A Guide to Milkfish Culture in the Western Indian Ocean Region

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Cover Photo: Salt ponds in Mkuranga, Tanzania, some of which have now been converted to milkfish farming
Cover Photo Credit: Aviti Mmochi

A Guide to Milkfish Culture in Tanzania

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The Sustainable Coastal Communities and Ecosystems Program (SUCCESS)
A Component of the Global Program for the Integrated Management of Coastal, and Freshwater Systems (IMCAFS)

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Preface

In 2004, the Coastal Resources Center (CRC) at the University of Rhode Island was awarded by the United States Agency for International Development (USAID) a five-year Leader with Associates Cooperative Agreement to implement a program entitled "Sustainable Coastal Communities and Ecosystems" (SUCCESS). This program is implemented in collaboration with the University of Hawaii Hilo, Western Indian Ocean Marine Science Association (WIOMSA), Institute of Marine Sciences, Eco-Costas and Universidad Centro America. Other partners are: Conservation International, The Nature Conservancy, World Wildlife Fund and Sea Grant Network. The overall objective of the SUCCESS program is to assist coastal communities in selected countries in Eastern Africa and Latin America improve their quality of life (health), income, education and their physical environment through good governance.

Working through this goal, in Eastern Africa, the program is initiating a number of mariculture activities for seaweed, tilapia, milkfish, shellfish and half pearls. Since many of these are unfamiliar to most coastal communities, it is critically important to produce publications that provide step-by-step details on how to undertake these activities. Currently, such publications are unavailable, particularly in Eastern Africa. Furthermore, implementation of these activities has generated interesting results, which are important to share widely within and outside the region.

This manual provides an overview of low-cost low-impact milkfish farming methods based on emerging experience of adapting Asian production methods to the East African context. Milkfish is a marine and brackish water species that is locally caught and eaten but rarely has it been cultured commercially in ponds in the East African Region. Milkfish farming is considered to have great potential to provide additional livelihood and food production opportunities for coastal communities in East Africa. The information in this manual is based on emerging experience in developing commercial milkfish farming methods in Tanzania. This manual is designed to help extension agents and other practitioners working with coastal communities on mariculture and supplemental livelihood activities to provide guidance on simple, locally appropriate and environmentally friendly techniques for milkfish farming.

Comments and suggestions are most welcome. The authors, the SUCCESS program, WIOMSA and the rest of the participating institutions believe this manual will be useful to Tanzania and the Region at large.

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1 Introduction

Milkfish culture had been practiced for over a hundred years in Asia, particularly in Philippines, Indonesia, and Taiwan. Much has been learned about proper milkfish culture over this period and how milkfish culture can be a sustainable mariculture[1] practice that results in minimal impact to coastal environments. Irresponsible development practices in Asia, that have led to the widespread destruction of mangroves, have given aquaculture a bad reputation in the eyes of many environmentalists, as well as others concerned about environmental degradation.

However, mariculture can help supply much needed requirements of dietary protein for growing populations as well as contribute to poverty alleviation in coastal communities if developed and managed appropriately. Aquaculturists need to be responsible for the conservation, protection and sustained management of our fisheries and aquatic resources.

In the Western Indian Ocean (WIO) Region, mariculture is not widely practiced except for seaweed farming. Other forms of mariculture are under trial and development. For instance Tanzania is pioneering commercial and backyard methods of milkfish farming from which the information on this manual is based. Tanzania is learning from experience in Asia which provides an opportunity to avoid many of the early mistakes and promote milkfish farming in a responsible way in the WIO 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. Preferred areas for milkfish pond development are in areas that were formerly used for salt production or in the salt pans found behind the mangrove zone. Milkfish farmers have a responsibility for conscientious farming practices that are environmentally sustainable. However, government must also play a role in the early stages of development of this form of mariculture practice to protect and regulate the industry in a way to avoid mistakes learned from other places, so they will not be repeated.

Regulatory framework for mariculture in Tanzania

In Tanzania, there are policies and strategies on environment, fisheries and aquaculture that are already in place that support responsible and sustainable mariculture practices. The ministry of natural resources and tourism has developed mariculture guidelines to be used on development of aquaculture in Tanzania (TCMP, 1999; TCMP. 2001a and b). The guidelines discuss all aspects of mariculture from approval procedures, water rights, environmental impact assessments, and species and site selection including the gaps in the current policy setups especially in the approval processes.

From environment stand point milkfish ponds would not be built in mangrove areas but behind the mangroves or replacing salt pans or abandoned ponds. To avoid problems down the road, long time lease or permit need to be sought before any construction is done.

[1] Mariculture is the culture of marine or brackish water organisms in estuarine or marine environments. It is a specialized form of aquaculture.

History of milkfish farming in Tanzania

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 IMS 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. First, more attention needs to be paid to economics and marketing considerations. Careful attention also needs to be given to pond construction. Construction is the most costly phase of milkfish farming and may therefore constrain the poor from attempting milkfish farming. Subsidizing pond construction via development projects may be justified as a means of getting the industry started and a critical mass of ponds operating. Another approach is to work with salt pond operators. Salt pond operators may want to start by experimenting on a small scale, converting a few active or abandoned salt ponds for trials first. This approach also helps keep start-up costs low. In addition, in some ponds already in operation in Tanzania, not much attention is paid to sorting fry or fingerlings so in some instances, the predator fish “tenpounders“ (*Elops sp*.), are unintentionally stocked along with milkfish – leading to very low and unprofitable production levels. Proper pond preparation and good water management are also essential.

2 Biology of Milkfish

Milkfish is scientifically known as *Chanos chanos* (Figure 1). In Tanzania, there are several local names. In Zanzibar it is called mwatiko, but in some parts of the mainland, such as in Mkuranga, it is referred to as mkuyui. Ironically in Zanzibar mkuyui or kihalua is the name used for tenpounder, which is a predator and should not be in the same pond with milkfish. In Mkuranga the tenpounder is called mwatiko. Another name used for milkfish in the coast region in the mainland is kowazi. Many people in the mainland however call the milkfish mwatiko and the ten pounder kihanisi or hanisi and these are the names that appear in the FAO field guide for marine and brackish water species in Tanzania (Bianchi, 1985).

The mean weight of the market-size adult milkfish caught in the wild is 12kg and therefore many people are not familiar with the smaller sizes that are not normally caught. Accordingly, there are worries on the marketability of the farmed fish. However, the fish have already been sold competitively in tourist hotels (Mushi – Bagamoyo, personal communication) and city market (SUCCESS-global – Mkuranga)

Figure 1: Market-sized milkfish, *Chanos chanos*, Bagamoyo ponds.

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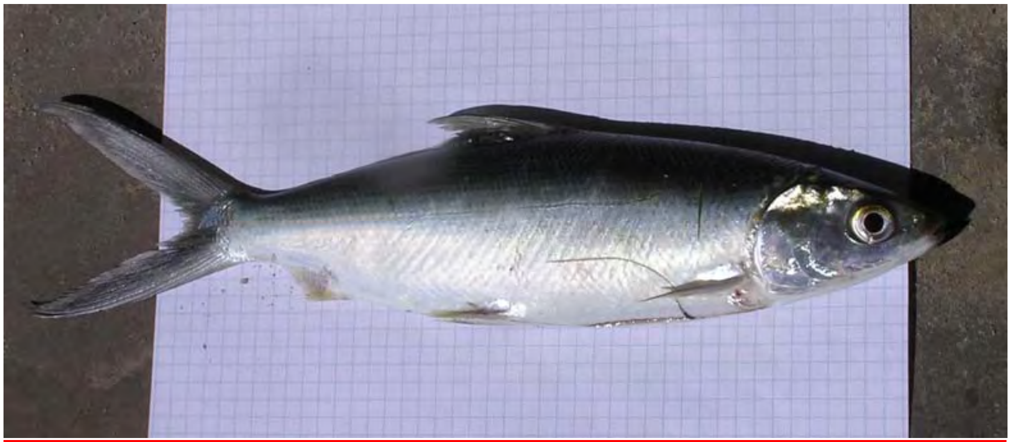


Photo credit: Edwin D. Requintina Sr.

