An Economic Analysis of Milkfish Farming in Tanzania: Potential for Economic Development and Policy Issues

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2007

Sustainable Coastal Communities and Ecosystems Program

IMS-UDSM

This publication is available electronically on the Coastal Resources Center's website: www.crc.uri.edu. It is also available on the Western Indian Ocean Marine Science Association's website: www.wiomsa.org and the Institute of Marine Sciences website at www.ims.udsm.ac.tz/. For more information contact: Coastal Resources Center, University of Rhode Island, Narragansett Bay Campus, South Ferry Road, Narragansett, RI 02882, USA. Email: info@crc.uri.edu

Citation: K. Sullivan, A.J. Mmochi and B. Crawford. 2007. An Economic Analysis of Milkfish Farming in Tanzania: Potential for Economic Development and Policy Issues. The Sustainable Coastal Communities and Ecosystems Program. Coastal Resources Center, University of Rhode Island, the Western Indian Ocean Marine Science Association, and the Institute of Marine Sciences, University of Dar es Salaam. 23p.

Disclaimer: This report was made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents are the responsibility of the authors and do not necessarily reflect the views of USAID or the United States Government.
Cooperative agreement # EPP-A-00-04-00014-00

Cover Photos:

Left, milkfish ponds in Mkuranga
Center, milkfish fingerling collection
Right, Mr. Kirago, a milkfish farmer in Mkuranga

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1. Introduction

Milkfish culture has been practiced for over a hundred years in Asia, particularly in the Philippines, Indonesia, and China but it is just beginning to become a mariculture activity in the Western Indian Ocean (WIO) Region. For instance, Tanzania is pioneering commercial and backyard milkfish farming and is learning from experiences in Asia. There have already been a number of attempts at experimental and pilot stages to culture milkfish in Tanzania (Dubi et al. 2004). A number of academic institutions are involved in milkfish farming experiments. The Institute of Marine Sciences (IMS) at the University of Dar es Salaam for example has been involved in milkfish pond aquaculture consistently since 1996 (Mmochi et al. 2005). However, milkfish farming has not taken off on a commercial scale by private operators for several reasons, including a need for more information on the economic and marketing aspects of milkfish farming and a lack of farm level trials of practical rearing methods and pond designs conducive to commercial production. Additionally, careful attention must be given to pond construction and management, which if not done properly can constrain the ability to produce viable milkfish crops and some of the initial experimental trials previously conducted did not use commercial pond designs or were improperly built.

However, Tanzania's rural coastal communities face many economic development challenges with few alternatives readily apparent. Development of small-scale mariculture has been recommended as one way to improve the quality of life for coastal Tanzanians by increasing employment, household incomes, and food security (Rice et al. 2006). Milkfish (*Chanos chanos*) is native to Tanzania and is found in the wild but until only recently has its culture been attempted, based on adapting longstanding Asian practices to Tanzania. For instance, in Unguja Island there are several small ponds in Makoba owned by the Prisons Department. Two farmers in Pemba Island have been culturing milkfish and mullet for the last ten years and several farmers have been assisted by the Sustainable Costal Communities and Ecosystems (SUCCESS) Program – Mr. Mushi in Bagamoyo, who has been operating for several years, Mr. Kirago and Mkadam in Mpafu, Mkuranga who have harvested at least twice before their ponds were washed out by extreme high tides, and a community group in Byuni village of Pangani. There are also 11 groups of people who own ponds in Mtwara, one pond in Kilwa and Rufiji and one in Machui, Tanga who have harvested at least once. There are several other pond sites in different stages of construction and some that have been declared a failure due to poor siting and construction.

Recent mainland trials conducted by the SUCCESS Program have proven ponds can be built in barren salt pan areas with a harvest after just six months of over 1 MT of fish per hectare and revenues close to US$ 2000. SUCCESS household surveys show median coastal household incomes of approximately $1000/year. Thus, a one hectare pond could double household income. Over 50,000 hectares of saline areas hold potential as sites for milkfish ponds, making the long term income potential nationally significant. Within a decade or so, increases in high quality protein food supply could easily reach 10,000 MT or more annually, employing thousands of persons, increasing incomes of thousands of coastal households and generating over US$ 20 million annually in crop value. In light of the opportunity that milkfish farming presents, in 2005 through 2006, the SUCCESS Program constructed commercial style milkfish ponds and conducted production trials in cooperation with several owners of salt farms in Mkuranga, Bagamoyo and with a community group in Pangani.

The purpose of this economic analysis is to examine the costs and potential returns of constructing and operating a commercial milkfish pond in Tanzania in order to determine the economic feasibility of commercial production. The paper provides an overview of the basic steps in milkfish farming followed by two actual case studies. Several methods were used for collecting the information used in this analysis. First, existing information from previous reports (Requintina et al. 2006) were used to identity the construction and operating costs of a 1-hectare milkfish pond, the estimated productivity, the estimated cash flow and issues associated with marketing milkfish in Tanzania. Cost and productivity information in Requintina et al. (2006) is based on trials conducted at a 1-hectare milkfish pond site at the Kirago salt farm in Mkuranga District. Additional information was collected directly from key informants at a second trial milkfish pond site operated by Regent Enterprises in Bagamoyo. In cases where direct information of costs or earnings was not available at either of the locations several assumptions and general estimates were made to fill the gaps so that a complete and thorough analysis of both sites could be made. This report then compares the estimated costs and returns at these sites and discusses the implications with respect to economic and marketing feasibility of milkfish farming in general. Policy issues to promote milkfish farming are also discussed.

2. An Overview of Milkfish Farming

An overview of milkfish farming based on Tanzanian experience is provided in this section and abstracted from Requintina et al. (2006).

2.1 Milkfish Pond Site Selection

Tanzania is learning from experiences in Asia, which provides an opportunity to avoid any of the early mistakes and promote milkfish farming in a responsible way in the Western Indian Ocean region. One key area of concern is selecting farming areas that will not have an impact on surrounding environments such as mangroves, coral reefs and other fragile ecosystems. Milkfish farmers have a responsibility for conscientious farming practices that are environmentally sustainable. Preferred areas for milkfish pond development are areas used for salt production or in salt flats found behind the mangrove zone. Other than environmental consideration, pond selection requires specific water levels, soil texture and supporting infrastructure. Technical aspects of pond site selection criteria are detailed in Requintina et al. (2006).

2.2 Pond Layout and Design

Pond systems can be classified as either a backyard (Figure 1) or a commercial pond system. Backyard ponds range in size from 0.1 to 0.2 ha, and are operated mainly for household food consumption. In backyard ponds, fish are stocked and harvested continuously. The pond construction and management costs are less for backyard ponds as they are much smaller in size. In Tanzania there are several ponds operating at this scale. Commercial pond systems range from 1 ha and upwards, are more capital and labor intensive, and require more elaborate construction and management strategies than backyard pond systems. SUCCESS has constructed three commercial ponds - two in Mkuranga and one in Bagamoyo and two backyard systems in Pangani. The larger scale commercial pond system is the subject of this report.

