

TRAINING MANUAL ON SMALL-SCALE TILAPIA CAGE FARMING IN PAKISTAN



**FISHERIES DEVELOPMENT BOARD
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TRAINING MANUAL ON SMALL-SCALE TILAPIA CAGE FARMING IN PAKISTAN

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PREFACE

Cage farming in Asia is practiced in fresh, brackish and inshore coastal waters. Freshwater cage farming is a very old tradition that is thought to have originated in some of the Mekong Basin countries. Currently occurs in all freshwater habitats and is extremely diverse in nature, varying in cage design, intensity of practice, husbandry methods and the species farmed.

Brackish water and marine cage farming is relatively new in Asia, having first been developed in Japan for marine cage culture for species such as the Japanese amberjack or yellowtail (*Seriola quinqueradiata*) and red sea bream (*Pagrus major*). Over the last 20 years, marine finfish aquaculture, predominantly cage farming, has spread throughout Asia. The predominant countries engaged in this activity are China, Indonesia, Taiwan and Viet Nam.

Pakistan has lot of large size water bodies, including dams, barrages, lakes, running canals and rivers and sheltered bays and lagoons, etc. these water bodies can be used to grow fish in cages. The cage farming technology was introduced by Fisheries Development Board in 2010 at experimental level. That piloting of technology rolled the ball and have resulted in the establishment of small size input industry like one tilapia hatchery in Private sector and few small-scale feed mills, but this is a great achievement of the initial pilot as these facilities had not developed in last 70 years of the history of Pakistan. Keeping in view the results of the initial pilot, there is a need to practice / upscale the cage farming technology to produce fish at commercial level through cluster development approach.

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CHAPTER-1: INTRODUCTION TO CAGE FISH FARMING

a) What is Cage Culture

Cage fish farming is the growing of fish in cages. A cage is totally enclosed on all sides (or on all sides but the top) by mesh or netting.

Cage culture is an aquaculture production system where fish kept in floating net. Cage culture of fish utilizes existing water resources but encloses the fish in a cage or basket which allows water to pass frequently from the net. Cages are used for culture of several types of finfish species, in Fresh water, brackish water and marine water.



b) History of Cage Culture

The origins of cage culture are a little vague. It can be assumed that at the beginning fishermen may have used the cages as holding structures to store the captured fish until they sent to the market. The first cages which were used for producing fish were developed in Southeast Asia around the end of the 19th century. Wood or bamboos were used to construct these ancient cages and the fish were fed by trash fish and food scraps. In 1950s modern cage culture began with the initiation of production of synthetic materials for cage construction. The earliest record of cage culture practices dates back to the late 1800 in Southeast Asia, particularly in the freshwater lakes and river systems of Kampuchea. Marine fish farming in cages traces its beginning to the 1950s in Japan where fish farming research at the Fisheries

Laboratory of the Kinki University led to the commercial culture of yellow tail (*Seriola quinqueradiata*) and developed into a significant industry as early as 1960. Since the 1970, Thailand has developed cage culture techniques for two important marine finfish: the sea bream (*Pagrus major*) and grouper (*Epinephelus spp.*). Large scale cage farming of groupers was established in Malaysia in 1980. Korea started cage culture in the late 1970s and by the end of 1980, cage culture of the olive flounder (*Paralichthys olivacens*) and black rockfish (*Sebastes schlegelii*) was established and developed into a successful aquaculture industry in the 1990s. Cage culture of groupers (*Epinephelus spp.*) in the Philippines has been practiced since 1980s. Mariculture of milkfish in the 1990s led to the further growth and development of the industry.

c) Importance of cage fish farming

- a) For income generation
- b) For employment/job creation
- c) To satisfy nutritional needs
- d) For food security and health
- e) As an alternate source of fish production
- f) As an additional in situ use of large water bodies

d) Planning a cage fish farm

To begin farming, you should:

1. Locate a suitable water body to install your cage (it should be at least 8 metres deep).
2. Identify an adjoining piece of land or site not earmarked for another activity.
3. Identify potential sources of inputs such as fingerlings and feeds.
4. Obtain access to farm equipment such as cages, scales, boats, water quality kits, bowls, scoop nets, farm structure, feed storage room, feeding kits, graders, etc.
5. Find buyers who will purchase your fish when they are ready to be sold.
6. Speak to a fishery officer or an Extension Officer/source of technical information (if necessary).
7. Develop basic fish farming skills.
8. Make sure that you have a reliable source of capital.
9. Develop a business plan.

Generally, the quantity of fish you want to grow commercially will depend on:

1. The size of the fish market (how much fish customers will buy from you in a period (e.g., one year)).
2. The annual availability of good quality water.
3. The availability of capital (money) for the aquaculture business.

e) Know your fish

There are different kinds of freshwater fish species for culture. Before deciding to culture a particular species of fish, consider its:

- 1) Growth rate.
- 2) Reproductive behavior.
- 3) Nutritional requirements.
- 4) Market value.
- 5) Ability to withstand environmental conditions.
- 6) Ability to survive in an artificial environment.

Additionally, you'll want to consider other factors such as:

- 1) Social acceptability/cultural issues related to the fish species.
- 2) Aquaculture technology development and research support.
- 3) National regulations and policy direction.

In Pakistan, freshwater cage fish farming primarily revolves around 2 species: Nile tilapia, *Oreochromis niloticus*, and *Pangasius* spp. Nile tilapia is the predominant species being cultured. This species is relatively easy to culture, grows faster and has the ability to withstand and grow in harsh environmental conditions. In marine waters cage culture, research is being conducted to culture local fish species like seabass, grouper, seabream and other species. However, imported seabass is the only option at this moment. Below is detail account of one most suitable species in tropical freshwater cage farming system.

f) Tilapia species

Several species of tilapia and their hybrids have been reared in cages. Species most often cultured are *Oreochromis niloticus*. Tilapia is truly a tropical fish with origins in central Africa. They tolerate high temperatures well, can feed on plankton and detritus, are resistant to water quality deterioration, reproduce readily, and have excellent flesh quality. In temperate climates, however, they cannot survive winter water temperatures. Optimum temperatures for tilapia are from 28 to 33°C, but good growth is maintained between 75 and 95°F. Death occurs at approximately 10 to 13°C depending on the species, and diseases become common below 60°F. Tilapia should not be stocked until the water temperature reaches 21°C.

Fingerlings should be stocked at 4 to 5 inches long (or larger) and can be stocked at the densities described in Table. One distinct advantage in the cage culture of tilapia is that they are unable to reproduce in cages and, therefore, do not overpopulate the pond.

Better growth is achieved if all-male populations are stocked. At the lower stocking densities tilapia will have excellent feed conversion because they filter feed on

plankton passing through the cage. Tilapia should be harvested before water temperature reaches 16oC. In poly culture with catfish, tilapia should be stocked at rates between 1 and 3 tilapias per 10 catfish.

Tilapia



g) Permits for cage aquaculture operations

To start cage culture in any public water body, a permit/ NOC from Provincial Fisheries Department shall be required. Various provincial governments are in process of development of legal framework for development and regulation of aquaculture in their jurisdiction. Therefore, a simple NOC shall be issued now, which will be converted into aquaculture permit later.

CHAPTER-2: CAGE SYSTEM

1. What is a cage system?

- a) A cage is a system that confines the fish or shellfish in a mesh enclosure.
- b) It can be put on anybody of flowing water (ponds, rivers, estuaries, open ocean, etc.), allowing for good water exchange while the fish are confined.
- c) The mesh retains the fish, making it easier to feed, observe and harvest them.
- d) It can be of any size, shape and form.

2. Types of cage systems

- a) **Submerged:** These cages are permanently kept under the water. They consist of a frame with slatsfor openings and are anchored to the substrate in flowing water.



3. Floating:

Floating cages are made from netting supported by a buoyant collar or a stable frame. This is the most widely used method of cage aquaculture. They are easy to be designed and manufactured in any size or shape.



- b) **Submersible:** These cages are built with a rigid frame and because they are submersible, they can be moved up and down in the water column to take advantage of water conditions.



- c) **Fixed cages:** A fixed cage is essentially a net bag supported by posts that are anchored to the bottom of a river or lake. Their use is limited to shallow, protected water with soft substrates.



4. Advantages of cage system

- a) Water flows freely in and out of the cage, flushing out waste and supplying much-needed oxygen
- b) There is greater protection from predators like birds, frogs, crocodiles, and other fish species
- c) It discourages reproduction (tilapia will not have any substrate to build their nests in)
- d) Harvesting is easier and less capital intensive as compared to other culture methods
- e) It can be used to increase the productivity of different types of water resources, including lakes, reservoirs, ponds, strip pits, streams and rivers
- f) It can be stocked at higher densities and simplifies the observation and sampling of fish.

5. Disadvantages of cage system

- a) Depends entirely on a supply of formulated floating feed which increases production costs
- b) Water quality problems and diseases may occur as a result of other farmers' activities
- c) Strong winds can destroy cages
- d) Matured fish that are ready for market can easily be stolen
- e) Predators can prey on your fish if there is an opening in the nets

- f) Clogging of cage net could cause mortality
- g) Fish may escape into the wild and cause gene pollution

CHAPTER-3: SITE SELECTION

1) SITING YOUR CAGE

The success of an aquaculture operation largely depends on the proper selection of the site to be developed into a fish farm or hatchery. Consider each of the factors below when selecting a site for your cage.

- a) **Water Depth:** The water should be deep enough (at least 2 meters from the bottom of your cage net during the dry season or at low water levels).
- b) **Water Quality:** Water quality parameters such as temperature, dissolved oxygen, pH, turbidity, etc. have to be in ranges acceptable for the growth of the fish.
- c) **Current:** Your cage should be in a place where the flow of water is gentle (about 4cm/s). The water current keeps fish supplied with good oxygen, ensures permanent water exchange between the water body inside and outside of the cage and removes waste from the cage. In addition, the area should be protected from strong winds.
- d) **Pollution:** Your area should be free of pollution and environmental problems (including industrial and human waste). The water should not contain materials or substances that could poison the fish.
- e) **Traffic:** Avoid setting your cage in water transport routes.
- f) **Accessibility:** The area should be free of physical obstacles, allowing for the easy supply of inputs and transportation of harvested products.

2) Economic and social factors

The following economic and social factors should be considered:

- a) Quantity and quality of available manpower.
- b) Social and religious customs.
- c) Consumer habits
- d) Availability and cost of construction materials and equipment.
- e) Transportation and communication facilities.
- f) Security of tenure.
- g) Industrial and agricultural planning in the area
- h) Accessibility and nearness to markets.

