FINAL TECHNICAL REPORT / RAPPORT TECHNIQUE FINAL

ANNEX 12A - UPDATED PROTOCOL AND TECHNICAL GUIDELINES FOR FISH HATCHERIES

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IDRC Grant / Subvention du CRDI: 107982-001-Scale Up of Homestead Food Production for Improved Nutrition in Cambodia (CIFSRF Phase 2)

Refined Protocol and Technical Guidelines for Hatchery

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1. Introduction

Fish hatcheries are used to aid in the breeding, hatching and rearing of fish through the early stages of life. They consist of a concrete cement tank system, a breeding tank and an incubating tank, which includes a water inlet and outlet system, and are constructed to enhance the mating process, produce more fish and increase production. Fish hatcheries can ensure a sustainable supply of fingerlings at the community level. Considering local demand, HKI and Fisheries Administration (FIA), Ministry of Agriculture, Forestry and Fisheries (MAFF) promoted fish hatcheries for fingerling production, starting with the Fish on Farms (FOF) program and expanding to the Family Farms for the Future (FF4F) project.

The development of a network of private sector fish hatcheries at the local level is important to support the growth of household level aquaculture production. Recognizing this, our team established ten fish hatcheries in the FOF and FF4F project areas. Here, local fish fingerling producers were encouraged and trained to supply large quantities of fingerling to local farmers and to educate farmers on small-scale aquaculture. The ten hatcheries supported by the project are functioning well and have been successful in ensuring a local supply of fingerlings for targeted and non-targeted households in those target provinces (Prey Veng, Kampong Cham and Kampot). Establishing fish hatcheries through a cost-share model proved to be a highly successful component of the project, as they became profitable within the program period. This has opened the door for expansion and supports the Cambodian government's '**Hatchery per Commune'** and **'Pond per Farm'** strategy.

2. Role and Importance of Hatcheries

Establishing Village Fish Hatcheries (VFH) in rural areas is strongly supported by the FIA of the Ministry of Agriculture, Forestry and Fisheries as a response to the Cambodian Government policy promoting aquaculture development and production, particularly in rural and low fish consumption areas. Following this strategy, FIA aimed to establish one VFH in each commune to produce and supply fish fingerlings to meet demand of fish farmers in the area. This VFH has not only minimizes the need for farmers to buy fingerlings from far away markets, but also serves as resources for farmers, holding demonstrations and transferring fish culture technologies to rural households.

3. Functions of the Fish Hatchery

Fish hatcheries serve to produce hatchlings (young fish) from brood fish (mature males and females) by using the cement breeding and incubating tanks. The hatchlings are then transferred to earthen ponds until they mature. The main functions of the hatcheries established in FF4F project are below:

- Providing fingerlings at the local level
- Reducing fingerling mortality (due to short distance of transportation)
- Reducing the cost of transportation of fingerlings
- Increasing different species of fingerlings available to households
- Increasing technical knowledge about and capacity to use hatcheries at the household level
- Providing an example for fish hatchery production that is geographically accessible

4. Hatchery Farmer Selection

Selection of the hatchery farmer or family is very important. In FF4F project, several meetings with the possible families were conducted to assess compatibility with selection criteria and their willingness, skill and experience, economic status and the facilities and resources available to them. Detailed discussions with interested households (including separate conversations with key household members) were also conducted to observe their impressions of the fish production process, willingness to invest resources in a fish hatchery, access to micro-credit if needed, and availability of time and human resources to operate the hatchery. Internal meetings with project partners to review and decide on households to choose, after which contracts were prepared and signed by involved parties.