Figure 1. Backyard ponds showing PVC pipes for water control

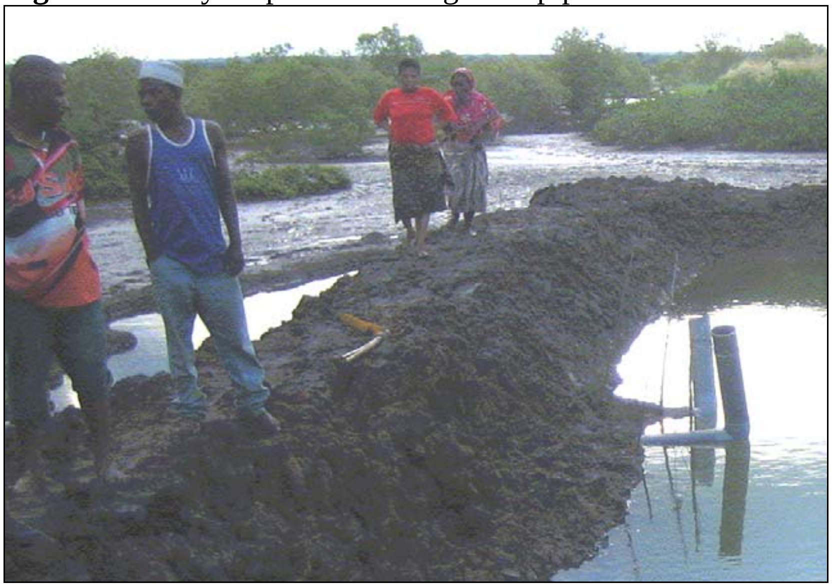
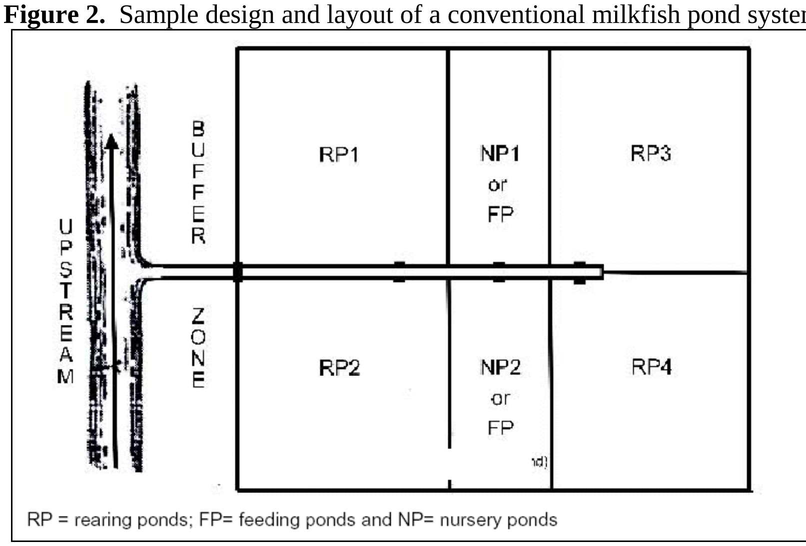


Photo credit: Baraka Kalangahe

2.3 Construction of a Commercial Milkfish Pond

The conventional commercial pond system is typically divided into two types of ponds: a nursery pond (15% of total pond area), and a rearing pond (80% of pond area). A feed pond (ideally 20% of total pond area) is an additional option. Dikes, gates and canals comprise the remaining 5% of the total area. Dikes are the main structures that hold water in the pond. A gate is a sluice, culvert or pipe, which is used to control water flow. A sample design of a conventional milkfish pond system is depicted in Figure 2 below (Requintina et al. 2006).

Figure 2. Sample design and layout of a conventional milkfish pond system



Source: Requintina et al. 2006

2.3.1 Dike Construction

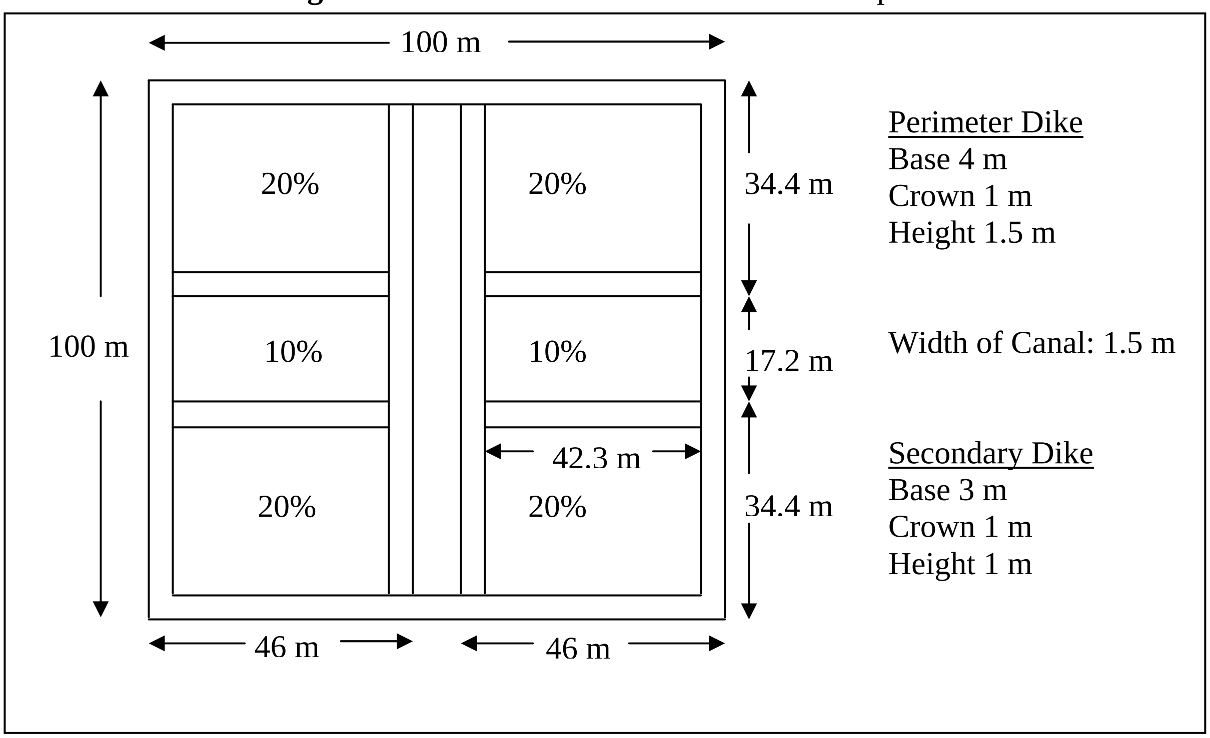
Dikes are the main structures that hold water in the ponds. They are built out of soil from the pond site. There are three classifications of dikes. The main dike that protects the whole fishpond from the outside environment is called the perimeter dike. It must be built high and big enough to withstand flooding and erosion. The dike that is used for the main supply canal should be as the same size as that of the perimeter dike, while those for the rearing pond compartments and secondary dikes are a little lower and smaller than the perimeter dike. The smallest and lowest dike is called the tertiary dike. The tertiary dike is used for the nursery and transition compartments (Requintina et al. 2006).

The volume of the soil to be moved is important in determining the size of the labor force and the cost involved. The volume of soil for dike construction can be computed by, first computing the cross-section area and multiply by the length of the dike. The formula for computing the volume of soil for dike construction is:

Area = Height x (Crown + Base)/2
Volume = Area x Length

Figure 3 shows the dimensions of a typical 1-hectare pond design (from Kirago farm) pond that can serve as the basis for calculations of construction and excavation costs.

Figure 3. Dimensions of a 1-hectare milkfish pond



2.3.2 Gate Construction

A gate is a sluice, culvert or pipe that is used to control water flow. A conventional milkfish pond has a main gate that is the main entrance of water supply for the whole fishpond, secondary gates that control water supply to the rearing ponds and a tertiary gate that is used to control water supply in the nursery pond. Other important structures that must also be built to withstand the water current and pressure are screens and slabs (Requintina et al. 2006).

2.4 Stocking and Management of a Commercial Milkfish Pond

2.4.1 Pond Preparation

Once the construction of the pond is complete the pond must be prepared before stocking fish. All pond compartments should be prepared a month or two before filling the pond with water. Pond preparation includes the following steps: draining and drying the pond bottom, tilling and cultivation of the pond bottom with shovels and rakes, leveling the pond bottom with shovels and rakes, and fertilization. Organic fertilizers such as chicken manure and cow dung are highly recommended for growing a benthic algal mat (lablab) that milkfish feed on. Organic fertilizer application ranges from 500 to 1000 kilograms per hectare per crop depending on how fertile the area is. Assuming the mid-range, 750 kilograms of chicken manure is equivalent to 15 bags of 50kg. Each bag costs 500 Tsh. therefore an average application of fertilizer would cost approximately 7,500 Tsh. per crop (Requintina et al. 2006). Transport of timber and fertilizers will differ from one place to another and are not considered in this analysis.