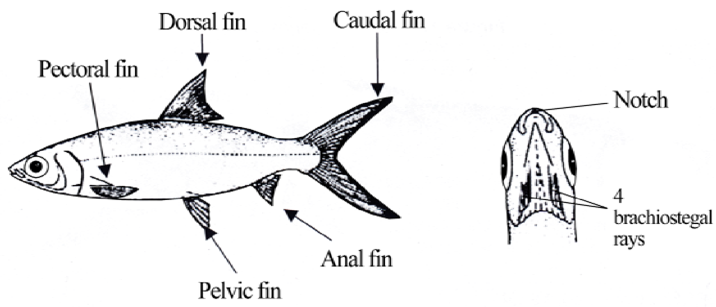
Milkfish is a desirable species for aquaculture for a number of reasons:

- Milkfish fry supply from the wild is abundant because of the high fecundity of spawners
- Milkfish fry are hardy and easy to handle; with a high tolerance and adaptability to salinity change
- Milkfish are herbivorous, thus benthic algae grown from fertilization of pond bottom is a suitable food.
- Growth rate of milkfish is much faster than other herbivorous fish
- Milkfish are not cannibalistic, thus stocking density can be high
- Milkfish has high resistance to diseases

Milkfish is a delicious food fish but it has a large number of intermuscular bones in the tissues that make some people avoid it, especially Europeans, but people on the coast of Tanzania are familiar with milkfish from wild fishery that are large in sizes and the bones are not considered a problem. Interestingly, eating trials by invited people to a tasting party by the IMS did not reveal any preference to rabbit fish, which is one of the local medium sized fish delicacies. In Asia, de-boned processed milkfish is gaining in popularity. Milkfish (Figure 2) are similar in appearance to many other species of fish but can be distinguished through a number of distinctive features:

- Body elongate, moderately compressed, smooth, and streamlined
- Body color: silvery on belly and sides grading to olive-green or blue on back
- Dorsal, anal, and caudal fins pale or yellowish with dark margins
- Caudal fin large and deeply forked
- Pelvic fins abdominal in position, with auxiliary scales
- Scales small and smooth
- Mouth small, terminal, without teeth
- Lower jaw with a small tubercle at tip, fitting into a notch in the upper jaw
- Only 4 branchiostegal rays support the underside of the gill covers
- Intermuscular bones long and numerous

Figure 2: The shape and the front lower part of the fish showing the main features



(SOURCE: Bagarinao, 1999)
Milkfish is similar looking to several other types of finfish (Figure 3) that are often mistaken as milkfish. In particular, it is often mistaken with the tenpounder (locally *known as mkuyui* in Zanzibar and *mwatiko* in Mkuranga *).* It is very important to distinguish between milkfish and tenpounders since tenpounders are carnivorous. If care is not taken to exclude these predators of milkfish during pond stocking, a pond owner can wind up with a few well-fed tenpounders and no milkfish, rather than a large number of milkfish at harvest time! Figure 4 shows a milkfish fry highlighting some of the distinguishing features of fishes that can be mistaken for milkfish, including the tenpounder.

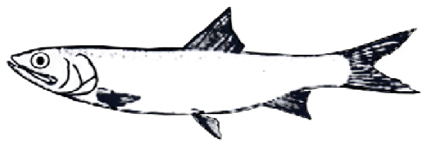
It is important to distinguish milkfish fry from other species during stocking stages, especially tenpounders that will prey on milkfish.

A Milkfish fry:

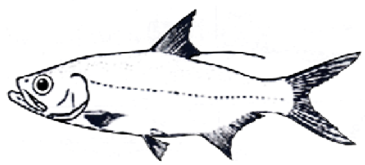
- Have large black eyes, elongated transparent bodies and a single line of black pigments on the ventral edge
- Have energetic schooling and circling behavior
- They stay alive after other species in the same catch have died

Milkfish fry are often mistaken for other fish fry (Figure 5).

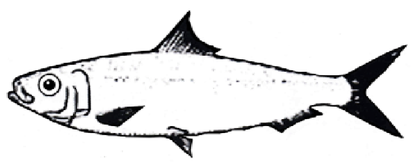
Figure 3: Distinguishing features of fishes commonly mistaken for milkfish



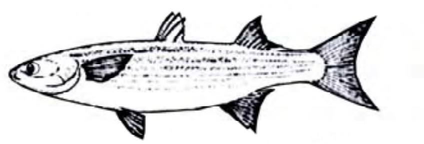
Tenpounder, *Elops hawaiiensis* or *Elops machnata*
- Mouth much larger, maxilla reaching back behind eye
- A bony gular plate present between arms of lower jaw
- The fish is carnivorous and should be avoided in milkfish ponds



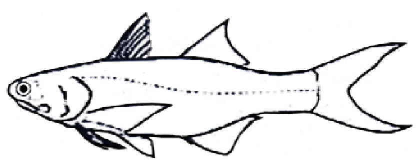
Tarpon, *Megalops cyprinoides*
- Has a bony gular plate
- Last dorsal fin ray filamentous
- Scales large, 30-40 in lateral line



Sardine, *Sardinella spp.*
- Size much smaller, usually 6-7 branchiostegal rays (only 4 in milkfish)
- No lateral line
- Scutes usually present along belly



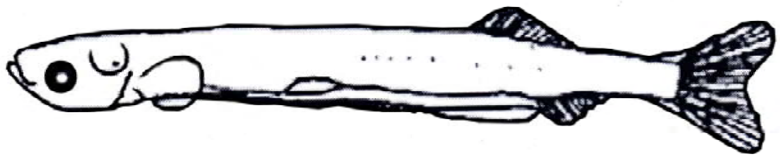
Mullet, *Lisa spp., Mugil cephalus* or *Valamugil*
- Two short dorsal fins, the first one with 4 spines
- Pectoral fins set high on body
- No lateral line
- Can be farmed with milkfish in polyculture



Threadfin, *Eleutheronema tetradactilum*
- Snout projects forward of inferior mouth
- Two dorsal fins
- Pectoral fins with separate rays

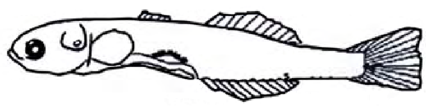
(SOURCE: Fisher and Whitehead, 1974)

Figure 4: Milkfish fry



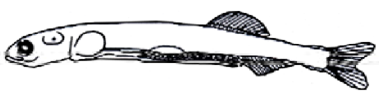
(SOURCE: Bagarinao and Kumagai, 1987)

Figure 5: Larvae of other fishes often confused with milkfish fry

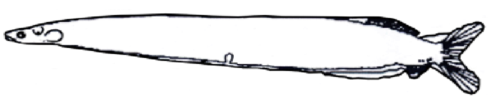


Goby fry
- Goby fry maybe shorter or longer than milkfish fry
- Two short dorsal fins and a prominent inflated swimbladder

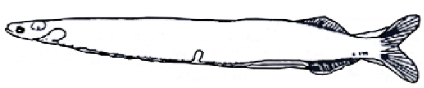
Sardine fry
- Transverse foldings in the gut



Anchovy fry
- As with sardines, anchovy fry also have transverse foldings in the gut



Tenpounder fry
- Longer (25-35 mm), deeper, flatter, ribbon-like, slightly amber bodies, smaller eyes than milkfish fry



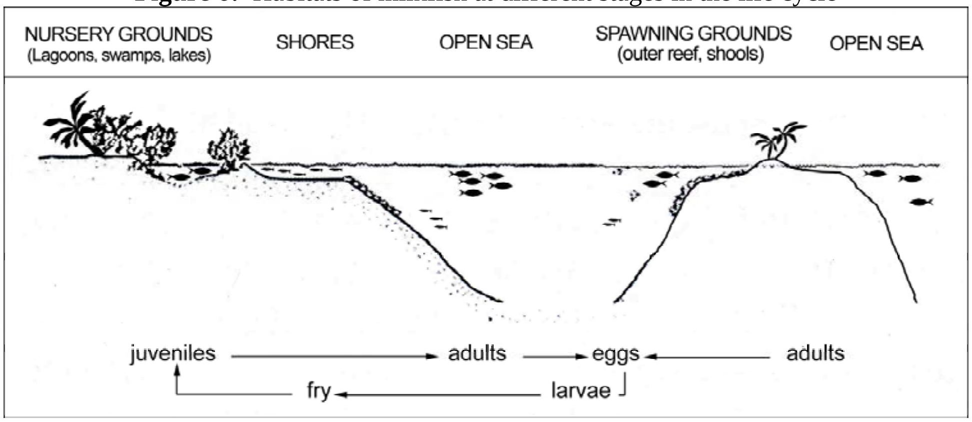
Tarpon fry
- Longer (25-35 mm), deeper, flatter, ribbon-like, slightly amber bodies and smaller eyes than milkfish fry

SOURCE: (Bagarinao and Kumagai, 1987)

3 Life Cycle, Habitats and Geographical Distribution of Milkfish

Milkfish is a large, long-lived species, and its habitat, behavior, and food habits change with size and stage in the life cycle. Milkfish in the wild migrate from one place to another. Adults spawn at sea, the larvae migrate to shore, juvenile settle in shallow-water habitats, and large juveniles and sub-adults return to sea. Accordingly, to ensure the survival of milkfish populations in the wild, coral reefs, beaches, mangrove swamps, estuaries, rivers and lakes must be protected. The life cycle of milkfish generally consist of four stages as illustrated in Figure 6.

Figure 6: Habitats of milkfish at different stages in the life cycle



(SOURCE:Buri et al, 1981))

Milkfish have a large bio-geographic distribution within the Pacific and Indonesian Oceans as illustrated in Figure 7. The Philippines, Indonesia and Taiwan are the center of geographic distribution. Milkfish have been recorded as far north as Japan and as far south in eastern Australia. They extend eastwards to the America and are common in the bays and lagoons of Mexico. They also occur in the Indian Ocean and along Eastern Africa. Milkfish are not found in tropical waters affected by cold ocean currents. The geographic range is limited to winter water temperatures greater than 20^o C (dashed lines). Such warm waters extend to temperate latitudes where there are major warm ocean currents (open arrows), but does not exist in tropical latitudes affected by cold ocean currents (dotted arrows) (Kumagai, 1990; Bagarinao 1994).