3) Environmental Impacts of Cage Culture

The success of cage culture depends on maintaining good water quality around the fish cages and so it is in the farmer's best interests to minimize environmental impacts. Some of the environmental issues related to cage culture are:

-) Nutrient enrichment of waters that may lead to increased algal growth and downstream impacts.
-) Interactions with wild fish populations.

- J Accumulation of uneaten feed and fish excreta under the cage can become an environmental problem, but this can be avoided by selecting a site with good water exchange to install the cage.

Generally, the environmental impacts of cage culture can be minimized through:

- J Proper site selection.
- J Appropriate anchoring or mooring systems.
- J Using extruded feed or stable pellet diets to avoid leaching of nutrients.
- J Keeping feed wastage in low level and higher Food Conversion Ratios.

4) How to build your cage

A cage can be of any shape and size. It can be round, square or rectangular.

5) Cage components

A cage consists of the following main components:

i) Cage frames

- a) Cages can be made of galvanized pipes, wooden frames, bamboo or other material that will not easily deteriorate in water.
- b) Cages can be of any size, depending on a farmer's specifications.
- c) The frame should be mechanically strong, resistant against corrosion, and easily repairable or replaceable.
- d) Special joints must be used for fixing the various frame elements together.



ii) Netting and ropes

- a) The netting has three major functions:
 - i. Keeping the fish stock together.
 - ii. Protecting the stocks against harmful external influences.
 - iii. Allowing water to flow freely through the cage.

- b) The mesh size of the cage bag or production net is 1 inch. The mesh size of the protective netting is 2 inches, and the cover net can be made with either a 1- or 2-inch mesh size or ropes (6 mm, 10mm, stroke 18, 21, nylon thread and braided twine).
- c) A quarter-inch net can be sewn and placed inside the production net to hold newly stocked fingerlings (weighing less than 2 grams) for nursing.
- d) A larger mesh size improves oxygen supply to the stocks and reduces fouling problems.
- e) Avoid clogging and fouling the net by cleaning it regularly or replacing it as needed.



iii) Floaters

- a) The floats should suspend the cage structure (netting, frame, feeder, walkway, etc.) safely on the water surface.
- b) Examples of floaters include drums (rubber barrels), gallons and PVC pipes.



HDPE Pipe



Drum



Styrofoam

iv) Anchors

The cage requires an anchor to hold it in place.

- a) An anchorage can be made with concrete and placed in the water column to hold the cage firmly in place with 16 mm rope.
- b) A wooden platform can be laid on top of the cage to facilitate movement and farm operation.

6) Installing your cage

- a) Cage components (frames and floaters) should be fixed on land first, and then towed to the specified location on the water to be fixed.
- b) Secure your cage firmly in place by anchoring or mooring system.



Mooring System

Anchors or cement blocks are necessary for mooring the floating cages especially in dams when there is current. The cement blocks used is the traditional type made of steel bar fixed in cement blocks ranges from 40 kg to 200 kg. The mooring line used is polyethylene rope attached to the iron bar attached to the cement block and the free end of the anchor line is tied firmly to the corner of the floating cage for keeping it fixed.

CHAPTER-4: TRANSPORTING FISH TO YOUR CAGE

Transport of fingerlings involves the movement of fish: within the same farm (on-farm movement), from one farm to another, from one country to another, or from one culture system to another (e.g., from pond to cage). Certain principles and techniques must be used to ensure high survival rates, a clean environment, and healthy fish.

Fish are generally transported in containers such as cans of different sizes, buckets, barrels, plastic bags, Styrofoam boxes, etc. In fact, almost any clean, waterproof container may be used if it provides suitable conditions for your fish. Certain containers offer good insulation from heat (e.g., wood or Styrofoam) while others, like metal or plastic, are poor insulators and may have to be wrapped with wet towels or packed with ice to keep temperatures down.

Once fish have been placed in their transport container they should be brought to their destination as quickly and smoothly as possible.

Whenever you're transporting fish, remember the principles below.

- a) Care must be taken when transporting fish to your cage.
- b) Fish must be well conditioned before transport.
- c) Transport fish in the early morning or late evening (before sunrise or after sunset)
- d) Fish must be healthy and transported in clean waters.
- e) Fish can be transported in polybags or containers.
- f) Use ice to reduce water temperature during transportation.
- g) Load your fish in a ratio of 1 kg of fish to 1 kg of water
- h) Allow enough oxygen for aeration
- i) If you carry your fish in poly bags, carry the bags in a box so that they will not break.
- j) Participate in the estimation of the fingerlings you want to buy

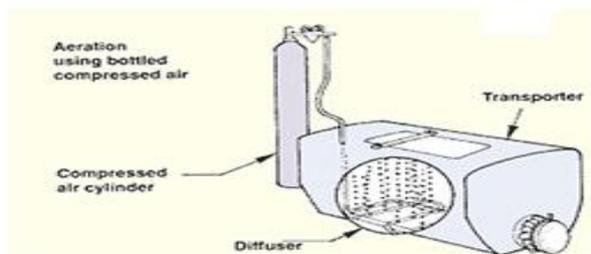
How to condition fish prior to transportation

(Conditioning is normally done by the hatchery or nursery.) The steps are given below:

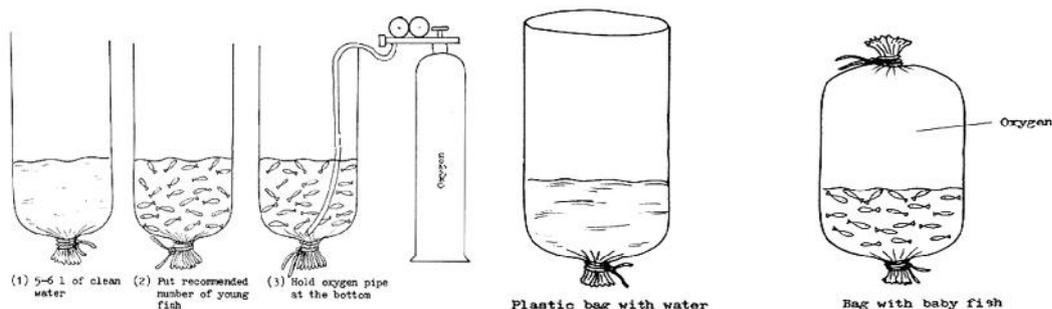
- a) Prepare holding system (hapa, tanks, cage) before harvesting your fish.
- b) Harvest your fingerlings into the holding system.
- c) Estimate your fingerlings in your holding system. This can be done during harvesting or after
- d) harvesting when the fingerlings are in stable condition.
- e) Stock 100 - 200 fingerlings (weighing 5 grams each, on average) per square meter of the
- f) holding system.
- g) Minimize feeding of fingerlings in the holding system.
- h) Observe the condition of fish and maintain good water quality.
- i) Condition your fish at least 7 days before transport.
- j) Do not feed your fish at least 1 day before transport.

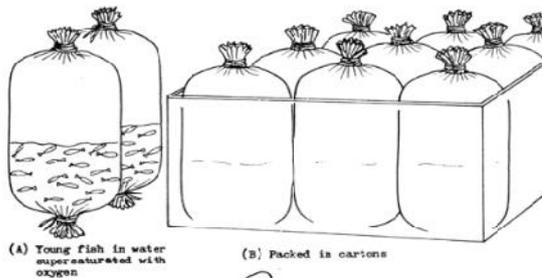
OXYGEN FILLING IN TRANSPORTATION BAGS

Dissolved oxygen (DO) is mainly used by fish for their respiration. After conditioning the fish, bags/ containers are filled with water. Fish is counted and shifted into the bags/ containers. Oxygen is filled in the bags with the help of rubber pipe. Amount of oxygen added depends on the size of fish and transportation time. In live fish hauler, oxygen is diffused with the help of grid of aero-tubes or diffuser stones.



Transportation in plastic bags





1. Stocking your cage

- a) Obtain fingerlings from a certified nursery
- b) Fingerlings should be at least 10 grams in size
- c) Stock between 50 – 80 fingerlings per cubic meter, depending on management and market need or demand
- d) Stock fish early in the morning if possible
- e) Before releasing fish into your cage, make sure the temperature of the receiving waters is about the same as the temperature of the transport water (do this by allowing a gradual exchange of water between the two)
- f) Fish should be allowed to swim out freely from the bags/containers into their new environment
- g) Be sure to take out any dead fish

Table 4.1. Size of cage and its appropriate stocking

Cage Size (LxBxH) (m)	Volume (m ³)	Effective production Volume (m ³)	Stocking Rate	Stocking Number
5x5x4	100	87.5	50-80	4,375-8,750
5x5x5	125	112.5	50-80	5,625-11,250
5x5x6	150	137.5	50-80	6,875 - 13750
6x6x6	216	198	50-80	9,900-19,800

NB: Survival of the fish and production outputs is subject to prevailing water quality conditions in the area and management options.

Cage culture systems (Large, small, stagnant water, flowing water/LVHD etc.).

Stocking density is different for each system and type. The following aspects are considered for determination of the stocking density for a system.

Carrying capacity

It is the capacity of a system to produce fish therein. It changes with the removal of the limiting factor at a particular standing crop. The limiting factor may be food, DO, over stocking etc.

Fish species growth potential

Each fish species has its own proper growth potential. Specific growth /growth in a specific period is different for different fish species. So, this is necessary to consider during calculation of the stocking density.

Growing period

It is must to consider the period for which the fish stock is to be reared therein. There will be overstocking or short stocking if this parameter is not considered.

Initial weight at the time of stocking

This factor is important for having an idea of net production of the system. Stocking density is inversely proportional to the initial size/weight of the fish to be stocked. Higher the initial weight, lower the stocking density. Lower the initial weight, higher the stocking density.

Final weight planned at the time of harvesting

It is also very important to consider this factor along with carrying capacity and rearing period to achieve the planned production from a unit. Otherwise, you may not achieve the target size.

Expected survival rate during the growth period

This factor is also very important. It is different for each system with reference to water quality and the management practice. It may be different for site to site. Generally, it is based on the experience/practice at a particular site.