2.4.2 Fingerling Collection

As the ponds are being prepared for stocking, fingerling collection should be started so enough can be accumulated for the intended stocking rate of the pond. In areas where milkfish culture has been practiced extensively, there are individuals or communities that are specialized in fingerling collection, as a separate business from the actual fish farm (Requintina et al. 2006). This type of operation does not exist yet in Tanzania so fishpond operators must hire labor to collect the fingerlings or collect the fingerlings themselves.

Fry and fingerling occurrence in the wild is seasonal and only present in certain locations, therefore care should be taken so that the start of the culture period coincides with the occurrence of the abundant supply of fingerling and that there are enough collectors to accumulate a substantial amount of fingerlings within a 2-4 week period. In the WIO region there are two peak seasons of fingerling occurrence coinciding with the long and short rainy seasons. In Zanzibar studies indicate peak abundance during the periods of February thru May and October thru November (Dubi et al. 2004).

2.5 Pond Management

Managing a milkfish farm is not that different from managing other businesses, therefore; there are additional costs for the labor that is required to manage the pond. Pond management involves maintaining proper water levels in the ponds, monitoring salinity and dissolved oxygen levels, conducting water exchange as needed to control salinity and dissolved oxygen, among other basic tasks such as dike maintenance. Some farmers may need to apply inorganic fertilizer or supplementary fish feed if food source runs out before the milkfish reach a marketable size.

2.6 Harvesting and Delivery to Market

There are several methods by which farmers can harvest the milkfish when they have reached a marketable size. For technical details on the various methods for harvesting milkfish see Requintina et al. (2006). These factors include: the availability of milkfish or close substitutes to milkfish in the market (managers should try to identify period of scarcity); the amount of food remaining in the pond; and anticipated extreme weather such as the rainy season, extreme heat or high tides. For example, at a milkfish pond in Tanga a milkfish stock was to be harvested in February but when confronted with extreme heat and an increased risk of milkfish mortality, managers chose to harvest in January. By harvesting early, the milkfish pond manager in Tanga had a smaller harvest then he or she would have in February but at the same time avoided the risk of losing the entire stock of the pond to the extreme heat. Once the fish are harvested, they must be sold immediately or packed with sufficient ice and must be handled with care to ensure that they stay fresh until they reach consumers.

2.7 Marketing and Distribution

Markets for mariculture products should be well known before any activity starts. If local communities accept and demand the products, marketing becomes easier. Acceptability also makes a mariculture operation more sustainable. If the community rejects a product, a mariculture operation may be forced to stop. Information on market trends helps producers and the government to make decisions regarding development of mariculture products. In Tanzania, the tradition of eating fish by communities living near water bodies, and the availability of tourist hotels offer great potential for local markets of mariculture products (TCMP, 1999). There are limited export markets for milkfish, mostly to small Asian populations living in the United States and Europe. At this stage in the industries development, export markets for milkfish are not envisioned as having much potential for Tanzania anytime soon.

Farmed milkfish is a new mariculture product for Tanzania but people on the coast of Tanzania are familiar with large size milkfish that are caught and sold from the wild fishery. Milkfish is a delicious food fish but it has a large number of intramuscular bones in the tissues that make some people avoid it, however Tanzanians are familiar with the milkfish from the wild fishery and do not consider the bones problematic. Initial tests of actually eating the fish (Mmochi et al. 2001; Prof. Kishimba, Pers. Comm., 2006) did not indicate any problems. In Asia, de-boned processed milkfish is gaining in popularity (Requintina et al. 2006) and this may be a similar value added post harvest processing strategy for Tanzania in the future.

The mean weight of the market-size adult milkfish caught in the wild in Tanzania is 12 kg; therefore, many people are not familiar with the smaller sizes (0.3 – 0.5 kg) that will be harvested from ponds (Requintina et al. 2006). Accordingly, there are concerns regarding the marketability of the farmed milkfish in Tanzania, however eating trials by invited people to a tasting party by the Institute of Marine Science at the University of Dar es Salaam did not reveal any preference to rabbit fish, which is one of the local medium sized fish delicacies. Furthermore, the milkfish have already been sold competitively in restaurants in Dar es Salaam (Mr. Mushi, Regent Enterprises Bagamoyo, Pers. Comm., 2007) and the city market (SUCCESS, Mkuranga).

A critical consideration in the decision to begin the development of a milkfish pond should be the farm's accessibility to a local market. Fishpond operation includes the packing and transporting of fish to the market. Since fish spoilage is largely controlled by temperature, enzymatic and bacterial activity, fish must be packed with sufficient ice and must be handled with care to ensure they stay fresh until they reach the consumers. Problems with infrastructure, including roads and other transport, facilities, electrical power and telecommunications, are fundamental and underlying issues in all aspects of development in coastal regions. Some internal shipping can be done within Tanzania, but poor road conditions and long transportation times will pose constraints to transporting perishable products, such as milkfish over long distances. Roads in coastal districts are often impassable during the rainy season. Not all coastal areas, especially in the south, are easily accessible by road (TCMP, 1999). Additionally, transport costs are estimated to be in the range of 1000 Tsh. per kilometer, making the cost of transporting products considerable. If milkfish must be sold outside a potential milkfish pond's immediate vicinity, then development of the pond should be considered carefully in light of slow transportation and the fact that milkfish is a perishable mariculture product.

2.8 Other Possible Operating Costs

The milkfish system described above is representative of a typical one-hectare commercial milkfish pond where one production cycle takes about 6-8 months. Operating costs vary depending on the particular characteristics of the pond and its location. For example, some farmers may need to apply inorganic fertilizer or feed if the food source runs out before the milkfish reach harvest size. The estimated cost of inorganic fertilizer is 2,000 Tsh. (approximately 4 kg at 500-600 Tsh./bag). Other operating costs might include security or emergency repairs. Therefore two case studies of costs and earnings from actual milkfish ponds are provided below and compared.

3. Case study of the Kirago Milkfish Farm

In this section, the costs of labor and materials required to convert a one-hectare salt producing pond into a milkfish pond is based on information from the Kirago Farm in Mkuranga and on 2006 prices. Where actual costs and earnings information was not available, estimates were made based on key informant information.

3.1 Construction of a Commercial Milkfish Pond at Kirago Farm

Preparation is the first step in milkfish pond construction. To prepare the site all vegetation must be removed. To clear a site of 10,000 m^2, the cost per meter was 20 Tsh., resulting in a total cost of 200,000 Tsh. Working tools for site preparations included 5 machetes (2500 Tsh./machete) and 20 shovels (3500 Tsh./shovel). The total cost of working tools was 82,500 Tsh.

3.1.1 Dike Construction

The cost of the earthwork required to construct a one-hectare milkfish pond at Kirago Farm in 2006 are depicted in Table 1. Figure 3 depicted previously shows the dimensions of the pond that served as the basis for these calculations. In addition to the total cost, there could be extra construction costs for excavating and leveling the pond under certain circumstances. For example, if the pond required some leveling after construction, then an additional 200,000 Tsh. might be required for constructing the milkfish pond.

Table 1. Total cost of earthwork to construct a 1-hectare milkfish pond

Structure	Size	Cross section area (m^2)	Volume (m^3)	Cost per 1 m^3 (Tsh.)	Estimated cost (Tsh.) = volume x cost per 1 m^3
Perimeter dike	400m	3.75	1,500	311	466,500
Canal dike	184m	2	368	500	184,000
Partitioning	42.25 x 4 = 169m	2	338	500	169,000
			Total estimated cost		**819,500**

3.1.2 Gate Construction

Gates can be constructed using timber, concrete or both. The cost of gate construction will vary depending on the size of the gate and the price of the construction materials used. Table 2 depicts the costs of gate construction for a one-hectare milkfish pond at Mkuranga in 2006, which were constructed entirely of timber. Both material and labor costs of one main gate and six secondary gates are listed. While timber is less costly initially compared to cement, it has a shorter life expectancy as well.