Figure 7: Occurrence of milkfish in the Indo-Pacific

(SOURCE: Kumagai, 1990)

4 Milkfish Pond Engineering and Construction

Fishpond Engineering is the science of planning, designing and constructing of fishponds, including water control structures. It plays an important role in attaining efficiency in farm management so that better farm production can be realized.

4.1 Site Selection and Evaluation

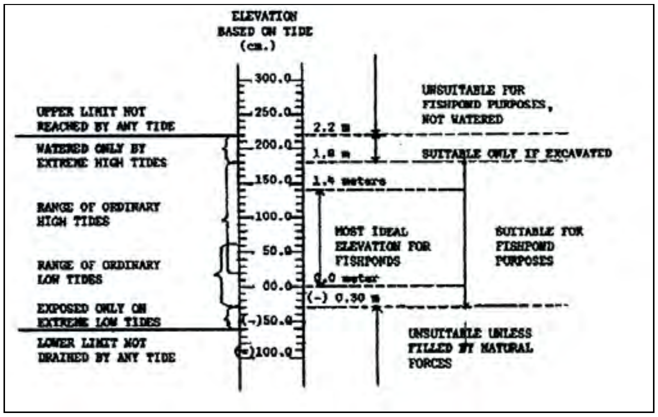
4.1.1 Water Supply

Water supply is the first and most important factor to consider in the suitability of a fishpond site. Usually, water supply comes from a river, creek or sea. It must meet the quality and quantity of the pond requirements throughout the year. It would be futile to develop a site if the source of water is polluted and/or the volume is inadequate.

4.1.2 Tidal Characteristics and Ground Elevation

The suitability of a tide-fed site for a milkfish pond depends on the relationship between the tide characteristic of the area and its ground elevation. Areas with ground level that are too high or too low in reference to 0-datum are not economically suitable to be developed as a fishpond for it will require a lot of excavation or filling. Suitability of pond construction area relative to 0 datum and ground elevations are illustrated by Figure 8. Areas reached only by the high spring tides should be ruled out as it is costly to excavate. Low areas on the other hand will require filling-up or else full draining cannot be accomplished. This is another unnecessary extra expense. The best elevation for a pond bottom would at least be 0.2 meter from the datum plane or at the elevation where 0.6 meter depth of water can be maintained inside the pond during ordinary tides. This index should satisfy the requirements of both fish and natural fish food. Photosynthesis should still be able to take place at the bottom of the pond to produce the benthic algal mat ("*lab lab*"), a natural food for milkfish

Figure 8: Suitability of proposed fishpond site based on tidal characteristics and ground elevation



(SOURCE:BFAR & FAO/UNDP Training Manual, 1980)

4.1.3 Soil Properties

Most fishponds are constructed on tidal lands consisting of alluvial soils, which are adjacent to rivers or creeks near the coastal shores and estuaries at or near sea level elevation. Examine it closely and you will find that it is made up of mineral and organic particles of varying sizes. The mineral particles are the clay, silt, and sand while the organic particles are plant and animal matter at various stages of decomposition. Table 1 shows classification of soil by particle size (soil texture).

Table 1. Classification of soil by particle sizes

GENERAL TERMS				
Common Names		Texture	Basic Soil Textural Class Names	
1.	Sandy Soils	Coarse	Sandy	
			Sandy Loam	
2.	Loamy Soils	Moderately Coarse	Sandy Loam	
			Fine sandy Loam	
		Medium	Very fine Sandy Loam	
		Moderately fine	Loam	
			Silty Loam	
			Silt	
3.	Clayey Soils	Fine	Sandy Clay	Clay Loam
			Silty Clay	Sandy Clay Loam
			Clay	Silty Clay Loam

(SOURCE: BFAR & FAO/UNDP Training Manual, 1980)

4.1.4 Soil Classification

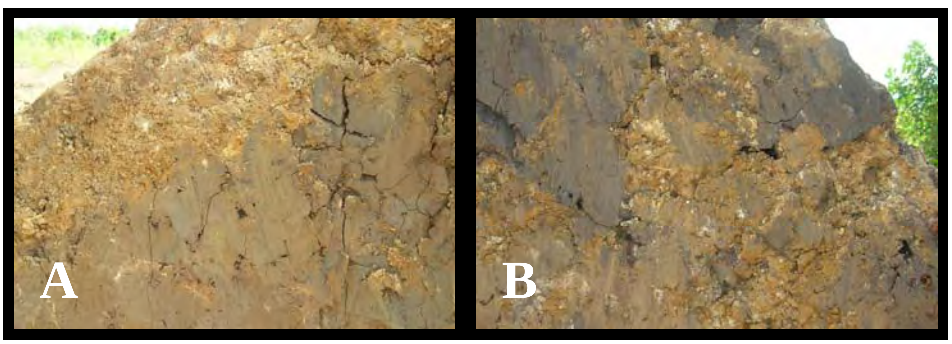
Soil texture is important in determining how well suited the area is for fishpond development. Finer textured soils are superior for fishpond purposes because of their good water retention properties. Ideally, dikes constructed with clay soils are preferred over dikes with sandy soils (fig 9). Fig 9a shows a solid clay core whereas figure 9b shows a mixture of clay and sand, which is more susceptible to water leakage and dike failure. Clay or sandy clay are best for dike construction but not as good as clay loam or silty clay loam in terms of growing natural food. Table 2 shows the suitability of the different soil classes in pond constructions.

Table 2. Relationship of soil classes and suitability for dike material

CLASS	RELATIVE CHARACTERISTIC		COMPACTION CHARACTERISTIC	SUITABILITY FOR DIKE MATERIAL
	PERMEABILITY	COMPRESSIBILITY		
Clay	impervious	medium	fair to good	excellent
Sandy clay	impervious	low	good	good
Loamy	semi-pervious to impervious	high high	fair to very poor	fair
Silty	semi-pervious to impervious	medium to high	good to very poor	poor
Sandy	pervious	negligible	good	poor
Peaty	-	-	-	very poor

(SOURCE: BFAR & FAO/UNDP Training Manual, 1980)

Figure 9 a and b: Cross section of dikes showing two different soil types.



There are various ways of identifying different classes of soil, especially using texture as described below.

Sand- Soil has granular appearance. It is free flowing when in a dry state. A handful of air-dried soil when pressed will fall apart when released. It will form a ball that will crumble when lightly touched. It cannot be ribboned between thumb and finger when moist.

Sandy loam- Essentially, it is a granular soil with sufficient silt and clay making it somewhat coherent. Sand characteristics predominate. It forms a ball which readily falls apart when lightly touched or when air-dried. It forms a ball, which bears careful handling without breaking. It cannot be ribboned.

Loam- A uniform mixture of sand, silt, and clay. Grading of sand fraction is quite uniform from coarse to fine. It is soft and has somewhat gritty feel, yet is fairly smooth and slightly plastic. When squeezed in hand and pressure is released, it will form a ball which can be handled freely without breaking. It cannot be ribboned between thumb and finger when moist.

Silty Loam- It contains a moderate amount of finer grades of sand and only a small amount of clay; over half of the particles are silt. When dry, it may appear quite cloddy; it can be readily broken and pulverized to powder. When air-dried, it forms a ball which can be freely handled. When wet, soil runs together and puddles. It will not ribbon but has a broken appearance; it feels smooth and maybe slightly plastic.

Silt- It contains over 80% of silt particles with very little fine sand and clay. When dry, it maybe cloddy; it is readily pulverized to powder with a soft flour-like feel. When air dried, it forms a ball which can be handled without breaking. When moist, it forms a cast which can be freely handled. When wet, it readily puddles. It has a tendency to ribbon with a broken appearance; it feels smooth.

Clay Loam-Fine texture soils break into lumps when dry. It contains more clay than silt loam. It resembles clay in a dry condition. Identification is made on physical behavior of moist soil. When air dried, it forms a ball which is freely handled without breaking. It can be worked into a dense mass. It forms a thin ribbon which readily breaks.

Clay-Fine texture soils break into very hard lumps when dry. It is difficult to pulverize into a soft flour-like powder when dry. Identification is based on cohesive properties of the moist soil. When air-dried, it forms long thin flexible ribbons. It can be worked into a dense compact mass. It has considerably plasticity, and can be molded.

Organic Soil-Identification is based on its high organic content. Much consists of thoroughly decomposed organic materials with considerable amount of mineral soil finely divided with some fibrous remains. When considerable fibrous material is present, it maybe classified as peat. Soil color ranges from brown to black. It has high shrinkage upon drying.

4.1.5 Flood Hazard
Flooding is considered to be one of the most destructive natural disasters in the fishpond industry. Floods cannot be controlled completely, but it is important to know how a fishpond can be free to some extent from flood hazard. It is necessary to know the weather conditions in the area and find out the highest flood that occurred. High tide plus the highest flood level on record should be considered so proper diking and drainage can be planned. In Eastern Africa, the main rainy season is March to May when the fingerlings are more abundant (Dubi et al, 2005). In addition to dike construction considerations, farmers may want to consider harvesting before the rainy season and restock the ponds just after the rainy season that coincides with flooding from land and the highest spring tides in the year with greater possibilities of breaking the pond walls.

