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# Best management practices guidelines for small-scale tilapia cage aquaculture in Ghana and Nigeria

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## About this manual

This manual was compiled for the Promoting Sustainable Cage Aquaculture in West Africa (ProSCAWA) project, which is currently being undertaken in Nigeria and Ghana with Orisha Farms NG (Nigeria) and the ProSCAWA Hub (Ghana) as local implementing partners. The ProSCAWA project, funded by the International Fund for Agricultural Development and the South-South Triangular Cooperation (IFAD-SSTC), aims to promote cage aquaculture in West Africa through Sino-Afro knowledge exchange. The information in this manual is based on the author's years of experience working as a practitioner and consultant in the tilapia cage aquaculture industry. It also includes information from various other sources, such as fisheries and aquaculture technical papers from the Food and Agriculture Organization (FAO) and manuals from WorldFish, as well as training manuals from research institutes and practicing fish farmers. The information has been tailored as much as possible to reflect fish farming conditions in Ghana and Nigeria. The manual covers the key aspects of tilapia grow-out in cage aquaculture that small-scale cage aquaculture producers in Ghana, Nigeria and the rest of West Africa will find invaluable. This manual has not been formally peer-reviewed, and any opinions stated are those of the author and do not represent the views of WorldFish, ProSCAWA or IFAD.

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# Introduction

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Africa accounts for about 7% of the world's total fish production (FAO 2020). Nile tilapia (*Oreochromis niloticus*), a native of Africa, is the third-most farmed fish species in the world (FAO 2020) and is consumed worldwide (Asiedu et al. 2015). Because of market demand and the availability of suitable water bodies, Nigeria and Ghana have enormous potential for tilapia aquaculture, particularly in cages (Njoku et al. 2022). Although cage aquaculture has been practiced in both countries since the 1960s, it has recently gained prominence with a significant increase in the number of cages in freshwater bodies in Nigeria and Ghana between 2010 and 2016 because of a decline in capture fisheries production (FAO 2020). This trend is expected to continue.

Cage aquaculture refers to rearing captive fish within a floating enclosure in a water body. Typically, the enclosure is encircled on all sides, with mesh netting that corresponds to the size of the fish in the cage. Floats keep the cage buoyant, sinkers at the base of the cage keep the water column stable, an anchor system is used for mooring, and walkways are used to maneuver around the cage. Cages are suitable for areas with high water quality and adequate current to continuously oxygenate and flush the cage. They can be installed in any type of water body, including lakes, rivers, estuaries and the ocean. To install them, however, feasibility studies and permit acquisitions are necessary to ensure that operations pose no threat to the environment and immediate surroundings, are performed under optimal environmental conditions, and are legally recognized.

Cage aquaculture has several advantages over other forms of conventional aquaculture. The velocity of the water flowing through and past the cages flushes out waste, allowing more fingerlings to be stocked than in ponds. The enclosed nature reduces the risk of predation by animals such as birds (fish eagles, cormorants and kingfishers, among others), snakes, monitor lizards and crocodiles (Table 1).

Harvesting fish from cages is also relatively easier. However, a significant issue with small-scale fish farmers in Africa has been the lack of adequate training and well-trained staff to operate such farms and the limited availability of extension services to assist distressed farmers. In addition, most farmers have jumped on the bandwagon because of promises of enormous profits and hearsay without proper planning or preparation, resulting in losses and failed businesses. A farmer can incur significant losses because of poor management practices that result in overstocking, escapes, poor water quality, overfeeding, negligent security, disease outbreaks and inadequate recordkeeping. More than ever, the recent boom in the sector means that training is needed to apply the best principles in farm management and help mitigate losses to farmers. The remaining sections in this manual lay out the guidelines for best management practices for your tilapia cage aquaculture venture.

Advantages	Disadvantages
Stocking densities are higher than in standard ponds and tanks.	High stocking densities lead to high mortalities and risk of disease outbreaks when the carrying capacity of the water body is exceeded.
The water current continuously flushes out waste.	Water quality must be checked regularly to prevent stress, diseases and mortalities that may arise from poor quality. Water quality upstream of the cage system must first be monitored to track inflow, and then downstream water quality checks must be carried out to ensure effluent compliance.
Regular checks require little maintenance.	Nets can easily get torn by propellers or carnivorous fish, or the stitches can fail.
Several types of water bodies can be used for cage culture.	There is risk of theft in open water.
Harvest is predictable.	Extra safety precautions need to be taken in risky areas (e.g. very deep-water bodies, swift currents, submerged tree stumps).
Sampling and harvests are easy to carry out.	Fish can escape into water bodies when nets are damaged.
The risk of predation by birds, snakes, crocodiles, etc., is lower.	Fish must be fed a specially formulated diet to grow fast.
Nets can be mended onsite.	Nets need to be cleaned and all fouling organisms removed before stocking. Regular checks for tears and failed stitches must also be carried out and nets maintained to prevent fish from escaping.
Cages can be moved, if necessary, and are easy to install.	Improperly installed cages can deform and strain materials, while poorly moored cages can snap and drift in the current or dangle loosely in the water column.

**Table 1.** Some advantages and disadvantages of cage aquaculture.

# 1. Financial considerations, feasibility studies and site selection: Permits

## 1.1. Financial considerations

Before you embark on your cage aquaculture venture, ensure that you have a well-researched and thought-out business plan:

- Assess the proposed scale of your project and get a consultant well-versed in cage aquaculture to help you carry out financial estimates.
- In your business plan, include an estimate of all costs, such as permits, company registration, feasibility studies, cage netting and materials, feed and seed, wages, equipment (canoes, scoop nets, weighing scales, bowls and basins), utilities, transportation, stationery, feed warehouse, water quality equipment, sheds, and housing for workers (if located onsite), among others.
- Mobilize finances (working capital) to sustain your project until it can begin to turn a profit. You may decide to recover your costs over a prolonged period (amortization) or recoup them as soon as you break even.
- Identify sources of fingerlings (seed) and feed, as well as potential customers and markets for harvested fish.
- Identify a source of land close to a suitable water body for feasibility studies (Plate 1). It should be easily accessible by road to make operations and transporting goods easier.



**Plate 1.** A sample water body to be investigated for suitability in tilapia cage culture.



## 1.2. Feasibility studies and site selection

Selecting a water body for cage aquaculture requires more than simply identifying an open stretch of water. A feasibility study must be carried out on your desired water body to determine the viability or suitability for cage aquaculture and the likelihood of a successful project. Factors such as water depth, submerged plants, bottom substrate type, underwater rocks, dissolved oxygen (DO), pH, ammonia, nitrates and nitrites all play a crucial role in this.

The following are some of the key factors to consider when looking for an appropriate location for your tilapia cages (Water Resources Commission 2019; Njoku et al. 2022):

- Ensure that the proposed water body is more than 300 m across at its narrowest point.
- The water body should not have eroding shores that deposit massive amounts of silt and sediments into it.
- There should be a distance of at least 2 m between the riverbed or bottom of your water body and the base of your proposed cage(s).
- The water quality parameters must conform to national and international standards for tilapia aquaculture.
- The most critical water quality variables in aquaculture are usually DO, un-ionized ammonia ( $\text{NH}_3$ ), nitrite, nitrate, total alkalinity, total hardness and pH. Test these variables against recommended reference points (Plate 2; Appendices 1 and 2).
- Ambient DO levels should be above 4 mg/L and measured at least twice a day, in the morning before the first feeding session and in mid-afternoon.
- The water body should be away from any industrial and domestic effluent discharge points.
- No harmful algae must be present.
- Avoid areas with rocky bottoms.
- The water should not have a high load of fish disease-causing pathogens.
- It is helpful to have an inventory of resident organisms in the sediment and water column of the proposed location.



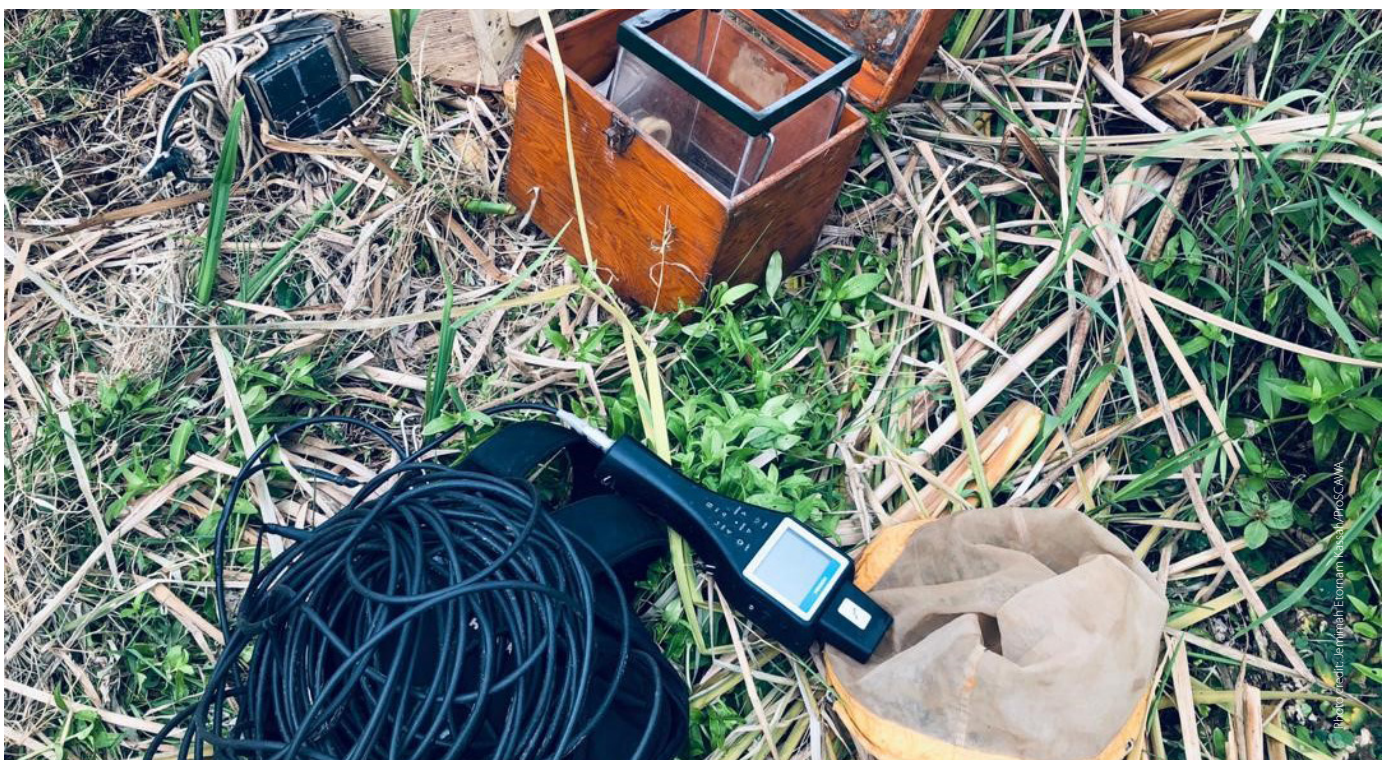
**Plate 2.** Testing water quality parameters at a proposed location for tilapia cage culture.

