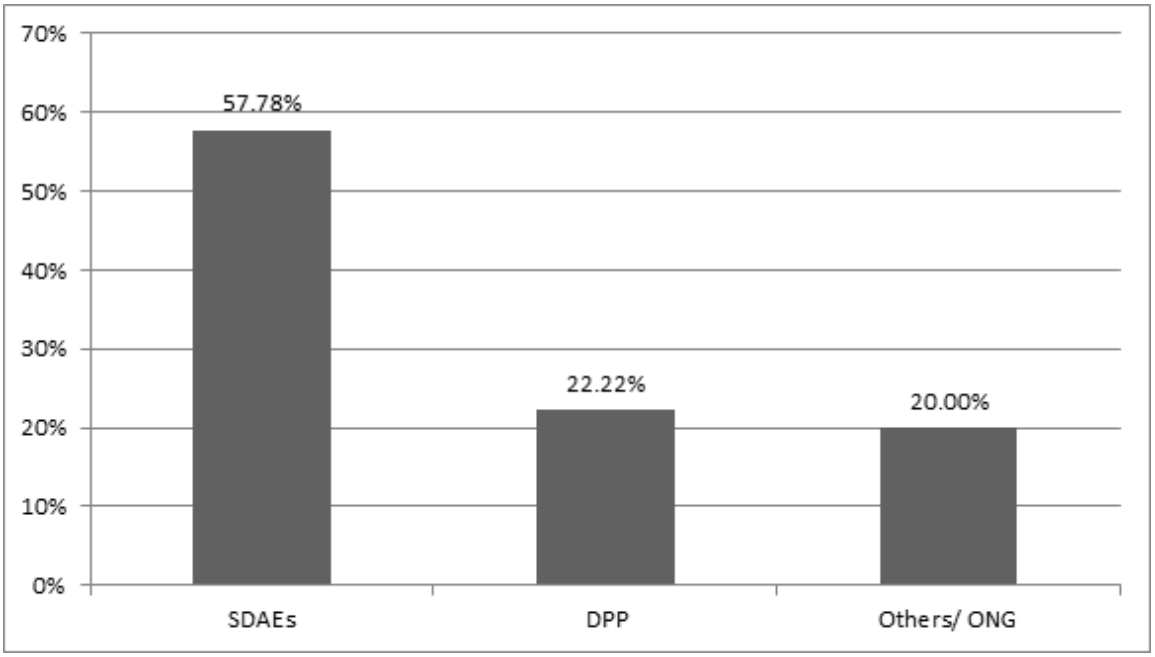

Figure 12: Technical assistance received.

4.15 Frequency of technical assistance

Most of fish farmers in Rapale, Murrupula, and Mecuburi received technical assistance monthly (Figure 13). In other districts (Malema, Ribaue) farmers generally received technical assistance quarterly. Fish farms in Mogovola and Lalaua districts most commonly received assistance semi-annually because this district did not have family owned fish farms, but had only have one association with 16 members and 7 ponds of small size and poor water quality.

