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Small-scale alternative hatchery methods for indigenous small fish and minor carp seed production

A practical booklet

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Small-scale alternative hatchery methods for indigenous small fish and minor carp seed production: A practical booklet

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1. Introduction

Persistent malnutrition remains a critical challenge in Asia, prompting the need for innovative solutions. Although aquaculture has been pivotal in enhancing food security, the sector has largely neglected the development of seed production techniques for nutrient-rich small indigenous fish species (SIS) and minor carps. Traditional approaches to artificial reproduction and hatchery practices have prioritized production and profit, often overlooking the nutritional composition of the species. Species like mola (*Amblypharyngodon mola*), pool barb (*Puntius sophore*) and reba carp (*Cirrhinus reba*) have emerged as promising candidates for nutrition-sensitive aquaculture. This approach emphasizes production from polyculture of nutrient-rich SIS alongside traditional carp, with the aim of improving overall nutritional outcomes.

The increasing market value of previously undervalued SIS presents new opportunities for farmers to profit from their production. This profit can then be reinvested to diversify diets and directly address household malnutrition. As such, there is an opportune moment to scale up SIS aquaculture. However, the lack of reliable techniques for mass seed production and distribution of SIS poses a significant obstacle to scaling up nutrition-sensitive carp–SIS cultivation. Recently, under a project funded by the German Federal Ministry for Economic Cooperation and Development (BMZ), WorldFish developed a protocol for mass seed production of mola and other important SIS by standardizing a method of hatchery-based breeding.[1]

The protocol developed under the project is highly scalable, even for small-scale farmers.[2] Establishing a SIS hatchery can leverage existing carp hatchery facilities with certain upgrades and add-on activities. Additionally, it is crucial to develop alternative seed production systems to address the challenge of distributing small fish seed and propagating carp–SIS polyculture among small-scale farmers, especially where hatchery or seed distribution networks are underdeveloped. Many small rural farms and homestead ponds are located far from commercial permanent hatcheries, making it difficult and costly to transport hatchlings over long distances.

In this context, this booklet presents some simple mobile or backyard hatchery systems and upgrade plans for existing carp hatcheries to produce seed of small fish, as well as minor carps, small catfish, etc. These systems require minimal installation and operational costs, compared to large industrial hatcheries, and are more energy efficient. They can be effectively implemented in community settings to enhance stock in reservoirs and wetlands. Many groups will find this document valuable, including small-scale farmers, hatchery operators, seed producer groups, farmer cooperatives, government agencies, and researchers.

[1] Rajts F, Dubey SK, Gogoi K, Das RR, Biswal SK, Padiyar AP, Rajendran S, Thilsted SH, Mohan CV and Belton B. 2023. Cracking the code of hatchery-based mass production of mola (*Amblypharyngodon mola*) seed for nutrition-sensitive aquaculture. *Frontiers in Aquaculture*, 2:1271715. https://doi.org/10.3389/faquc.2023.127171

[2] Gogoi K, Rajts F, Das RR, Dubey SK, Padiyar A, Rajendran S, Belton B and Mohan CV. 2023. Induced breeding of mola carplet (*Amblypharyngodon mola*) for mass seed production: A practical guideline. Penang, Malaysia: WorldFish. Guideline: 2023-23. https://hdl.handle.net/20.500.12348/5552

2. Small-scale mobile hatchery and equipment

2.1. Mobile hatchery for spawning and hatchling production in a stagnant pond

Suitable species

- Suitable species include mola, pool barb, cotio (*Osteobrama cotio*), darkina (*Esomus* danricus) and other scattered breeder species that have adhesive eggs.

Breeder preparation

- Harden or train breeders in a broodstock pond by netting and releasing them back into the broodstock pond three times over a period of 10 days prior to breeding.
- Prepare three hapas: (1) the conditioning hapa is made of small mesh synthetic material, such as a monofilament mosquito net, (2) the breeding hapa (inner hapa) is constructed from a 6 to 10 mm mesh net suspended tightly on an iron frame and not touching the bottom of the outer hapa, and (3) the egg and larval incubation hapa (outer hapa) is made of fine mesh synthetic material, approximately 250 µm.

Pond preparation

- Clean one pond and fill it with preferably soft water, ideally 1 day before breeding.
- Avoid fertilization to prevent excessive algal growth, which could lead to low dissolved oxygen levels in the morning and hinder water exchange by fouling the mesh of the incubation hapa.

Hapa installation

- Install the three hapas, with the inner hapa placed inside the incubation hapa.
- Ensure that the water depth in the hapas is 50 cm or less (Figure 1).

Breeding process

- In the morning, select mature mola breeders from the broodstock pond. The minimum size requirement is 5 g for females and 2.5 g for males.
- Maintain a sex ratio of 1:2 (females to males).
- Transfer the breeders to the conditioning hapa, at a density of 500 g/m^2 or lower.
- In the evening, inject the breeders with hormone (at proper doses), and then disinfect and transfer the breeders to the inner hapa.
- Breeding will occur early the next morning.
- Remove the breeders along with the inner hapa, and transfer them to a pond for spent fish.

Hatchling production

- Adhesive eggs are primarily attached to the bottom of the incubation hapa.
- Preferably, incubate non-adhesive eggs in the cylindro-conical incubator with flowing water to keep them in continuous motion (Section 2.2 and Section 3.2).
- Estimate the number of eggs attached to the bottom and the rate of fertilization in the afternoon.
- The best estimation method involves placing a one square decimeter (10 x 10 cm) frame on the net bottom in three different locations, taking photographs and counting the eggs in the printed pictures.
- Monitor the hatching rate during the evening and night.
- Hatchlings will begin to feed approximately 2.5–3 days after hatching, depending on the temperature.
- Transfer the produced hatchlings to a nursery pond or sell them.
- This system can produce 500,000 seeds of SIS in one week's time.