- The current velocity should be between 10 and 20 cm/s to ensure adequate flushing without excessive strain on cages.
- There should be a land-based working space for cleaning, repairs, post-harvest processing, storage and administrative work.
- Areas protected from wind and waves, such as coves and bays, in a water body are more suitable.
- Your proposed site should not be close to the shoreline, other aquaculture farms or other users of the water body. A distance of at least 1 km is recommended for spacing between two given farms.
- The proposed site in the water body must not have any tree stumps, floating vegetation, rocks or protrusions that can tear nets.
- Assess the location for any potential predators.
- Get a recognized aquatic health expert or environmental scientist to test the water for you using the right equipment (Plate 3).
- Investigate security and theft issues in the area, and factor security costs and installations into your plan, including video surveillance (CCTVs, sensors, etc.).

Do not site your cages in or near the following:

- a route used for navigation by vessels such as speed boats, ferries, barges, canoes, etc.
- installations such as domestic water intake points, hydroelectric dams and effluent discharge points
- stagnant water bodies, waters with a low flushing rate, stagnant sections of large lakes
- forest reserves, Ramsar sites or other protected areas.

Specific water quality parameters and requirements for tilapia cage aquaculture can be found at [www.wrc-gh.org/dmsdocument/114](http://www.wrc-gh.org/dmsdocument/114). Sample water quality parameters and optimal ranges are helpful to determine the suitability of a proposed location for cage aquaculture. Because of the increased operational risk, a water body that does not fulfill these requirements should not be used for cage aquaculture.



**Plate 3.** Equipment used to check water quality parameters. Clockwise from top: bottom grab, sieve box, plankton box, plankton net, multi-parametric water quality probe.

## 1.3. Permits and laws

### Ghana

Ghana has national laws, policies and regulations that regulate the aquaculture sector (Republic of Ghana 2002 and 2010): the Fisheries Act 625, 2002, and Fisheries Regulations, 2010. These spell out the rules and conditions for locating an aquaculture facility in Ghana. The mandate of the Fisheries Commission (FC) of the Ministry of Fisheries and Aquaculture Development (MOFAD) is to oversee all inland aquaculture in Ghana via the Inland Fisheries Division (IFD), in addition to providing extension services, training and regulating fish farmer operations. The FC also issues various certificates in the aquaculture sector (Agyakwah et al. 2020).

The following steps must be taken to carry out cage aquaculture in Ghana:

- Register your farm and obtain a Certificate of Incorporation and a Certificate to Commence Business.
- Register your business with the local government authority (LGA)—the Metropolitan, Municipal or District Assembly (MMDA)—in the area where your farm will be located.
- Obtain an environmental permit from the Environmental Protection Agency (EPA). You may need to undertake an environmental impact assessment (EIA) as part of the permit requirements.
- Obtain a water use permit from the Water Resources Commission if the scale of your operations requires it.
- Register with and obtain a fisheries license from the FC of MOFAD. If you produce feed and/or fingerlings, obtain a Certificate on Feed or a Certificate on Fingerlings, as required.
- Ensure that the Volta River Authority has no objections if your cages will be sited on the Volta Lake. Notify the Ghana Irrigation Authority if you intend to set up cages in any of their reservoirs. Check with the Ghana Maritime Authority to ensure that your cages will not obstruct riverine, lacustrine or maritime traffic on rivers with major navigational routes. It is also prudent to inform the chiefs and residents of the traditional area where your farm is to be located about your upcoming plans.

### Nigeria

In Nigeria, the Department of Fisheries and Aquaculture of the Federal Ministry of Agriculture and Rural Development has regulatory responsibilities for aquaculture. The department also seeks to provide an enabling environment for fish production, enforces Nigeria's fisheries laws and regulations, and issues the following, among others:

- Certificate of Fish Production
- Certificate of Fish Feed Production
- Fish Health Certificate for exporting fish and fishery products.

In addition, the department offers extension and training services to fish farmers through various capacity building initiatives, and it helps farmers implement best practices to comply with pre-determined standards. The Inland Fisheries Decree restricts the import and export of live aquatic species.

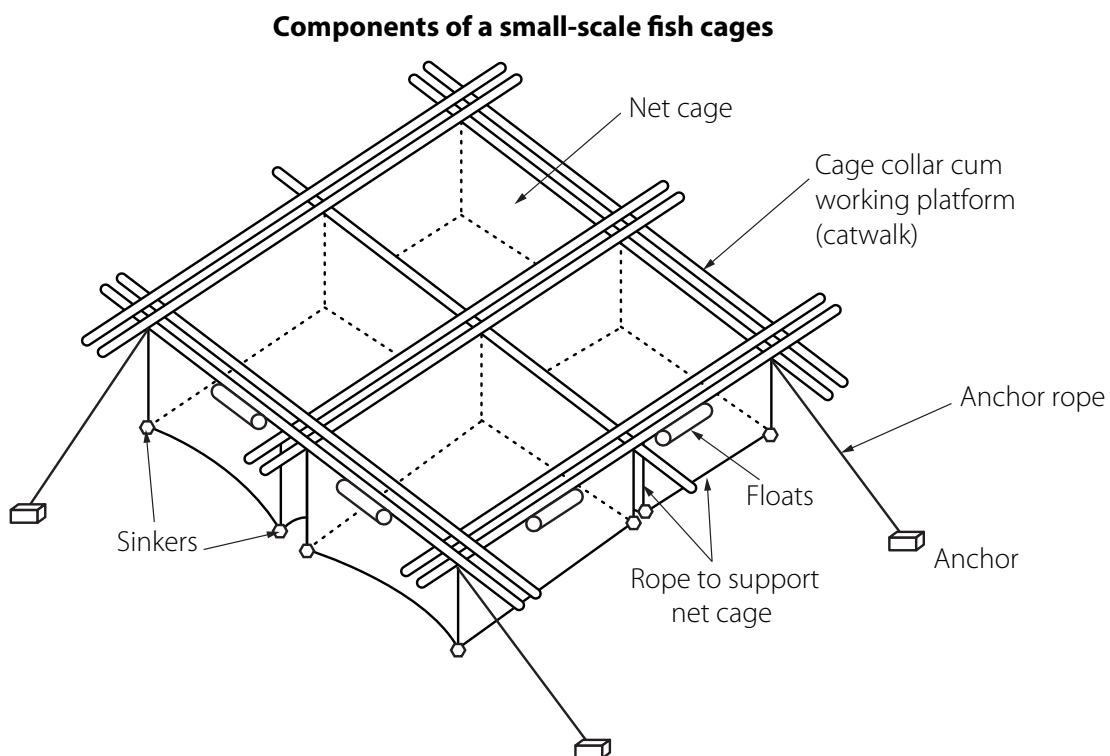
Before embarking on your cage aquaculture venture, you will need to obtain permits from the Ministry for Water Resources as well as the Ministry of Agriculture in your state.

After acquiring a suitable location for your cage farm and registering your business with the relevant authorities, visit the nearest Aquaculture Division of the Department of Fisheries and Aquaculture in your LGA for help with licensing your business as a registered fish farm. In addition, seek permission from the Federal Environmental Agency to carry out aquaculture activities. You may be required to conduct an EIA to determine how your farm will impact the environment and what efforts you will take to mitigate any adverse effects. As in the case of Ghana, it would be prudent to notify the chiefs and locals of the traditional area where your farm is to be sited about the impending activity.