4.1.6 Climatic Conditions
Seasonal climatic changes are important in scheduling and managing fishpond operations. The climatic elements that concern most operators are rainfall, temperature and prevailing wind direction because they greatly affect fish production directly or indirectly. Data on rainfall and wind direction are necessary in planning the layout and design of pond system. Knowing the past rainfall record can help you decide on dike heights or whether to include

drainage canals. Winds can also be very destructive since they generate wave action that can destroy the sides of the dikes. By knowing the prevailing wind direction, dike positioning can be planned, by exposing the least area possible to damaging waves. Heavy rain can suddenly change the salinity and temperature of pond water, which can be detrimental to fish. It is also important to know the period of the rainy season as this will affect pond preparation and stocking cycles. Drying of pond bottoms cannot be accomplished during rainy days but is a necessary step prior to stocking to reduce likelihood of disease outbreaks.

4.1.7 Type and Density of Vegetation

Type, size and density of vegetation and the root system of individual trees, greatly affect the method of clearing, procedure of farm development and construction cost. Thickly vegetated areas will take longer to clear and therefore cost more money. The estimation of the clearing cost will depend on how much vegetation is present and the labor cost, whether the charge is per tree or per area. It is highly recommended that pond sites be selected that are sited primarily in salt flat areas behind mangrove stands. Large scale clearing is not recommended as it increases construction costs and is environmentally destructive.

4.1.8 Support Infrastructure and Labor

Other factors that can affect the selection of a good fishpond site are:

- Accessibility to market
- Availability of fast and good transport facilities for marketing of fish
- Availability of fry for stocking
- Availability of skilled labor
- Availability of ice and cold storage facilities
- Availability of fertilizers (organic and inorganic) and supplementary feed
- Availability of construction materials
- Availability of financial institutions
- Peace and order conditions in the locality

4.2 Site Survey for Pre-Construction

4.2.1 Survey Equipment

Pond construction requires following equipments:

1. *Measuring Tape*- Used for measuring straight distances between points. Made of flat steel or fiberglass bands marked in various ways. Can be obtained in different lengths but 50-100 m. long are the convenient ones to use.
2. *Hand Level*- Used for rough measurements of differences in elevation. It is used by standing erect and sighting through the eyepiece, holding the tube and moving the objective end up and down until the image of the spirit level bubble on the mirror is centered on the fixed cross wire. The point where the line of sight in this position strikes the rod or other objects is then noted. The vertical distance from the ground to the surveyor's eye is used to determine the height of instrument and ground elevations. A rough line of levels maybe carried out with the hand level for distance of 10 to 15 meters.
3. *Level Transit*-Is a more accurate instrument for measuring the difference in elevations. The height of the instruments line of sight is well established and

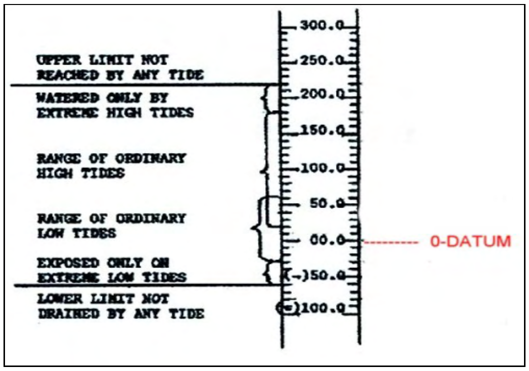
rotational movement is stable. As do all sighting instruments, it operates on the principle that any point along a level line of sight is exactly level with any point along that line.

4. *Self-Leveling level Transit*-The self-leveling level automatically levels its' line of sight with great accuracy. There is no tubular spirit level and no tilting screw. It levels itself by means of a compensator after the circular spirit level is centered approximately. It is precise as well as simple and quick to operate and can be used for any type of level survey.
5. *Engineer's Transit*-This instrument is used primarily for measuring horizontal and vertical angles, prolonging or setting points inline, measuring approximate distances by stadia principle, and for leveling operations. It can also be used as a compass when equipped with a compass needle.
6. *Tripod*-A three adjustable legged stand where the transit is mounted for a stable support.
7. *Leveling Rod*- Stadia rod and the range pole are two kinds of leveling rods which are commonly used in conducting site survey. Stadia rods are calibrated extension rods where you can read the elevations and sometimes distance if you are using an engineers transit.
8. *Marker Stakes*- These are use to mark elevations by transferring the stadia reading on them. These are also used to mark proposed locations of dikes and gates.
9. *Meter Sticks*- Convenient instrument to measure short distances.

4.2.2 Locating the 0-Datum

Zero datum is defined as Mean Lower Low Water (MLLW). It is the most important task in site selection and for design. The datum plane of reference for land elevation of fish farms is called 0-datum. It is the average water height of all the lower of low waters or mean lower low water (MLLW). It can also be called 0.00 elevation. The most accurate way to do this is through tidal observation right at the proposed site of the main gate for at least one-month duration or one lunar cycle. You can also get a rough estimate using few tidal cycles. This can be done by erecting a calibrated tidal pole in the deepest area near the proposed site of the main gate. Observe and record all the low tide readings that occurred for future calculations. Pick out the data from the range of ordinary low tide readings and add to the data of extremely low tide ones (*neap tide*) and get the average. This is where your datum plane (*0-datum*) will be set. Also observe and record all the high tide readings including the extremely high tide (*spring tide)* for the reference in the height of the perimeter dike and the main gate. An example of tidal readings, determination of 0 datum, and suitability of an area for pond construction is shown in Figure 10.

Figure 10: Sample of Tidal Readings and the location of 0-datum (MLLW)



(SOURCE: BFAR & FAO/UNDP Training Manual, 1980)

4.2.3 Setting up a Bench Mark

Without Geodetic Survey Markers in the proposed site, a temporary or permanent bench mark can be set up. This is based on 0-datum or (MLLW). Bench marks are set up at different strategic locations. It is used as reference for elevations during construction and therefore should be well marked and secured. A Bench Mark at the farm site is needed to gauge elevation based on 0-datum. In the absence of a Coast and Geodetic Survey “markers” at or near the site of a proposed fish farm, a secondary bench mark maybe established. The following steps describe this process:

1. Plan to be at the site when the tide is low
2. Somewhere halfway between the tide pole where 0-datum had been established and the proposed bench mark, set-up the level transit
3. Set the bottom of the stadia rod aligned to 0-datum and take a backsight (BS) reading
4. The backsight (BS) reading is the height of the level transit in reference to the 0-datum
5. Set up a bench mark (BM) by driving a wooden stake onto the ground
6. Distinguish the bench mark stake from other stakes by a distinctive paint. Set the stadia rod on top of the bench mark and take the foresight reading (FS)

Calculate the elevation by subtracting the height of the foresight (FS) reading from the height of the instrument (HI). HI-FS=BM elevation

4.2.4 Determining Elevations of Different Ground Locations

Drive some marker stakes at the locations where you want to know the elevations and identify each stake with a number. Set up the level transit at a location where you can spot the bench mark (BM) and the marker stakes. Place the bottom end of the stadia rod on top of the bench mark (BM) and take a reading. Place the bottom end of the stadia rod on the ground level (GL) where the marker stakes are located and take a reading. Ground level (GL) reading minus the bench mark reading (BM) will give you the elevation in reference to the bench mark. GL reading - BM reading = GL elevation in reference to BM elevation.

4.2.5 Setting Up Marker Stakes for Dike, Canal, and Gate Locations

Using a measuring tape, measure the distances between points where you want to construct your dikes, canals and gates. At every point where you have located the proper placement of the dikes, canals and gates, drive a primary stake in the ground. From these primary stakes, measure on both sides to mark the proposed width of the dikes, canals and gates and drive in the secondary stakes. Check if the set up is done as planned and adjust if something is not quite right before doing the actual construction.

4.3 Backyard and Commercial Pond Systems

4.3.1 Backyard Ponds

This is a type of pond farming operated mainly for domestic purposes. The pond sizes range from 0.1 – 0.2 ha. The pond construction and management costs are minimal. In this type of ponds fish are stocked and harvested continuously. The harvesting in this case is selective. There are several ponds in Tanzania operating at this scale one of which has recently been developed at Buyuni, Saadani in Pangani District, Tanga (Figure 11). Rather than using wooden or cement gates that are expensive to construct, PVC pipes can be used for water inflow and drainage (Fig 12)

Figure 11. Buyuni backyard mariculture pond.

Picture credit: Baraka Kalangahe –TCMP.

Figure 12: Backyard ponds showing PVC pipes for water control

Picture credit: Baraka Kalangahe –TCMP.

4.3.2 Commercial Pond Systems

Commercial pond systems range from 1 ha upwards. They are more capital and labour intensive. They have elaborate construction, management and marketing strategies and are relatively more capital intensive. Already three pond constructions of this scale have been constructed 2 in Mkuranga and 1 in Bagamoyo, both in the Coast Region. These are dealt with more elaborately in the following sections.