How to calculate the stocking density for a cage culture system

Example:

Carrying capacity of the cage: 1000kg

Volume of the cage: $6\text{m} \times 6\text{m} \times 3\text{m} = 108 \text{ m}^3$

Species: Tilapia

Initial weight at the time of stocking: 25 gm

Growing period: 180 days

Expected growth during the period: 475 gm

Final weight at the time of harvesting: 500 gm

Expected mortality during the period: 10%

Formula for calculation

Stocking number= (carrying capacity/individual final weight) + mortality

Stocking number= 1000/0.5+mortality

Mortality = Total number x mortality rate

Mortality=2000x10%=200

Total number required=2000 + 200 = 2200

Stocking density per cubic meter=total number of fish/total volume of the cage=
2200/108= 18 per cubic meter

CHAPTER-5: FEEDING YOUR FISH IN YOUR CAGE

1. Feeding your fish in your cage

- a) Feeding your fish is an important component of the cage system since fish are restricted from searching for their own feed
- b) It is advisable to use a complete/formulated diet from a certified source
- c) Feed your fish 3 to 5 times a day – your fish will grow better if you feed them regularly
- d) Spread feed on the surface of your cage and remember to hang a mosquito net within the edges of your production net (feed guard) to prevent feed from moving out of your cage
- e) Avoid underfeeding
- f) Your fish will eat more as they grow but be careful not to overfeed
- g) Feed your fish based on their body weight (quantity of feed per day = biomass x % body weight,
- h) where biomass = average weight x total no. of fish)
- i) The bigger your fish grow, the more food they will need
- j) Put in the food little by little so that you can watch the fish and see that they are eating.
- k) If you see that the fish eat all their food quickly, give them a little more
- l) If fish aren't eating all their food, give them a little less
- m) Uneaten food could indicate a problem (e.g., poor quality feed or deteriorated feed, low water temperature, sick fish)
- n) Ensure the feed is appropriate for the size/age of the fish
- o) For fingerlings and juvenile fish, use feeds with protein levels of 38% and above
- p) As fish age, feed them with grower feeds of crude protein below 38% (Table 5-1)
- q) A feeding protocol guide on tilapia is shown in Table 5-2 to help you identify the right feeding rate

Recommended feed size for different development stages:

- a) Fry and larvae (0.01 - < 1 g): powdered feed.
- b) Fingerlings (1 – 5 g): Particle size, 0.5-2 mm (granules or crumbles).
- c) Juveniles (5 – 50 g): Particle size 2-3 mm.
- d) Adults (> 50 g): Particle size 3-6 mm (Plate 5-1)

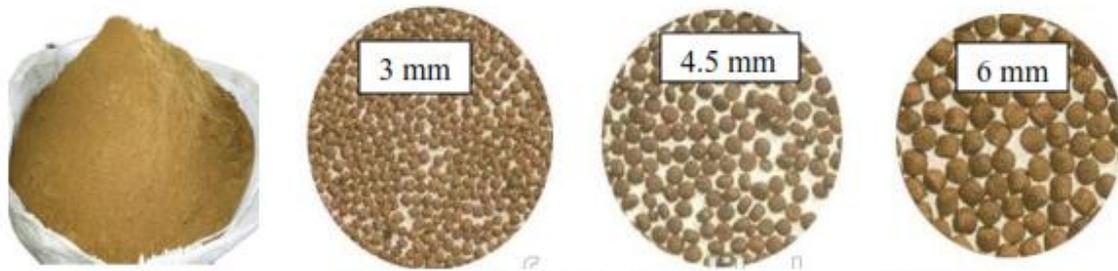
Protein requirement for different sizes of tilapia

Fish Size	% CP Required
< 20 g	40 - 45%
20 - 100 g	38 - 40%
100 - 250 g	33 - 35%
250 - 450 g	32 - 30%
> 450 g	28 - 30%

Feeding protocol for tilapia based on optimal water quality and water temperature of 28 °C

INITIAL WEIGHT (GRAM)	FINAL WEIGHT (GRAM)	FEED LEVEL (%BW/DAY)	FEED SIZE (MM)
15	30	4.5	2
30	40	4.0	2
40	50	3.7	2
50	70	3.3	2
70	100	2.9	3
100	150	2.5	3
150	200	2.2	3
200	300	2.0	3
300	400	1.9	3/4.5
400	500	1.7	4.5
500	600	1.5	4.5
600	700	1.4	4.5
700	800	1.3	4.5
800	900	1.2	4.5

Different feed sizes for feeding different stages of fish



2. Feed purchase, storage and handling

- a) Always check the labels and confirm expiry day – buy the freshest diet in the store
- b) ii. Purchase only the quantity of diet that will be consumed within 4 to 6 weeks
- c) During transportation and handling, protect the feed from moisture, heat and direct sunlight
- d) Feeds should be kept in a dry and cool place
- e) Pests such as mice, rats, cockroaches and ants must be prevented from getting to the feeds
- f) Do not store and use pesticides or other toxic materials near the feeds
- g) Rough handling of feeds should be avoided
- h) Do not stack bags of feed directly against a wall or on a concrete floor
- i) Bags of feed should be kept on wooden pallets, away from the floor and wall to allow air to circulate
- j) around them and to prevent moisture from coming in contact with the bags
- k) Inventory should be used on a first-in/first-out basis
- l) Do not keep or use moldy or spoiled feed

3. Fish sampling

- a) You can monitor your fish growth and make adjustments for feed when you sample at regular time intervals (i.e., every month)
- b) To sample, remove fish from cages by partially lifting the cage bag and scooping fish out of the water with a dip net
- c) Weigh fish as quickly as possible and return them to the cage

Sampling is done for purpose of checking on the health, growth and general well-being of your fish.

- a) It is always advisable to sample frequently (i.e., monthly)
- b) Sample early in the morning before feeding
- c) Scoop a sample of fish stock (minimum 30 pieces), place it on a scale and divide the displayed weight by the total number of fish to get the average weight of the fish (Plate 5-2)
- d) The change in weight from the previous sample will tell you how your fish are growing
- e) Remember fish must always be in water to minimize handling stress
- f) Wear gloves to handle fish
- g) Isolate fish that show signs of sickness and report immediately to an Extension Officer
- h) Do not sample during extreme stress or poor/bad water quality
- i) When you see a different fish in your sample other than your tilapia, you must discard it
- j) Regularly inspect the cage nets (production, protective, etc.) to correct any damage.

Processes of fish sampling



CHAPTER-6: WATER QUALITY MANAGEMENT

Fish carry out all bodily functions in water. These functions include breathing, feeding, growth, reproduction, and excretion. Water quality affects fish health, growth and performance. It is therefore a critical component of any fish-farming venture.

1. How to maintain good water in your cage

- a) Remove any dead fish as soon as you spot them
- b) Watch out for signs of bad water quality
- c) When water quality is bad, reduce feeding

2. Signs and effects of poor water quality

- a) Changes in watercolor (e.g., too greenish or brownish)
- b) Foul smell (water smells bad)
- c) Fish gasp for air at surface
- d) Increase in turbidity (water looks murky)
- e) Fish don't respond to feeding
- f) Slow growth of fish
- g) Changes in swimming patterns
- h) Dead fish (Plate 6-1)

3. Causes of bad water quality

- a) Use of poor-quality feed
- b) Overfeeding
- c) Overstocking
- d) Decomposition of vegetation
- e) Polluted water source (agro-chemicals, pesticides, etc.)
- f) Water upturn
- g) Dead fish in the cage

A sign of bad water quality



4. How to manage water quality

- a) Regular monitoring of key parameters
- b) Aerate when necessary
- c) Remove all dead fish from the cage as soon as you observe them
- d) Keep to appropriate stocking density
- e) Ensure appropriate feeding plan – do not overfeed
- f) Regular cleaning of cage nets and structures
- g) Reduce feeding when water quality is bad

5. Effects of poor water quality

- a) Poor growth
- b) High mortality
- c) Poor harvest/yield
- d) High financial losses

6. Benefits of good water quality management

- a) Good harvest/yield
- b) Minimized mortalities
- c) Minimized vulnerability to fish diseases
- d) Tasty fish – no off-flavor
- e) Increased profitability

7. Important water quality parameters and their acceptable ranges

a) pH (6.5 – 8.5)

Power of Hydrogen is most important factor. The optimum range of pH is 7 when it decreases the water will be acidic and when it increases from 9ppm the water will be acidic, both conditions of water is harmful for fish. pH can be monitor by pH meter. 6.5 – 8.5 is the suitable range for tilapia.

pH METER



b) Dissolved Oxygen (> 3 mg/l)

Dissolved oxygen is very important for cage culture, normally fish required 4ppm of oxygen but when it reduced fish may get stress and mortality happen

in cages so water current is important to increase the DO in cages if DO goes below 4ppm then may use aerators to avoid any mortality in cages. DO meter is used for the monitoring of Dissolved Oxygen in cages.

c) Temperature (25 – 30 °C)

The most important physical factor controlling the life of a cold-blooded animal like fish is temperature. It is critical in growth, reproduction and sometimes survival. Each species of fish has an optimum temperature range for growth, as well as upper and lower lethal temperatures. Temperature can be monitor by thermometer. 22 – 32°C is the range of suitable temperature.

THERMOMETER



- d) Ammonia (< 0.03 mg/l)
- e) Nitrite (< 0.6 mg/l)
- f) Turbidity (< 75 NTU)

8. Caring for your fish

- a) Monitor your fish regularly
- b) Fish will show signs if conditions are not favorable (e.g., erratic swimming, loss of appetite, unusual gasping for air, mortalities)
- c) If your fish show these signs, check the water quality and try improving it if necessary
- d) If condition remains unchanged, stop feeding immediately for a day or two, and seek help or advice from a fishery officer or an Extension Officer
- e) When you begin to feed them again, first give them small amounts of food and then slowly increase the amount
- f) When your fish begin to eat as before, you will know that they are well again
- g) Remove any dead fish as soon as you spot them

9. Cleaning and maintaining your cage

- a) The meshes in a cage get clogged with dirt, debris, algae and other matter that may be found in the water column.
- b) This prevents the free flow of water, nutrients and dissolved oxygen into and out of the cage.
- c) Effective cleaning of the cage must be carried out regularly for optimum performance of the fish and cage.
- d) The netting material should be cleaned with a brush or soft broom, if possible.
- e) Check the cage routinely to make sure there are no holes or gaps in the netting.
- f) Gaps in the netting should be mended immediately with mending twine.
- g) You also need to inspect your anchorage intermittently to make sure your cages are firmly in position.