## 2. Cage construction and installation

Floating cages can be of any shape or size. However, the most prevalent cage shapes are circular, square and rectangular (Agyakwah et al. 2020). Currently, square cages are preferred in most freshwater water bodies. The primary components of a floating cage system include the following:

- The main cage frame can be made from prefabricated HDPE pipes, galvanized pipes with bracings, wood or bamboo. The material of choice should not corrode or deteriorate in water. It should also be mechanically robust and easy to repair or replace (Agyakwah et al. 2020). As such, the most common types of cages in Ghana and Nigeria are often made using welded galvanized pipes or HDPE plastic with special joints to hold the various components together.
- Floats/floaters are fixed at the upper section to ensure buoyancy. While some farms use HDPE floats, others use sealed plastic barrels or Styrofoam boxes to do so. HDPE floats are less prone to leakage and deterioration. The floats are attached to the cages using braided twine or pre-fabricated "pins."
- Sinkers are placed at different points along the bottom of the nets so that they hang properly in the water and do not distort from water drag. Sinkers can be made of iron, concrete or even sand-filled bags and bottles.
- A mooring system is made up of several anchors linked to cages by anchor ropes to make sure cages do not drift or snap in the current. Main anchors are typically made of heavy concrete blocks or metal that sinks to the bottom of the water body. Cages are also connected to a land-based mooring system. Marker buoys float on the water surface to indicate the locations of the anchors. Depending on the nature of the water body and depth, anchor ropes may be installed so that they can be loosened or tightened to maintain the integrity of the cage. Anchor ropes have a cross-sectional area of 16 or 18 mm and are strong and durable. They should be three to five times the depth of the water column and attached diagonally to the cage frame (Piccolotti and Lovatelli 2013).



Source: Sunil Suriwaderna, WorldFish.

**Figure 1.** Components of a small floating fish cage.

- Walkways are made to move about cages, and they prevent accidental slips and falls.
- Cage netting and ropes enclose the fish, protect them from predators and damage, and allow gas exchange and waste removal. Nets must be made from a durable material with an appropriate mesh size that does not clog easily. Materials can be bought from a registered marine equipment vendor (Appendix 3).
- The inner net, also known as the production net, is positioned in the inner part of the cage frame and is shorter than the outer net to flush debris and to hang its sinkers. The dimensions are 3.3 cm.
- A bird net, also known as the cover net (Plate 5), is stretched across the surface of the cage frame to prevent birds from capturing fish. It also enables feeding without having to always lift the net. Typically, the dimensions of the mesh are 2.54 cm or 5.08 cm, with ropes for attachment to the cage frame.

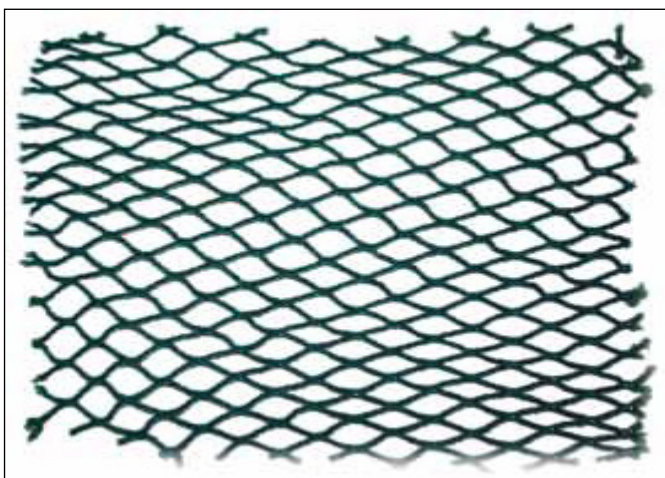
## 2.1. Types of nets used in tilapia culture

Tilapia cage nets are sewn to fit the dimensions of the cages. Various sizes (diameters) of PE rope are used to form the corners and reinforce the netting and serve as links to attach sinkers. Two types of nets are currently used for cages: knotted and knotless. Knotless nets are more expensive than knotted nets but are more durable and less prone to fouling/clogging (Plate 4). They are also less prone to damage and tearing when compared with knotted material. Order your nets from a reputable supplier, and if you want the nets to be stitched, hire a skilled tailor with a proven track record of fixing nets that do not unravel at the seams, which can cause escapes.

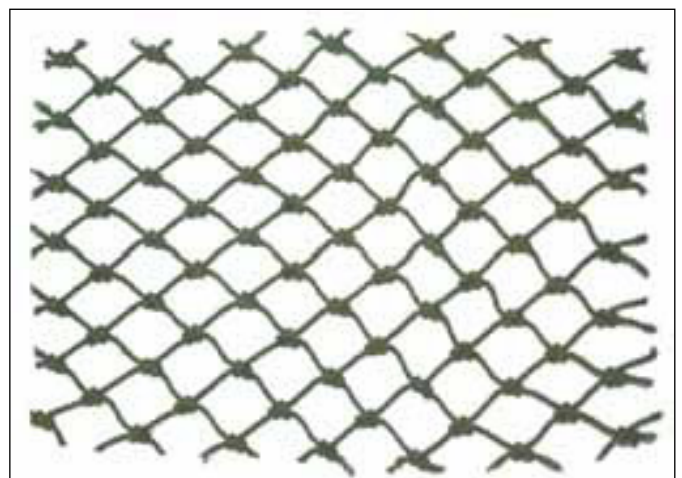
- The outer protection net has a wide mesh (holes) and functions as the outer net to prevent wild fish and predators from attacking fish in the main net. It is attached to the cage's outer frame. The dimensions are 5.61 cm or 4.27 cm.

When stocking small fingerlings that could escape through a production net, a temporary nursery net with a 2 mm mesh size or a 9.65 cm nursery net can be fitted to the cage until the fingerlings are big enough to transfer them into the production net during grading.

Hapa netting with a 1 mm mesh size is sewn onto the upper part of nursery/production nets to keep the floating feed inside the cage for the fish to eat by preventing the feed from floating through the mesh of the cage net (Plate 6).



**Knotless net material**



**Knotted net material**

Source: WorldFish.

**Plate 4.** Knotless net material vs. knotted net material.



**Plate 5.** The main components of a cage made locally from galvanized pipes: frame, floaters, protection net, production net, ropes, hapa net and bird net.



**Plate 6.** Cage with a hapa net sewn in to prevent feed loss during feeding.

Nets should be sewn on a smooth, flat surface by competent aquaculture net artisans, who must check them thoroughly for holes, tears, gaps and poor sewing (Plate 7). It would help if you also inspect the nets after delivery, then stow them away in secure bags and a pest-free shed until the cage is ready to be installed. Before installation (Plate 8), recheck the cage nets and mend them if there are any defects. Use a sewing line, braided twine, weaving shuttles and weaving needles for mending.

## 2.2. Installing cages on a water body

- Purchase and assemble all your logistics at the shore close to your establishment.
- Prepare the required number of weights and anchors for your cages.
- Ensure you have the right quantities of ropes, twines, floaters, cage nets, frames, tools, etc.
- Let the artisans assemble the frames of the cages and fix the floaters and walkways to the frames.
- Sink your anchors and moorings at designated spots determined by the artisans/mooring crew.
- Recheck your nets and mend them if required.
- Transport your cage frame to the designated spot and position it perpendicular to the prevailing water current for adequate flushing (Plate 8).
- Anchor the cage frame in place using mooring ropes.
- Bring your nets and sinkers to the cage. Fix the upper ends of the cages first. Lift up the base of your cage nets and fix the sinkers to the ropes using the right knots. Fix the nursery or production nets first, then the outer nets and, lastly, the bird nets, which do not have sinkers and are tied to the main cage frame.



**Plate 7.** Artisans weaving and inspecting a cage net.



**Plate 8.** Positioning cage frames before installing the net.

### 3. Transporting and stocking fingerlings

Fingerlings are young tilapia that are stocked in a cage. In cage aquaculture of Nile tilapia, all-male (sex-reversed) fingerlings are preferred because they grow faster and are bigger than females, so they provide greater value for money. Engage only with suppliers from registered hatcheries with a proven track record of producing healthy, disease-free fish at the correct sizes.

Fingerlings can be transported from one location on the same farm to another or from one farm to another over several kilometers. Fingerlings stressed during transportation often succumb to death or become susceptible to diseases.

Follow these instructions when it is time to stock your cage(s):

- Place your order for fingerlings with a certified hatchery near your farm.
- Fingerlings should weigh more than 10 g, though 5 g fish can be grown in nursery nets until they are graded into production nets.
- Make sure the ordered fish are as uniform in size as possible. If not, prepare separate cages for the different sizes expected before transporting the fish to the farm.
- Arrange for the fish to be packed and delivered to you early in the morning or late in the evening. This is to avoid high temperatures during transit, which causes low DO in transportation tanks/bags and increases fish stress.
- Starve and condition the fingerlings before transportation to avoid toxic metabolites from accumulating in the tanks/bags.
- Fish transported in bags with oxygen (Plate 9) survive better than those transported in open containers. In the absence of insulation, place wet towels, wet straw, or ice over the bags in a receptacle to stop the water from overheating, cool down the fish and reduce their metabolic activity.
- If the fish arrive at your farm in bags, carefully place the bags into the cage and wait about 10 minutes for the fish to acclimatize to any

difference in temperature. Perforate the bottom of the bags and gently let the fish swim out into the water. If the fingerlings arrive in tanks, acclimatize them by mixing some water from your cage system with the tank water. Place the fish in a bowl and let them swim gently out of the bowl in several batches into the cage. **Do not drop the fish into the cage from above.**

- Determine the stocking density by the desired final average weight. The recommended density is 50–80 fish per cubic meter (Agyakwah et al. 2020).
- Stock your cages in the early morning or late evening when the temperature is lower. This will reduce the stress on your fingerlings.
- After stocking, cover the cage with a bird net and refrain from feeding the fish until the next day.
- Label the cage clearly and include the date of stocking on the label.
- Stock your cages at different times of the year to harvest at regular intervals and maximize market returns. Having a steady supply of fingerlings from hatcheries is essential for staggered stocking.
- Maintain daily records of all farm activities, particularly stocking, feeding, harvests and mortalities.