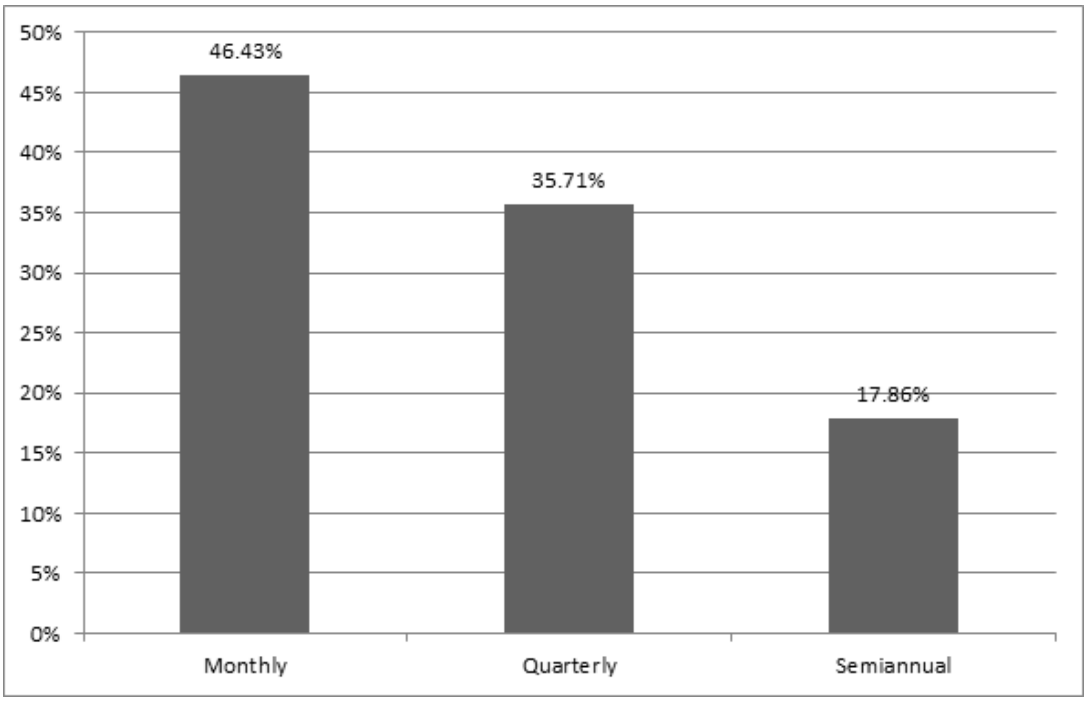

Figure 13: Frequency of assistance.

4.16 Problems faced

Most of the fish farmers indicated that they had faced problems with their farms. Mainly the problems were associated with poor water quality, difficulty in the acquiring fingerlings, materials and tools for ponds construction and low technical assistance (Figure 14).

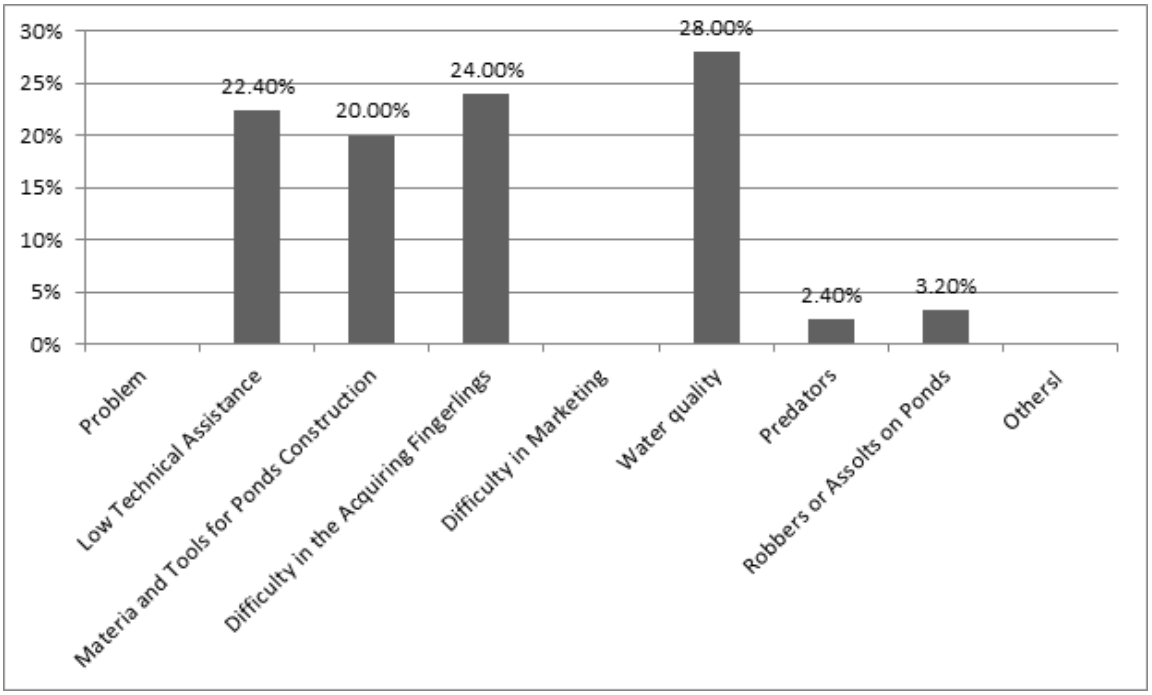

Figure 14: Problems faced by the farms during fish farming.