Cleaning cage net with a brush



CHAPTER-7: BIOSECURITY MEASURES AND FISH HEALTH MANAGEMENT

1. Choice of farm location

The location of your fish farm is vital to its success. The location may influence other factors like the type of cage you choose and the source of water your fish rely on to survive. Choose a location suitable for the type of fish farming you intend to set up.

2. Design of farms

- I. Know the planned land-use activities of the area
- II. Measures to be adopted on farm
 - a. Ensure that all inputs and supplies (e.g., animals, feed, drugs and chemicals, etc.) coming into farm are from a certified source
 - b. Incoming water should be safe, adequate and good quality
 - c. Vehicles, equipment and visitors must have designated points with clear signage
 - d. Regularly disinfect all equipment used to handle fish (Table 7-1)
 - e. Maintain and improve standard of farm sanitation and hygiene (farm, equipment and staff/visitors) (Table 7-2)
 - f. Dead animals and trash fish should be properly disposed of at designated sites
 - g. Moribund animals should be kept in a safe location and properly disposed of at designated sites once dead
 - h. Reduce stress levels in animals by avoiding overcrowding, overfeeding, underfeeding, excessive handling, etc.

3. Stress in fish

Environmental stressors (poor water quality, loads of sedimented waste that produce toxic gases), and the presence of opportunistic or infectious pathogens (viruses, bacteria, parasites and fungi) (Figure 7-1) and non-infectious (nutritional, genetic) defects can all lead to sick fish.

A change or shift in any of these factors can result in disease occurrence. Take note, this change does not just apply to infectious diseases but also to non-infectious diseases.

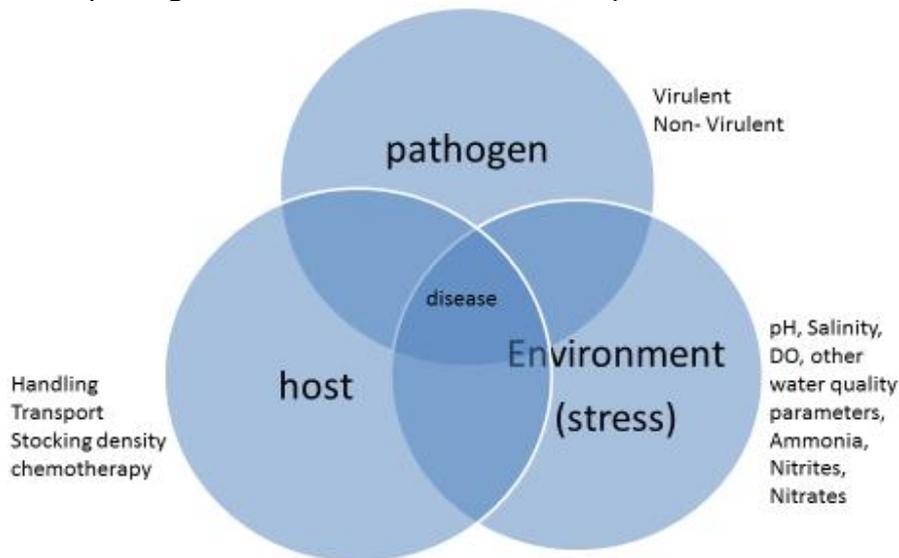
Disinfection of equipment

Household bleach	<ul style="list-style-type: none">● for non-metallic equipment only● make a stock solution at 250 ml/l● use diluted solution = 5 percent stock solution (3 to 4 tablespoons/l)
Iodophores	dosage = 250 ppm AI <ul style="list-style-type: none">● Romeiod (0.5 percent AI): 50 ml/l (10 teaspoons/l)● Wescodyne (1.6 percent AI): 50 ml/3 l (10 teaspoons/3 l)● FAM 30 (2.75 percent AI): 50 ml/5 l (10 teaspoons/5 l)
Benzalkonium chlorides	dosage = 200 ppm AI <ul style="list-style-type: none">● Roccal (25 percent AI): 4 ml/5 l (4 teaspoons/25 l)● Hyamine 3500 (50 percent AI): 2 ml/5 l (2 teaspoons/25 l)

Disinfection of farm and production materials

Chlorine bleach	for non-metallic tank dosage = 1 000 ppm AI for 20 min or 500 ppm AI for at least 1 h <ul style="list-style-type: none">● Chlorine bleach liquid 13 percent AI: 7.5 ml/l (7 500 ppm or about 1 200 ppm AI) for 20 min● Chlorine bleach powder (33 percent AI): 3 ml/l (3 000 ppm or 1 000 ppm AI) for 20 min
Iodophores	dosage = 500 ppm AI for 10 min <ul style="list-style-type: none">● FAM 30 2.75 percent AI: 20 ml/l (4 teaspoons/l)● Wescodyne 1.6 percent AI: 30 ml/l (2 tablespoons/l)
Potassium permanganate	dosage: = 1 g/100 l for 15 min

Host, pathogen and environment relationship



4. What are the causes of stress on fish?

- Poor water quality (low dissolved oxygen, improper pH, high temperature)
- Pollution (chemical treatments, agro-based chemicals, spills)
- Diet composition
- Overcrowding
- Predation and aggression
- Microorganisms (internal and external parasites, bacteria, viruses and fungi)
- Procedural stressors (handling, transport, treatments)

5. Common signs of diseases in fish (Plate 7-1)

- Erratic swimming
- Gulping for air
- Crowding at inlets and outlets
- Rubbing body against cage walls or protruding objects
- Reduced or no feeding
- Swollen/protruded abdomen (stomach)
- Pop/blind eye
- Wounds

These signs may not be definitive indicators of disease. Therefore, report any observed signs to an Extension Officer.

6. Sampling for laboratory diagnosis

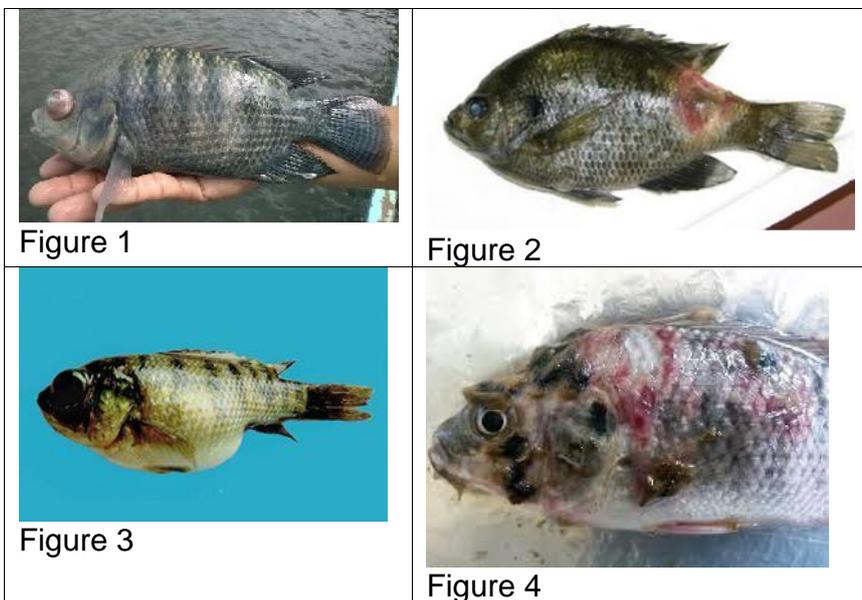
- Collect a dying or weak fish with a clean scoop net (disinfect scoop net before and after use)
- Put this fish into a clean (new) transparent plastic or cellophane bag

- c) Put the bag on ice in an ice-chest and transport to the laboratory
- d) Make sure this material is received appropriately at the laboratory with proper documentation

7. Controlling the spread of fish diseases

Upon signs of diseases, quarantine and restrict movement of fish. Immediately report to an Extension Officer for advice on how to control fish diseases. Remove and bury dead fish as soon as you spot them (Figure 1-4).

Some diseases of tilapia: a. pop eye, b. ulcerations on skin, c. swollen abdomen, d. molds and ulceration on skin



Mortalities being buried



CHAPTER-8: HARVESTING AND MARKETING YOUR FISH

1. Considerations before harvesting fish for market

- a) Do a market survey for fish prices
- b) Estimate your potential income from the harvest
- c) Decide whether to sell your fish to retail or wholesale buyers
- d) Ensure that market has been arranged first and is ready to take the fish (advertisement)
- e) Decide on partial or total harvesting
- f) It is advisable not to feed fish for at least one day prior to harvesting for sale
- g) If possible, sample your fish prior to sale to check the flesh quality and/or taste

2. Harvesting your fish

- a) When fish have reached a desired size or market demand is sufficient, it's time to harvest
- b) Harvesting is done based on your marketing plan
- c) Before harvest and sales, fish should be subjected to a health inspection
- d) You can conduct partial or complete harvesting depending on the market demand
- e) To harvest your fish, lift your net so that the fish are concentrated towards one end, and then scoop
- f) them with a hand net into a container (Plate 8-1)
- g) After you have harvested your fish, clean and repair your cage as quickly as you can so that you can begin another production cycle.



3. Advantages and disadvantages of partial harvesting

- a) You harvest your fish upon order
- b) You can get more value for your fish as you can target specific markets

- c) Greater frequency and additional harvesting times puts more stress on farm workers
- d) It causes stress and weight loss in reserved fish
- e) You must feed reserved fish until your stock is sold – this could lead to additional costs
- f) Reserved fish can be stolen

4. Effects of total harvesting

- a) Less stressful for both fish and farmers
- b) Eliminates opportunities for thieves to steal your fish

5. How to maintain the freshness of your fish

- a) Stop feeding your fish at least 1 day before harvest
- b) Kill the fish rapidly before gutting or filleting them
- c) Use clean water and containers and avoid placing fish directly on the ground
- d) If fish are to be sold fresh, the best way to guarantee freshness is to sell the fish alive or on ice
- e) For value addition and extension of shelf life, you can store fish on ice, in cold storage, smoke or salt, or you can dry or fillet your fish

6. Marketing plan

Good marketing is essential for the commercial fish farmer to remain economically successful. To be able to sell more of your table-size fish at better prices, consider the following questions:

- a) Where can you sell your table fish?
- b) Which kind of fish do the consumers prefer?
- c) To whom to sell your fish?
- d) How to sell your fish?
- e) When to sell your fish?
- f) At which price to sell your fish?

Consider the channels below to identify advertising opportunities and build demand for your fish before harvesting.

- a) Social media (mobile phones)
- b) Farmer associations
- c) Community radio announcements
- d) Fish dealers

CHAPTER 9: GOOD FARM MANAGEMENT PRACTICES

Good farm management practices include all farming activities that enable your fish to grow at an optimum rate.