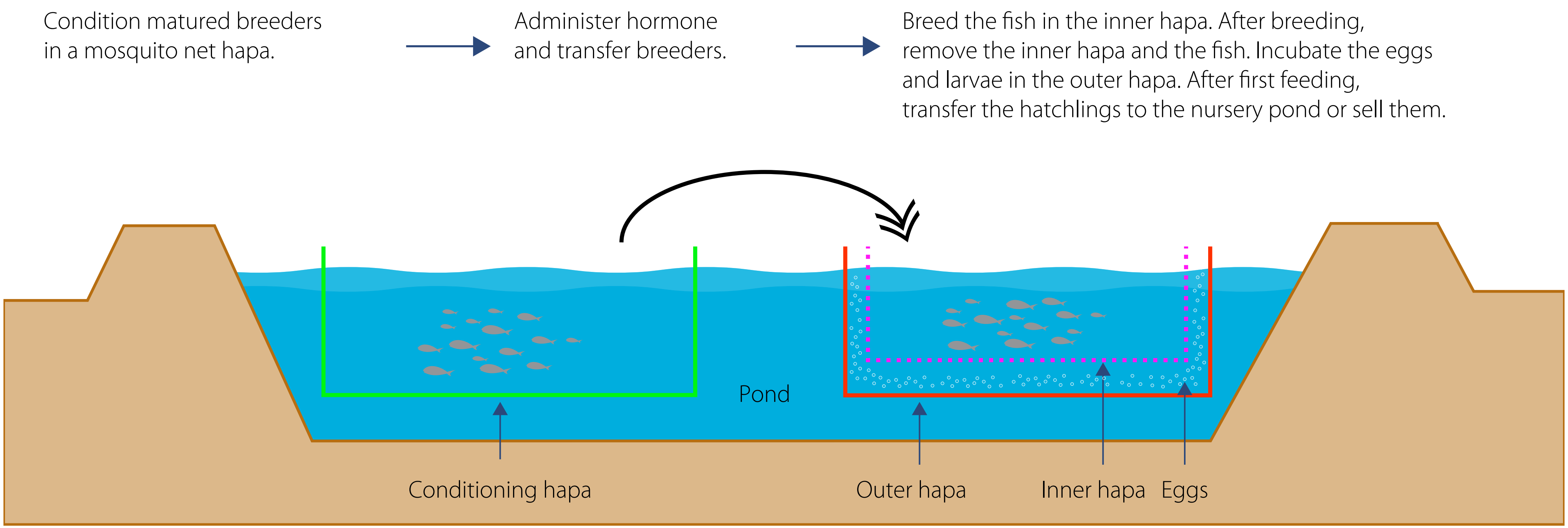

Figure 1. Breeding process for mola and other species in stagnant water within a hapa placed in a pond.

2.2. Mobile hatchery for spawning and hatchling production in hapas kept in the pond with water exchange

Suitable species

- Mola, pool barb, cotio, darkina, reba carp and other scattered breeder species.

Design feature

- This basic breeding technology shares similarities with the method discussed in Section 2.1, but replacing the water enhances it. It involves syphoning water from one pond to the conditioning and breeding hapas or a funnel incubator kept in the adjacent pond (Figure 2).
- This method can produce about 750,000 seeds.

Description

- To operate the mobile hatchery, lift water from one pond to the other to create at least a 1 m difference in the water level between the two ponds. Lift water by placing a filter hapa within the pond.
- Initial pumping from the breeding or incubation pond to the reservoir pond requires a 0.5 m water column lift. This creates a 1 m difference in water levels between equal-sized ponds, which is sufficient for 1 week of operation in 1000 m^2 ponds.
- By comparison, commercial hatcheries pump water from a borehole to an elevated reinforced cement concrete (RCC) water reservoir. This involves a total lift of approximately 13 m, including the aeration tower.
- Incubate non-adhesive eggs under flowing water to keep them in continuous motion. To do this, collect the fertilized eggs from the outer hapa and transfer them to a submergible funnel-type incubator (Plate 1).
- This technique applies not only to traditional dug-out ponds but also to burrow pits. Build embankments to create two or more ponds. Then use a diesel pump to pump water from the breeding pond to the adjacent pond, which serves as an elevated water reservoir.
- Alternatively, farmers can install a hapa or a submergible funnel-type incubator directly into the nursery pond as well (Plate 1).

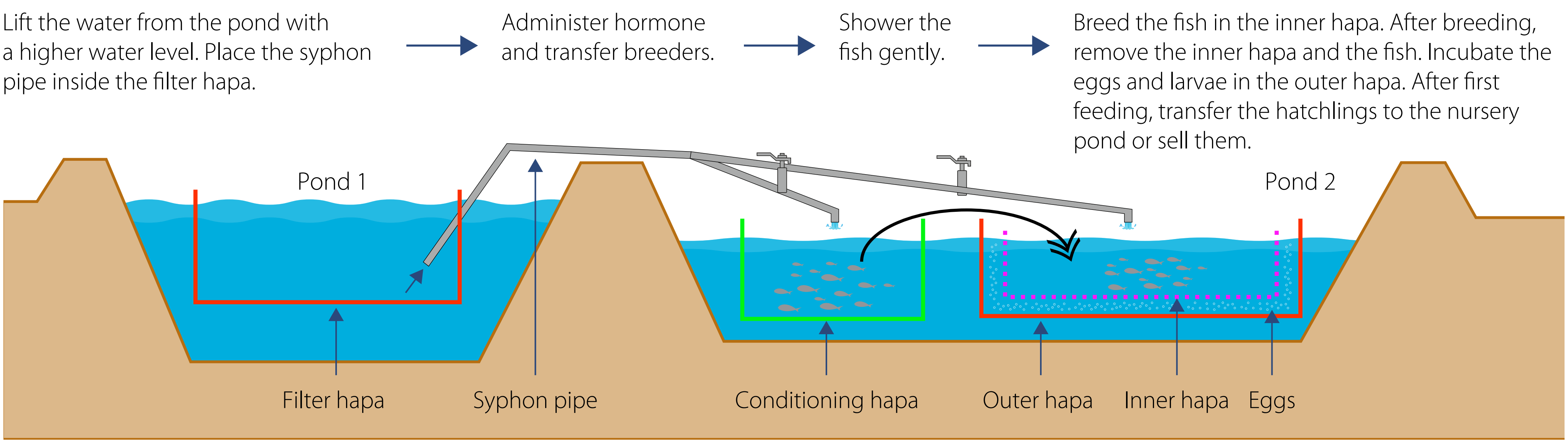

Figure 2. Mobile hatchery for spawning and hatchling production in hapas kept in a pond with water exchange.

Transporting the mobile hatchery, including a diesel pump, in a rickshaw.

Installing the breeding hapa and gravity water supply to the breeding hapa.

Assembling the incubator to hatch reba carp eggs and develop larvae.

Close view of the lower part of the incubator.

Installing a water flow pipe in the incubator. Water is supplied to the incubator via a siphon pipe connected to the reservoir pond

Complete view of an indigenous mobile hatchery system.

Harvesting fertilized reba carp eggs from the breeding hapa.

Transferring fertilized reba carp eggs to the incubator in the nursery pond.

Plate 1. Photo story: Reba carp bred successfully using a portable mobile hatchery in Bangladesh in 1997.

Box 1. Advantages of a small-scale mobile hatchery.