**Plate 9.** Packaging fingerlings in oxygen-inflated plastic bags with used sacks as protective covering prior to transportation.



## 4. Fish feed selection, feeding and management

Fish must be fed to ensure optimal growth within the shortest possible time, so the amount of feed must be enough to yield maximum returns at minimum cost. This is because feed accounts for about 60 percent of your farm's total operating cost. Commercially prepared floating tilapia feed works best in tilapia cage aquaculture, because it has been formulated to give optimal growth at each stage. It is also palatable and easy for the fish to digest. These feeds are known as starter feeds. They come in crumbled or powdered form for easy uptake, while grower and finisher feeds are

pelletized. Feed for adult tilapia has a lower crude protein content and is given at a lower average weight, as the fish have reached an adult size and do not need to build new muscle (Table 2).

Tilapia are fed daily rations according to their weight. Fingerlings and juveniles are fed at a higher percentage of weight and crude protein (Table 3) than adults, as juveniles grow very fast. Fish feed comes in powdered, crumbled or pelleted forms of different diameters specific to various size classes.

Size class of fish	Average weight (g)	Pellet/particle size (mm)	Type of feed/appearance
Fry and larvae	0.10–below 1	Powdered feed	Powder
Fingerlings	1–5	0.5–2	Crumbled/crushed
Juveniles	5–50	2–3	Pellets
Adults	>50	3–6	Pellets

Source: Adapted from Agyakwah et al. 2020.

**Table 2.** Recommended pellet sizes for formulated feed.

Initial weight (g)	Final weight (g)	Daily feed ration (% of weight)	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

Source: Agyakwah et al. 2020.

**Table 3.** Recommended feeding rations for tilapia culture (water temperature of 28°C).

## 4.1. How to estimate feed rations

To accurately estimate how much feed to give your fish, you must first estimate how many fish you currently have in your cages by subtracting the number of fish that have died since the cage was stocked.

- Multiply the number of remaining fish by the average individual weight of the remaining fish in your cage. For example, if cage X has 1000 fish left, with each fish weighing 50 g, then  $1000 \times 50 \text{ g} = 50,000 \text{ g} = 50 \text{ kg}$  of fish biomass at that time.
- From Table 2, 50 g of fish need to eat 3.3% of their weight in feed per day. So, a cage with 1000 fish needs, on average,  $50 \times 0.033 = 1.65 \text{ kg}$  of feed per day spread out over three feeding sessions.
- Either the farmer or the worker responsible for feeding the fish must distribute the estimated daily ration of feed in the cages across three separate feeding sessions.
- Assuming these fish have grown to 200 g in 3 months, what will the new ration be? Assuming cage X has lost 15 fish since the last time the biomass was estimated, the new number of fish in the cage would be  $985 \text{ individuals} \times 200 \text{ g} = 197,000 \text{ g} = 197 \text{ kg}$  of fish.
- From Table 2, 200 g of fish need to eat 2% of their weight in feed per day. So, the calculation is  $197 \text{ kg} \times 0.02 = 3.94 \text{ kg}$  of feed for that cage per day, divided into three feeding sessions.

Here, we see that the amount of feed that the fish in a cage will consume increases with time, though the percentage of crude protein and the percentage of weight to feed decreases. You must be able to estimate these figures before stocking so that you have enough financial resources to ensure the success of your farming venture.

The amount of feed that the fish in your cage will actually consume on a daily basis depends on several factors, including water quality, health, ambient weather and stress levels, among others.

- Feed fish only certified feed intended for use in fish farms.
- Do not attempt to feed fish their entire daily meal at once. Adjust it to suit their feeding

response by giving them more or less, as necessary.

- Feed your fish at specific intervals each day.
- Feed your fish three times a day: at sunrise, midday and early evening.
- Disperse the feed in small amounts throughout the cage. Do not stand in one spot while feeding the fish in your cage.
- The fish should eat the feed within 15 minutes. Adjust how much to give at each feeding session based on the feeding response.
- If the fish do not eat the feed in 15 minutes, or they stop feeding entirely, do not feed them again until they respond more eagerly to the feed. Adjust the daily ration as necessary, depending on consumption. Do not feed the fish if the response is minimal. Investigate the cause.
- When the water quality is poor, you might have to restrict feeding until the situation improves or you can address the cause.
- Feed your fish with your back facing the prevailing wind direction to make sure the feed falls into the cage and is not lost in the open water.

## 4.2. When NOT to feed

Fish tend to eat less during cold weather and when they are stressed or sick. Feeding picks up during the day and slows down again in the evening. There are a few situations when feeding fish might need to be controlled.

Do not feed your fish if any of the following occur:

- When the feeding response is poor. If this happens, wasted, uneaten feed will accumulate at the base of the cage and befoul the water, leading to poor water quality and low oxygen directly at the base of the cages if flushing is inadequate.
- During disease outbreaks. When fish are sick, they typically do not eat.
- For better post-harvest product quality. It is best to starve fish a day before sampling, transportation or harvest to reduce stress and also to empty their guts so that freshness is maintained.

- In anticipation of stress to fish. Stop feeding a day after sampling and/or transportation to help mitigate shocks and mortalities.
- If an impending water quality change is expected. It is better to suspend feeding briefly after rains, as this could cause water quality to deteriorate suddenly. Feeding response is usually low on cloudy, overcast days, so do not overfeed your fish when this happens.
- When temperatures are highest and oxygen levels are lowest. The best time is usually early morning.
- Check for rancidity, mold, moisture, etc., in the feed before you buy. Do not use the feed if it is wet, moldy or smells foul.
- Protect feed from moisture, heat and rainfall during transportation and in storage.
- Store feed in a well-ventilated, dry, cool room.
- Do not stack feed on a bare floor. Stack the bags on pallets to keep them dry (Plate 10).
- Ensure rodents and other pests do not get to your feed shed/warehouse.
- Do not use pesticides and insecticides near feed bags.
- Immediately discard any feed that is going bad, such as feed that is moldy or wet, smells off or has changed color.

### 4.3. Feed records

Maintaining proper records of feeds and feeding schemes is vital to track fish growth and feed intake and to assess the effectiveness of your feeding regimen. Record the daily amount of feed given to each cage and upload it into your digital records.

Specifically, keep records of the following:

- feed stocks in a warehouse (opening and closing stocks, the quantity sent out to cages per day, feed received from suppliers)
- weight (kg) of feed supplied to each cage on a daily basis
- spoiled, rancid, wet or moldy feed (number of bags and total weight)
- variations in the appearance of feed.

Notify feed supervisors and suppliers of any unusual occurrences. Enter the data into a simple data analysis tool to generate monthly reports and projections.

### 4.4. Handling and storing feed

- Always buy feed from your suppliers that is as fresh as possible.
- To prevent your feed from going putrid or rancid, store enough feed for only up to 2–3 months in your shed/warehouse. Older feed tends to go rancid and loses nutrients such as vitamin C. It is better to buy what will be consumed within 4–6 weeks.
- Distribute feed on a first-in-first-out basis so that the oldest feed in the warehouse is delivered to the cages first.

### 4.5. Feed consumption indicators

The feed conversion ratio (FCR) is one of the most useful indicators of feed efficiency in an aquaculture system. The FCR indicates the amount of feed required to produce one unit of fish. The lower the FCR, the better the feed conversion. FCR measurements reveal how efficiently feed is transformed into biomass, as well as any wastage. You can compare FCRs of different feed formulations to determine which one is the most effective. It also shows how well a particular brand performs.

FCR is calculated as follows:

$$\text{FCR} = (\text{Total amount of feed (kg) fed since stocking}) / (\text{Biomass (kg) of fish produced})$$

The biomass of fish = final biomass – initial biomass (at stocking or prior reference point).

An FCR between 1.5 and 2 is indicative of effective feed use. A good grow-out operation should aim for FCRs between 1.5 and 2. FCRs above 2 indicate poor use of feed, waste or poor quality feed. They can also indicate high mortalities and poor water quality parameters.

FCRs need to be checked to enable farm managers to make timely decisions to sustain the aquaculture venture. FCRs can be determined during routine sampling or harvest.



Photo credit: Kamini Bironam, Kasah/ProSCAWA

**Plate 10.** Feed stacked neatly on pallets in a warehouse.

## 5. Sampling, grading and transfers

### 5.1. Sampling

Sampling fish periodically helps to determine changes in average weight and to adjust feed rations accordingly in order to assess how well the fish are growing. It also helps estimate biomass and detect health issues early. Sampling should be carried out in monthly intervals early in the morning to reduce stress to fish. To sample fish, perform the following steps:

- Do not feed the fish for 24 hours if they are due for sampling.
- Gather all necessary equipment, including scoop nets, weighing scale, plastic perforated baskets, notebooks and stationery, basins, fish handling gloves, etc.
- Proceed to the cages to be sampled and assemble the crew. They should work very fast.
- Gradually raise one end of the cage net and remove the weights.
- Quickly collect a sizeable number of fish (about 30) using a scoop net.
- Count and then immediately transfer them into perforated baskets placed in basins of water from your water body.
- Bring back the main net to the water after reattaching the weights.
- Weigh the fish sample in the basket after removing the basket weight using the tare function of the balance.
- Quickly note the total weight of all the fish and divide it by the number of fish counted. This gives the average weight of fish in your cage.
- Ensure that the fish are always submerged in water in a basin throughout the sampling period. Return the fish to the cage as soon as weighing is completed.