Below are the main criteria for the selection of hatchery farmers in the FF4F project:

- Be interested and have some experience with fish and fingerling production
- Be economically investable
- Have at least 1 to 2 existing ponds
- Have sufficient flood-free land for the hatchery, in a highland area but close to water source for expanding ponds
- Have sufficient time and family labor available
- Be willing to follow the necessary technical guidance
- Be located near the center of the target village(s)
- Have access to credit if required, or be able to mobilize resources to establish hatchery

Additionally, a reliable water source is very important for fish hatcheries. This may be an irrigation canal, river, creek, reservoir, lake, spring, rainwater or a well. As well as the availability of the water source, water and soil quality must also be considered, as temperature, color, smell, turbidity, pH, dissolved oxygen and free carbon dioxide affect hatchery success. To assess water and soil quality, observations were conducted of existing ponds and other available lands areas close to the farmer’s house for establishing new fish ponds.

5. Numbers of Fish Hatcheries Established in FF4F Project

By using environmentally friendly practices and locally available materials, we were able to support the development of four new hatcheries and renovate four existing ones, on the condition that they supply an initial stock of fingerlings to project households involved in aquaculture. The return on investment from these hatcheries has been tremendous, as they have become microenterprises serving as distribution sites for fingerlings for both targeted and non-targeted households, as well as information centers for farmers interested in small-scale aquaculture. In the last year alone, these hatcheries have produced and sold more than 1 million fingerlings (2017) to project households and community members.

6. Cost Sharing

Average cost for the establishment of each fish hatchery was $3,500. Each hatchery received $1,000 from HKI as a loan, which they paid back to project in the form of fingerlings.

7. Environmental Impact Assessment

An Environmental Impact Assessment (EIA) was conducted by an external and independent conultant to assess the environmental effects of the renovation and construction of fish ponds. The EIA consultant visited all the eight fish hatcheries to assess the environmental impact of the program in the project area, considering the recommended minimum size of the hatchery for this project. She also visited fish hatcheries to assess the risks of releasing pollution into nearby water bodies. The consultant prepared an environmental assessment and screening report, which was used to improve program design.

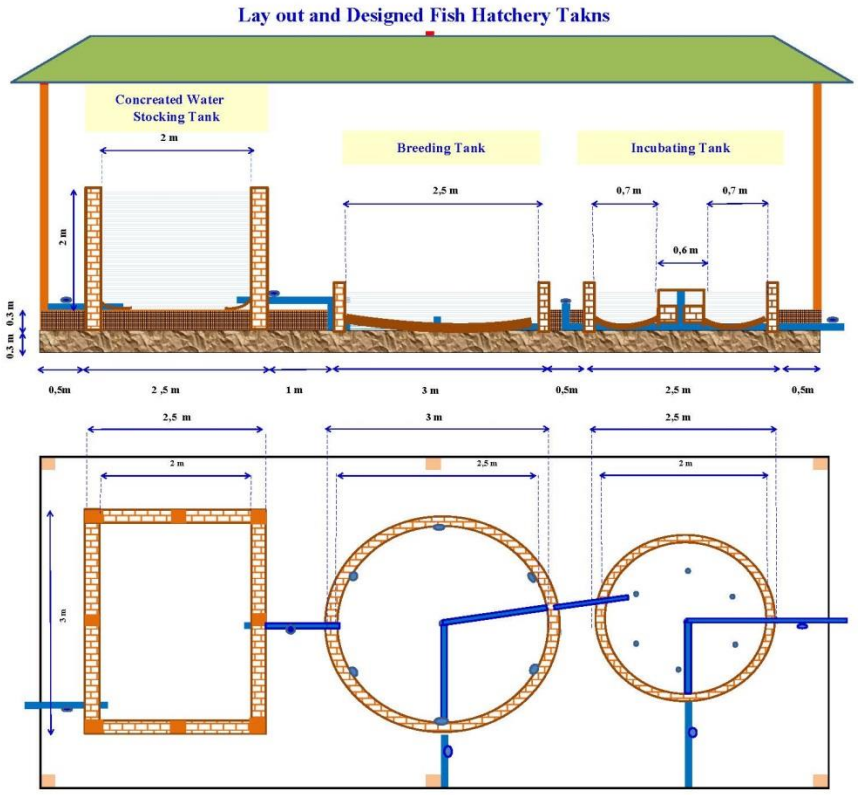
8. Required Materials for Hatchery Operation