4.17 Yield

Figures 15 and Tables 4, 5, 6 and 7 show the yield in different districts, yield in family owned and associations, yield with different feeding, yield with technical assistance and yield with harvested method.

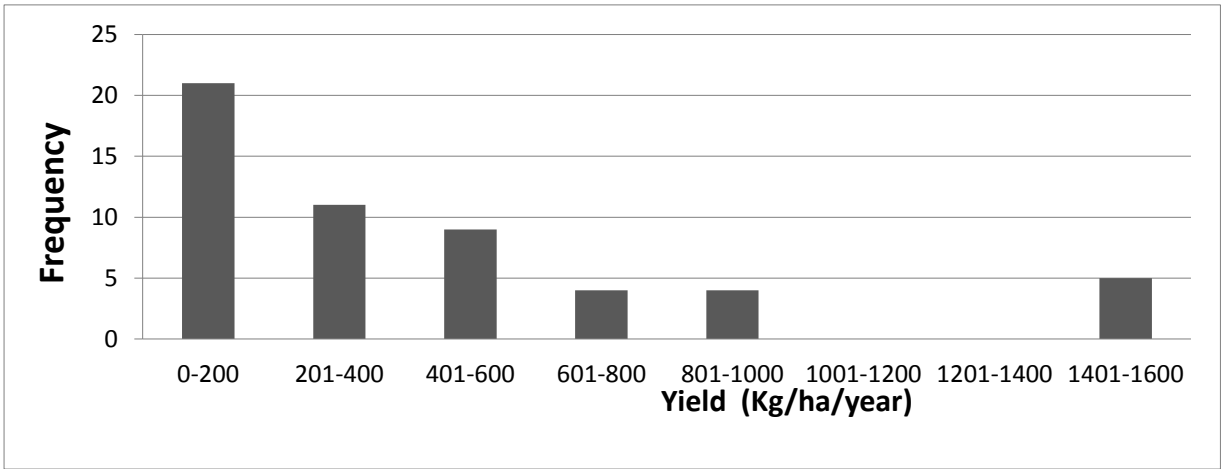

Figure 15: Yield in different districts.

Table 4: Yield in family owned and associations.

Average of Yield (Kg/ha/year)	Family / Associations		
Districts	Associations	Family	Grand total
Lalaua	132	955.5555	837.9047
Malema		404.2735	404.2735
Mecuburi	61.2244898	804.4444	680.5744
Mogovolas	61.22449		466.6666
Murrupula	446.66667	332.9644	174.4784
Rapale	100	616.1375	530.1146
Ribaue	164.0544	381.0317	332.8145
Grand total	169.9269	577.1829	449.9154

Table 5: Yield with different feeding.

Different feeding	Average of Yield (Kg/ha/year)
Food scrap	264.1002
Vegetables	432.00309
Millet bran	461.15402
Sorghum bran	580.09874
Rice bran	1044.44444
Grand total	449.91542

Table 6: Yield with technical assistance

Average of Yield (Kg/ha/year)	Technical assistance
SDAEs	448.42460
DPP	504.12648
Others / ONG	380.519943
Grand total	449.91542

Table 7: Yield with harvested method

Average of Yield (Kg/ha/year)	Harvest
Fishing net	451.9905874
Mosquito net	533.239797
Hook	102.0918494
Grand total	449.91542

5 DISCUSSION

The discussion will address the key indicators that affect the yield of small-scale rural aquaculture (location of fish farm, labour, feeding and fertilization, technical assistance and area of farm).

5.1 Location of fish farm

Most of the fish farms are in the districts of Murrupula, Mecúburi and Ribaue, which is likely for the following reasons; these are the regions with higher population density; most available land for fish farm; strong support from government and NGOs in two districts (Murrupula and Ribaue).

The location of ponds usually is near to the residence of the fish farmer. This gives an advantage in a way that facilitates the fish farmers to feed the fish at least two times a day, food scraps, protect against robbers and predators (birds).