### 5.2. Grading

Grading is done when your cage has fish of different sizes, which can affect feed conversion because of competition. The starting protocols

are similar for sampling, but two or more new cages are towed to the location of the cage to be graded. Grading bars or baskets allow fish of a particular size to slip through the gaps while retaining bigger fish of the required size (Plate 11). Basins are used so that fish can move between the two new cages. Small fish are gently stocked into one cage, and bigger fish are stocked into a second cage, where they are allowed to rest for 6 hours, and then gently towed to their final destination. Graded fish should not be fed for 24 hours after grading.

### 5.3. Transferring or thinning out fish

Fish stocked in cages occasionally require transfers on a case-by-case basis. The procedure for such transfers is similar to grading and is often carried out when external water quality parameters necessitate reducing the number of fish in a cage. These do not involve grading fish into various size classes. They are done only in emergencies when stocking densities are high and to avoid mass mortalities.



**Plate 11.** Manual grader for grading fingerlings.

## 6. Monitoring, assessing and managing water quality

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Effective water quality monitoring is critical to the success of your farm. Parameters such as DO, salinity, turbidity, pH, ammonia, nitrates and nitrites need to be measured routinely to ensure fish health and optimal culture conditions. Dead fish can easily compromise healthy fish and lead to disease outbreaks. Uneaten feed, fecal matter, overcrowding, warm weather, trapped floating vegetation, anoxia and overturn, among other factors, all tend to have a negative effect on water quality. Poor water quality also proliferates pathogens, attacking weak and immuno-compromised fish. Among the effects of deteriorating water quality are increased mortality, stunted growth, a loss of revenue for farmers, and a loss of subsistence for employees. On the other hand, good water quality leads to healthier, tastier fish and more income for the farmer.

### 6.1. Some causes of poor water quality in cages

- decomposition of uneaten food and waste materials
- overstocked cages with more fish than recommended
- high water temperatures
- algal blooms
- clogged cages because of turbidity from suspended sediment particles, wastes, weeds, etc.

### 6.2. Some signs of deteriorating water quality

- foul-smelling water
- dead fish
- changes in the color of the water
- poor feeding response, reduced appetite
- low DO levels
- stunted growth
- lethargic or erratic swimming
- fish gasping for air at the surface.

### 6.3. Mitigation measures

- Avoid overstocking your cage.
- Remove dead or dying fish as soon as you see them and bury them in a trench away from predators.
- Delay feeding when the water quality is not optimal, and reintroduce feed in small portions.
- Inform your fisheries extension officer about any changes in your water quality or the health of your fish.
- Monitor your water quality parameters regularly using field test kits, probes and spectrophotometers (Plate 12). Check inside and outside the cage and in the main water column. Compare with recognized standards to know the status of your cages (Table 4). If possible, check the DO levels twice a day.
- Train the staff responsible for feeding fish to identify warning signals and stop feeding if necessary.
- Check regularly for invasive species and ensure that they do not clog the nets.
- Clean the cage nets and inspect them for holes and wear and tear as part of routine operations. Mend any holes as a matter of urgency.
- Check the mooring system and anchors to ensure they are still in position and have not shifted (Agyakwah et al. 2020).

Every farmer must invest in essential water quality monitoring equipment that can provide early warnings. These can be found in pet shops, fish feed input stores and some agro-input shops, as well as online. Most farmers who are able to prevent severe disease outbreaks on their fish farms use water quality equipment to warn them in advance of deteriorating conditions in the water bodies where their cages are located.



**Plate 12.** Testing the water quality outside a cage using a portable probe.

Parameter	Desired range	Frequency of testing	Best times for monitoring
pH	6.5–8.5	Twice daily	Morning and evening
DO	>3 mg/L	Twice daily	Morning and evening
Temperature	25°C–30°C	Twice daily	Morning and evening
Ammonia	<0.03 mg/L	Once daily	Weekly
Nitrite	0.6 mg/L	Once daily	Weekly
Turbidity	< 75 NTU*	Once daily	Weekly

\* Nephelometric turbidity units.

Source: Adapted from Agyakwah et al. 2020.

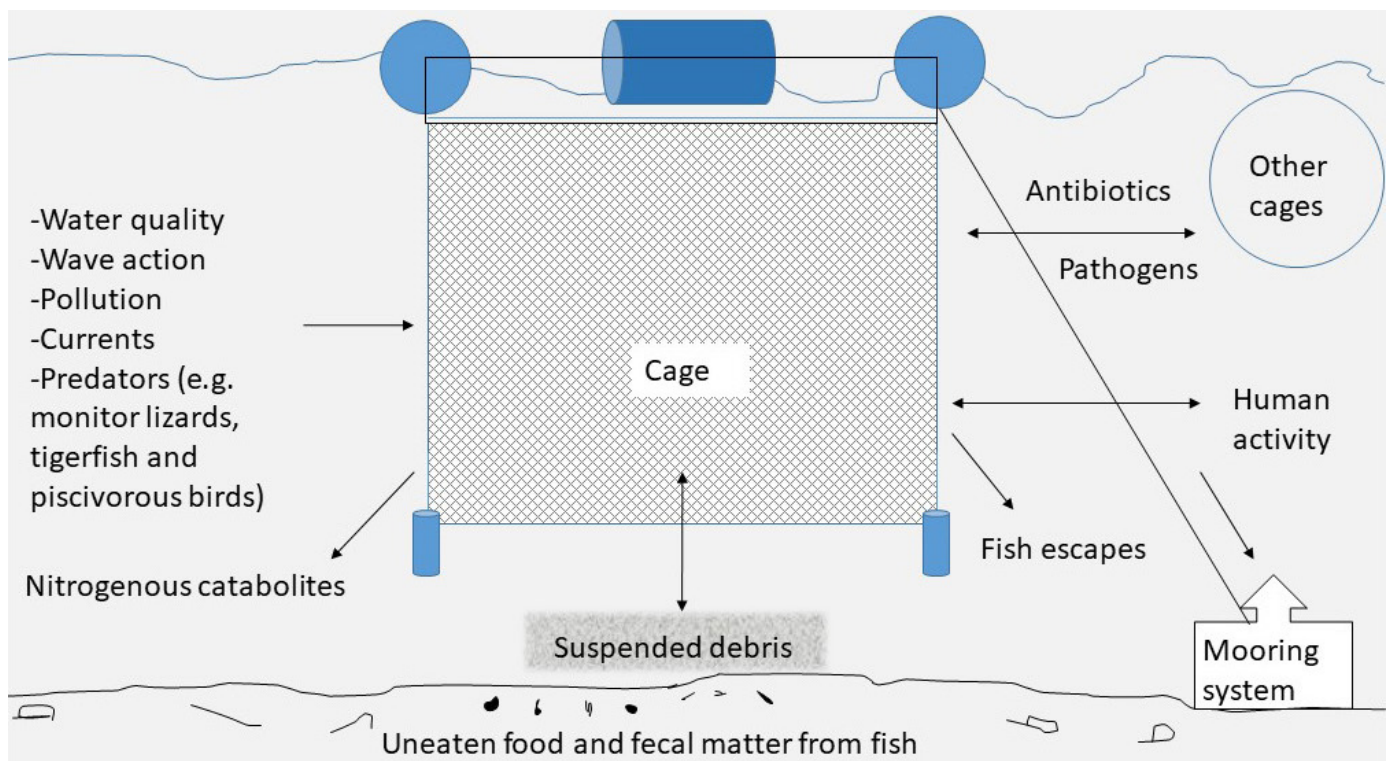
**Table 4.** Desired ranges for water quality parameters in tilapia aquaculture.

## 7. Biosecurity on your farm

Preventing pathogens from entering your farm through either internal or external sources is essential to avoid disease outbreaks. Disease affects farm revenue and operations, which might eventually lead to a total loss of business, and even fish that recover can be physically deformed resulting in a lower market price. Biosecurity measures consist of establishing and implementing various protocols and procedures on your farm to prevent or mitigate diseases. The intensive nature of cage aquaculture means that fish are susceptible to disease, and culture activities negatively impact the surrounding aquatic environment (Plate 13). In addition, external factors such as water quality, wave action, current velocity, predation and pollution can also directly impact the cage infrastructure and cultured fish.

As a farmer, it is important for you to ensure that biosecurity measures are followed to minimize disease outbreaks, avoid the spread of pathogens and maintain overall fish health (WWF 2011; Din and Subasinghe 2017). Many of these measures are easy to follow, inexpensive and reduce incidences of disease.

If all required guidelines have been followed and your cages have been installed in water with optimal conditions, adhering to biosecurity principles should be easy. Locating your cages in areas close to land where there is a lot of activity and effluent discharge can endanger the health of your cage system. Likewise, establishing your farm close to other aquaculture facilities will have the same results (Agyakwah et al. 2020).



Source: Adapted from Piccolotti and Lovatelli 2013.