Low installation costs and equipment accessibility	• The system's installation and equipment costs are minimal, allowing small-scale farmers to easily set up the system. • The primary expense lies in procuring a diesel pump, which farmers can alternatively rent.
Mobility and employment opportunities	• Farmers can transport the entire hatchery conveniently with just one rickshaw. • This mobility could potentially foster the emergence of specialized mobile hatchery operators, creating employment opportunities in rural regions.
Simplicity and infrastructure savings	• The system requires only two adjacent ponds, eliminating the need for building overhead water tanks, breeding tanks or hatchery buildings.
Energy efficiency	• No electrical supply is required, as a single diesel pump can effectively supply water from one pond to another
Direct installation in nursery ponds	• Farmers can install a mobile hatchery directly into the nursery pond, eliminating the need to transport hatchlings.
Enhancement of culture-based fisheries	• This system can be done in community mode to enhance self-recruiting and endangered species and to promote culture-based fisheries in reservoirs and wetlands.
Sustainability	• It is water smart, energy saving, climate smart and has a negligible carbon footprint.

2.3. Fiber-reinforced plastic model of a hatchery for small indigenous species

Suitable species

- This hatchery is designed to breed SIS such as mola, pool barb, cotio, darkina and other scattered breeder species.

Design features

- Built using fiber-reinforced plastic (FRP), this rectangular breeding and incubation unit offers durability and versatility.
- The walls and bottom are made of FRP engineered to withstand water pressure at an operational depth of 50 cm, with the capacity for accidental filling up to 60 cm.
- It is imperative to place the tank on a hard platform to prevent damage from the potential movement of moist soil underneath.
- The drain removes effluent efficiently.
- The FRP model SIS hatchery is equipped with both inner and outer hapas to make it easier to handle breeders and hatchlings.
- With its adaptability and utility, farmers can easily integrate it into existing conventional circular carp hatchery facilities.
- It conserves water with a mild water showering system that minimizes water use during the breeding operation.
- It can produce up to a maximum of 1 million mola and other SIS seeds per batch within 1 week's time.

Description

- The FRP model hatchery is 2.5 m long, 1.25 m wide and 0.6 m high. It features a gentle slope of 1 percent at the bottom toward the outlet to facilitate efficient water flow (Figure 3 and Plate 2).
- A 2-inch diameter partially perforated removable polyvinyl chloride (PVC) pipe supports the outlet, ensuring continuous outflow of excess water while preventing breeders from escaping.
- An adjustable outlet is attached outside the unit to maintain the desired water level.
- The top of the unit is fitted with an iron frame to support the inner and outer hapas as well as the showering pipe.
- The inner hapa, made of knotless net materials with a mesh size of 8–10 mm, is suspended inside the outer hapa of 250-µm mesh, maintaining a 3-inch distance from all sides with the support of the iron frame.
- The water showering pipe, crafted from a 1-inch PVC pipe with multiple 1-mm holes, is positioned above the breeding unit, further supported by the iron frame.

Box 2. Advantages of an FRP model SIS hatchery

- It has a water smart design that requires comparatively less water than conventional circular hatchery operations.
- It is cost-effective and durable.
- It takes up minimal space.
- It is easy to incorporate into existing hatchery facilities, promoting efficiency and convenience.

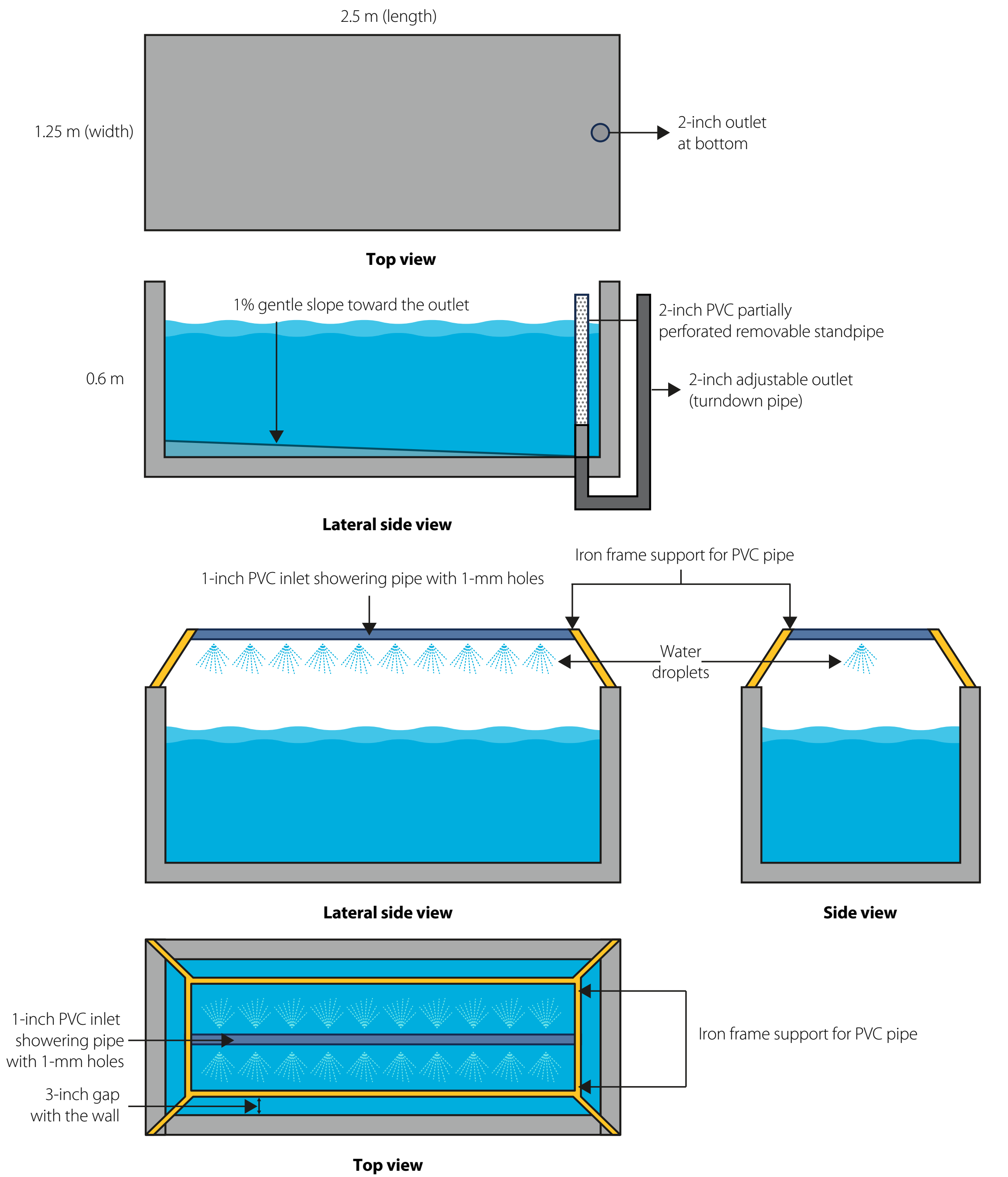

Figure 3. Different views of an FRP model SIS hatchery.