The following materials were used in the establishment of VFHs:

- Small mesh nylon net for screening the nursery ponds (size and quantity to depend on numbers and size fish ponds of the target farmers)
- Hapas for the temporary stocking of brood fish or fish eggs before, during or after catching, breeding, nursing and harvesting fish eggs. The size of Hapa should be between 1.5m by 2.5m with 1m depth and 2m by 3m with 1m depth, depending on size of farmer's fish ponds. Each target farmer should have 2 sets of each Hapa size for more effective VFH operation
- Two drag nets (for brood fish and fingerling), if possible
- PVC pipes (70-80 m)
- Breeding hormones
- Brood fish (30kg)
- Scale for weighing the brood fish before injection
- Fish feed
- Oxygen bottle/cylinder

- Battery
- A set of air pumps for breeding and incubation
- A set of water pumps for pumping water in and out of fish ponds and hatchery

9. Hatchery Layout and Design



10. Components of Fish Hatchery

The fish hatchery system includes an overhead tank, breeding tank, hatching tank, nursery tank, filter tank and a set of inlet and outlet water systems connecting all the hatchery tanks. Additional materials used to operate the fish hatchery include a filter tank, water source, water pump, air pump, hapas, fish nets, brood fish, and hormones. Filter tanks are a required component of all fish hatcheries, as often the quality of water sources is not sufficient, particularly if it is turbid, green in color, or contains too much plankton, as low quality water can increase fish egg and hatchling mortality. In rural areas, rain water retained by farmers in earthen ponds is generally sufficient as a water supply, but sometimes other sources are needed, such as ground water and nearby public water canals or lakes.

Other necessary materials for VFHs include water pumps, air pumps, hapas, fish nets, brood fish, hormones and fish ponds themselves (to rear brood fish and fish eggs). For small scale fish hatchery farmers, at least 4 fish ponds should be used to produce the fish eggs, with dimensions of at least $100m^2$. More fish ponds lead to increased fish egg production, and a hatchery with at least 6 fish ponds of $150m^2$ can produce 20,000 to 50,000 fish eggs a year.

11. Hatchery Construction

Cement fish hatchery tank systems should constructed on high ground to avoid flooding, as well as close to the farmer's house and to a water source. The fish hatchery includes a water head tank, a breeding tank and an incubating tank with a water inlet and outlet system. For small-scale fish hatcheries, the dimension of land should be around 5m wide and 10m long. For hatchery farmers with larger budgets, dimensions can be up to 15m longer. For both, an extra 5m length of land is used to construct 2 cement rectangular tanks sized 2m by 3m for conditioning brood fish before breeding, and fingerlings before selling. Hatchery construction followed the below steps:

- A roof for the fish hatchery should be constructed to protect the hatchery from rain and heat. This will cover total surface of 5m by 10m of the fish hatchery, and may be made of sugar palm leaves, as they are cheap, sustainable, available in the rural areas and can be used for at least 3 years.

- The bottom surface of the fish hatchery is then constructed with cement, gravel and iron. It is to be at least 20cm thick, but 50cm thick at the bottom surface of water head tank to make it strong. Before construction, the water head tank, a breeding tank, an incubating tank and a set of water inlet and outlet system must be designed and marked on the bottom surface. Then, the water PVC pipes for the water inlet and outlet system can be set up in the cement bottom surface.

- The water head tank used is to store clean and safe water before use in the breeding and incubating tanks system. It should be constructed with iron and gravels in the ground, and with 4 sides of the tank walls in order to store a total water volume of $12m^3$. Total volume can be lesser than $12m^3$ of depending on budget of fish hatchery farmer.

- After the water head tank construction, a breeding tank is to be constructed, consisting of a round wall tank made of brick. The diameter of the round breeding tank should be between 2m to 3m, depending on the budget of fish hatchery farmer, with bigger sizes leading to increased production. The bottom of the breeding tank is sloped to the middle part so water can flow out of the tank during the fish breeding operation. In the middle part of brick wall, 4 to 6 holes are connected by PVC pipes to form the water inlet pipe system. In the middle part of the tank, the bottom is connected with a PVC pipe to form water outlet pipe system.