**Figure 2.** Interactions between cage aquaculture and the environment.



## 7.1. Precautions

- Obtain your inputs and supplies from certified sources.
- Ensure that all vehicles entering the facility park in a designated area at a safe distance from your operations.
- Disinfect fish handling equipment using safe, environmentally friendly chemicals (Table 5).
- Do not cross-contaminate cages by using highly contaminated equipment (such as equipment used to remove dead or moribund fish) in another cage without proper disinfection.
- Provide multiple scoop nets, basins, canoes, etc., to collect dead, sick or moribund fish. Store them separately, and do not use these accessories to handle healthy fish in the farm.
- Collect all dead and moribund fish promptly and bury dead fish in a deep trench away from the farm. Make sure the trench is filled with soil and well-tamped (pressed down until firm) to prevent scavengers such as dogs from digging up the dead fish.
- Stressed fish are susceptible to disease, which leads to inferior quality fish when harvested. Reduce stress as much as possible by using recommended stocking densities, maintaining good water quality, feeding your fish appropriately and minimizing handling. Excessive handling can result in wounds or lesions, which allow pathogens to infect your fish.
- If you must move or handle your fish, do so early in the morning or at dusk, when ambient temperatures are low.
- As much as possible, mitigate predatory attacks by maintaining your outer protection nets and bird nets, securing them and keeping them in good condition.
- Wear personal protective equipment (PPE) when handling disinfectants or hazardous materials.
- Clean, disinfect and dry nets, trays, basins and scoop nets thoroughly using recommended disinfectants (Table 5).

- Minimize the movement of workers between departments as much as possible.
- Do not allow unauthorized persons into your farm unless permission has been obtained.

A disinfectant is a chemical or substance that destroys disease-causing organisms (Din and Subasinghe 2017). All farm equipment must be cleaned with soap and water, after which the recommended concentrations of disinfectant are applied. Dry all sanitized equipment thoroughly in the sun to eliminate as many germs as possible.

## 7.2. Fish stress reduction

Multiple factors contribute to increased stress in fish. Inadequate water quality, pollution, poor diet, overcrowding, predation, aggression and the presence of pathogens in the immediate aquatic environment can all increase the likelihood of disease outbreaks. Ulcers and lesions caused by improper or excessive handling also stress fish and reduce their resistance to infections. Try to avoid handling fish as much as possible. When handling and transporting fish, avoid stressing them unnecessarily to reduce mortalities. Release live fish gently into the water and do not subject them to undue stress during routine handling or other farm operations.

Disinfectant	Concentration	Duration/soak time	Uses
Benzalkonium chloride	250–500 ppm	10–30 minutes	Plastics, floors, footbaths, equipment, furnishings
Didecyl dimethyl ammonium chloride	400 ppm	5 minutes	Plastics, floors
Phenols	2%–5% active ingredients	10–30 minutes	General use
Chlorine	200–500 ppm	10–60 minutes	All surfaces except plastics. In the event of tank disinfection, disinfect for 24 hours, neutralize, rinse thoroughly and dry
Ethyl alcohol	70%–80%	10–30 minutes	Hands, tools, work surfaces
Iodine	100–250 ppm	20–30 minutes	Antiseptic on tissues (follow instructions for use)
Hydrogen peroxide	3%–30% (weight percentage) 3%–5%	5–30 minutes 5–15 minutes	General disinfection (follow instructions for treating or disinfecting eggs)
Virkon® Aquatic (concentrated disinfectant powder)	0.5%–1% or 50–100 g per 10 L of water	10–15 minutes	General disinfection, usually used for footbaths
Isopropyl alcohol	60%–80%	10–30 minutes	Hands, tools, work surfaces
Chlorhexidine solution (mostly 2% active chlorhexidine)	100 ml per 1 L of water	5–10 minutes	General disinfection, usually used for footbaths

**Table 5.** Disinfectants for sterilizing cage aquaculture equipment.

## 8. Diseases, monitoring and managing fish health

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Fish will only fall sick if they are stressed, pathogens have impaired their immunity or their environment spreads disease. Having open wounds and lesions from injury will make them even more susceptible to infection, as will a poor diet. The key to preventing mass mortalities is quick action. As highlighted in previous sections, proper monitoring and adherence to biosecurity principles can make a tremendous impact during disease outbreaks.

### 8.1. Symptoms of illness in fish

- lethargy
- listlessness
- erratic swimming
- swollen or distended abdomen
- puffy, protruding eyes
- poor appetite
- gasping for air
- splashing against the sides of the cage
- swimming in circles or whirling
- torn or tattered fins
- lesions and ulcers on the skin
- fin and tail rot
- increased mucus production
- high mortalities.

### 8.2. In the event of a disease outbreak on your farm

- Do not feed your fish immediately, especially in cages with a poor feeding response.
- Transfer fish from crowded cages into multiple cages, if possible.
- Contact your aquaculture extension officer immediately.
- Inform the fish health specialist or veterinary officer close to your farm.
- Remove all dead fish, bury them in a deep trench, cover with dirt and then tamp securely to prevent predators from digging them up.

- Disinfect the entire farm and strengthen biosecurity.
- Quarantine sick fish, if possible, in a separate holding facility or receptacle while awaiting expert medical advice.
- Collect samples for onward testing at an accredited laboratory, research institute or fish health unit, and contact the laboratory ahead of time to be sure they can receive your sample for testing (Appendix 3).
- Do not attempt to medicate the fish yourself in the cages. Let a fish health officer assess the situation and make recommendations for treatment.

### 8.3. Sending diseased fish samples to the laboratory

- Do not send dead fish to a laboratory.
- Use a clean scoop net to collect samples of weak, sick and dying fish exhibiting the same symptoms. Disinfect the net when done and then dry it.
- Place the diseased fish into a clear plastic bag and label it with enough information for tracking purposes, and add a sample of a healthy fish for comparison.
- Transport the sample on ice to the laboratory.
- Provide as much information as possible to help the diagnosis.

The use of antibiotics in grow-out operations is strongly discouraged. There are concerns regarding health, residues entering the main water supply, and pathogen resistance, among other reasons. The indiscriminate use of antibiotic compounds in aquaculture has resulted in widespread antimicrobial resistance among bacterial pathogens, which has become a global human health hazard. Do not attempt to treat fish without prior authorization from a fish health expert or veterinarian duly licensed and certified by your country.

## 9. Harvesting, post-harvest handling and marketing

### 9.1. Harvesting

If all management practices are adhered to, tilapia are ready for harvest in 5–6 months after stocking juveniles. The standard table size at this point is 350 g. Catering establishments prefer fish weighing 350 g and above for grilling, while fried fish vendors mostly favor smaller sizes. However, the tilapia sizes harvested and sold are categorized into different “size classes,” ranging from 200 to 900 g in Ghana and up to 1 kg in Nigeria. Typically, the lower the weight of the size class, the lower the price. Larger size classes command a premium. Usually, the local aquaculture association that the farmer belongs to sets a standard price at which the various sizes of fish are to be sold. The farmer should make every effort to ensure their farmgate prices reflect prevailing market conditions while allowing to generate a profit. A quick market survey before harvesting will inform the farmer of current selling prices.

Freshly harvested fish, processed and packaged hygienically, is of superior quality and commands a premium price. Using ice allows farmers to keep harvested fish fresh for onward storage or transportation to market centers or consumers. Freshly harvested fish must be gutted (have the internal organs removed) and washed thoroughly to minimize spoilage and preserve flavor. Always ensure you have an adequate amount of ice for your harvested fish. A ratio of about 1 kg of ice for every kilogram of gutted fish is recommended.

Before harvesting, be sure to carry out the following:

- Sample the selected grow-out cages to determine if fish have reached table/market size.
  - Select the cage(s) for harvest.
  - Estimate the total biomass of the fish in the selected cages, and factor cumulative mortalities into your calculation.
  - Decide on whether you want to carry out a partial or complete harvest, or harvest from multiple cages.
- Estimate your projected revenue based on prevailing market prices for whole and gutted fish.
  - Calculate how much feed the fish intended for harvest have consumed.
  - Ensure you have the market, fish mongers and/or customers ready to buy the estimated metric tons of your harvest.
  - Advertise your harvest date(s) across various media and local platforms to maximize sales.
  - Starve your fish for at least 24 hours before harvesting so that they flush all waste from their internal organs. This will eliminate off-flavors and metabolites, which affect the final product’s taste and quality, and will improve your revenue and clientele.

Before harvesting, complete the following preparations:

- Gather a crew of at least 12 farm workers per cage (usually 6 × 6 × 6 m).
- Have two or three wide-diameter harvest scoop nets on hand, as well as other necessary equipment, including scoop nets, crates and insulated fish tanks.
- Use high-quality, durable gloves to handle and sort fish.
- You will need a vessel to transport the harvested fish to shore.
- Ensure your post-harvest unit is well set up and has enough ice available.
- Have your post-harvest processing team, prepared with clean equipment and running water, alert and on standby.

#### 9.1.1. The harvest process

When there is a low demand for fish, you can decide to do a partial harvest. A complete harvest is carried out if demand is high and your cages can meet the order.

Harvesting procedures could include the following:

- Assemble the team early in the morning, preferably at sunrise, and transfer them to the designated cage(s).
- Remove bird nets, if any.
- Have about four workers remove the weights at the bottom of one end of your cage and lift the ends onto the cage frame, securing the edges firmly (Plate 13).
- Lift the unweighted ends of the cage to form a “bag.”
- Use the harvest scoop nets to quickly scoop the fish into fish tanks or crates, and then move them immediately ashore (Plate 14). Do not wait to harvest the entire cage before departing for the shore. The first fish harvested must be the first to go to shore.



**Plate 13.** Fish farm crew doing a partial harvest.



**Plate 14.** Scooping out freshly harvested fish into crates.

- For a partial harvest, once you have harvested the desired quantity of fish, release the bagged fish back into the cage by lowering the net and replacing the weights.
- For a complete harvest, empty the cage, remove the inner production net and harvest any wild fish in your outer protection net.
- Transport all nets to your cage washing or maintenance facility for cleaning, drying, mending, inspection and storage.
- Wait a few hours before feeding any cages in the immediate vicinity of the harvested fish.
- Do not feed a partially harvested cage right after harvest because the fish will be stressed. Allow them to recover overnight before resuming feeding.
- Make sure everyone disinfects their feet in a foot bath before entering the facility to avoid contamination.
- Clean and sanitize equipment for post-harvest clean-up.
- Have notebooks, stationery or digital equipment on hand to maintain records.
- Weigh fish on platform scales.