4.4 Fishpond Layout and Design

A well-designed fishpond can make water management and stock manipulation simple and efficient. Operational expenses are also lowered. It is a matter of proper location, sizing and elevations of dikes, canals, gates and compartments. A semi- intensive milkfish pond design is the best design approach for Tanzania as it is a simple design and easily managed. A typical layout of a conventional pond system is shown in figure 13. Typical features include the following:

4.4.1 Nursery Pond (NP)

The nursery pond comprises about 1-10 % of the total area. The most suitable place is where it can be easily supplied with fresh unpolluted water at all times, and at elevation where it can be readily drained even during ordinary low tides. Water depth should be 15 to 25 cm. A manageable area ranges from 0.01 to 0.25 ha.

4.4.2 Transition Pond (TP)

The transition pond is located adjacent to the nursery pond in order to have an effective and easy transfer of fry. It is about 10-20% of the total area. It is in this compartment where fingerlings are stocked before they are transferred to the rearing pond. The pond bottom elevation is a little bit lower than the nursery pond and a little higher than the rearing pond. The water depth should be 20 to 30 cm. A manageable area ranges from 0.25 to 1.5 ha.

Figure 13: Sample design and layout of a conventional milkfish pond system

RP = rearing ponds; FP= feeding ponds and NP= nursery ponds

4.4.3 Rearing Pond-(RP)

The rearing pond is the largest compartment in the pond system. It is about 70-80% of the total area. It is in this pond where the fingerlings are raised to marketable sizes. It is desirable that the pond bottom elevation should be15 cm. lower than that of the transition pond. The water depth should be 30 to 50 cm deep. A manageable size ranges from 2.0 to 5.0 hectares.

4.4.4 Feed Pond (FP)

A feed pond is optional. In fishpond areas where natural food does not grow well and supplementary feeding is a necessity, one of the RP's, TP's and NP's could be utilized as a "feed pond". The main purpose of this pond is to produce supplemental natural fish food or for fattening fish before they are harvested. The ideal size of a feed pond is about 20 % of the rearing pond.

4.4.5 Dikes and canals

Dikes and canals comprise about 5% of the total area.

4.5. Water Control Structures

4.5.1 Gates

A gate is a sluice, culvert, or pipe which is used to control water flow. The most commonly used is the sluice gate. Conventional milkfish pond has a *Main Gate* which is the main entrance of water that supply the whole fishpond, *Secondary Gates* which control water supply to the rearing ponds and a *Tertiary gate* which 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 the slabs. Double screening is best because you can have two sizes mesh, the coarse to filter out big debris and a fine mesh to hold out other types of fish or their eggs. Double slab is also good because you can seal the water well by filling the space in between with mud. The cost of gate construction will vary on the size of the gate and the price of the construction materials. A typical gate consists of the following parts as shown in these sample illustrations in figure 14 for a concrete gate and figure 15 for a wooden gate. The actual wooden gate built at Mkadam site in Mkuranga is shown in figure 16.

Figures 14, 15: Sample designs for concrete and wooden gates

Fig. 14 Concrete gate

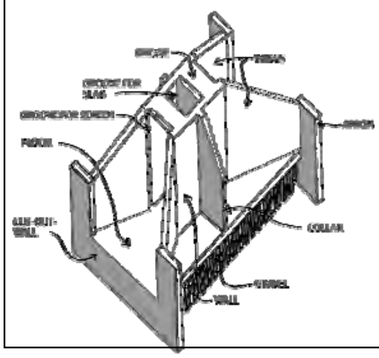
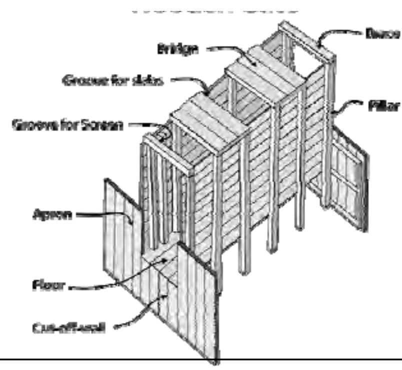


Fig. 15 Wooden gate



(SOURCE: BFAR & FAO/UNDP Training Manual, 1980)

Figure 16: Wooden gate under construction at Mkadam farm, Mkuranga, Tanzania

Photo credit By Edwin Requintina Sr,

4.6 Earth Work

4.6.1 Dikes

The dikes are the main structures that hold water in the pond. They are built out of soil materials that are in the pond site. The top is called the *crown* and the bottom is called the *base.* The side *slope* (ratio of horizontal length to vertical rise) or steepness (Fig 17) is determined by the height of the dike and the quality of soil material used. Dikes less than 3 m. high can have a slope ratio of 1:1 unless the soil material is of poor quality. Dikes that are higher than 3 m need to have a 1.5:1 to 2:1 ratio (Table 3). There are three classifications of dikes namely:

Perimeter Dike - The main dike that protects the whole fishpond from the outside environment. It has to be high and big to withstand flooding and erosion.
Secondary Dike - The dike that is used for the main supply canal and for the rearing pond compartments. They are a little lower and smaller than the perimeter dike.
Tertiary Dike - The smallest and lowest dike. It is used for the nursery and transition compartments.

Figure 17: Cross-section of a typical earthen dike

(SOURCE: BFAR & FAO/UNDP Training Manual, 1980)

Table 3. Relationship of the top width, bottom width and height of dike with a given side slope

Height (m)	Top width of crown (m)	Bottom width at given side slope (m)		
		1:1 ratio	1.5:1 ratio	2:1 ratio
1.5	1	4	5.5	7
2	1	5	7	9
3	2	8	11	14
4	3	11	15	19

The width of the bottom of the dike relative to the slope and width of the surface are important in determining the stability of the dike which is also related to the type of soil. The bottom width is calculated as follows:

Bottom width= height x 2 (ratio) + width of crown

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

Formula for computing the volume of soil for dike construction:

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

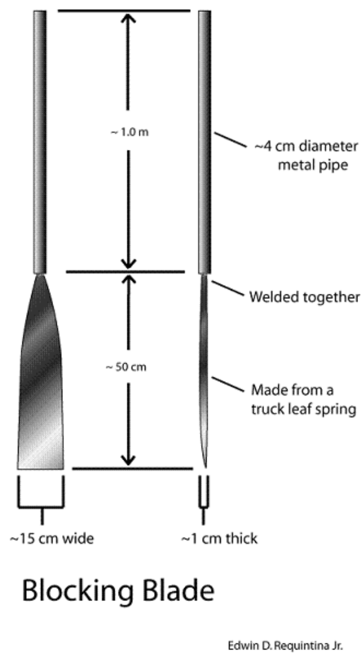
Example: Height=2.0 m, Crown=1.0 m, Base=5.0 m, Length=50.0 m
Area = 2.0 m x (1.0 m + 5.0 m)/2 = 6 m^2
Volume = 6 m^2 *x 50.0 m = 300.0* m^3

To determine the cost of dike construction, you should know how much the contractor charges per m^3. Then multiply the price per m^3 to the total volume calculated.

4.7 Excavation and Leveling

Manual excavation can be more efficient with at least four people working as a tag-team. Manual excavation is normally done with the use of blocking blade (Fig. 18). Shovels and digging tools are also needed (Fig. 19). Part of the excavation is done during dike construction, so you should take note that you don't need to pay for the digging of certain areas. But for areas that need to be excavated, the price of labor should also be per cubic meter with a simple formula of *Length x width x depth.* The depth of excavation will always depend on the elevation of the pond bottom relative to 0-datum and tidal range. An example of a main supply canal is shown in figure 20.

Figure 18: A blocking blade



Figures 19: Manual excavation and dike construction

Figure 20: Main canal and dike with the main gate in the foreground in April 2006 at the farm of Mr Mkadam, Mkuranga, Tanzania.

Photo credit to WIOMSA.

5 Stocking, Management, Marketing and Book-Keeping

Managing a milkfish pond is not that different from managing other businesses. To run a business, one would expect some sufficient profit so further production can be encouraged. Production can be increased with good management. Furthermore, by keeping expenses low, a larger margin of profit will be realized.

The best way to start milkfish pond culture is to start small and simple. Then, expand later when you are comfortable with the whole operation. Use the cheapest source of energy, i.e., tidal energy, solar energy and organic fertilizers that come from animal manure or rice bran. A rule of the thumb, never spend what you cannot afford to loose.

Tanzania is blessed with a good tidal range to fill up milkfish ponds, good sunny days to energize the natural food production in the pond and plenty of animal manure to fertilize pond bottom. Milkfish, which is one of the best species to culture coastal areas, is also present. All the ingredients to operate a milkfish aquaculture are present.

An important point to make is that raising milkfish takes a certain degree of knowledge and attention just like any other animal husbandry or farming operation on land. If farmers think they can just build any sort of pond, throw in a number of any type of fingerlings, walk away and come back to harvest in 4 months, they will be very disappointed in the results. Milkfish farming requires commitment to learning the technical knowledge and skills necessary to do it right and commitment of time and labor to make it profitable.