Table 2. Total gate construction costs for a 1-hectare milkfish pond at Mkuranga

Item	Base (cm)	Height (cm)	Length (m)	Quantity	Cost per piece (Tsh.)	Total cost (Tsh.)
One main gate (Size: Base=3.0m, Height =1.5m, Lengths=2.5m)						
Timber	2.54	25.4	3.66	30	4,900	147,000
Timber	5.08	10.16	3.66	10	3,900	39,000
Timber	5.08	15.24	3.66	16	4,900	78,000
Carpentry works	-	-	-	-	-	15,000
Earthwork for gate installation	-	-	-	-	-	15,000
			Total construction cost for one main gate			**294,000**
Six secondary gates (Size: Base=2.0m, Height=1.0m, Width=1.25m)						
Timber	2.54	25.4	3.66	26 x 6 = 156	4,900	764,400
Timber	5.08	10.16	3.66	8 x 6 = 48	3,900	187,200
Timber	5.08	5.08	3.66	15 x 6 = 90	2,000	180,000
Timber	5.08	15.24	3.66	12 x 6 = 72	4,900	352,800
Carpentry Works	-	-	-	6	10,000	60,000
Earthwork for gate installation	-	-	-	6	10,000	60,000
			Total construction cost for six secondary gates			**1,604,400**

3.1.3 Summary of Dike Construction Costs

Table 3 summarizes the costs of constructing a one-hectare milkfish pond at Mkuranga. It is worth noting that 50% of the total construction costs are for the material and labor to construct the secondary gates. At Kirago Farm, timber was used for the secondary gates but the timber gates can easily be substituted with plastic pipes until the farmer is comfortable enough to install other more expensive types of gates. This is a potential way to reduce the initial capital costs of milkfish farming.

Table 3. Summary of construction costs for a 1-hectare milkfish pond at Mkuranga

Cost description	Total cost (Tsh.)
Site Preparation	200,000
Working Tools	82,500
Earthwork	819,500
One Main Gate – Material and Labor	294,000
Six Secondary Gates – Material and Labor	1,604,400
Total estimated construction cost	**3,000,400**

3.2 Stocking and Management of the Kirago Farm

3.2.1 Pond Preparation

Organic fertilizers such as chicken manure and cow dung are highly recommended for growing a benthic algal mat (lablab) that milkfish feed on. Organic fertilizer application ranges from 500 to 1000 kilograms per hectare per crop depending on how fertile the area is. Assuming the mid-range, 750 kilograms of chicken manure is equivalent to 15 bags of 50 kg, which was the approximate amount of fertilizer applied in Mkuranga ponds. Each bag costs 500 Tsh.; therefore an average application of fertilizer would cost approximately 7,500 Tsh. per crop (Requintina et al. 2006). Transport of timber and fertilizers will differ from one place to another and are not considered in this analysis.

3.2.2 Fingerling Collection

The labor cost for collecting 12,000 fingerlings at Mkuranga was 120,000 Tsh., or 10 Tsh. per fingerling.

3.2.3 Labor for Pond Management

Pond management consumes approximately 180 hours per harvest. Assuming that there is only one harvest in a year and that the wage is 260 Tsh. per hour, the total cost for pond management is 46,800 Tsh.

3.2.4 Harvesting and Delivery to Market

The estimated cost for harvesting labor is 12,000 Tsh. This is based on an estimate of six laborers, each paid 2,000 Tsh. Once the fish are harvested, they must be packed with sufficient ice and handled with care to ensure that they stay fresh until they reach market. The estimated amount of ice required to transport the milkfish to the market is 500 kilograms. At 250 Tsh. per kg the total cost of ice for transporting fish to the market is 125,000 Tsh. (Requintina et al. 2006). The estimated cost of transporting the milkfish to the market is 1,000 Tsh. per kilometer. This is based on the estimated fuel costs. The first harvest from the Kirago farm in Mkuranga was brought to the main fish market in Dar es Salaam, approximately 100 kilometers from the farm site in Mkuranga. The total cost for transportation was 200,000 Tsh. As depicted in Table 4, the total estimated cost of materials and labor for harvesting and delivery to the market is 337,000 Tsh. A summary of operating costs for the Kirago farm is provided in Table 5.

Table 4. Harvest and delivery costs for a 1-hectare milkfish pond at Mkuranga

Item	Quantity	Price per item (Tsh.)	Total cost (Tsh.)
Net for harvesting (1 m x 15 m, mesh size of 2.5 cm)	1	300,000	300,000
Wages for harvest labor	6	2,000	12,000
Ice for packing (kg)	500	250	125,000
Transport to market	1	200,000	200,000
		Total estimated cost of harvest and delivery	**637,000**

Table 5. Summary of operating costs for a 1-hectare milkfish pond at Mkuranga

Cost description	Total cost (Tsh)
Pond preparation	7,500
Pond management	46,800
Fry collection (Labor)	120,000
Harvesting (Net and labor)	312,000
Delivery to market (Ice and transport)	325,000
Total operating costs	**811,300**

3.3 Production and Cash Flow

The capital costs of pond construction are the greatest expense, and may be a barrier to entry for many individuals, especially poorer sectors of coastal communities. Although the initial investment costs of pond construction may appear large, with minor annual maintenance the pond will last 20 years or more.

In this example, the total annual revenue is based on the first marketing of milkfish from Mkuranga where milkfish were sold at the Dar es Salaam market for 1,000 Tsh. per kilogram. The first harvest from these ponds was less than one hundred kilograms, and the second harvest was lost a month before the next scheduled harvest due to a dike collapse from unusually high spring tides. Therefore, the amount harvested used in this analysis is based on a reasonable estimate of production for an extensive milkfish farm of this size - 1 fish per square meter and 4 fish weigh 1 kilogram. With these assumptions, the estimated total revenue is 2,000,000 Tsh.

Based on the costs from the Mkuranga pond site, it will take approximately three growing cycles before the pond owner breaks even and starts turning a profit. After the initial costs are recuperated, the annual profits in this example are estimated to be 1,188,700 Tsh. Annual estimated profits are calculated by subtracting the pond operating costs from the total annual revenue. Using the construction costs, operating costs, and revenue we can calculate the cash flow over five growing seasons as depicted in Table 6.

Table 6. Cash flow (Tsh.) over 5 growing seasons

Year	Expenses	Revenues	Annual Net Revenues	Cumulative Net Revenues
1	3,811,700	2,000,000	-1,811,700	-1,811,700
2	811,300	2,000,000	1,188,700	-623,000
3	811,300	2,000,000	1,188,700	565,700
4	811,300	2,000,000	1,188,700	1,754,400
5	811,300	2,000,000	1,188,700	2,943,100

The above example demonstrates that milkfish farming has very good income earning potential. In Asia, a single household can easily manage a one-hectare pond once it is fully constructed and placed in operation. Therefore the potential for significantly increasing household incomes in coastal communities of Tanzania would seem to be quite good based on this case example.

4. Case study of the Regent Enterprises Milkfish Farm

The Regent Enterprises site in Changwahela, Bagamoyo was selected as a demonstration site by the SUCCESS program in 2005. The construction and operating costs of this demonstration site will be examined as an additional case study and will be compared with the costs and returns of the Mkuranga case study. Both pond systems are approximately one hectare in size.