5.2 Labour (People involved in the care of fish)

Most of the fish farm rely on members of the family as labour. Small-scale rural pond farms generally rely on family labour. Larger farms employ regularly seasonal workers or casual workers for pond preparation, stocking and harvesting. The most labour intensive activity in small-scale aquaculture is pond construction. This is not restricted to a certain time of the year and is generally undertaken during periods of light demand on male labour (ADB 2005).

Exchange labour from members of the local community is also used where neighbours and other members of the community provide labour exchange (e.g., for ponds preparation or harvesting) without financial payment. The pond owner is expected to reciprocate the initiative by helping fellow farmers when needed. If the activity is harvesting, fish are normally given to those who participate. In rural areas, with limited employment opportunities and high unemployment, labour supply is abundant. Men, women, and even children assist in pond operations (Sen *et al.* 2000).

In Ribaue district the results showed that family members have good yield in comparison with associations. Most of the privately owned farmers practice the semi-intensive system, use the fertilizer to improve natural productivity and/or supplementary feeding, whereas associations practice extensive system where economic and labour inputs are usually low.

5.3 Other sources of income than fish farming

Low production and the fact that nearly all farms are also involved in other farming activities suggest that aquaculture is secondary and not the main source of food and income. According to INE (2010) 70% of households in Mozambique are located in rural areas and virtually all of these (96%) are engaged in agriculture in some way. Agriculture is the major economic activity in northern Mozambique and is complemented by small animal husbandry (mainly poultry) (MAE 2005). Agriculture is conducted by small hold farmers and is largely subsistence oriented. The area cultivated is directly related to the availability of family labour. Livestock, particularly chicken and goats are common; however, cows and other larger animals are relatively rare. Crop surpluses are sold to obtain other basic goods and inputs.

5.4 Feeding and Fertilization

Most of fish farms feed the fish using by-products from the farming; sorghum, maize, rice, and millet; leguminous crops such as pigeon peas, cowpeas and beans; vegetables such as onions, tomatoes, potatoes, cabbage, carrot, and lettuce; oilseeds such as groundnuts (MAE 2005).

Fertilized ponds and feed supplementary (rice bran) have a yield 4 times more than fish farms using food scraps. Fertilization adds compounds to the pond (fertilizers) that increase the levels of mainly nitrogen and phosphorus in the ponds water with the objective of increasing pond algae (phytoplankton) production. The water in well-fertilized ponds looks green because there are more algae (phytoplankton) suspended in the water.

Sen *et al.* (2000) argues that fertilization of fishponds with cattle manure stimulates the growth of plankton in the water and of microorganisms and invertebrate animals on the bottom. Manure has alternative use as a fuel and a crop fertilizer because of the profitability of fish farming. Chicken, pig, and cattle manure, leaves, rice bran and other farm by products are normally used in small-scale rural aquaculture. In some cases these materials are composted before fertilizing ponds. Commercial feeds are rarely used.

5.5 Harvest

Fish farm harvested with mosquito nets have good yield in comparison with fish farms harvested with fishing net; with the disadvantage of mosquito net removal of fish from any stages of the production cycle.

Sen *et al.* (2000) argues that in small-scale rural aquaculture, poor farmers often cannot afford to buy a net. Many countries do not produce fishnets requiring the importation of such items. In other situation, even if nets are provided by the project, they eventually deteriorate, and when funds are exhausted, fishing pressure and yields diminish. Ponds for self-sufficiency should be harvested periodically using different gear such as hook and line, traps, seines, trawl.

Timmons *et al*. (2001) defines harvest, as the removal of harvested sized fish or removal of fish from any stage of the production cycle.

5.6 Yield

There is a high variation in the yield of the farms that is associated with farming practices. There is the large difference among districts (Figure 15). The yield in Mogovolas was more than four times than Murrupula, the district with the lowest yield. Another factor contributing to the variation in yield was the ownership of the farms. The privately owned fish farms had more than three times better yield than the farm that are members of associations, possibly due to better and more diligent management. The high yield was also associated with feeding practices and farms that used sorghum, maize, rice, and millet.

5.7 Technical assistance

Fish farm with technical assistance of Provincial Directorate of Fisheries have a good yield in comparison with other sources of technical assistance. This was associated with the type of system the fish farm visited used.