Plate 2. Different views of a FRP model SIS hatchery with hapa arrangement, showering system and cover.

2.4. Mini raceway for induced breeding and fry rearing of catfish

Suitable species

- Mini raceways are suitable for induced breeding and rearing fry (up to 1 g) of indigenous freshwater small catfish species, such as tengra catfish (*Mystus* spp.), walking catfish (*Clarias magur*) and stinging catfish (*Heteropneustes fossilis*). These species produce demersal, adhesive eggs.

Design features

- Depending on the size of the breeders, farmers can employ spawning or stripping methods after administering hormone.
- Adequate space is essential to evenly distribute adhesive eggs on a substrate to prevent mortality caused by oxygen deficiency and fungal infections.
- As such, the raceway design ensures ample space for egg scattering and continuous water flow to mitigate these risks.
- This kind of mini raceway can produce as many as 100,000 hatchlings and 10,000 fry.

Description

- Construct raceways from either galvanized sheets or fiberglass, with dimensions of 200 x 50 x 20 cm (length x width x height). Angle iron structures support the raceway (Figure 4 and Plate 3).
- Shallow water depth helps continuously remove pathogens through water flow from the inlet to outlet, minimizing the chance of water recirculation.
- Water flows unidirectionally, from one end to the other, typically at a rate of 10 L/minute.
- During fry rearing, farmers can spray additional water from a perforated PVC pipe above the raceway.
- A filter net (mesh size 250 µm) at the outlet prevents larvae or fry from escaping.
- The water level is regulated by adjusting the height of the standpipe at the outlet using a PVC pipe.

Incubating the eggs of walking catfish.

Rearing fry from walking catfish.

Plate 3. A mini raceway for breeding small catfish.

- Egg-holding trays, suspended by 2–3 mm galvanized wires, are made from mosquito nets fixed on iron frames. The mesh size is adjusted to prevent the eggs from falling through but allows hatched larvae to descend to the bottom.
- Stripped eggs are evenly sprayed on the trays immediately after fertilization before the adhesive layer develops.
- After hatching, the trays are carefully removed along with any unfertilized eggs and hatched eggshells.

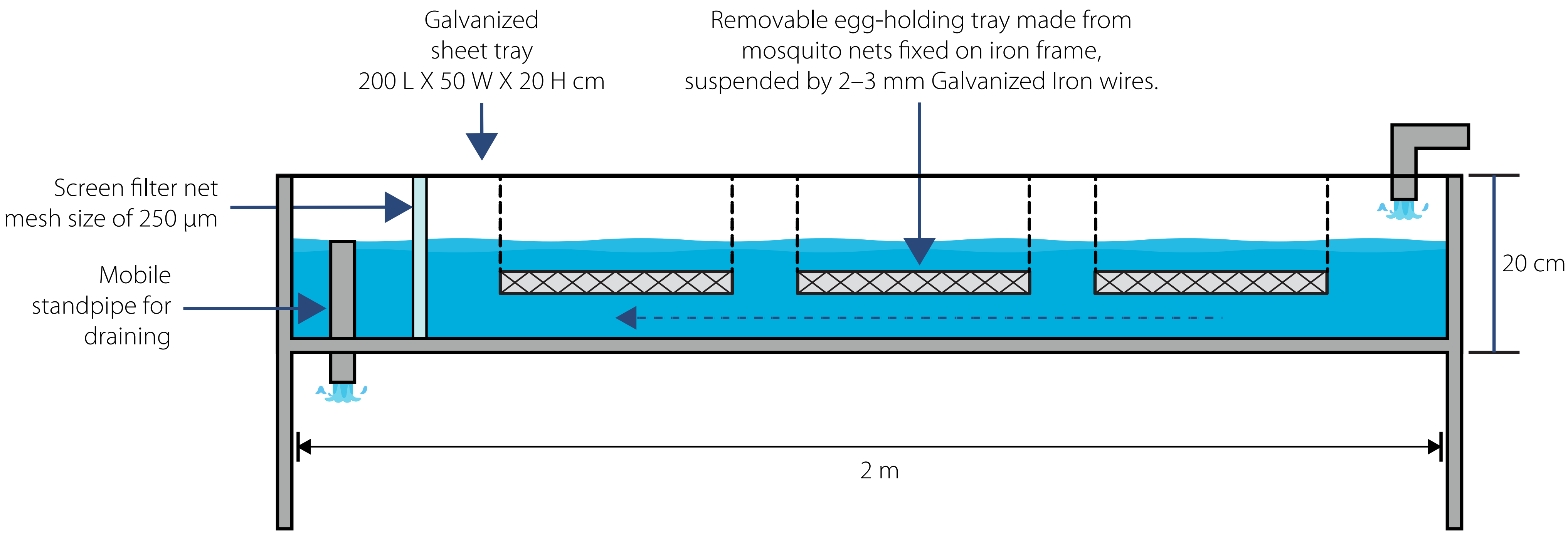

Figure 4. A mini raceway for breeding small catfish.

3. Upgrading the infrastructure of an existing carp hatchery for SIS seed production

To produce mola and other SIS seeds within an existing carp hatchery, several additional facilities are necessary:

- A borewell pump and groundwater lifting source.
- An overhead water reservoir tank.
- Broodstock ponds: Four ponds, each with a water area of 500 m^2, are ideal for supporting 200–300 kg of SIS breeders. The water should be 1–1.5 m deep to develop benthos and plankton. Water supply should primarily come from the borehole, with occasional flushing using surface water during the breeding season for early gonadal development.
- A pond for spent fish: One pond is required to hold hormone-administered breeders for approximately 1 month for recovery. The size of the pond would be similar to a broodstock pond.
- Nursery ponds: Four ponds, each measuring 400 m^2, are needed for optimal conditions. The water depth should not exceed 1.2 m, with water pumped from the borehole.
- A seine net adapted to the width of the pond, with the mesh size of a mosquito net.
- A scoop net with a mesh size of 250 µm.
- Outer hapas with a mesh size of 250 µm, measuring 2.7 m x 1.2 m x 0.6 m (length x width x height).
- Inner hapas with a mesh size of 8–10 mm, measuring 2.5 m x 1 m x 0.6 m (length x width x height).
- An iron frame to support the hapas.
- Diabetic syringes for injecting small fish.