Regent Enterprises is a very successful and profitable salt evaporator business, located within a one hour drive from Dar es Salaam by mostly paved roads and relatively light traffic except for the last stretch of approximately 5 km which is unpaved and very difficult in the rainy season. The Regent Enterprises site consists of 121 hectares of salt flats and reclaimed mangrove area with 60 hectares currently used for salt production. The site has several characteristics which led to its selection as a demonstration milkfish pond including: a soil quality perfect for constructing fishpond dikes, a tidal range exterior to the perimeter dike of 1.0 to 1.5 meters - the optimum tidal range for milkfish pond construction, easily accessible potential milkfish fry and fingerling collection areas, a permanent workforce who are knowledgeable about dike construction technique, and a site manager living on the site. Additionally, the operators of the company exhibited a strong business sense in their operation of the salt evaporator business. For example, the operators have a salt warehouse on site which they keep well stocked with bagged salt ready to be delivered to markets during the rainy season which is ‘off season’ of salt sales. Furthermore, the site was selected as a demonstration site because it would only require technical assistance from the SUCCESS program. The operator assumed all of the costs of developing the milkfish demonstration project except technical advice, which he obtained from SUCCESS staff. Furthermore, the site has good accessibility as it is very close to main road running between Bagamoyo and Dar es Salaam, making visits to the site as a demonstration area very convenient.

Construction of the demonstration site started in October 2005 and was completed in May of 2006. The operator made three harvests to date; 700 pieces of milkfish in 2004 (prior to SUCCESS involvement milkfish were harvested from a salt pond whereby fingerlings came in naturally with intake water), 1,500 pieces of milkfish in 2005 and 2,403 pieces of milkfish in 2006-2007. The pond operator, Mr. Mushi, kept books on the expenses for the construction, development and operation of the demonstration pond. We will now examine these costs in detail and compare them with those from the Kirago Farm Pond in Mkuranga.

4.1 Construction of the Commercial Milkfish Pond at Regent Enterprises

4.1.1 Site Preparation

The demonstration site is located on a former salt pond, and therefore; the costs of clearing the site were less for the demonstration site than for the Mkuranga pond. The Regent Enterprises demonstration site only incurred a cost of 100,000 Tsh. for clearing the site to prepare for pond construction. Also, we had estimated a cost of 82,500 Tsh. for the purchase of working tools but the Regent Enterprises demonstration site did not incur these costs, as they already owned the various working tools required to prepare the site. So the total cost of site preparation for the Regent Enterprises demonstration site was 100,000 Tsh.

4.1.2 Dike Construction

The cost of the earthwork for construction of the perimeter dike, canal dike and partitioning at the Mkuranga pond was 819,500 Tsh. This cost is very close to that incurred by the Regent Enterprises demonstration site, which came to 809,000 Tsh.

4.1.3 Gate Construction

The estimated costs of constructing one main gate and six secondary gates at the Mkuranga pond were 294,000 and 1,604,400 Tsh., respectively. Recall that this estimate includes the labor and material required to build gates that were based on the construction of gates made only of timber. The Regent Enterprises demonstration site has constructed their main gate entirely of concrete except for the shutter, which is wooden. Concrete gates are more expensive to construct than timber gates but they have a longer lifespan and require less maintenance.

Regent Enterprises reported costs of 1,058,000 Tsh. for materials and 750,00 Tsh. for the labor required to construct one main gate. This results in the total cost of 1,808,000 Tsh. for one main gate. The cost of Regent Enterprise's main gate is substantially higher than our estimated costs but the difference is attributable to the difference in materials used. To date Regent Enterprises has constructed only two secondary gates. The material and labor costs for construction of the two secondary gates was 325,000 Tsh. Assuming the costs for the remaining gates will be similar to the costs of the gates that have already been constructed, the total estimated cost of constructing six secondary gates is 975,000 Tsh., which is slightly lower than the costs of 1,604,400 Tsh. at Kirago Farm. Table 7 summarizes both Regent Enterprises and Mkuranga construction costs.

Table 7. Summary of construction costs

Construction Costs	Total Cost (Tsh.)	
	Mkuranga	Regent Enterprises
Site preparation	200,000	100,000
Working tools	82,500	0
Earthwork	819,500	809,000
One main gate (material and labor)	294,000	1,808,000
Six secondary gates (material and labor)	1,604,400	975,000
Total construction costs	**3,000,400**	**3,692,000**

4.2 Stocking and Management of the Regent Enterprises' Milkfish Farm

4.2.1 Pond Preparation

The Regent Enterprises demonstration site used 20 bags of fertilizer (chicken manure). Each bag cost 400 Tsh.; therefore, Regent Enterprises spent 8,000 Tsh. on fertilizer to prepare the pond. This is very close to costs for the Mkuranga ponds that used 15 bags, each costing 500 Tsh., for a total of 7,500 Tsh. per crop.

4.2.2 Fingerling Collection

The Regent Enterprises demonstration site incurred a total cost of 156,000 Tsh. for the collection of 5,626 fingerlings. This total cost includes: the purchase of 3 fingerling collecting nets (75,000 Tsh.), the purchase of plastic dishes and buckets for holding fingerlings (18,000 Tsh.), and the wage payment required to purchase labor for collecting the fingerlings (63,000 Tsh.). The wage payment was comprised of wages for three people for 21 days at a wage of 1,000 Tsh. per person per day (the actual daily duration of labor was a half-day of time).

Regent Enterprises would have preferred to stock 12,000 fingerlings in their pond but unfortunately they were faced with a general scarcity of fingerlings in their area. SUCCESS is looking into avenues through which Regent Enterprise may be able to increase the number of fingerlings collected to stock their pond as they may be a constraint to further expansion.

In the Mkuranga pond the cost for the labor required to collect 12,000 fingerlings was 120,000 Tsh. or 10 Tsh. per fingerling. The labor cost of collecting fingerlings for Regent Enterprises is approximately 28 Tsh. per fingerling, however; the cost per fingerling would likely decrease if fingerlings were more abundant in their area.

4.2.3 Harvesting and Delivery to Market

As soon as the milkfish reached marketable size, the Regent Enterprises demonstration site harvested them by draining some of the water from the pond, which entices the fish to congregate in the deeper channels. Fishnets were then used to harvest the milkfish from the deeper channels. The demonstration site's total cost of harvesting was 120,000 Tsh., which includes 60,000 Tsh. for the purchase of a harvest net and 60,000 Tsh. for wages for harvesting labor. The demonstration site is located in Bagamoyo and so there is only about 30 kilometers between the site and the market. The milkfish were transported to the market six times; therefore, the estimated cost of transport to the market is 360,000 Tsh. for fuel. The cost of ice for this past year's harvests was 24,000 Tsh. In sum, the total cost of harvesting and delivery to the market by Regent Enterprises was 504,000 Tsh.

4.2.4 Labor for Pond Management

The manager of Regent Enterprises coordinates both the milkfish farming and the salt production operations. The manager spends thirty percent of his time managing the milkfish pond and the remaining seventy percent on the salt ponds. Pro-rating his salary according to the time spent on each operation, the manager is paid 360,000 Tsh. per year for the time he spends managing the milkfish pond.

Additionally, Regent Enterprise has reported the cost of 48,000 Tsh. for transferring fish from the NP to GP, which took 3 days.

4.2.5 Extra Operating Costs

The Regent Enterprises demonstration site requires security to keep both birds and fisherman away from the pond. The cost of security for 9 months (April – December 2006) is 135,000 Tsh.

Table 8 summarizes operating costs from both the Regent Enterprises' demonstration site and the Mkuranga milkfish pond site.

Table 8. Summary of operating costs for a 1-hectare milkfish pond

Operating Costs	**Total Cost (Tsh.)**	
	Mkuranga	**Regent Enterprises**
Pond preparation	7,500	8,000
Pond management	46,800	408,000
Fry collection	120,000	156,000
Harvesting (Net and labor)	312,000	120,000
Delivery to market (Ice and transport)	325,000	384,000
Extra operating costs (Security)	0	135,000
Total operating costs	**811,300**	**1,211,000**

4.3 Production and Cash Flow

Regent Enterprise harvested and sold 2,403 milkfish over the course of three months (November 2006 to January 2007) to small hotels, restaurants and fish markets in Dar es Salaam. Six trips were made to the market over this time period. The first harvest was in November, at which time only 25 milkfish pieces were harvested and brought to the market as samples. The remaining five harvests were 200, 250, 1600, 50 and 78 milkfish pieces in size.