5.1 Pond Preparation

Before stocking fish in the pond, good preparation is needed to ensure success. All pond compartments should be prepared and this is done a month or two before filling the pond with water. It involves the following steps:

5.2 Draining and Drying the Pond Bottom

The pond bottom is drained and dried by completely draining the water and allowing the pond to dry for a week or two, depending on the weather. The purposes of draining and drying are to:

1. Eradicate pests, predators and competitors
2. Hasten the chemical decomposition of organic matter deposited so nutrients will be available for the growth of natural fish food.
3. Totally harvest the fish stock from previous culture
4. Kill organisms that may cause some diseases. Avoid chemical pesticides for they are harmful to the environment.

5.3 Tilling-Cultivation of the Pond Bottom

The pond bottom is prepared by cultivating with shovels and rakes. The purposes are to:

1. Make the sub-surface nutrients available at the surface for the growth of natural fish food
2. Eradicate burrowing fish and crustaceans that can cause pond seepage
3. Eradicate fry predators such as mud skippers who otherwise are capable of surviving underground for some time
4. Eliminate and Destroy pond weeds that are not desirable in the ponds

5.4 Leveling

This is done so bottom surface irregularities, such as mounds, depressions and holes are leveled. The natural fish food grows better with a good-leveled surface. This is done with the use of shovels and rakes.

5.5 Pest Control

Complete drying of the pond bottom and picking-up of obvious pest is the safest and the most economical way.

5.6 Fertilization

Organic fertilizer is highly recommended for conventional milkfish culture. Sources of organic fertilizers are chicken manure, pig and cow dung. This is best for growing a benthic algal mat (*lablab*) that milkfish feed on.

Steps in the pond preparation for *lablab* growth are as follows:

1. Allow the bottom to sun-dry until it cracks
2. Refill the bottom with water to 5 to 10 cm depth, and allow it to evaporate until completely dry
3. The process is repeated 2 to 3 times
4. Spread organic fertilizer over the pond bottom (500-1000 kg./ha/crop)
5. Add fresh brackish water to a depth of 10 to 15 cm.
6. After several weeks, benthic algae will grow to about 1.0 to 3.0 mm.
7. Apply lime if the pond turns acidic (optional)

Organic fertilizer application ranges from 500 to 1000 kg./ha/crop. Most of the application should be during pond preparation. Fertilizer application at the pond preparation stage should be to a dry cracked bottom (Fig 21). No Additional application administered if fish food (lab-lab) growth is slowing down especially close to the end of the culture period when food consumption is at a higher rate. The amount is dependent on how fertile the soil in the area is, that is why there is a range, and farmers need to use their best judgment as to the proper amount for their ponds.

What is *Lab-lab*?

Lab-lab (Fig 22 is one of the natural fish food in the ponds (others: filamentous green algae, plankton). It is a benthic mat with various components including unicellular, colonial and filamentous blue-green algae or cyanobacteria, a great variety of diatoms, some unicellular or very fine threads of green algae, bacteria, protozoans, minute worms, copepods and other small crustaceans. Cyanobacteria dominate in fertilized ponds, but diatoms take over in unfertilized ponds. Under some conditions, the benthic mat can detach and float. *Lab-lab* is about 6-20% protein, and is preferred by all sizes of milkfish. Fingerlings, 2.5 grams in body weight, consume 60 % of their body weight. Juveniles, 100-300 grams in body weight, eat about 25% of their body weight. Lab-lab has been cultivated and used in milkfish farming in the Philippines since the 1920s. A hectare of nursery ponds with a good growth of *lab-lab* can support 300,000-500,000 fry for 4-6 weeks until they reach 4-5 cm. A fertilized grow-out pond with *lab-lab* can support 500-700 kg/ha total fish weight over 2-3 months. About 25,000 kg/ha of *lab-lab* is needed to produce 2,000 kg/ha of milkfish. Clay-loam and loam soils with a pH of 7-9 and more than 3% organic matter are favorable for the growth of *lab-lab* in milkfish ponds. Shallow ponds allow the growth of *lab-lab*.

Figure 21: Dried chicken manure being applied at Mkadam farm, Mkuranga, Tanzania.

Figure 22: Lab-lab in Makoba Bay Ponds in Zanzibar, Tanzania

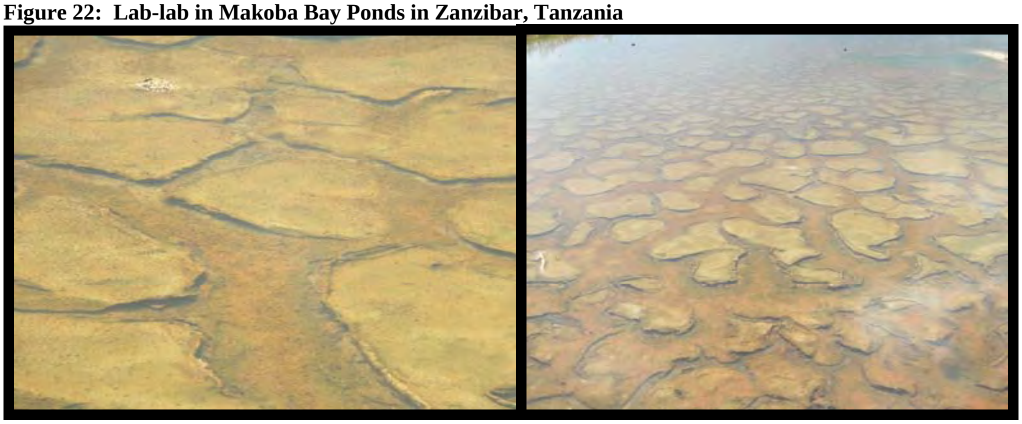


Photo credit: Aviti J. Mmochi

5.7 Fry Collection

As the ponds are being prepared for stocking, fry collection should be started so enough can be accumulated for the intended stocking rate of the pond. Normally in places where milkfish culture had been practiced extensively, there are individuals or communities that are specialized in fry collection as a separate business from the actual fish farming.

This kind of operation is not practiced here in Tanzania so fishpond operators can buy milkfish fry directly from the local collectors or do the collection themselves. Fry occurrence in the wild is seasonal and only present in certain locations. Thus, in order to accumulate a substantial amount of fry, there should be enough number of collectors. It is therefore very important that the start of the culture period coincides with the occurrence of the abundant supply of fry.

5.7.1 How to Locate Milkfish Fry

Seasonality in the abundance of milkfish fry varies for different regions of the world. In the WIO region there are two peak seasons of fry occurrence coinciding with long and short rainy seasons. In Zanzibar studies indicate peak abundance in the February – May and October – November periods (Dubi et al. 2004). Lunar cycles also influence the occurrence of fry in the coastal waters. Milkfish spawn in the wild during the first and last quarter moon, so fry are abundant in coastal waters during full and new moons. Fry catches increase when the wind direction is towards the shore. They are normally caught in sandy shores, estuaries and mangrove areas.

5.7.2 Different Methods and Gears Used in Milkfish Fry Collection

The methods of fry collection have evolved through the years. The different collection gears vary according to structure, materials and methods of operation, with modifications made to suit the behavior of the fry and the conditions of the milkfish fry grounds as well as the capability of the fry collectors. Fry collection could be passive or active filtration. Illustrations of active fry collection gears used in Asia are shown below. In Tanzania, fry gear has not yet been developed as there is not yet an extensive culture industry or market demand for fry as exists in the Philippines and Indonesia. Therefore, operators at present must catch their own fry for stocking or stock fingerlings that are caught in the estuarine areas. Hatcheries for milkfish fry are possible, but milkfish breading and larval rearing is difficult, complicated and costly. Tanzania is not ready yet for hatchery development until the industry reaches a certain critical size in the future where it may become economically feasible. While capture and dependence on wild fry is a concern from an environmental standpoint, the scale of the industry is not yet of sufficient size to warrant concern. Different types of gear for fry collection are shown in figure 23. They include:

Skimming nets are gear that has triangular or semicircular frames. Nets may be made of abaca cloth or fine mesh nylon netting. It works by filtering milkfish fry from the water when the operator pushes it forward.

Push nets are gear consists of a V-shaped bamboo frame, a detachable fine mesh netting and a bag net located at the narrow end. The wings and bag net are weighed down with lead sinkers. The top portions are tied to the frame above the water line, while the lower parts are 5-15 cm below the water surface. Usually they operated along the shore or river bank by two people, one pushing the gear and scooping the fry from the bag net and another shuttling and sorting the fry on the shore. Push nets can be used as a stationary gear along the shore or river mouth. An example of how to use a push net is shown in figure 24.