After transporting the fish to the post-harvest processing facility, place them on sorting tables. Have the crew station around the table(s) and begin to separate the fish according to size by placing them into color-coded fish baskets. Avoid placing the fish directly on the bare floor.

Deliver all fish belonging to a specific size to the workers responsible for eviscerating fish of that size. Using sharp knives, slit the belly of the fish open and remove the internal organs and viscera. Wash the gutted fish under clean running water and place them in perforated crates for weighing. Do not use a single bowl of water to wash several fish, as this increases the risk of contamination. A standard crate of fish weighs 25 kg. Use crushed ice (Plate 16) to chill and transport the fish. This keeps the fish chilled evenly and guarantees freshness upon delivery.

## 9.2. Post-harvest handling of fish

After you have moved your harvested fish ashore, transport them to your post-harvest processing facility for sorting, gutting, cleaning and packing. The post-harvest team should clean their hands thoroughly, put on clean boots and wear hairnets to prevent their hair from coming into contact with processed fish. Aprons (PVC) should also be worn to protect clothes.

Have pre-determined size classes for the various sizes of fish. Carry out the following to handle fish properly during post-harvest procedures:

- Have sorting tables ready, preferably made out of stainless steel, to sort fish into various sizes.
- Use cut-resistant fish sorting gloves.
- Place the fish into color-coded crates of different size classes.
- Transport the fish crates to clients.
- Clean and flake ice in the required quantities (Plate 15).
- Use taps with running potable water.
- Use knives to gut the fish.
- Make sure workers wear aprons and hairnets.
- Discard viscera into waste bins.
- Tag the fish according to their size.
- Send each weighed crate of fish for icing.
- Take a clean fish crate, and line the base with a layer of crushed ice.
- Add a layer of fish from a 25 kg crate, then top it up with another layer of crushed ice, and so on, until 25 kg have been layered into the crate. Top up with an extra layer of ice.
- Do not use large chunks of ice, as the fish will not chill uniformly. Make sure your ice is adequately crushed.
- Move the fish into a refrigerated truck or refrigerated holding facility for onward transport to customers or the market.
- Record how many kilograms of fish were harvested, the number of crates sent to the market or clients, and details of sizes harvested for your records.



**Plate 15.** Freshly harvested fish on an Improved sorting table made of wood.



**Plate 16.** Crushed ice for chilling freshly harvested fish.

### 9.2.1. Value addition

Store harvested fish on ice in neatly wrapped packaging as whole gutted or filleted fish to add value and extend their shelf life. You can also smoke your fish using the hot-smoking method or salt and dry it, depending on market preferences. Hot-smoked fish in Ghana currently have high levels of polycyclic aromatic hydrocarbons (PAHs), which are carcinogenic and can cause mutations and deformities. A combination of factors such as choice of fuel wood, oven type, duration of smoking and anatomy of the fish affect the levels of PAHs found in hot-smoked fish (Asiedu et al. 2015; Asamoah et al. 2021). Hot-smoked fish and fresh fish fillets can be exported to generate more income, if they satisfy regulatory requirements and have low quantities of PAHs. Contact the nearest fisheries office or your extension officer for recommendations on environmentally friendly smoking ovens and fuel wood.

### 9.3. Marketing

A successful fish farmer should also have excellent marketing skills. Before harvesting, identify potential customers and reach out to them. Carry out a market survey to know what potential clients prefer in terms of form and size of fish. When you are ready to harvest, let prospective customers know the date(s) and time(s). To ensure good sales on the day of harvest, advertise your farm through various channels, including social media, radio announcements, your local aquaculture association, fish mongers, visits to restaurants, hotels, eateries, the internet and flyers. Allow clients to come to the farmgate to buy your fish, or transport your fish to various market centers or outlets for sale. Have an adequate supply of ice on hand to keep the fish fresh. Make arrangements with any wholesalers to buy your harvest in bulk.

# 10. Record keeping

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To ensure traceability and quick access to information, a fish farm needs to maintain up-to-date records that can be accessed easily. Keep daily records of all farm activities, including the month, day and year, name of the person maintaining the records, and any specific notes or remarks as necessary. Fill out hard copies manually and digitize them later, at the end of the day. Label all cages clearly for reference and records to track fish throughout the production cycle.

Some of these records include the following:

- daily water quality parameters
- fingerling stocking
- movement of fish
- cage observations
- repairs and maintenance
- reports of incidents
- changes in the behavior of the fish
- daily mortalities for all cages
- reports on causes of mortalities and treatments, if any
- training and skill development for staff
- nets bought, mended, discarded, etc.
- logistics
- feed intake
- daily feed-use sheets
- weight and number of fish harvested per cage
- prices of fish and revenue earned
- repairs
- purchases and procurement
- asset inventory
- permits
- details of cages in use
- financial documents
- extension visits
- salaries and wages
- inputs and logistics
- any other important records.

Maintaining up-to-date farm records enables periodic performance reviews and helps you make well-informed decisions to improve productivity and profitability. Tables 6–11 include samples of some basic farm record sheets.



Recorded by:					
Date	Cage ID	Initial weight	Number of fish stocked	Hatchery source	Remarks

**Table 6.** Sample of a nursery cage stocking record sheet.

Recorded by:					
Date	Cage ID	Feed type	Feed amount (kg)	Remarks	Interventions

**Table 7.** Sample of a daily feed record sheet.

Recorded by:							
Date	Cage ID	Mortalities	DO (mg/L)	pH	Temperature (°C)	Remarks	Interventions

**Table 8.** Sample of a water quality and mortality record sheet.

**Recorded by:**

**Department:**

Date	Incident	Nature of incident	Remarks/Action taken

**Table 9.** Sample of an incident record sheet.

<b>Recorded by:</b>						
<b>Date</b>	<b>Item</b>	<b>Activity/Purpose</b>	<b>Unit cost</b>	<b>Quantity</b>	<b>Total cost</b>	<b>Remarks</b>

**Table 10.** Sample of a farm expenses record sheet.

Recorded by:					
Date	Feed type/name	Number of kg in	Number of kg out	Number of bags with issues	Remarks

**Table 11.** Sample of a feed warehouse record sheet.

# 11. Social responsibilities

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As a good fish farmer and an employer, you should seek the welfare of your employees and make sure to fulfill all social obligations. The farmer must ensure that, as much as possible, the farm personnel operate in an environment that is not exploitative, have their capacities enhanced, and receive a fair hearing or arbitration in the event of wrongdoing. According to the International Standards for Responsible Tilapia Aquaculture, the farmer has the following duties and obligations to the farm employees and the larger community (WWF 2011).

## 11.1. Child labor

- Do not permanently employ workers below the minimum legal working age, which is 16 years old in Ghana and 14 in Nigeria. In both countries, however, children under 18 years of age who qualify to be employed are only permitted to perform light work that will not impair their development or impede their education.
- Because of the high risks and rigorous nature involved in aquaculture operations, ensure that permanent farm workers are over 18 years old. Recruit younger staff for casual jobs (e.g. record keeping, net mending, sorting, etc.) on a part-time basis (e.g. weekends and during vacations).

## 11.2. Working conditions

- Provide workers with conditions of service and standard reporting and closing times.
- Ensure that all employees have read and understood the terms of their employment contracts.
- Be considerate when overtime is required, and adequately compensate workers for any additional working hours.
- Do not compel employees to remain on their job.
- Avoid a culture of threats, insults, enslavement and dominance on your farm by treating workers with respect.

- Conduct routine capacity-building training programs on innovations and best practices for your employees, at your own expense.
- Do not withhold a worker's original documents for any reason.
- Do not withhold all or part of a worker's salary or benefits to compel them to remain in your employment or repay a debt.
- Never discriminate against your workers based on their race, nationality, religion, disability, gender, age, sexual orientation, etc. If a worker is in a situation that could affect their health or impede their work, transfer them to another department that poses a lower risk. For example, a pregnant staff member responsible for feeding fish may be assigned record keeping or data entry duties so that she does not endanger herself or her pregnancy by working on cages in open water.
- Establish a mediation or arbitration committee to resolve any issues of discrimination with no fear of reprisal.
- Train staff on diversity and discrimination as well as how to deal with such situations.
- Make it a priority to recruit workers from the surrounding communities as much as possible. In exceptional cases, if you cannot find the required level of expertise in the local community, you may hire workers from other areas.
- Allow your workers to join a trade union or association, if they wish, without interfering with their membership.
- Ensure that your conditions of service are fair and equitable.
- Make sure that workers have access to potable drinking water, sanitary facilities and working areas and offices that protect them from the elements or natural disasters.
- Allow workers to have easy access to nutritious food provided by the farm or bought independently.

### 11.3. Occupational health and safety

- Develop standard safety protocols and policies to prevent and mitigate any risks and hazards.
- Train staff routinely on these protocols (at least yearly for regular staff and at orientations for new staff) and carry out simulation exercises regularly.
- Put up posters in visible areas throughout the farm that have essential information and signage with relevant safety information.
- Ensure that all staff have medical insurance.
- Label and store all hazardous equipment and machinery appropriately.
- Provide your workers with safety equipment and PPE.
- Maintain a regularly updated emergency response plan for emergencies such as fires, earthquakes, toxic spills, etc. Provide employees with the training needed to respond to such situations.