- The incubating tank is then constructed, consisting of a round wall tank made of brick. The dimension of the incubating tank is smaller than the breeding tank, with a diameter between 1.5m to 2m depending on the budget of fish hatchery farmer. The incubating tank is sloped to the middle so that water can flow around the tank during the fish egg incubating process. In the bottom of the incubating tank, 4 to 6 holes are connected by PVC pipes to form the water inlet pipe system. In the middle part of the tank, the bottom is connected with a PVC pipe to form water outlet pipe system.

- For hatchery farmers with larger budgets, 2 more cement rectangular tanks sized 2m by 3m can be constructed to condition brood fish before breeding, and fingerlings before selling. These two cement rectangular tanks are made of bricks and cement as well.

All parts of fish farms (fish ponds as well as the hatchery) have to be raised above the embankment to avoid flooding during raining season. In general, all fish ponds contain fish predators that can decrease fish egg production. Fish hatchery farmers can place mosquito nets around fish nursing ponds to decrease the effecs of predators and increase survival rate of fish eggs. Furthermore, water quality is also more important for fish eggs to grow. To avoid turbidity of pond water, grass on the fish ponds' dike is required, but in the middle part of the ponds' dike should be used to grow vegetables.

11. Fingerling Production and Nursing

For the fish species mentioned, fish eggs can be produced in the hatchery, and can be raised in fish ponds by using local agriculture products, such as rice or broken rice, soya bean, corn, and cassava. First, fish eggs are produced from the fish hatchery, which takes 2 to 3 days (including nursing by feeding the fish the cooked yolks of duck eggs) and then transferred to earthen fish ponds for further nursing for 3 months. In this step, fish hatchlings can have a survival rate of 30% of total fertilized fish eggs, depending on hatchery management.

Next, all the fish hatchlings are transferred into earthen fish ponds and fed 3 to 4 times a day for two weeks. Feed consists of 50% fish powder and 50% rice, with or without cooked yolk duck egg. During this nursing period, fish eggs should be screened every 2 to 4 weeks in order to get same size of fish eggs and ensure fast growth and a high survival rate. In both steps, high water quality in the fish nursing ponds is vital for fish growth and survival.

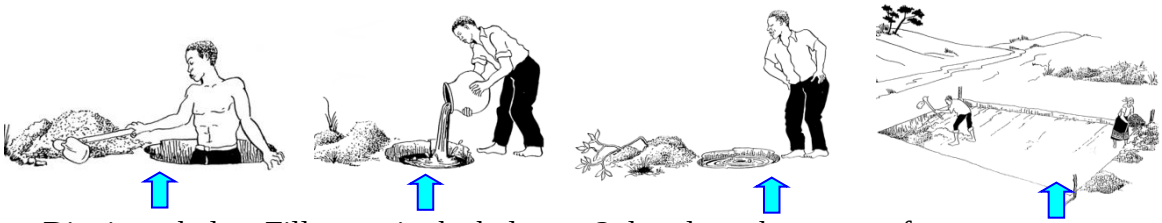
12. Soil Treatment

The site for fish hatchery farm construction should be selected close to the family's house and in a highland area so that it is easy to manage and flooding is

avoided during raining season. Soil in the construction area should be hard, if possible, but any kinds of soil can be used except mud or silt soil.

As for fish pond construction for the rearing brood fish and fish eggs, soil should be of good quality to avoid absorbing acidity or other toxicants. Good quality soil should contain a high percentage of clay so that water can be retained for 6 to 8 months. Clay with alluvial soil (fertile soil) is ideal for nursing fish eggs, as it can retain water for long periods and adds to the fertility of the fish pond. Before digging a new fish pond, the soil should be tested, following the steps below:

- Dig a hole with a diameter of 0.6m and a depth of 0.8m. Fill this in with water and wait for 1 to 2 days. If some water remains in the hole, then the soil is good for digging a pond. See diagram below.