These facilities will ensure the hatchery operates efficiently for SIS seed production.

3.1. A multi-utility breeding and larval rearing tank

Suitable species

- Mola, pool barb, cotio, darkina and other scattered breeder species.

Design features

- The multi-utility tank complex is designed to serve three purposes within a single setup: conditioning brooders, induced breeding, and incubating eggs and larvae. This innovative approach maximizes efficiency and resource use.
- Depending on factors such as temperature, water quality and breeder characteristics, using 1.5–3 kg of mature female mola brooders with a 1:2 female-to-male ratio can yield up to 1 million hatchlings in a single batch from a single tank. This demonstrates the potential for high-volume hatchling production within a compact space.
- To increase the capacity for seed production, farmers can implement a four-tank setup, with two tanks dedicated to conditioning and another two for breeding fish and incubating eggs and larvae for hatchling production.
- Breeding tanks can be strategically positioned to receive a constant shower of oxygen-rich water from an overhead tank equipped with an aeration tower (Section 3.3.). This ensures optimal oxygen levels within the breeding environment, promoting healthy breeding conditions and hatchling development.

Descriptions

- Its internal dimensions are 3 m long x 1.5 m wide x 0.6 m high (Figure 5).
- With a water depth of 50 cm, the tank's water volume at this depth is 2.25 m^3.
- The tank's walls are constructed using locally available 5-inch thick cement blocks or bricks. Cement plastering on both the walls and the bottom ensures a smooth finish.
- The tank's bottom is constructed from a 4-inch thick RCC slab for durability and stability.
- The bottom of the tank has a 1 percent slope toward a removable vertical inner outlet pipe with a 1.5-inch diameter to drain and clean the water quickly and efficiently.
- A "turndown pipe" (1.5 inches in diameter) positioned outside the tank regulates the water depth in the tank.
- The vertical inner outlet pipe has two parts. The upper part is perforated (5 mm in diameter) to prevent fish from escaping when stocked freely in the tank. The lower part is not perforated to keep water in the tank during draining in order to concentrate the fish there for quick harvesting. This removable pipe also prevents the tank from emptying completely, in case of accidental disfunction of the outside turndown pipe.
- The tank has a 1-inch pipe with a gate or bulb valve as the water inlet to fill the tank quickly.
- During operation, a mobile 1-inch diameter horizontal perforated pipe extends the water inlet to ensure showering. The perforations on this pipe have a diameter of 1 mm, allowing for efficient water distribution and water aeration within the tank.
- Depending on the temperature, species and biomass of the fish used, the volume of water supplied to the tank by spraying through the above pipe is between 10 and 20 L/minute.

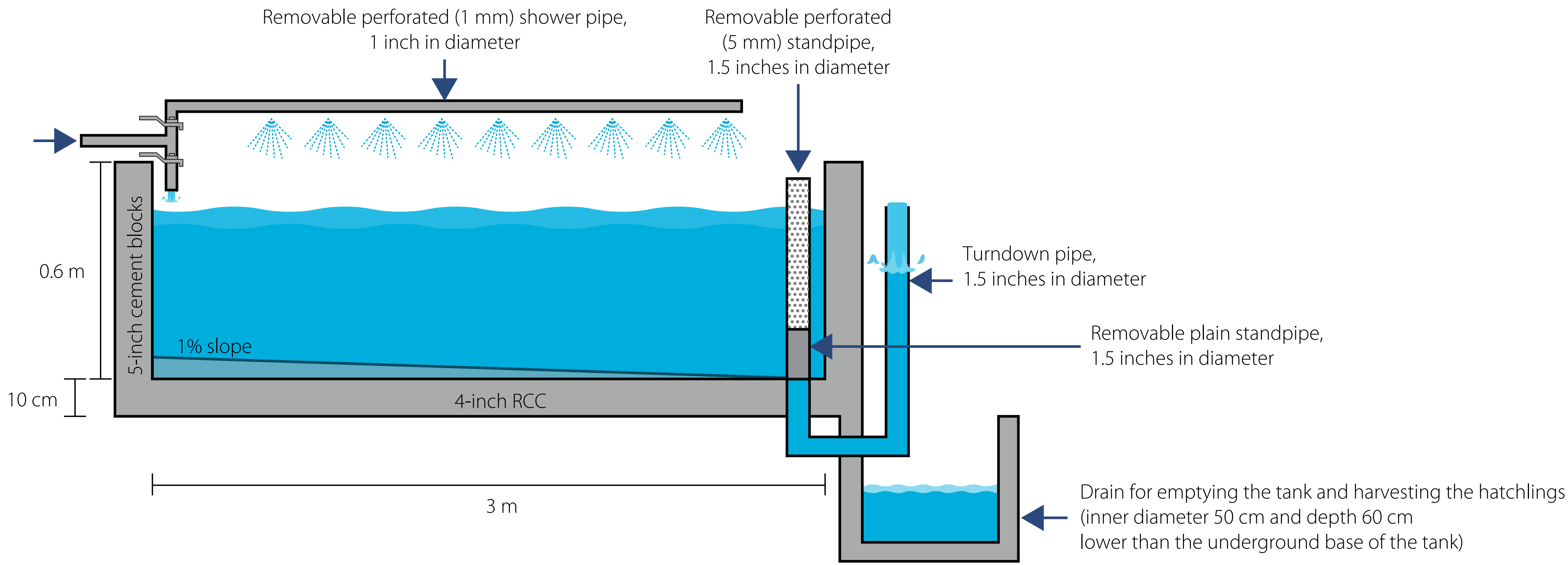

Figure 5. A long section of one multi-utility tank for breeding SIS and rearing larvae.

- Continuous showering imitates heavy rain, which stimulates the final maturation of breeders.
- The dissolved oxygen level in the water should remain close to 100 percent saturation but not less than 80 percent. Farmers can measure this using a sample taken from the outflowing water in the turndown pipe.
- Alternatively, farmers can install a normal showering system at the four corners of the tank for gentle and controlled water spraying.
- The drain efficiently removes effluent, maintaining water quality and cleanliness within the tank. It serves a dual purpose: emptying the tank and harvesting hatchlings. The drain has an inner diameter of 50 cm and extends 60 cm below the tank's underground base.
- It is important to shelter the tank from direct sunlight and ensure a silent environment.