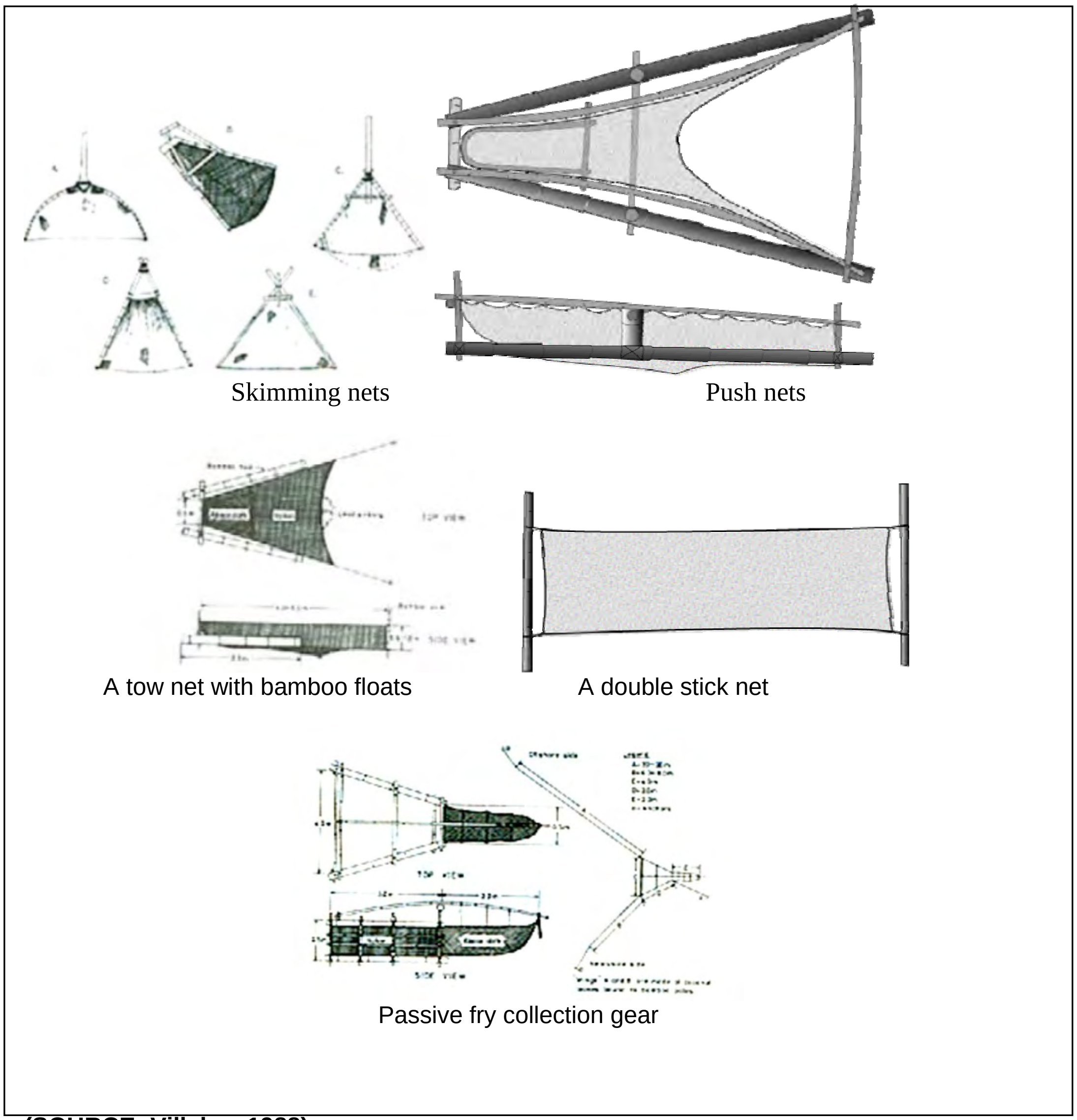
Tow nets with bamboo floats are gear that consist of wings made of fine mesh netting and a cylindrical bag made of sail cloth. A float is attached at the upper mid-portion of the bag net‘s opening while the lead sinkers are placed at the lower edge. They are used in areas with steep shore profiles, high waves and stormy winds. Typically, they are operated by two people, each pulling on the bamboo pole at the end of one wing

Double stick net gear consists of a rectangular netting material suspended between bamboo poles. It is towed along the shore or at a river mouth by two people. The netting at the wings are made of fine-mesh nylon netting and the center is made of finer netting or cloth where the fry is concentrated and scooped.

Passive fry collection gear can also be used and may be appropriate for many estuarine areas in Tanzania (Fig 25). These types of passive gears can also be used for larger size fingerling collection. A *Floating tidal set net* is one form of passive gear. The gear consists of V-shaped floating wings made of coconut leaves tied to bamboo poles and connected to a bamboo frame. The sides are made of fine mesh nylon netting and the catching chamber is made of an even finer netting or cloth. The offshore side of the wings is longer (30-30 m) than the near-shore side (6-8 m). The opening between the two tips of the wing is from (20-30 m). This is set against long-shore currents. This is operated during flood tide but also can be used when wind or current direction is towards the gear.

Fingerling collection by using mosquito net is so far the commonest method in Tanzania (Fig 26). The net is used for catching fingerlings from 5 g in tidal pools and trapped waters in reservoirs and abandoned ponds.

Figure 23: Types of milkfish fry collection gear used in the Philippines



(SOURCE: Villaluz, 1988)

Figure 24: Collection of milkfish fry using a push net, Mlingotini, Bagamoyo

(Photo by Edwin Requintina, Sr)

Fig. 25 A passive tidal set net at Regent Enterprises, Changwahela, Bagamoyo, Tanzania

Photo by A. J. Mmochi

Figure 26: Collecting milkfish fingerling by mosquito net at Mkadam Farm, Mkuranga, Tanzania

Photo by Sande Nundwe, SUCCESS, Tanzania

5.8 Sorting and Counting

The whole catch, which may include other fish fry and crustacean species, is brought to shore after capture. It is easy to see and sort if they are placed in a white plastic basin. A small white bowl is used for sorting and counting (Fig. 27). The sorted and counted fry are placed in an earthen jar or another plastic container for storage and the rest of the unwanted species should be returned to the water where they were caught. This is very important because these unwanted species are part of the larger ecosystem and therefore should be preserved. Actual counts of fry can be done with the aid of pebbles. For instance, one small pebble represents 100 fry, while a bigger one represents 1,000 fry.

Figure 27: Sorting and counting of fry using pebbles.

(SOURCE: Bagarinao, 1999)

The fry are not fed overnight after they are caught. The storage water generally is diluted with one part freshwater and three parts seawater and the storage containers are about 20-30 liter capacity. For longer storage, water is further diluted to approximately 18-25 parts per thousand (ppt). Containers are covered to minimize fry activity and to prevent dirt from getting in.

The milkfish fry are fed with yolk of hard boiled eggs, pulverized rice, or dried wheat flour, once a day for one or two days. The stored fry are checked twice a day and the excess food, feces, dead fry and debris are removed by scooping or siphoning out the potentially hazardous waste.

5.9 Transport of Milkfish Fry

Transport is done using oxygenated plastic bags with capacity of 16-20 liters. Seawater in the bag should be diluted to salinity of about 10-22 ppt, filling the bag to about ½ its capacity. Fry are placed inside the bag, The ambient air is then flushed out as oxygen is added to fill up the remaining 1/2 airspace of the total bag volume.

The bags are then sealed tightly with a rubber band and placed inside woven palm bags, cardboard boxes, or Styrofoam boxes. Each bag holds about 4000-8,000 fry. It is important to keep the bags in cool temperature (about 20^{o}C) during transport to lower oxygen consumption and metabolic rate. Cool temperature also decreases fish activity, thus, preventing physical injuries to the fry.

5.10 Stocking Techniques

Upon delivery to the fishpond, the milkfish fry should be transferred to another container (20-30 liters capacity) for conditioning, final counting and sorting. The water in the conditioning container is gradually diluted with pond water, every 2 hours, a quarter of the volume at a time, until the salinity comes close to that of the pond water. To reduce temperature shock to the fry, the conditioning container is floated in the pond for 10-15 minutes before the fry are set free in the pond. The best time for stocking the fry in nursery ponds is during the cooler time of the day, i.e., the early morning or late afternoon.

5.10.1 Stocking Density

Milkfish fry are first grown in the nursery pond for 1-2 months until the fry reach the fingerling stage. The fingerlings are then transferred to the transition pond for 1month, and finally, to the rearing pond for 3-4 months. The stocking densities for all the different stages are shown in table 4. Having different compartments for different growth periods ensure enough fresh *lablab* for the different stages of fish growth, helping to provide for optimal growth conditions.

Table 4. Stocking densities at different stages of growth

Pond compartment	Growing stage (g)	Culture period (days)	Growth rate (g/day)	Stocking density (per m^2)	Harvest size (pc/kg)
Nursery pond	0.02 to 0.50	30-60	0.016	40 fry	2000
Transition pond	0.50 to 50.0	30	0.5-1.0	5 fingerlings	100
Rearing pond	50.0 to 275.0	90-120	2-3	1 fish	3-4

For fish to attain optimal growth, water quality should be at a level that is most favorable. It is therefore necessary that water quality parameters be monitored regularly. The optimum water quality conditions for milkfish farming are shown in Table 5.

Table 5. Optimum water quality conditions for milkfish farming

Parameter	Optimum
Dissolved Oxygen	3-5 ppm
Temperature	22-35^{o}C
pH	6.8-8.7
Salinity	18-32 ppt
Turbidity	0.5 m

To avoid disastrous occurrences due to unhealthy water quality and/or other incidences, ensure sufficient supply of clean water. Change water as often as possible, at least every two weeks. Install a stand-by water pump to maintain desired water depth when water management through tidal fluctuation is not possible (optional). Anticipate adverse weather conditions and be ready for such occurrences as sudden changes in water temperature and salinity. Adverse weather conditions can also cause dike wash-out and/or flooding. Always stock good and healthy fry. Monitor survival rate, biomass, growth and health.