- a) It is advisable to have several cages in order to harvest fish all year round
- b) Stock your cages at different times in order to harvest all year round
- c) Keep records of all activities (stocking, mortalities, feeding, harvesting, purchases, etc.) on your farm
- d) You can further improve your fish farming by growing only male tilapia in your cages (male tilapia grow faster than females because all of their food is used for growth only)
- e) Seek advice from an Extension/Fisheries Officer, routinely

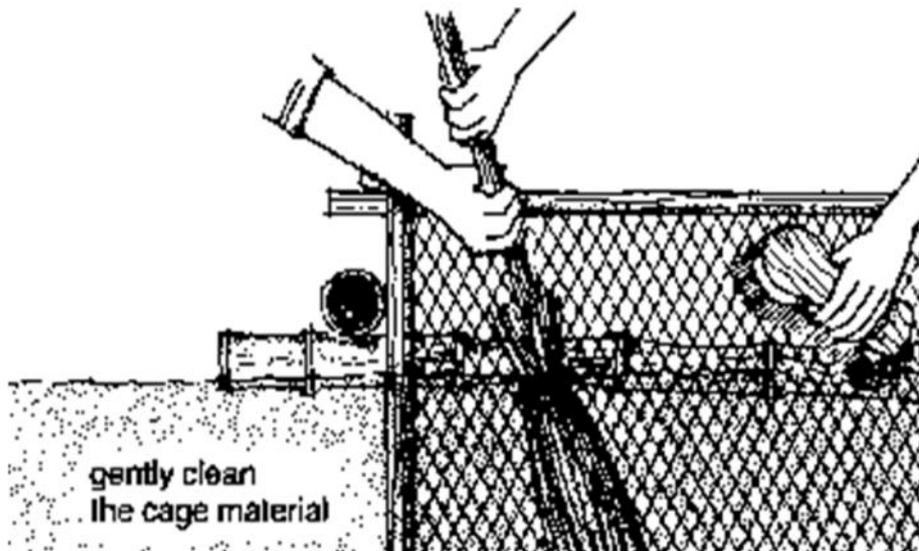
GOOD FARM MANAGEMENT PRACTICES

There are various types of cage farm management which are given as below.

1. Physical Management
2. Water quality management
3. Stock management
4. Feed management
5. Growth Monitoring
6. Record keeping management

1. Physical Cage Management

Physical cage management means management of net, sinkers, mooring or anchoring. Net must be cleaned weakly by using water pressure guns and also using brush by removing the foul as high density of foul interrupts the exchange of water. As a result, quality of water deteriorates which directly affects the growth of the fishes. Position of the cage is also very important as during the flood conditions you have to drag the cage to a safer site. Sinkers also need to be cleaned with anti-fouling agents.



2. Water quality Management

Water quality management is most important factor in cages. Dissolved Oxygen, Power of Hydrogen pH and Temperature should monitor twice a day. If Dissolved Oxygen is less than 4mg/l, then we should use aerator to avoid any stress for the fish which may cause mortality. The runoff of water should also check to avoid any contaminated water which may cause any disease in cages, if contaminated water comes, then cage may be move to another side.

3. Stock fish Management

Fish stock management is very important aspect in cages. Some fish can grow faster which called shooters so it is recommended that one or two cages should be empty to shift such kind of fish because shooters may take enough food which may deficiency of food for other fish stock and if any kind of disease happened in any fish so fish may be shift to another cage for treatment. Fish also prevent from predators like birds, snakes, frogs and turtles.

Nursery

Sex-reversed tilapia are usually sold to grow-out farms as fry with wet body weights between 0.2 and 0.5 g. A thousand tilapia fry cost about Rs. 3000/, depending on quality, location and availability. When available at short distances,

some farmers prefer acquiring juvenile fish of 10- to 30-g weight, although their prices may exceed Rs. 10-25 per fish. At this stage, fish mortality can be significantly reduced, and the grow-out cycle shortened.

Earthen ponds may be used for the nursery of tilapia fry prior to stocking in cages. However, cages equipped internally with flexible 5-mm mesh nets are usually more common, as they facilitate fish handling and transfer to grow-out cages. In cages, it takes five to eight weeks to grow 0.5-g fry to 30-g juveniles, depending on stocking density, feed and water quality.

Size Grading

Tilapia growth can vary widely within the same stock, especially when the fish are subjected to high density. This is in part due to genetic differences, but also because of competitive interactions among fish. Some fish outcompete others for feed and consequently grow faster. As a result, size grading becomes a major management component of tilapia cage farming.

When tilapia is transferred to different cages, it also allows moving the stock to clean units with larger mesh sizes, which promotes greater water exchange within the rearing unit. From 5-mm mesh sizes, 10-g fish are usually moved to cages with mesh sizes of up to 15 mm. Then 30 to 200-g tilapia are held within nets of 15- to 25-mm mesh. The mesh on nets for fish larger than 200 g is 25 mm or wider.

Grading frequency depends on a number of variables, including the targeted fish size at harvest, number of cages available on site, stock size variation, degree of prevalent stress and health status of the stocked population. Many farmers target tilapia above 900 g in weight to achieve premium prices. For this fish weight, grading can be carried out two to three times in a production cycle (Figure 1).

During the rainy season, when fish become more susceptible to disease outbreaks, there is a reduction in tilapia stocking density as well as grading frequency. When size grading is adopted, final tilapia body weight variation can be reduced from 40 per cent at initial stages to about 15 per cent at harvest time. Tilapias are often sorted into four size categories, with the smallest, most challenged fish removed as early as possible since their delay in growth cannot be recovered during the production cycle. Fish are usually sorted manually by eye, but in large operations, this procedure can be mechanized. A grading plan for cage of 75 m³ size is given below:

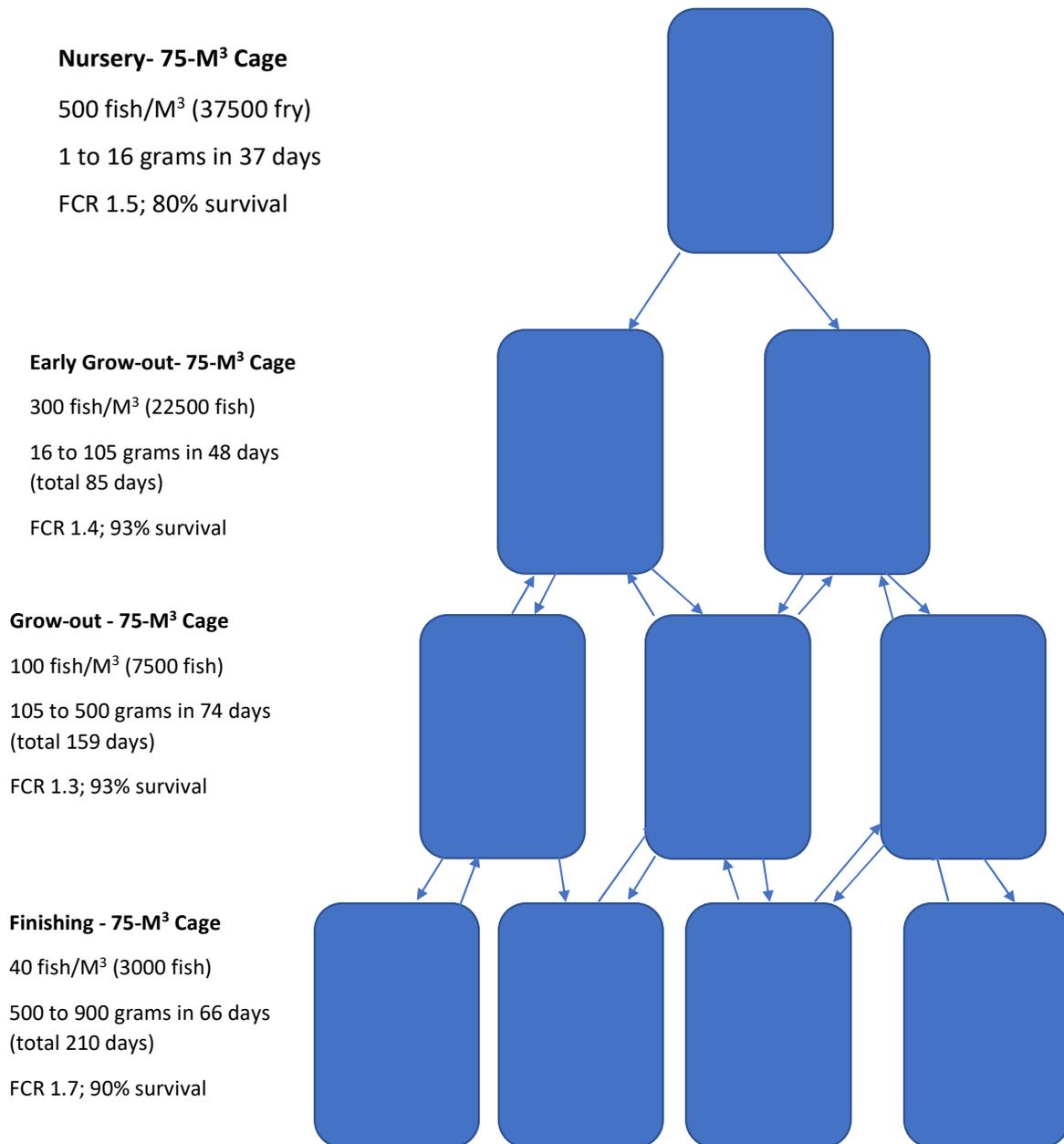


Figure 1. Example of a tilapia size-grading strategy over a normal production cycle.

4. Feeding Management

Feed management is also very important aspect in cages because all fish stock depends upon artificial feed, so it is important to give feed on time-to-time which fish

required by their body weight and also ensure to wastage of feed some time feed tray may use for sinking feed. Mostly floating feed used in cages depends upon species of fish and weighing depends upon size of fish.

Cage-farmed tilapia in Pakistan receive only extruded diets. Feed protein content, pellet size and suggested feeding rates may vary according to the feed manufacturer. Fish feeds tend to be high in protein content at initial stages and drop as fish attain larger sizes (Table 1). Grow-out and finishing feeds are usually 32 per cent in protein content and may represent up to 80 per cent of all feeding costs at a cage farm. Feed costs to produce a 1-kg tilapia can range Rs. 110-140/kg of fish harvested. As such, feed management is critical to the economics of a cage operation.