Breeding and hatchling production

- A double hapa system makes the breeding tanks more efficient. Install a 250-µm nylon mesh outer hapa within the tank. Then, position the inner hapa, with a mesh size of 6 to 10 mm, inside the outer hapa using a galvanized iron frame (Figure 6 and Plate 4) (as described in Section 2.1).
- Immediately after administering the required inducing solution during the evening, return the broodfish to the inner hapa.
- The following morning, the eggs will typically be found attached to the lower bottom part and lower lateral side of the 250-µm mesh outer hapa. Remove all breeders from the inner hapa and relocate them to a designated spent brood pond.
- Harvest hatchlings or spawn 60–72 hours after hatching, just before the yolk sac is fully absorbed.
- For details, please follow Gogoi et al. (2023)[1] and Rajts et al. (2023)[2].

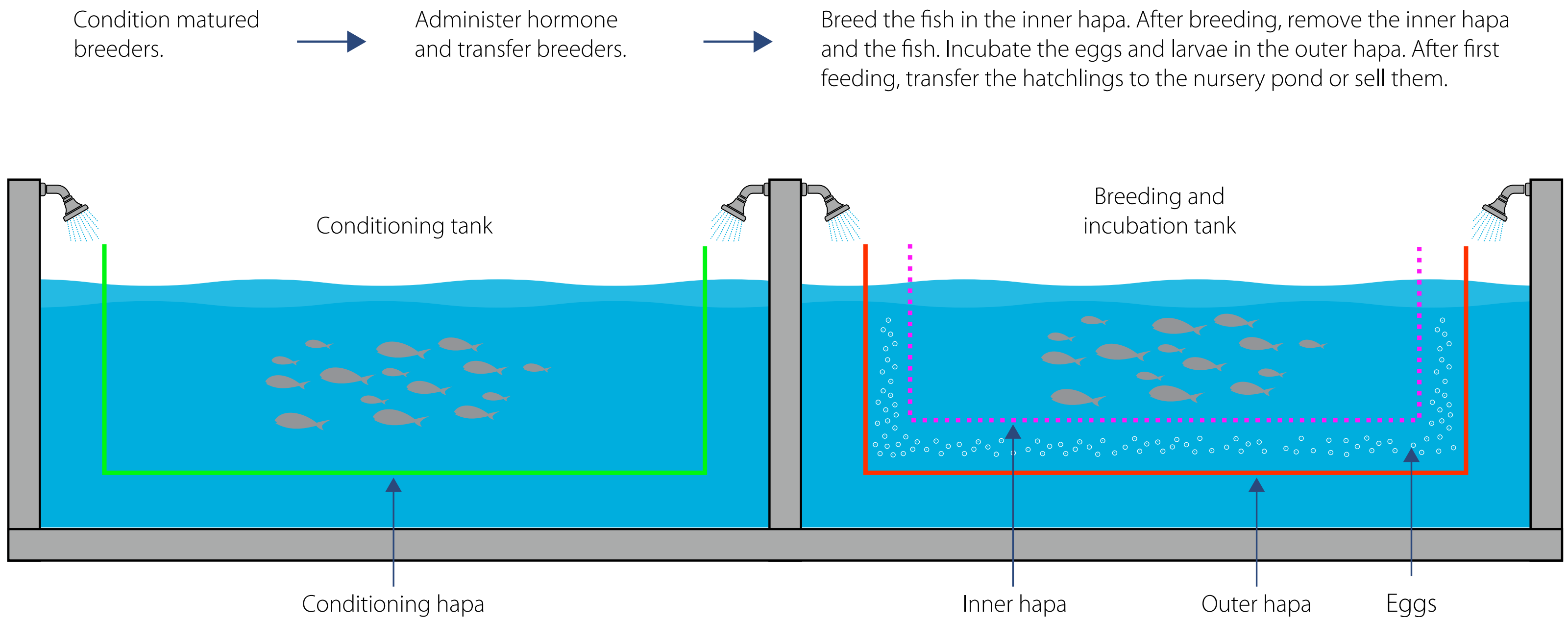

Figure 6. Hapa arrangement for conditioning and induced breeding of SIS in a concrete multi-utility tank.

[1] Rajts F, Dubey SK, Gogoi K, Das RR, Biswal SK, Padiyar AP, Rajendran S, Thilsted SH, Mohan CV and Belton B. 2023. Cracking the code of hatchery-based mass production of mola (*Amblypharyngodon mola*) seed for nutrition-sensitive aquaculture. *Frontiers in Aquaculture*, 2:1271715. https://doi.org/10.3389/faquc.2023.127171

[2] Gogoi K, Rajts F, Das RR, Dubey SK, Padiyar A, Rajendran S, Belton B and Mohan CV. 2023. Induced breeding of mola carplet (*Amblypharyngodon mola*) for mass seed production: A practical guideline. Penang, Malaysia: WorldFish. Guideline: 2023-23. https://hdl.handle.net/20.500.12348/5552

Plate 4. A multi-utility fish breeding and larval rearing tank with hapa arrangements.

3.2. Cylindro-conical incubator

Suitable species

- Reba carp, bata (*Labeo bata*) and other scattered SIS breeders with non-adhesive eggs are ideal for this type of incubator. Additionally, it can accommodate larger species such as Indian major carps.

Design features

- The cylindro-conical incubator, also known as a funnel-type incubator, features a funnel-shaped bottom and a cylindrical wall. It resembles a Zug jar but on a larger scale.
- Typically, eggs and/or larvae are housed within this structure. It has a water-holding capacity of approximately 300 L, with an egg density of up to 4000/L.
- In the case of reba carp, a single cylindro-conical incubator can yield 1.2 million hatchlings.

Description

- After administering hormone and inducing breeding, fertilized eggs are collected from the breeding tank and transferred into the incubator (Figure 7 and Plate 5).
- Water enters from the bottom and exits from the top, generating circulation to keep the eggs and larvae in motion. A filter net, composed of synthetic cloth with a mesh size of about 250 µm, prevents the eggs and larvae from falling through. At the bottom, a weighted rubber ball helps disperse incoming water flowing upward.
- Depending on factors such as temperature, species and egg or larvae biomass, the amount of water required ranges from 10 to 20 L per minute.
- After 3 days, farmers can harvest hatchlings from the top of the structure using a scoop net. For complete harvesting, the bottom pipe opens, making it easy to collect the hatchlings in a bucket.