### 11.4. Community relations

- Do not restrict the access of surrounding settlements to any public property or natural resource, such as a water body. If human traffic through your farm is a nuisance, create an alternative route for the community.
- Operate your farm in harmony with any neighboring communities.
- Hold bi-annual meetings with indigenous communities to socialize, spread information and resolve potential conflicts.



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# Appendix

Parameter	Guidelines/Optimal ranges
Alkalinity (mg/L)	20–100
Aluminium (mg/L)	<0.03
Ammonia (mg/L)	0.0–0.03
Arsenic (mg/L)	0.0–0.05
BOD <sub>5</sub> (mg/L)	<15
CO <sub>2</sub> (mg/L)	<12
COD (mg/L)	<40
Chlorine (mg/L)	2–10
Color (Pt. Co units)	30–40
DO (mg/L)	5–8
<i>E. coli</i> ( <i>E. coli</i> /g)	0–10
Hydrogen sulfide (mg/L)	<0.001
Iron (mg/L)	<0.01
Lead (mg/L)	<0.01
Manganese (mg/L)	<0.1
Mercury (mg/L)	<1
Nitrate (mg/L)	<50
Nitrite (mg/L)	0.0–0.25
pH (pH units)	6.5–9.0
Phosphates (mg/L)	<0.1
Salinity (mg/L)	<3
Sulfides (mg/L)	<0.001
Temperature (°C) – <i>Clarias</i> sp.	28–30
Temperature (°C) – <i>Clarias</i> sp.	27–30
Temperature (°C) – <i>Oreochromis</i> sp.	28–30

**Table 12.** Selected water quality guidelines for cage aquaculture.

Organization	Contact	Services
Dickem Aquatech	No. 19 Dickem Farm Close, Dickem Bus Stop, Isashi, Lagos	Aquaculture equipment, feed manufacturing, training
Olam Nigeria Limited	Plot 5 and 6, Abebe Village Road, Iganmu, Lagos	Extension services, feed milling
Everlush Nigeria Limited	90 Obafemi Awolowo Way, Ikeja, Lagos <a href="mailto:everlushlimited@yahoo.com">everlushlimited@yahoo.com</a>	Aquaculture equipment, water quality kits, probiotics, feed
Animal Care Konsult	Kilometer 2, Iperu Ogere Road, 121108, Ogere Remo, Ogun State	Fish health diagnostic laboratory services, training and extension services
Department of Veterinary Public Health  Department of Aquaculture and Fisheries Management	University of Ibadan, Ibadan, Oyo State	Fish health, fish pathology, research, training, extension services
Department of Veterinary Medicine	University of Nigeria, Nsukka, Enugu State	Fish health and pathology, research
National Institute for Freshwater Fisheries Research	PMB 6006, New Bussa, Niger State	Research, training, extension services
Department of Veterinary Pathology, Faculty of Veterinary Medicine, University of Ilorin	University of Ilorin, PMB 1515, Ilorin, Kwara State	Fish health and pathology, research, training, extension services

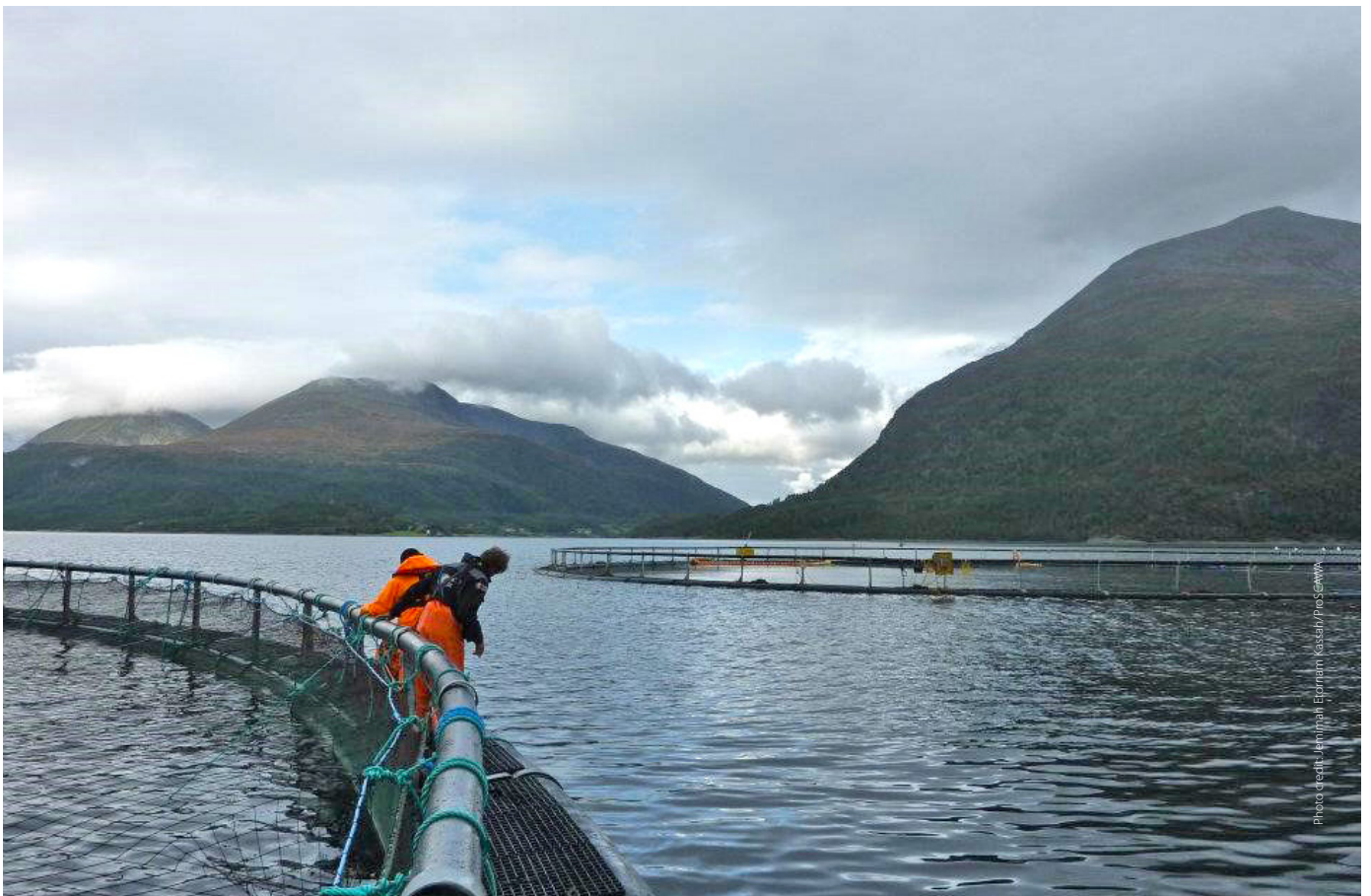
**Table 13.** Vendors of cage aquaculture equipment, logistics and service providers in Nigeria.

Organization	Contact	Services
Raanan Fish Feed West Africa	Opposite Ashaiman Timber Market, Ashaiman	Aquaculture equipment, water quality test kits, feed manufacturing, training
Enam Papa Fish Feed (Cycle Farms)	MXJX+45, Steel Works Road, Tema	Feed manufacturing, extension services
R&B Farms	Gomoa Nsuaem, Central Region P.O. Box CT 6412, Accra	Supplying fingerlings, feed manufacturing, training
CSIR-Water Research Institute Aquaculture Research and Development Center	73M4+47, Near Ghana National Fire Service, Asuogyaman-Atimpoku Road, Akosombo P.O. Box 139, Akosombo	Research, hatchery, training and extension services, fish health
Fish Health Unit Fisheries Commission of Ghana	Fisheries Commission Headquarters, near Efu Sutherland Children's Park, Ridge, Accra	Fish health and pathology, research, training, extension services
Department of Marine and Fisheries Sciences, University of Ghana	P.O. Box LG 99, University of Ghana, Legon  mafs@ug.edu.gh	Research, training, fish health and pathology
Africa Center of Excellence in Coastal Resilience-CCM  Department of Fisheries and Aquatic Science	University of Cape Coast, Cape Coast	Research, training, extension services
Seaworld Fishing Nets	GQVR+JG5, Kwame Nkrumah Avenue, Accra	Aquaculture nets and equipment
CCTC Ghana Limited	2nd Floor, #E87/3, Tudu Crescent, Kojo Thompson Road, Accra	Aquaculture nets and equipment
Duraplast Ghana Limited	Plot Numbers: 10, 11 and 12 Dadeban Road, North Industrial Area, Accra North	Pontoon cages, floats, kayaks, fish crates

**Table 14.** Vendors of cage aquaculture equipment, logistics and service providers in Ghana.



**Plate 17.** Pontoon type cage.



**Plate 18.** Circular HDPE cages.



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### **About WorldFish**

WorldFish is an international, not-for-profit research organization that works to reduce hunger and poverty by improving aquatic food systems, including fisheries and aquaculture. It collaborates with numerous international, regional and national partners to deliver transformational impacts to millions of people who depend on fish for food, nutrition and income in the developing world.

The WorldFish headquarters is in Penang, Malaysia, with regional offices across Africa, Asia and the Pacific. The organization is a member of CGIAR, the world's largest research partnership for a food secure future dedicated to reducing poverty, enhancing food and nutrition security and improving natural resources.

For more information, please visit [www.worldfishcenter.org](http://www.worldfishcenter.org)