5.11 Harvesting

The most commonly used method for harvesting milkfish that have reached marketable size is the “water current” method. This method takes advantage of the tendency of the fish to swim against the current. The method is carried out by draining water in the pond to induce fish to swim through the gate. The gate is then closed when all the fish have been compounded. Harvesting can also be done by the use of seine nets (Fig. 28). Gill netting is usually employed as a harvesting technique if selective harvesting is done. The size of the net mesh would determine the size of the fish harvested. Another method is the total draining method. Total harvesting is done by manually collecting or picking the remaining fish from the pond bottom. After the harvest, fish are prepared for marketing.

Figure 29: Harvesting of milkfish using a seine

5.12 Marketing and Distribution

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.

How to pack fish for transport: Wash the fish with pond water prior to icing and sort them according to size. Immerse the fish in a tank filled with ice water immediately after harvest to keep them from loosing their scales. Spread a layer of crushed ice about 15 cm thick at the bottom of the transport box. Lay about 100 kg of fish on top of the crushed ice with their head facing one direction. Spread another layer of crushed ice about 5 cm thick on top of the fish. Repeat the process until the last layer of fish is about 15 cm below the top of the box. Place the last layer of crushed ice about 15 cm thick on top of the fish. Cover the top ready for transport. The boxes of fish should be loaded to the transport vehicle carefully, and if possible to be done early in the morning when the temperature is cooler. Make sure it goes to the market without unnecessary delays. Make sure you sell your fish at a good price to ensure profits.

Timetable and checklist of pond management activities

	Activity	**Duration**(Days)
Week 1-2	Drain pond, level and repair pond bottom	1-2
	Dry pond until bottom cracks. Till the pond to further kill organisms bellow the surface	7-14
Week 3-4	Add lime if soil pH is low (< 7)	1
	Fill pond with water, 10 cm	1
	Drain pond	1
	Dry pond	7-14
Week 4-5	Add organic fertilizer (500 – 1000 kg/ha)	1
	Fill pond with water, 10 cm depth	1
	Dry pond	7-14
	Fill pond with water, 10 cm depth	1
Week 6-7	Allow *lab-lab* to grow	7-14
Week 1-7	Fry/fingerling collection	30-50
	Stock fingerlings (3 fingerlings/m^2)	1-2
	Add water to maintain depth at 10-12 cm, increase the depth up 30 as the fish grow	1
	Monitor water depth, salinity, pH and dissolved oxygen frequently, especially during adverse environmental conditions or fish mortalities	1
	Refresh water (at least 15%) for 3 days in each spring tide	3
	If the lab lab is consumed (usually in six months) add inorganic manure, or shift the fish into another pond with lab lab or harvest	
	You may put wooden stakes with plastic or cloth stripes to chase away birds. The stakes also discourage thieves using nets in the ponds	
24 - 32	Harvest	7

5.13 Book Keeping

Although it does not have the complexity of other business venues, milkfish farming is still considered a business. You need to understand the financial situation to guide you for the future operation. To know the expenses incurred for the development and operation of the milkfish pond you need to record everything. This is called *book keeping.* This is important because the records are the basis of how much you have spent to run the whole operation in order to determine whether you have gained or lost after the cost has been deducted from the total sales of the fish or the gross income.

The budget in the table below shows that capital costs of pond construction are the greatest expense. While this may appear large, it should be noted that this is an initial non-recurrent capital investment. Once the ponds are constructed, and with proper maintenance, they will remain operational for many years. The only other costs that one may incur will be for maintenance and other operational running expenses. In this example it will take approximately three growing cycles before the pond breaks even and starts to turn a profit. Once the initial costs are recuperated, the annual estimated profits in this example are TSH 1,100

In addition to labor costs for dike construction, additional capital will be needed for the purchase of pond construction and clearing equipment such as a shovel, machete, etc. and purchase of materials for main and secondary gates construction.

If the ponds are constructed directly by the owner or are managed as a community or group pond, the community or group can organize themselves to provide the labor without direct pay. While this may seem to be a cost savings measure, there are opportunity costs for anyone providing labor for construction (they could be earning money from another form of employment if not constructing the pond). Hence, while this may require less direct capital in the form of cash required up-front for construction, owners or communities or groups would be wise to consider this labor as a cost. Individuals who work on construction can then be paid at a later date for their time as revenues are generated. This may take longer to get pond construction completed.

If pond construction and initial operating expenses are provided through a loan, the total amount for 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 (not shown in this example).

Table 6 Milkfish Pond Capital Costs for Construction and Development Expenses for an Area of I Ha Formally Used as Saltpan (4 grow out ponds covering 80% and two fingerling ponds covering 20% of pond area)

Purchases		**Amount**
Clearing equipment (shovel, machete, saw)		82,500
materials for the six secondary gates (wood)		1,484,400
materials for the main gate (wood)		264,000
	Total Materials	***1,830,900***
Clearing the area		200,000
perimeter dike construction (400 metres @ 1000Tsh/metre)		400,000
main gate construction		50,000
main canal construction (200 metres @ 1000 tsh/metre)		200,000
compartment dikes construction (200 metres @ 1000 tsh/metre)		200,000
excavation and leveling of pond		200,000
secondary gate construction @ 20,000/gate X 6 gates		120,000
	Total Labor	***1,370,000***
	TOTAL POND CONSTRUCTION COSTS	**3,200,900**

(Note: the above figures are based on 2006 costs in Mkuranga and may change depending on situation)

The budget may appear large but it should be noted that the initial capital investment for pond construction will last for approximately 20-30 years. Once the ponds are constructed the dikes will remain there in perpetuity with minor maintenance costs annually. The annual operational or running costs will be much lower once the ponds are already constructed. Labor makes up the biggest share of pond construction costs. If labor is provided by the fishpond owner, family or community group, then the actual cash outlays needed for construction are only for the purchase of the clearing equipment and gates. The total amount for construction and development can be paid or depreciated over a few years of operation depending on the amount of yearly revenues and net income. If cement gates are used, initial construction costs will be higher but they will not need to be replaced every few years as is the case with wood gates. The capital costs above assume no purchase of land

Table 7 Operating Costs (1 Hectare pond, one production cycle of 6-8 months)

Item	**Expenses**
Purchase of chicken manure (750 kg @ 10 tsh/kg)	7,500
Purchase of lime 2 bags at T Shs 2000/bag	2,000
Purchase of 12,000 fry at T Shs 10 per fry	120,000
Purchase of net for harvesting (1 meter X 15 meters, mesh size of 2.5 cm)	300,000
Wages and labor for pond management, maintenance (260TSH /hour X 180 hours)	46,800
Wages and labor for harvest 6 people @ 2,000/person	12,000
Purchase of ice for harvest and marketing (500kg ice X 250/kg)	125,000
Transport of fish harvest to market	100,000
TOTAL OPERATING EXPENSES	**713,300**

Net Revenues for First Harvest

Revenues (Sale of fish: 1 fish per square meter and 4 fish per kg (2000 kg @ 1000 T Shs/kg))	2,000,000
Capital Costs (assumes 5 year payback period and no interest: 3,200,900/5)	640,180
Operating Costs	713,300
TOTAL	**646,520**

(Note: the above figures are example amounts and are not intended for actual application.) As shown in the above example, the net profit for one culture period operation is T Shs 646,520.

Based on this example, a small net profit for the first several growing seasons could be made if the construction expenses are paid over 5 growing seasons (depending on the length of time to get fish to marketable size, there could be 1 –2 growing season per year). After construction costs are paid back, net profits would increase substantially. (Also – please note in this simplified example, interest on a loan for construction and initial operating costs are not factored into costs. For a multi cycle cash flow, inflation would also need to be factored in).

Table 8 Cash Flow over 5 growing seasons				
Year	Expenses	Revenues	Annual Net Revenues	Cumulative Net Revenues
1	3,914,200	2,000,000	-1,914,200	-1,914,200
2	713,300	2,000,000	1,286,700	-627,500
3	713,300	2,000,000	1,286,700	659,200
4	713,300	2,000,000	1,286,700	1,945,900
5	713,300	2,000,000	1,286,700	3,232,600

The cash flow projection shows that total investment payback will occur after the third growing cycle. Assuming 6-8 month growing cycles or 1 -2 crops per year, total payback and start of profits will take 18 months to 3 years

The initial investment for milkfish farming in Tanzania may seem high compared to average incomes of rural coastal households. The profitability overall, however, seems quite good. The construction costs are the primary up-front expenses needed, but then recurring expenses per crop are much lower. Since capital costs occur in the beginning of the operation, a key issue for households interested to invest in milkfish farming may be how the initial capital for constructions is acquired. As previously mentioned, if local labor is used either from the household or community group, it may be possible to defer payment and 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 capital 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 to break even and profitability will be lengthier and dependent on the interest rate or fees charged for such loans.

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