Sen *et al*. (2000) also argue that in general, governmental extension service lack the necessary fund and adequate infrastructure to offer the assistance required by small farmers in such areas as integrated crop production, fish health, fish nutrition, seed production, aquaculture infrastructure, production economics and water quality.

Aquaculture extension should be integrated with agriculture extension and should be part of the overall rural development. The extension approach should change and become participatory. In rural development the challenge is not to ensure that fish farmers adopt certain activities or techniques, but to ensure that they are aware of the specific opportunities that exist in their situation.

Extension is defined as the overall structure, which can develop high quality aquaculture training programmes and disseminate information for farmers through seminars, workshops, journals and different publications that involve aquaculture knowledge.

Fish farmers face many constrains in adopting to fish farming because of lack of access to capital and resources, inadequate supply of fish seed, lack of feed, lack of diversity in species cultured, inadequate number and capacity of extension staff, limited dissemination of information, vulnerability and aversion to risks.

6 CONCLUSIONS

The small–scale aquaculture in Nampula province, Mozambique is primarily extensive or semi-intensive. The total production of small holds farms is low and the production is mainly for household consumption. The main reasons for low production are; lack of fingerlings, lack of feed, low technical assistance and dry season or rain dependency in the Rapale, Mogovolas, Mecuburi and Lalaua districts where the ponds rely on rainfall to supply water. Nampula province has 19 associations consisting of 467 members (242 men & 225 women) and 39 individual fish farms with 218 ponds, stocked with *O. niloticus*. There is a production of about 4008 kg/year.

The privately owned have good yield in comparison with farm associations because of the practice of the semi-intensive system in the Ribaue and Malema districts, use of supplementary and fertilizer (manure) for increased natural productivity.

In general, the production is low. The small-scale rural aquaculture in Nampula province did not contribute to livelihoods (cash income, employment generation and reduced vulnerability to poverty). The questionnaire is a very useful tool to assess the status of small hold aquaculture in Mozambique.

Aquaculture development in terms of poverty alleviation requires a continuing need for adaptive, small-scale technological development in order to meet the needs of poor people. The main emphasis includes extending these technologies to poor people by creating opportunities to derive livelihoods benefits. This emphasis of development programmes in rural areas should use aquaculture for development to address the poverty (creation of infrastructural facilities, appropriate skills, land and water, financial capital, organizational arrangements and extension).

7 RECOMMENDATIONS

7.1 Financing Aquaculture Investments.

Small-scale farmers need access to financial capital to enter fish farming. Affordable access to credit is an important feature of household finance. Small-scale farmers frequently do not borrow from banks because of inflexible requirements for collateral and various administrative hurdles. Micro-finance can make a difference to the poor.

7.2 Roles of Services, Facilities and Support Infrastructure.

Small-scale farm households have limited resources at their disposal. Government agencies may remain important source of technical advice for small-scale farmers. The role of other players like farm input suppliers, social networks information exchange and knowledge sharing and the extent to which farmer-to-farmer contacts contribute to the flow of information should be assessed and should complement the government extension service. Aquaculture development cannot succeed without adequate support service and markets. Roads, transportation, and communications play important roles in the flow of goods, services, and information.

7.3 Inclusion of local Civil Societies and Self Help Groups into the process.

Public institutions can catalyse and facilitate development in the private sector, but they must not hinder or replace the private sector. Partnerships and collaborations in research and development in key support areas, such as fish breeding, genetic improvement, farming systems, and aquaculture husbandry should be explored as part of an assessment of sector context.

7.4 Multiple Uses of Water and Minimizing Conflicts.

Freshwater aquaculture coexists with other water uses, with potential conflicts, for example, between fish farm and rice farmers and between lake fishers. Relationships between freshwater aquaculture and other sectors need to be based on recognizing the limited availability of freshwater bodies and finding ways to benefit as many co-users of water as possible. Growing fish before, during, and after the use of waters for other purposes can add greatly to those benefits.

7.5 Protection of Aquatic Resources, Environment, and Aquatic Health

The development of aquaculture cannot be sustained without adequate attention to aquatic resource management, environment, and aquatic health. Steps must be taken to ensure sustainability of environment by taking measures for biosafety, disease prevention, and environmental protection.

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