To determine maximum ration sizes, farmers usually follow suggested rates from commercial feeding tables. However, rations are adjusted on a daily basis depending on fish appetite. In small-volume cages, rations are never delivered in full amounts. Initially, fish can be fed only half of the calculated ration. The remainder is offered if the first ration is fully consumed within 30 minutes after distribution. After this period, uneaten feed can be oversaturated with water, and the heavier pellets exit the confined feed area, leading to feed loss.

Cage operations equipped with walkways allow more detailed inspections of feed consumption. They facilitate feed handling and storage and promote feed delivery to as often as 8 times/day during grow-out compared to three times when distributed from feed boats. Walkways also allow the collection of fish debris and more frequent clean-up of feeding rings or net curtains.

Fish Weight	Crude Protein	Particle Size	Feeding Rate
< 0.1-5.0 g	40-45 per cent	< 1 mm	10.0-18.0 per cent
5.0-30.0 g	40-45 per cent	1-2 mm	6.0-10.0 per cent
30.0-100.0 g	35-40 per cent	2-4 mm	3.0-6.0 per cent
100.0-200.0 g	30-35 per cent	4-6 mm	2.5-3.0 per cent
200.0-500.0 g	30-32 per cent	6-8 mm	2.0-2.5 per cent
500.0 g-1.2 kg	28-32 per cent	6-8 mm	1.5-2.0 per cent

5. Growth Monitoring

In fish farming, nutrition is critical because feed constitutes over 50% of the production cost. Feeding of fish in cages aims at producing the maximum weight of marketable fish within the shortest time at a low cost. The feed should be able to supply the necessary energy for movement and provide nutrients for body maintenance and growth.

Good nutrition in fish production is essential to economically produce high quality fish. Fish stocked at high densities in cages require adequate quantity of good quality feed to promote fish growth. When fish are fed, water exchange is needed to bring oxygen into the cage and to remove waste products from the cage generated by the fish as a result of feeding. Waste removal becomes more critical when water temperatures are high and water current from wave action is minimal.

Fish growth rate in captivity freshwater farming systems (aquaculture) has to be monitored throughout the growth period. Any change in the expected growth rate could indicate feeding problems, poor water quality or diseases. Disturbances caused by humans or animals can also cause stress and lead to slow growth.

6. Sampling and Monitoring

-) Sampling is a routine process in cage culture, carried out fortnightly and on monthly basis depending upon seasonal variations
-) Sampling is done by gathering all the fish population of at one pole of the cage by the help of bamboo
-) Randomly scoop the fish having all the varied size in each population
-) For effective sampling, sample size should be 2-5 % of stock.
-) Put the fish in a tub filled up to one quarter of water
-) Weigh the individual and whole sample, count the number, and find the max, min. and average body weight of the sample.



7. Instructions for Sampling

-) Do not feed the fish prior to sampling
-) Monitor the water quality at first e.g., Temperature should not be high, light penetration should be minimum, DO level should be in suitable range
-) Keep your necessary belongings disinfected
-) Mesh size of scoop net should be proper as per size of the fish
-) Do not hold the fish in hands for longer period
-) Handle fish gently during sizing, counting and shifting back into the cage
-) If fish is injured during sampling, disinfect the fish with KMNO₄ @ 2 g/100 L for one minute

8. Fish Growth Monitoring in 'Cage Culture

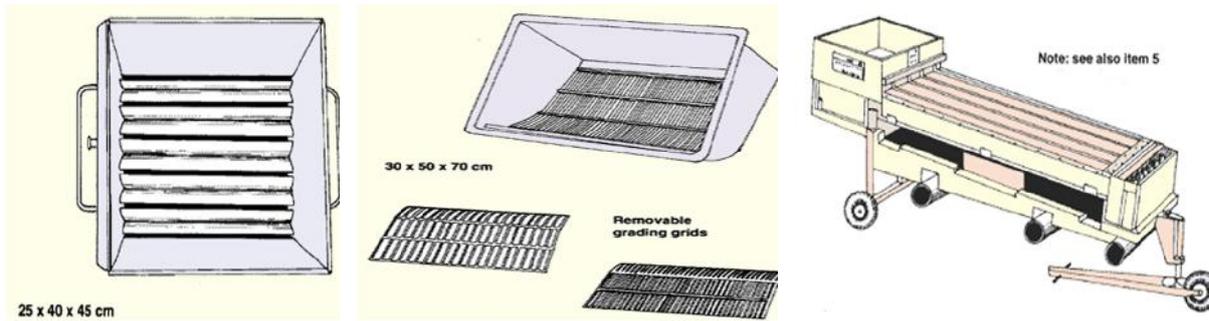
-) To assess the individual and average size & weight, food conversion efficiency, physical health of fish and effect of varying water quality parameters.
-) To review the current biomass
-) To adjust the ration and feeding schedule
-) Taking action accordingly to the water quality
-) For stock adjustment e.g., Partial harvesting



9. Grading and Biomass Assessment

Why Fish Grading

-) Fish seed of same age, stocking day and sharing same space grows differently.
-) Proper utilization of feed, resources and improved production
-) Allows accurate determination of size and number.
-) Sex differentiation in Tilapia as the male grows twice than females
-) Reducing Cannibalism in carnivore fish e.g., Seabass, African catfish etc.



10. If No Grading

-) Increased production costs
-) Poor Survival in carnivore fishes e.g., Seabass, African catfish
-) Poor fish production (Un-even Size)

11. Biomass Assessment

Calculate total biomass by multiplying the average weight of a fish with the number of fish in the cage. FCR is an important measure for judging the economic performance of an animal. To calculate the FCR will help a fish farmer judge his feeding program and see how his fish are gaining weight. Evaluate feed conversion ratios monthly. Calculate the FCR by dividing the weight gain of fish biomass since the last sample by the feed consumption for that period. The FCR can vary and depends on the fish species, kind of feed, water quality and natural food availability. Also, FCR is much better for younger fish than for larger fish of the same species in the same environment.

12. Recordkeeping

a) How to keep records on your farm

- 1) It is always advisable to keep proper records of your farming operations.
- 2) A lack of records or poor recordkeeping in any venture is likely to result in bad decision making due to a lack of business insight.
- 3) Records that are properly designed and stored and easily accessible are the best sources of information about your business – use them to drive your decisions.
- 4) Proper farm records are needed to improve the efficiency of the farm's operations and preserve the memory of the farm for future reference
- 5) Some important fish farming records include:

b) Summary Cost of Production,

-) Cage construction
-) Permits: NOC from Fisheries Department,
-) Inventory of farm assets.
-) Source and cost of fingerlings.
-) Cost of feeds.
-) Sale price
-) Total number of cages,
-) Individual cage identity/dimensions,
-) Stocking densities/numbers
-) Dates of stocking and harvesting,
-) Size/quantity of fish at stocking and harvesting,
-) Mortalities,
-) Quantities and cost of inputs used,
-) Cage productions in quantities and value
-) Daily occurrences,
-) Salaries of farm workers,
-) Disease situations/outbreaks
-) Repairs and maintenance
-) Visitors/Extension Officer observation

Below are some important formats for keeping record of farm operation at any cage farm.

1. Fish Stock Format

cage No.	Fish Species	Initial Fish Stock			Source of Stocking Fish			Total fish			Remarks Fish Received from other sources
		Date	No.	total wt. (kg)	From Cage No.	No.	Total Wt. kg	No.	total wt. kg	Avg. wt. kg	
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											

2. Fish Stock assessment Format

cage No.	sampling			total wt. of in the cage	Growth g/day	Remarks
	No. of Fish sample 10%	Total wt. kg	Avg. wt. kg			
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						

3. Fish Feeding Format

cage No.	date	Total wt. of fish last growth check kg	Feeding rate/ (5% or 3%) body wt. /feed per day	total feed kg/month	Remarks
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

4. Monthly Mortality report

cage No.	Date	Fish Mortality	Total wt. of dead fish in kg
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

5. Water Quality data report

date	Water Temperature	Oxygen mg/l	PH,	Ammonia	Nitrate	Remarks, wind direction, speed, water level change
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

6. General Operation Register

Month

Sr. No.	Date	Type of Activities
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		

19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		

c) Economic analysis

Actual price of cage materials, fingerlings stocked, and feed used should be factored into the analysis. You should use local market price in calculating the value of table-size fish.

$$\text{Net Profit (P)} = (\text{Production} \times \text{Price}) - \text{Cost (K)}$$

or

$$\text{Net profit (P)} = \text{Total Sale (S)} - \text{Total Cost (K)}$$

$$\text{Return on total investment (\%)} = \frac{\text{Net profit (P)}}{\text{Total cost (K)}} \times 100$$

CHAPTER 10: BUSINESS MANAGEMENT AND PLANNING

Successful cage farming of tilapia as a commercial activity (business) requires knowledge and understanding of the aquaculture industry system, marketing system and its relationship to small-scale aquaculture enterprise (Figure 10-1). The most profitable cage farmers rigorously apply the fundamental principles of enterprise management in the context of inland freshwater aquaculture.