Both Regent Enterprise's manager and owner expressed excitement about the price and speed at which the fish sold at the market. The milkfish sold for between 970 and 983 Tsh. per piece. One piece weighs between ½ and ¾ kilogram. This price is approximately twice as much as the price of 1,000 Tsh. per kilogram of milkfish that was estimated in Requintina et al. (2006) and used for the Mkuranga farm site analysis. Assuming a middle of the road price of 976.5 Tsh. per piece, Regent Enterprise received 2,346,530 Tsh. in revenue from milkfish sales. With Regent Enterprise's pond operating at the same capacity over the next five years, it would take three growing cycles before they break even and start turning a profit (see Table 9). After the initial costs are recuperated, the annual profits in this example are estimated to be 1,135,530 Tsh.

However, it should be noted that revenue could increase significantly in the future because currently the pond is not operating at full capacity as a result of two issues. The first issue is that due to scarcity of fingerlings in the area, the pond was stocked with only 5,626 fingerlings, which is much less than the pond's capacity. The second issue is that the mortality rate in Regent Enterprise's pond was relatively high, with only 2,403 of the 5,626 fingerlings surviving and reaching a marketable size. The high mortality rate is likely due to poor management of the salinity and water levels in the pond and predation by birds. SUCCESS is currently working with Regent Enterprise to correct these issues. For an example of the potential future revenue, we can assume the pond can be stocked with 12,000 fingerlings and with a mortality rate of 25%, then 9,000 milkfish would be harvested and revenue of 8,788,500 Tsh. would be achieved (assuming a price of 976.5 Tsh.) In this scenario, the milkfish pond owners would turn a profit during the first growing season and in each consecutive growing season. Milkfish farming at Regent Enterprise is profitable at its current operating level but as depicted by this example, there is significant potential to increase profitability if the problems of fingerling scarcity and a high mortality rate can be addressed.

Table 9. Cash flow over 5 growing seasons at Regent Enterprise (Tsh.)

Year	Expense	Revenues	Annual Net Revenues	Cumulative Net Revenues
1	4,903,000	2,346,530	-2,556,470	-2,556,470
2	1,211,000	2,346,530	1,135,530	-1,420,940
3	1,211,000	2,346,530	1,135,530	-285,410
4	1,211,000	2,346,530	1,135,530	850,120
5	1,211,000	2,346,530	1,135,530	1,985,650

As mentioned earlier, Regent Enterprises is a very successful and profitable salt evaporator business. Currently, 60 hectares of the property are used for salt production. From those 60 hectares, 35,000 bags of salt (50 kg each) are produced per year. Each bag of salt sells for 1,800 Tsh., therefore; total revenue from salt production is 63,000,000 Tsh. This is equivalent to revenue of 1,050,000 Tsh. per hectare per year, which is approximately half of the annual revenue from the one-hectare milkfish pond operating on the Regent Enterprises site. This suggests that milkfish farming is much more profitable than salt production and that it would be advantageous to increase milkfish farming at the Regent Enterprise's site. Furthermore, the manual labor involved in salt pan management is more than that for fish pond management. At a site visit in March 2007, the manager of Regent Enterprises was asked hypothetically if he had a choice of which business he would go into, milkfish farming or salt production. The manager quickly responded, "Milkfish."

5. Discussion

Table 10 summarizes the construction and operating costs, annual revenue and annual profit for the two case study milkfish farms analyzed in this report. Pilot farms developed in Bagamoyo and Mkuranga show pond construction costs between 3 and 3.7 million Tsh. per hectare. Pond trials demonstrated that total harvests of 1 MT per hectare per year can be achieved. At a sale price of approximately 2000 Tsh. per kg, annual revenues per hectare can reach 2 million Tsh. With annual pond management costs between 811,300 and 1,211,000 Tsh, profits of approximately 1.2 million Tsh. per hectare can be achieved within three to four years.

The SUCCESS program recently conducted coastal household surveys that estimated median household income of approximately 12,000,000 Tsh. per annum. Therefore, initial investment for milkfish farming in Tanzania may seem high compared to incomes of rural coastal households. The profitability, however, is quite good. The primary up-front construction costs are high but the recurring expenses per crop are much lower, therefore a key issue for households interested in investing in milkfish farming is how to acquire the initial capital required for construction. If local labor is used either from the household or community group, it may be possible to defer payment or spread labor costs over time. Additionally, using concrete gates will make a more permanent pond system and would require less maintenance, but it is more expensive initially. Alternatively, wood gates could be used which are cheaper to construct and would keep initial costs down, but then they would need to be replaced every several years. If loans could be acquired from either formal or informal lending institutions, cement gates are recommended, but the time needed to break even will be longer and profitability will be lengthier and dependent on the interest rate or fees charged for such loans.

Table 10. Summary of milkfish farm profitability at Kirago Farm and Regent Enterprises

Costs and Returns (Tsh.)	Kirago Farm	Regent Enterprises
Total construction costs	3,000,400	3,692,000
Total operating costs	811,300	1,211,000
Annual revenue[1]	2,000,000	2,346,530
Annual profit after construction costs have been recouped	**Tsh 1,188,700**	**Tsh 1,135,530**

[1]Kirago Farm's annual revenue is estimated. Regent Enterprise's annual revenue is real.

If pond construction is financed through a loan, then the total amount of construction and development can be paid through a loan over 5 to 10 years of operation depending on the actual costs and earnings calculated for a particular site. In such cases the loan amount (principal and interest) needs to be amortized as an annual cost and included as an operating expense. As an example and to see what impact this will have on profitability, we will examine the costs of a loan on the Kirago Farm in Mkuranga, which also has similar cost and revenue streams as the Regent Enterprises farm. If we assume a 5-year loan is used to cover initial construction costs at Kirago Farm in Mkuranga, then the loan repayment amount would be 600,080 Tsh. per year plus interest. Commercial banks would be the likely loaning agent; therefore we use the current interest rate at commercial banks of 36% (March 2007) in our calculations to determine that an additional 1,080,144 Tsh. would be paid in interest over the life of the loan. Based on these assumptions an annual profit of 372,591 Tsh. is expected for the first 5 years and 1,188,700 Tsh. for each year thereafter (Table 11). Note that for simplicity we have not factored in inflation.

Table 11. Cash flow (Tsh.) over 7 growing seasons with a 5-year loan

Year	Expense	Revenues	Annual Net Revenues	Cumulative Net Revenues
1	1,627,409	2,000,000	372,591	372,591
2	1,627,409	2,000,000	372,591	745,182
3	1,627,409	2,000,000	372,591	1,117,773
4	1,627,409	2,000,000	372,591	1,490,364
5	1,627,409	2,000,000	372,591	1,862,955
6	811,300	2,000,000	1,188,700	3,051,654
7	811,300	2,000,000	1,188,700	4,240,354

Note: Assumes no inflation and an interest rate of 36 percent per annum

Even with the relatively high interest rates of a commercial loan and relatively modest production levels achieved to date, from our calculations above, milkfish farming is still a very profitable enterprise potential for coastal communities and households to consider.