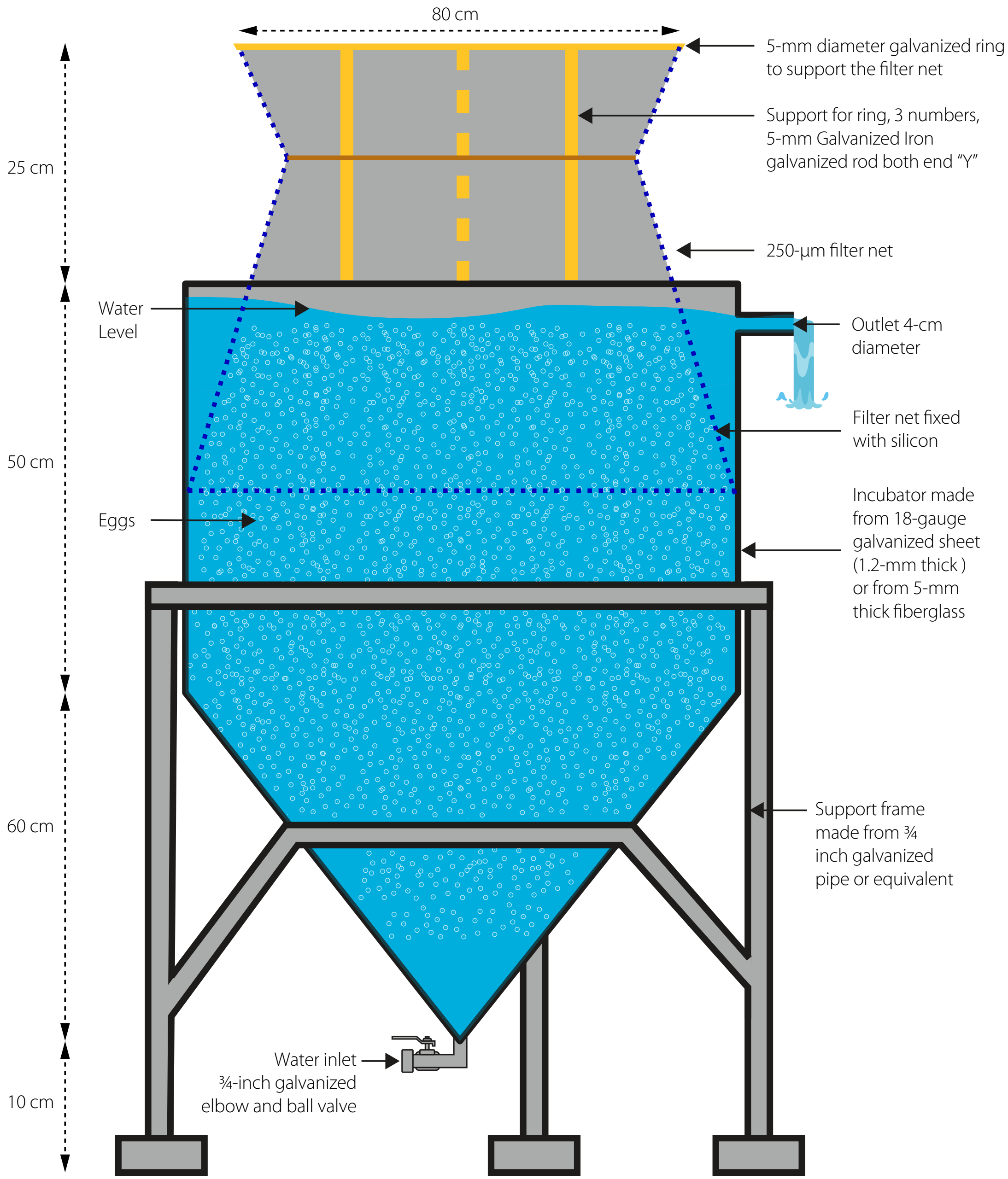

Figure 7. Sketch of a funnel-type incubator (330 L capacity).

Plate 5. Funnel-type incubators.

3.3. Installing an aeration tower

Importance of aeration tower

- Many hatcheries use water from boreholes, typically sourced 50–150 m below the ground. Although groundwater is generally free from harmful bacteria and fish parasites, it often lacks oxygen and contains toxic gases, notably carbon dioxide.
- In the Ganges-Brahmaputra watershed, water from boreholes has been found to have high levels of carbon dioxide, ranging from 30 to 130 mg/L, which is unsuitable for use in a hatchery.
- Adequate dissolved oxygen and lower carbon dioxide levels are essential for successful induced breeding, fertilization, and hatching rates. The presence of carbon dioxide is more harmful than low dissolved oxygen levels.
- Hatchlings transported in well-oxygenated water experience minimal mortalities over longer distances and periods.
- Therefore, in any hatchery setup, including an aeration tower within the overhead water reservoir tank is crucial to maintain optimal dissolved oxygen levels and de-gas groundwater.

Design features

- Water pumped from borewells first passes through the tower, effectively removing toxic gases such as carbon dioxide, ammonia and hydrogen sulphide before reaching the reservoir (Plate 6).
- Additionally, the tower introduces oxygen into the water, ensuring near-saturation levels, which is vital to enhance larval survival rates and hatchery success.
- The effectiveness of the aeration tower depends on factors like droplet size, falling distance, atmospheric pressure, initial gas concentrations and water characteristics.

Description

- The aeration tower is constructed from angle iron and tray-shaped platforms with 10-mm diameter perforations, allowing water to flow at 3 L/minute each (Figure 8 and 9).
- The number of holes on each platform is determined by dividing the total water discharge of the filling pump by 3. Additional platforms may be needed if carbon dioxide levels are too high.
- Ideally, carbon dioxide levels should be higher than 15 mg/L.
- For smaller hatcheries, simpler farm-made aeration setups can be arranged with indigenous technical knowledge, as depicted in Plate 6.

Box 3. Benefits of an aeration tower

An aeration tower offers the significant advantage of eliminating the need for additional aeration systems in the elevated reservoir tank. As water reaches the reservoir, it is automatically fully aerated. In contrast, other systems such as air diffusers, water agitators, and venturi tubes pump water to the reservoir without prior aeration. As a result, some of the water flows directly to the tanks and incubators without sufficient oxygenation or removal of toxic gases. Additionally, these alternative systems require the use of two machines instead of a single pump.

Plate 6. Different types of aeration towers.