Digging a hole Fill water in the hole 2 days later, has some of water
Appropriate to dig pond

13. Embankment and Dike Preparation

A good fish farm should be safe from flooding, so must be constructed with a strong embankment surrounding the fish farm. If possible, the embankment should not only be solid, but also bigger than the fish pond dike, where farmers can grow vegetable their own consumption and income. Trees should not be planted here as they can harm the embankment over time, but grass should be planted on the slope of the embankment in order to avoid erosion. As for the dikes, for all fish ponds connected to each other should not be less than 2 meters to avoid erosion.

14. Boundary and Screening Construction

To increase fish production, all nursing ponds should be screened with small mesh nylon nets in order to avoid fish predators jumping into fish ponds and eating smaller fish and fish eggs. To screen the fish nursing pond effectively, besides the small mesh nylon nets, the following materials are used:

- Wooden or bamboo posts – number depends on size of the whole fish ponds, availability in community, and cost
- Strings for tying the small mesh nylon nets to the posts

- Axe and hoe for preparing the screen surrounding the fish pond

To screen the fish nursing pond effectively, the following steps should be taken to prepare a nylon net screen around the fish pond at 0.8m high:

- Prepare the small mesh nylon nets, ensuring they are 1m tall, with length depending on the size of the fish pond (for 150 m^2 of pond, total length of the small mesh nylon nets should be 56m)
- At 0.5m from edge of fish pond, farmer should dig small trench (0.2m deep) surrounding the fish pond
- In intervals of 1 to 2m (depending on individual farmers) in the dug trench, farmers should dig holes and put the wooden or bamboo posts into each
- After placing poles in all the dug holes, farmers should place the small mesh nylon nets, with the bottom part placed in the dug trench, buried, and tied to the post with string

15. Fish Feed Preparation and Use

There are two different kinds of fish feed, one for nursing brood fish and another one for nursing fish eggs. For rural hatchling and egg production, agricultural products with high protein levels, such as rice bran, broken rice, soya bean, soil bean, corn, or discarded fish, are the main ingredient for making fish food. Other live feeds such as termites, earthworms, insects, and other waste vegetables can also be used if available. These are fed to the fish in addition to the naturally occurring plankton that the fish consume.

For nursing fish eggs, organic manures including the dung of cows, buffalos, pigs, chickens, ducks and other green manures are good fertilizers for fish ponds, and are available, accessible and money-saving for rural farmers. These organic manures can be used as feed for fish because of the application of all these organic manures for fish pond increases plankton in fish pond, which serve as an important source of food for fish eggs. However, application of additional feeds as mentioned above is still necessary to speed up growth rate of brood fish and fish eggs. The below table shows various feed options for small and large fish.

No.	Description	1st Option (protein 34%; for feeding small fish)	2nd Option (protein 28%; for feeding large fish)
		(%)	(%)
1	Rice bran	50	60
2	Broken rice	5	5
3	Soya-bean powder	5	15
4	Fish powder	40	20
	Total	**100**	**100**

All the 4 different fish feed raw materials should be cooked together but only up to one day in advance, as food quality decreases over time. As mentioned in the above table, all four raw materials should be prepared so that protein content is

below 30% for brood fish, and between 30% to 40% for nursing fish eggs, depending on fish species. If possible, some farmers can use dried fish pellets sold in markets to feed brood fish and fish eggs, even though they have the same percent of protein. More technical guidelines for feeding fish are as follows:

- Use one or two plastic or bamboo buckets, depending on numbers of fish, as feeding trays for feed. The cooked feeds are wet and should be placed in the feeding tray then submerged in the pond at 0.2-0.3m below surface level, so that feeding can be observed.
- Always feed the fish at the same time of day and in the same area of the pond, so that the fish know where to get food and their feeding and growth can be observed.
- For brood fish, feeding rate is between 3% to 5% of the fish's body weight per day. They should be fed at this rate from October to December, then feed quantity should be reduced to 2% to 3% from January until the breeding period. This prevents female brood fish gaining too much weight, which can negatively impact egg production.
- For nursing fish eggs, the feeding rate is between 8% to 10% of the total fish body weight per day.
- Small fish and fish eggs have normally required lower food quantities than large fish, but they needed higher protein than large fish to enhance health and growth.
- Do not overfeed the fish, as too much food will lead to excessive weight gain or be wasted, with decaying food using up valuable oxygen in the pond. Provide only appropriate amounts of food, calculated based on the total fish body weight.
- The amount of food can be tweaked based on observation - if the fish seem to be waiting near the surface in the feeding area, more food is required.
- Younger or small fish need less food. Farmers are wise to start with a smaller amount of food estimated, then increase food amounts as needed.
- Additional foods should be supplied at least 2 times a day for larger fish and 3-4 times for smaller fish. Feeding should take place in the morning and the afternoon, when the sun is shining brightly. Do not feed fish early morning, or before, during and after raining, as oxygen and pH in the pond are reduced at that time. The feeding should be provided after sun is shining as oxygen contents are increasing, as this is the ideal time for fish to eat.
- If the color of the pond water turns to deep green, feed application should be decreased or stopped momentarily and pond water should be changed to ensure it is safe and clean.

17. **Fish Species Selection**

Tilapia and Common Carp are the best fish species to use, and 3 other species will also be available as it is easy to produce fingerlings and production is almost the same. Note that Tilapia eats small baby fish. We will continue to encourage small fish farming, and farmers will choose which large species they would like to farm. Five different large

species can coexist in a pond and consume all the kinds of feed in the three levels of water, increasing efficiency during feeding. During the training, farmers will be asked to adhere to the following percentages of different kinds of fish: Common Carp (5-10%), Silver Barb and Tilapia (30%), Rohu and Mrigal (15%).

18. Brood Fish Management and Communicable Diseases

Brood fish are important in fish egg production, as they greatly affect the quantities and quality of fish eggs. For ideal fish egg production, brood fish nursing must be closely monitored, ensuring they are healthy in order to increase production and quality of fish eggs. Here, farmers should avoid inbreeding of brood fish, as it slows growth and decreases egg survival rate. Steps should also be taken to avoid disease outbreaks, and to ensure fish eggs are produced early in the rainy season to increase production. These will result in higher quality and safety of the farmed fish when harvested. To achieve these goals, brood fish management should focus on the following points:

- **Sources of brood fish:** Brood fish must be selected carefully to avoid communicable diseases and to ensure healthy fish. The egg station should be reputable and the fish of high quality and health.
- **Brood fish transportation:** Transportation of purchased fish must be careful. The day before, fish should not be fed to avoid defecation in the transporting containers, as this can increase mortality during or after transport.
- **Brood fish operation:** All brood fish should be used for breeding for a maximum of 3 years in order to avoid inbreeding, as this slows growth and decreases the survival rate of next generation of eggs. After each breeding season, brood fish should be stocked in a separate pond for rearing.
- **Number and size of ponds:** For good brood fish management, at least 2 fish ponds should be prepared well for nursing the male and female fish separately. If possible, each pond should be at least 200 m^2 (10m by 20m) and 2 meter depth in depth. This size can stock 100 to 200 brood fish, with a maximum stocking density between 1 to 2 fish per m^2.
- **Pond construction:** Ponds should be constructed with proper slopes and embankment, the latter of which should be grassy and used for vegetable farming. This prevents flooding and erosion during rainy season, which can harm pond water quality and increase turbidity.
- **Water quality and quantity:** Pond water should be constantly monitored and changed, particularly when fish pond water is turbid and green. New water should be supplied adequately, otherwise brood fish will become stressed from lack of oxygen and overheating.
- **Feed quality and quantity:** Feed must be prepared applied correctly following the technical advice as mentioned above.
- **Catching fish:** When selecting fish for breeding, brood fish should be carefully net-caught from the ponds to prevent harm.