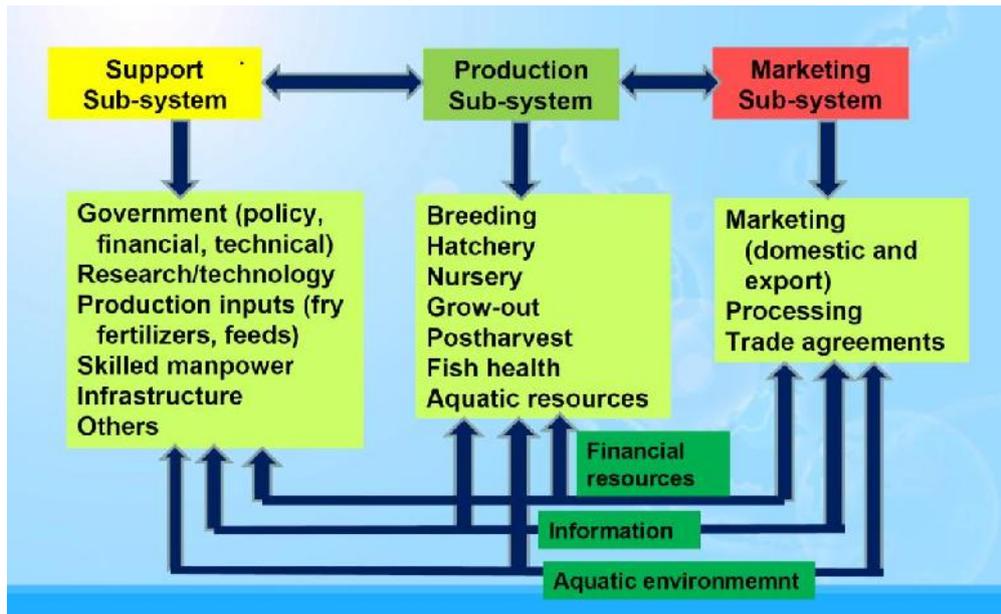


Figure 10-1: Aquaculture industry system showing relationships among the aquatic environment, production, marketing and support systems (Source: JICA-SEAFDEC 2019 Aquaculture Training Handout)

1. Factors affecting profitability of aquaculture enterprise

1. Increase in production
2. Increase in farm prices
3. Reduction in cost

2. Enterprise management principles/rules

- a) Know your business
- b) Understand your customers' requirements and preferences
- c) Prepare a realistic plan
- d) Build a good team with a good definition of roles
- e) Monitor operation status and compare with starting point (baseline)
- f) Write down important matters, share it and save it
- g) Ensure customer satisfaction

3. Marketing strategies

When operating a tilapia farm, you should develop and stick to market strategies that provide maximum benefits or returns to the business. Four (4) key factors (Figure 10-2),

also referred to as “the marketing mix,” that can be controlled to satisfy customers in target markets are:

1. Product - the good (e.g., table-size fish) or service that you provide
2. Price - how much the consumer pays
3. Place - the location where a product is marketed (e.g., on the farm, TV show, radio, web pages)
4. Promotion - advertising the product to show consumers why they need it and should pay a certain price for it.

The four Ps (i.e., Product, Price, Place and Promotion) are constrained by internal and external factors in the overall business environment, and they interact significantly with one another.

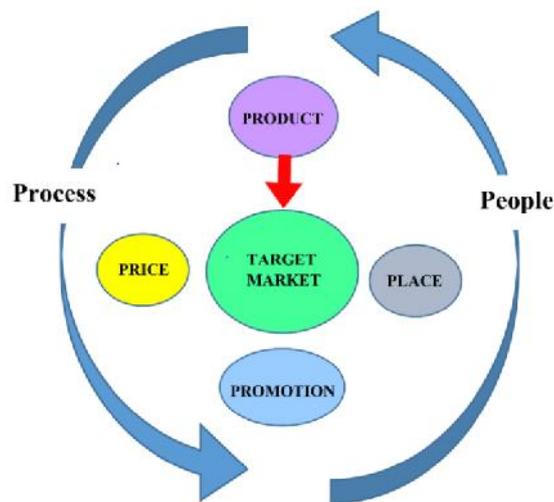


Figure 10-2: The marketing mix with the four Ps (Product, Price, Place and Promotion) and the interactive roles of process and people

- a) Identify your key markets
- b) You can manipulate any of the four 4 Ps in an optimal manner to satisfy customers in targetmarket

4. Market study

A resilient Nile tilapia grow-out farm (business) operator will desire to conduct market study from time totime on customers' preferences for product (grow-out fish), price and even how to supply theproduce/products. A market study should help you better understand the following:

- a) Size, nature and growth of total demand for table-size fish
- b) Description and price of the fish product at different market levels
- c) Overall trend in supply, demand and prices in the fish market

- d) Market channels, pricing strategies and promotional tactics
- e) Institutional, socio-economic and cultural characteristics of consumers

5. Dealing with risks and uncertainties in aquaculture

In aquaculture business planning, it is important to identify sources of risks and approaches to dealing with them, to prevent eventual collapse of the business. Some important sources of risks are:

- a) Management and practices
- b) Environmental factors
- c) Weather and climatic factors
- d) Social considerations
- e) Markets and prices of inputs and outputs
- f) Credit availability and interest rates
- g) Government regulations and policies (tax rates, subsidies)

6. Strategies to reduce risks and uncertainties:

- a) Diversification into other aquaculture systems (e.g., nursery, polyculture, species switch) and agriculture operations (e.g., integration with vegetable, poultry or rice)
- b) Aquaculture insurance (though not operational in Ghana presently)
- c) Improvement in production technology and practices
- d) Financial planning (improving cash flow)
- e) Contract pricing (reducing cost)
- f) Equipment back-up (pumps, aerators)
- g) Management (improved practices)
- h) Education/training (improved skills)
- i) Adherence to regulatory requirements

GLOSSARY

Aeration: The mechanical mixing of air and water

Algae: they are primary producers, i.e., they are the start of the food chain

Ammonia: a colorless gas with a characteristic pungent smell, which dissolves in water to give a strongly alkaline solution

Anchorage: a place where something, say cage is fastened firmly

Clog: block or become blocked with an accumulation of thick, wet matter

Culture: to grow or rear

Debris: scattered pieces of rubbish or remains

Decomposition: the state or process of rotting; decay.

Disinfect: clean (something), especially with a chemical, to destroy bacteria

Dissolved oxygen: is a measure of how much oxygen is dissolved in the water

Erratic swimming: swimming in a way that is not regular, certain, or expected

Excretion: the process of eliminating or expelling waste matter.

Filleting: to remove the bones from the fish

Fingerling: Related to any fish from advanced fry to about the size of a human finger

Fouling: make foul or dirty; pollute.

Gulping: breathe or swallow with difficulty

Gutting: remove the intestines and other internal organs from (a fish or other animal)

Juveniles: young fish

Hapa: it refers to a small, fine-mesh net enclosure set up in a shallow pond to raise fish larvae

Infectious pathogen: is a biological agent that causes disease or illness to its host

Loss of appetite means you do not have the same desire to eat as you used to

Mesh size: The size of holes in fishing net

Microorganisms: An organism that can be seen only through a microscope and capable of causing infection

Moribund: being in the state of dying

Mortality: the state of being subject to death.

Mold: is a fungus that grows in the form of multicellular filaments called hyphae

Nursery: a pond designated for nursing young fish

pH: a figure expressing the acidity or alkalinity of a solution

Polluted: contaminated with harmful or poisonous substances

Predators: an animal that naturally preys on others.

Production cycle: is comprised of all activities related to the conversion of raw materials into finished goods

Stress: to subject to pressure or tension.

Temperature: the degree or intensity of heat present in a substance or object

Turbidity: the quality of being cloudy, opaque, or thick with suspended matter.

Waterproof: not allowing water to pass through

Water quality: refers to the chemical, physical and biological characteristics of water

Cage Specifications

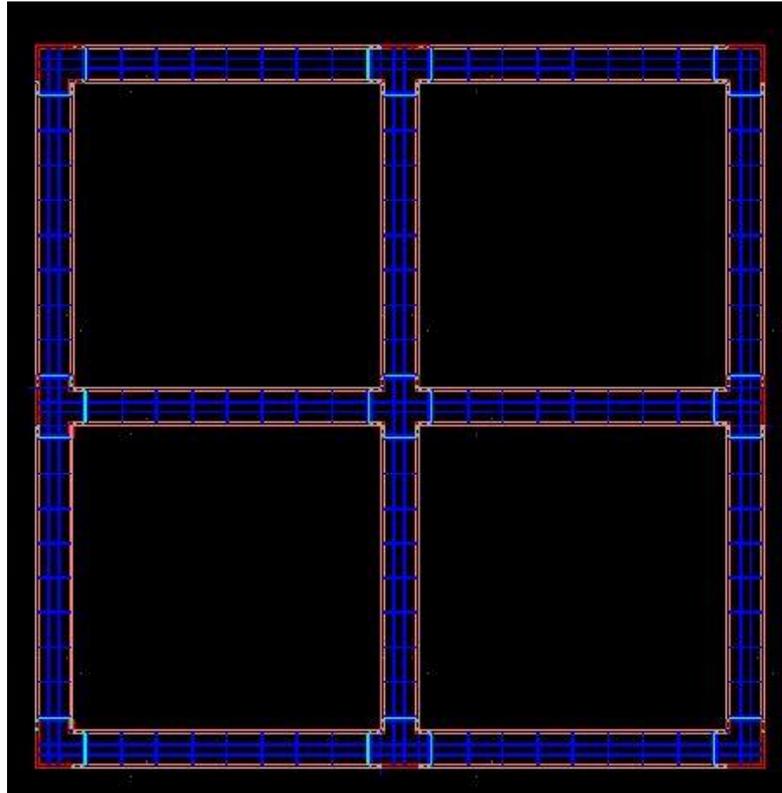
(01 UNIT/SET (10 CAGES IN BATTERY))

Sr.No.	Particulars	Specifications	No. of Unit/Set
1.	Unit/Set	Battery of 10 (5x2) cages and each cage comprising of quick assemble able components	10-units cages
2.	Frame	<p>- Each cage size: 6mx6m inner side plus walkways around the cages.</p> <p>-Outer main double pipe: Diameter 50mm minimum (inner side) high quality GI pipe. Thickness: 11-gauge minimum</p> <p>-Inner supporting double pipe: Diameter 50 mm minimum (Inner side) high quality GI pipe. Thickness: 15/14 gauge minimum depends on availability</p>	As per diagram below
3.	Walkway	<p>Length: All-around of each cage.</p> <p>Width: 30 inches minimum all around (outer walkway, inner walkway and path between two cages)</p> <p>- Meshed (Burfy) mat made of galvanized (GI) 3mm thickness</p> <p>-Horizontal Thickness: 3 mm minimum</p> <p>-Vertical Thickness: 5 mm minimum</p> <p>-Mesh Size: 1.5 x 1.5-inch maximum</p> <p>-Supporting Bars/ Rods: Cross pipe of 1-inch Diameter on walkway frame will be welded at the distance of every 2 ft.</p>	As per diagram below
4.	Mooring Rope	<p>- 6 points mooring (4 on corners and two in middle)</p> <p>-Material: USA Tire Cut rope (Ship Anchoring Rope)</p> <p>-Thickness: 35 - 40 mm minimum depends on availability to avoid the delay in installation</p> <p>-Length:Minimum 300 m (50m x6 or as per requirement of water depth whichever is more, shall be responsibility of the supplier to install the cages.</p>	Single point grid mooring With load buffers