6. Conclusions and Recommendations

This economic analysis has demonstrated the economic feasibility of mariculture technology for this native species of fish which can be cultured in brackish water ponds in coastal areas of the nation. It provides great potential for increasing employment and incomes in coastal communities as well as promoting food security through expanded fish protein supply. Pilot farms developed in Bagamoyo and Mkuranga show that pond construction, the largest investment component for milkfish farming, costs approximately 3 million Tsh. per hectare. Pond trials demonstrated that total harvests of 1 MT per hectare per year can be achieved. At a sale price of approximately 2000 Tsh. per kg, annual revenues per hectare can reach 2 million Tsh. With annual pond management costs between 800,000 and 1.2 million Tsh., profits of approximately 1.2 million Tsh. per hectare can be achieved within three to four years. This annual profitability is roughly equivalent to the median annual household income as recently estimated by the SUCCESS Program through a survey of selected villages in several coastal districts. Once ponds are constructed, milkfish farms of 1 hectare or greater in size can be managed by a single household. It should also be noted that current production levels per hectare are low and as farmers gain experience and skills in milkfish farming, profits will likely continue to grow and could experience a several fold increase. As previously stated, if the Regent Enterprise pond managers are able to increase the number of fingerlings stocked to 12,000 and decrease the mortality rate to 25%, then 9,000 milkfish could potentially be harvested and a revenue of 8,788,5000 Tsh. could achieved. In this scenario, the milkfish pond owner would turn a profit during the first growing season and in each consecutive growing season.

The Tanzania mainland has approximately 50,000 hectares of non-forested mangrove areas[1]. Assuming that only 20 percent of these areas are suitable for milkfish farming and converted to

[1] Eastern Africa Atlas of Coastal Resources

milkfish farms, ultimately 10,000 households could be employed in this industry, generating 10,000 MT of fish worth 20 billion Tsh. annually. This enormous potential is yet to be realized and could be catalyzed by concerned efforts of the government of Tanzania, international donors and the private sector that could help the industry grow quickly and in a stable and environmentally sound manner. Some of the policy issues that must be addressed for the industry to take off are described below followed by specific recommendations that could help Tanzania realize this mariculture potential.

6.1 Policy Issues and Implications

While the results of this economic analysis demonstrate that the potential from milkfish farming seems promising, there are a number of policy issues that need to be resolved to ensure that this new industry grows in an economically and environmentally sustainable manner. Policy questions that must be addressed include proper siting and permitting of milkfish ponds, collection of wild fry and fingerlings, developing technical extension capabilities and financing new fishpond development. Already, many projects and programs are supporting the development of milkfish culture in the absence of a sound policy framework. However, without strengthened milkfish farming policies that provide environmental safeguards and support sound economic development, the industry could face a chaotic future with limited socio-economic successes and causing unwanted environmental damage. It is critical that policies specific to milkfish farming be implemented quickly that build from the national mariculture guidelines of the Department of Fisheries, so that milkfish farming can contribute to the Government of Tanzania goals concerning poverty alleviation and enhanced food security.

6.1.1 Challenges to Economic Development of Milkfish Farming in Tanzania

<u>Pond Siting</u>: Proper siting of milkfish ponds is a very important aspect in pond construction. Poor siting can lead to inadequate supply of water, make it impossible to dry the ponds between harvests, or keep them filled properly during growing periods. Siting must also take into consideration environmental concerns including protection of mangroves and carrying capacity of the estuarine environment. Important criteria in choosing adequate ponds sites include vegetation type, soil type, water availability and elevation. Environmental criteria include locations behind mangrove stands in salt pan areas and not within mangrove stands. Additionally, ponds should be developed in locations where existing ponds have not been overdeveloped in one area and dominate the upper intertidal zone. Failure to select and control proper siting can lead to ponds that cannot be economically productive, suffer from disease problems, and create unwanted environmental impacts.

<u>Financing Farm Development and Pond Construction</u>: Most potential farmers in rural coastal communities are too poor to raise enough capital to develop fish ponds and pay for management operations until profits are achieved in the second year of operation. Estimated capital requirements are on the order of 3.5 million Tsh. before the first harvest. Microfinance institutions provide far less capital than is required for this form of operation and expect the first re-payments almost immediately. Therefore, microcredit schemes are not appropriate for promoting milkfish farming and other financing mechanisms will be needed in order to get poorer households involved in this industry as smallholders. Without some form of easy

financing of pond construction in particular, it is unlikely the industry will rapidly expand and will be an option only for more well off coastal residents with access to such capital.

Extension Services and Farmer Capacity for Pond Construction and Management: There are very few fisheries extension officers and farmers skilled at brackish water fishpond construction and milkfish farming at this stage of the industry's development in Tanzania. This is a critical constraint to more rapid expansion of the industry. Dissemination and training of a core group of technical extension agents is needed along with establishment of more demonstration farms where interested farmers can learn the needed skills for milkfish farming. Milkfish farming is more than just throwing a few fingerlings in a hole dug in the mud and harvesting after 6 months. Careful practices must be followed from locating an appropriate farm site, construction of ponds, stocking and managing ponds through harvest, and marketing.

Fry and Fingerling Collection: Fry and fingerling collection from the wild is needed at this stage of the industry's development to supply the seed stock for grow out in ponds. Very little is known about the seasonal abundance and distribution of milkfish fry along the shorelines and estuarine areas of Tanzania's coast. Additionally, very little is known about the best harvest methods for fry and fingerlings and locally appropriate fry/fingerling transport methods. This is currently a limiting factor to extensive expansion of farming. Furthermore, the current fisheries regulations only allow mesh sizes greater than 4 inches for seining in nearshore waters. Fingerling collection for the pilot milkfish ponds was done under the understanding that the ponds are for research purposes and use fine mesh nets such as mosquito netting. There is a need for action research on fingerling/fry collection and transport methods as well as regulations that will allow for legal collection of milkfish fingerling/fry collection for commercial farming purposes without jeopardizing the environment.

Approval and Permitting of Milkfish Ponds: At present there are no specific procedures for the permitting and approval of sites for milkfish farming. Since most milkfish farming is likely to be small-holder farms, they will in most cases fall under minor permitting procedures (see section 1.5.2 of the mariculture guidelines) and undertaken wholly at the district level (see figure 4 – page 80 of the mariculture guidelines). There is a lack of clarity over jurisdiction in coastal habitat areas and several institutions will likely have jurisdiction (see page 154 of the mariculture guidelines) over review and approval of milkfish farm development proposals. Key agencies will be the Department of Fisheries (aquaculture activity), Department of Lands (land tenure, titles and leasing) and Department of Forestry (protection of mangroves). There is a danger that unless specific procedures are developed and implemented, milkfish ponds may be developed illegally under conditions of uncertain tenure or where jurisdictional disputes will delay or stifle approval for pond development. Therefore, a coordinated permitting and approval procedure among key institutions is needed to provide for an efficient regulatory enabling environment. In addition, as this industry has a the potential to grow substantially over the next decade, the Department of Fisheries needs to establish a management information system for tracking the annual growth in the number of ponds developed and their production.

6.1.2 Environmental Issues

There are several key areas of environmental concern related to milkfish farming. These deal with (1) the siting/location of ponds (2) their management, and (3) collection of wild fry and fingerlings.

<u>Milkfish Pond Siting and Management:</u> Siting of milkfish ponds has a potential for mangrove degradation. It is therefore essential that ponds should not be sited in forested mangrove areas. Ideal areas for siting should be non-forested areas behind the mangroves, in salt flats, or salt farming areas, some of which are abandoned and can be used for aquaculture. It is likely that some trees or small stands of mangrove may have to be cut for pond and water canal construction, but appropriate siting can minimize such disturbance. Siting of ponds fully inside mangrove forests over time can lead to extensive cumulative impacts and loss of mangrove forests in the country and needs to be avoided. Development of too many ponds in any one estuary system can lead to increasing disease problems inside ponds as well as water quality problems in the adjacent receiving waters. Overdevelopment of estuarine ecosystems needs to be avoided.

<u>Pond Management:</u> Over-fertilization as well as over-use and mis-use of feeds can lead to significant water quality problems in the adjacent water bodies receiving discharge waters from ponds. This is a typical situation that can arise when intensive farming systems are promoted and needs to be avoided.