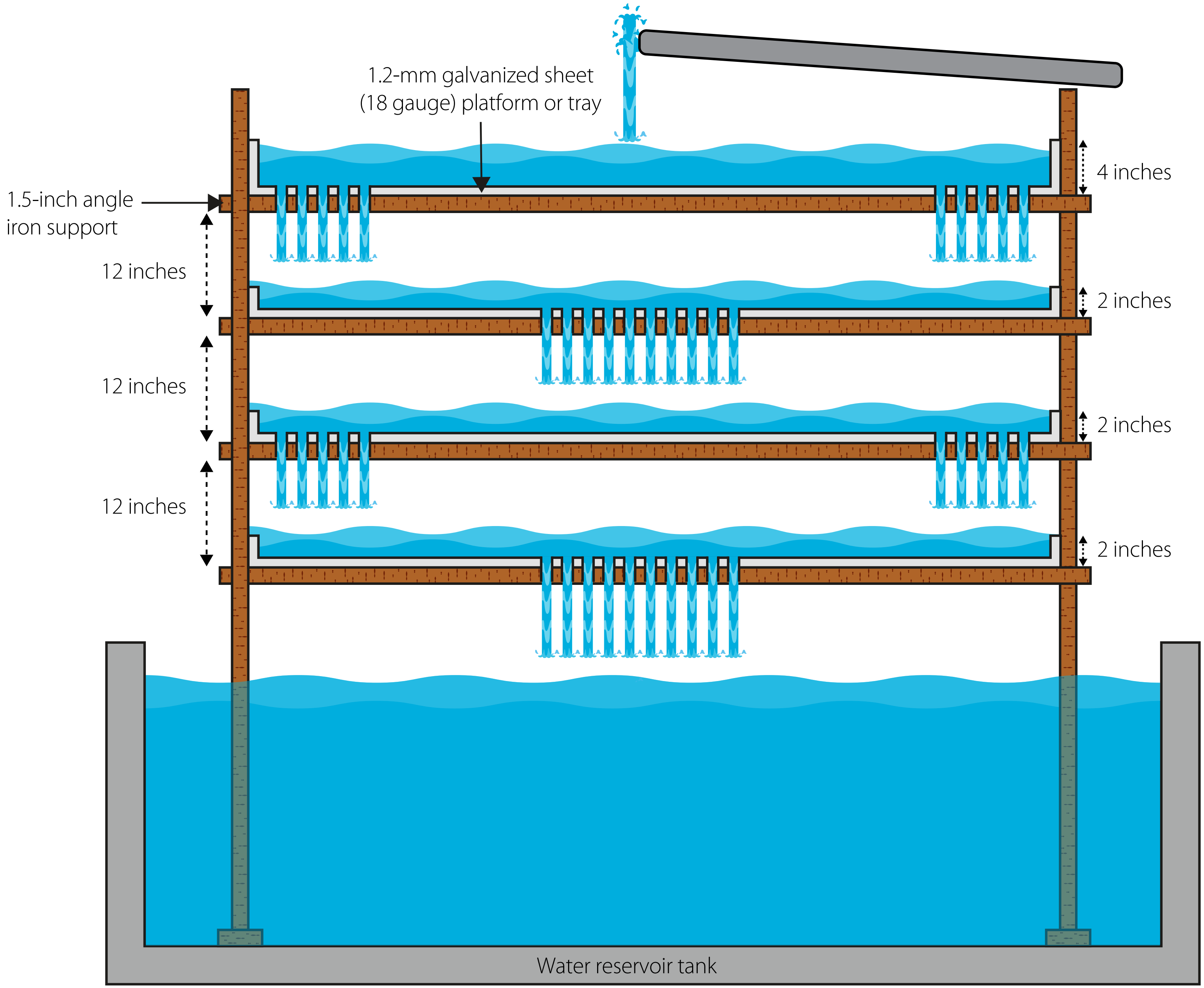

Figure 8. Cross section of an aeration tower structure.

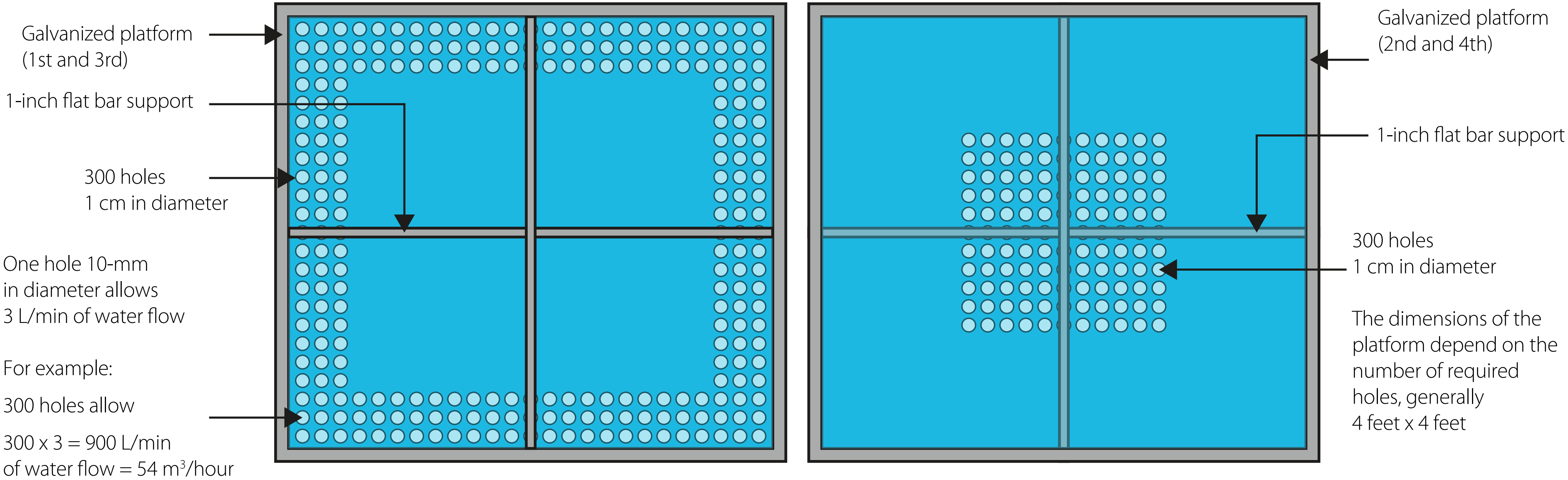

Figure 9. Structure of a galvanized platform or tray of an aeration tower.

About WorldFish

WorldFish is a leading international research organization working to transform aquatic food systems to reduce hunger, malnutrition and poverty. It collaborates with international, regional and national partners to co-develop and deliver scientific innovations, evidence for policy, and knowledge to enable equitable and inclusive impact for millions who depend on fish for their livelihoods. As a member of CGIAR, WorldFish contributes to building a food- and nutrition-secure future and restoring natural resources. Headquartered in Penang, Malaysia, with country offices across Africa, Asia and the Pacific, WorldFish strives to create resilient and inclusive food systems for shared prosperity.

For more information, please visit www.worldfishcenter.org