5.	Anchor	-6 Nos. per Unit/Set weighing 200 kg of each block of RCC (1:2:3) with iron rod and hook (2-inch-thick min. with cross distribution in block). -80 Nos. (10x8) per Unit/Set each weighing 5 kg block of PCC (1:1.5:3) with hook (1/2-inch-thick min).	
6.	Net Holding Rope	- Thickness: 20 - 25 mm - Length: Minimum 360feet per Unit cage. (Top-1 (80 feet), bottom-1 (80 feet), corners-4(10x4=40 feet) and bottom and sides net-4 (40x4=160)). Fitting: Tightly stitched with netting material using strong nylon multifilament thread. Hook Rope: 8 hook ropes at top and 8 hook ropes at bottom of the net.	
7.	Drum as a Floater	- No. of drums per battery: 108 No. - Type: Single used Double collar hollow plastic drum - Color: Dark Blue Color - Height/ Length: 33 inches - Diameter: 22 inches - Fitting: Fix with GI wire to hold the movement of drum through 4-point attachment.	
8.	Cover Net (10 No.)	- Cover net Size: 6m x 6m - Mesh size: 2 inches knot to knot - Thread type: 20 ply polyesters	
9.	Grow out nets (14 No.)	- Net Size: 6m x 6m x 3m depth including blind net (Length x Width x Depth) - Quality/Type: HDPE (polyethylene) net thread 36 ply (Knotless) - Net mesh size: 20-25 mm, 36 Ply	
10.	Blind Net (Zero mesh)	-3x800 ft (width x length) / each unit / Battery (all around the top of nursing and grow out net) properly stitched on the top side and bottom side of the blind net with the cage net.	
11.	Nursing Net (4 No.)	Net Size: 6m x 6m x3m (Length x Width x Depth) Quality/Type: PE/PES net thread 12 - 15 ply (Knotless) Depending upon availability to avoid delay in completion of the project	

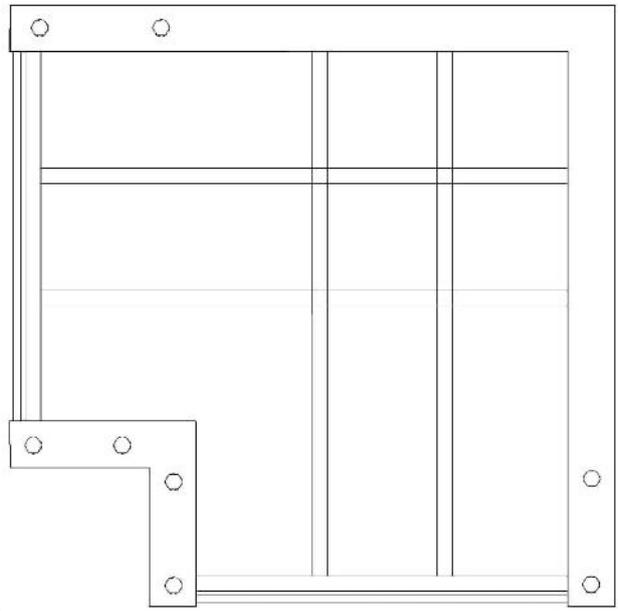
		-Net mesh size: 6-8 mm	
12.	Joints	Joints of main frame will be fixed with nuts & bolts -Material made of GI Pipe, as per skitch/drawing.	
13.	Cage rafting	Two cage unit to be modified to prepare a raft on cage the detail of which is given in below diagram.	

Four cage
Full
Schematic
diagram

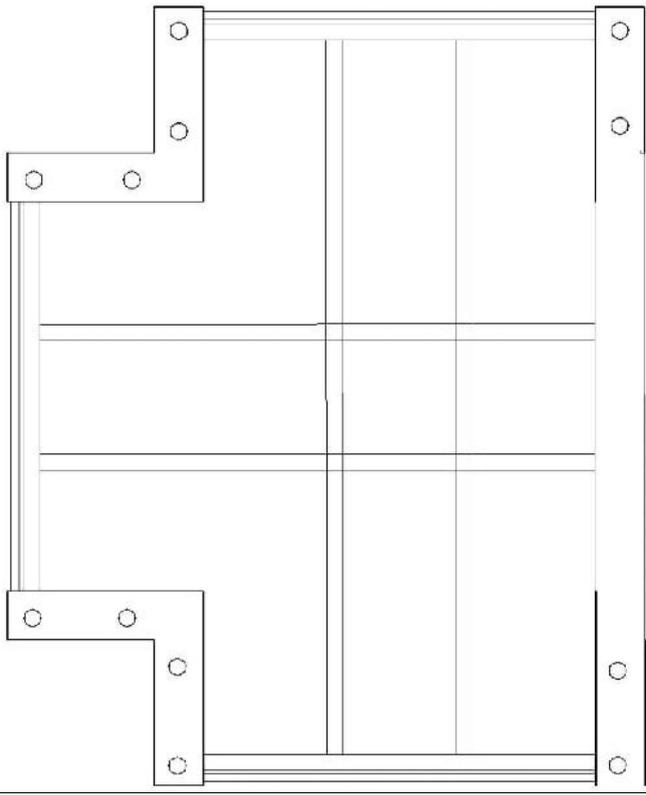


Showing
joining ring
designs

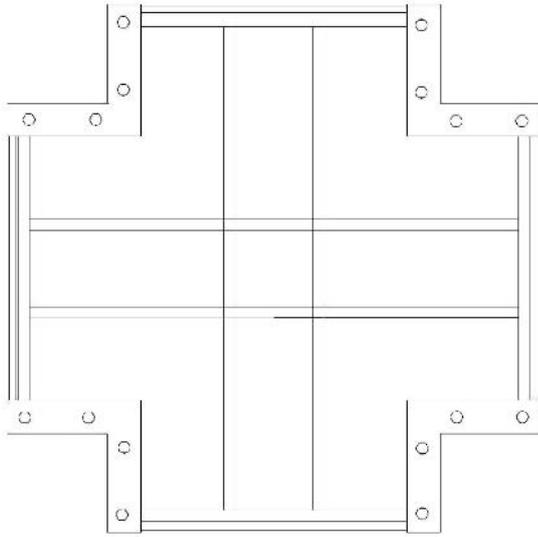
One cage
Corner



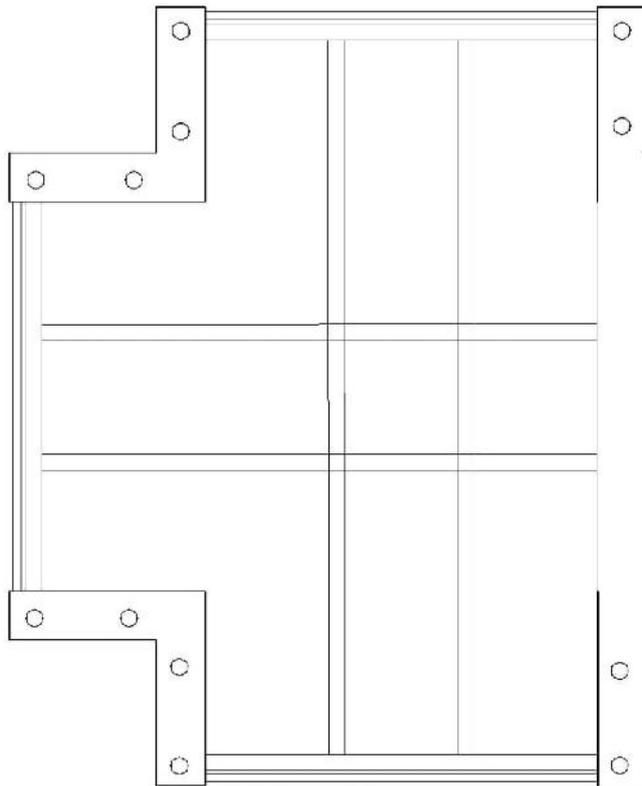
Two cage
corner
joining



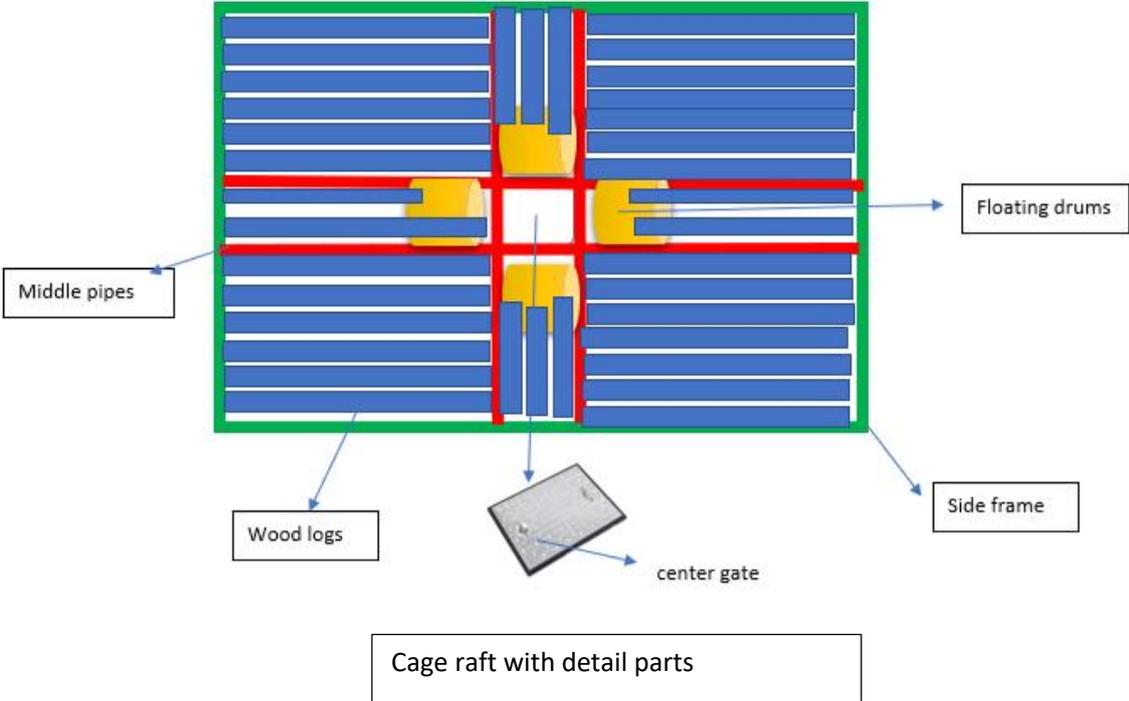
Four
cage
corner



Two
cage
joining
corner



Cage Raft: Schematic diagram





**FISHERIES DEVELOPMENT BOARD
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