<u>Collection of Wild Fry and Fingerlings:</u> While economical hatcheries are starting to be developed in Southeast Asia where milkfish farming is a longstanding and widespread industry, it will be necessary to rely on fry and fingerlings from the wild in Tanzania until the industry reaches a size large enough to justify hatcheries. In addition, milkfish take up to seven years to reach maturity so even the growing of breeders to use in hatchery operations will be a long and expensive process. Since it will be necessary to collect wild fry for the foreseeable future, significant environmental impacts need to be avoided. The main concerns are the potential over-collection of milkfish fry and fingerlings, and impacts of large scale extraction of unused fry and juvenile by-catch of non-targeted species. This is one of the main reasons why use of fine mesh fish nets is prohibited in Tanzania. There is little danger at the initial stages of the industry's development of over-collection of fingerlings and fry by-catch using small scale gears to a level significant enough to effect fisheries recruitment and traditional fisheries harvests. However as soon as the milkfish farming industry matures and there is a critical mass of people farming, the nation will need to be prepared to move from wild fry harvests to hatcheries that can supply all farm fry and fingerling needs. Fingerling collection will need to be carefully regulated under The Fisheries Act No 22 of 2003, which allows the director of fisheries and local authorities to provide licenses and permission for fry and fingerling collection as well as fish farming.

6.2 Recommendations

The Fisheries Department needs to lead the development of specific implementing procedures within the Ministry of Natural Resources and Tourism for the rapid and efficient approval of small-holder milkfish farming development projects by coastal districts that promotes *sustainable farming practices.* A brackish water pond farming permitting system should be instituted that ensures environmental concerns from milkfish farming are adequately addressed and so that significant environmental impacts are avoided. The system should also ensure that milkfish development projects can be approved in a timely and efficient manner. This will require the development and agreement of key agencies concerned of a coordinated and sequenced approval process among the Departments of Fisheries, Forestry, Environment, Lands, local governments, etc. This process should be a written procedure/rule and made accessible to all persons interested in milkfish farming development. These specific procedures should build on the recommendations in the national mariculture guidelines. These should start by focusing on small-holder farms that are of a size that would fall under minor permitting guidelines and procedures administered at the district level. Parallel to a permitting procedure should be establishment of a management information system at the national level that collects information from the districts on the amount of milkfish ponds developed, where, and the level of fish produced annually. This should be a very simple and easy system to use but one that also provides useful information for tracking and management of the industry overall.

Specific criteria for granting milkfish farm development permits need to include:

- Allow milkfish farming only in the non-forested mangrove areas – in salt flat areas or existing/abandoned salt farms.
- Do not allow too many ponds to be built in any one estuary with a rule that no more than 30% of all salt flats and non-forested areas in any one estuary can be converted to mariculture ponds.
- Condition the milkfish farming permit on allowing only extensive or semi-intensive farming methods and prohibiting use of intensive farming practices.
- Condition the permit on the need for replanting any mangroves cut at a ratio of 2:1 of the area or number of trees cut.
- Issue a milkfish fry/fingerling collection permit to approved milkfish farm owners that allows them to legally collect milkfish fry and fingerlings for stocking in their ponds but requires that all by-catch be returned to the water body rather than killed and dumped on the beach.

The Department of Fisheries needs to articulate a written milkfish farming policy that promotes small-holder milkfish farming using extensive and semi-intensive methods only. In order to promote social equity and a large number of coastal households and communities benefiting from milkfish farming, only small-holder farms of less than 10 hectares in size should be promoted. In addition, to avoid potential environmental impacts from over feeding and over use of fertilizers, promote only extensive and semi-intensive farming practices. Two types of farming systems should be promoted – the small scale, less than 1 hectare, extensive backyard system for local home and village consumption, and, larger sized commercial units using extensive or semi-intensive methods, of from 1 – 10 hectares in size for commercial sale of milkfish in local domestic markets. Poly-culture of prawns, mullets, marine tilapia, milkfish, etc. in these systems should also be encouraged and action research on such systems carried out.

The Department of Fisheries needs to articulate a written milkfish farming policy that acknowledges the need, at least temporarily, to rely on wild collection of fry and fingerlings. The policy should also state that it is the intention of the government to transition away from wild fry/fingerling collection once the industry is well established and of a size and infrastructure large enough to sustain and support hatchery facilities. In the interim – scientific capacity can be built on milkfish hatchery management through scientific exchanges with Southeast Asia.

Coastal Donor Projects together with the Department of Fisheries needs to implement a series of training courses that builds the capacity of fisheries extension agents who can promote and assist farmers in developing profitable small-holder milkfish farms. This training program should emphasize appropriate pond siting, construction, fingerling collection and pond management practices as well as environmental concerns and procedures for approval of milkfish farming developments.

Coastal Donor Projects promoting livelihood diversification in costal communities needs to consider providing subsidies for the costs of construction of milkfish ponds, especially among the poorer segments of society. If direct subsidies for pond construction cannot be provided by the government or donors, than efforts should be made to identify and make available alternative financing mechanisms that can help the industry to grow and prosper. While promoting involvement in milkfish farming by the poorer segments of the community, projects should specifically target salt producers for adopting milkfish farming as a diversified crop in their farms and to serve as demonstration and training sites. Salt farmers are likely to have greater resources to invest in milkfish farming as well as entrepreneurial skills necessary to mange commercial farms.

Coastal Donor Projects need to pilot models of estuarine ecosystem-based mariculture development and zoning plans. These plans should be simple so they can be implemented locally by the districts. They should spatially delineate allowable and prohibited areas for mariculture pond development and set limits to the total area that can be permitted for pond mariculture. Permitting procedures also need to be clearly articulated in these plans.

Research Institutions and donors supporting local research need to sponsor more applied research on milkfish farming and potential critical constraints in the industry. Top priority should be given to research on milkfish larvae fry and fingerling abundance distribution and seasonality. Secondly, more research on on-site pond farming practices, use of periphyton and poly-culture with shrimp in particular should be supported. Lastly, scientific and technical training on milkfish hatchery management should be supported – through on-site training at facilities in Southeast Asia and/or exchanges with Southeast Asian specialists.

References

Dubi, A.M., A.J. Mmochi, M.S. Kyewalyanga, N.S. Jiddawi, F.E. Msuya and Z. Ngazy 2004. Advances in mariculture of finfish, shellfish and seaweed in Tanzania. Report of stakeholders meeting held at Mazson's Hotel from 25th-27th October, 2004.

Mmochi, A.J. Mozes, N., Powell, H., Dubi, A.M., Gordin, H., Jiddawi, N., Kissil, G., Msuya, F. and Mwangamilo, J. 2001. Design and preliminary results of an integrated mariculture pond system (IMPS) at Makoba, Zanzibar, Tanzania. In Richmond, M.D. and Francis J. Proceedings of the 20th Anniversary on Advances of Marine Sciences in Tanzania. WIOMSA Book Series No. 1 pp 431-450.

Mmochi, A. J., A.M. Dubi, N.S. Jiddawi, M.S. Kyewalyanga, and F.E. Msuya. 2005. Ten years of active mariculture research in the Institute of Marine Sciences. Paper presented in the 5th WIOMSA symposium, Grande Baie, Mauritius, 28th August to 3 September, 2005.

Requintina, E. D. Mmochi, A.J. and Msuya, F.E. 2006. A Guide to Milkfish Culture in Tanzania. Sustainable Coastal Communities and Ecosystems Program. Western Indian Ocean Marine Science Association, Institute of Marine Sciences, University of Hawaii, Hilo and the Coastal Resources Center, University of Rhode Island. 49 p.

Rice, M.A., A.J. Mmochi, L. Zubieri and R.M. Savoie. 2006. Aquaculture in Tanzania. *World Aquaculture* 37(4):50-57.

TCMP 1999. *Tanzania Mariculture Issue Profile*. Tanzania Coastal Management Partnership and Mariculture Working Group. Dar es Salaam, Tanzania. University of Rhode Island Coastal Resources Center, U.S.A. 102 pp.