Final Technical Report

Piloting floating cage aquageoponics system in polders: an innovation to increase fish and vegetable production in polder based farming system
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Disclaimer:

These are the views and expressions of the author, and do not necessarily represent the view of the Netherlands Embassy in Dhaka or the Blue Gold program.
Executive summary

Aquageoponics is an economically viable and environmentally responsible system for coproduction of fish and vegetables in vulnerable coastal aquatic environment. Aquageoponics and similar other farming solutions can bring revolution in future sustainable farming as it has the potential to give access to water body for the poor and commercial entrepreneurs, control water pollution during intensification. Aiming to develop a viable business model of integrated floating cage aquageoponics system (IFCAS) for salinity affected people in coastal Bangladesh, 35 cages were installed mostly in canals and some ponds within polder based aquatic system of Satkhira district with 30 participants (includes male & female) in three business groups. In business modeling different combination of aquageoponics larger cages (9m$^3$) and non-aqua geoponics, smaller cages (1m$^3$) were used to understand benefits of multiple combination of cages or farm units. The main researchable issue was to understand the economic viability of the IFCAS system in salinity affected coastal areas and risk mitigation strategies for entrepreneurs.

Three groups of poorer households were mobilized to develop entrepreneurial capacity to run such business. Three groups were designated as Micro, Small and Medium. The Micro Group started the enterprise with five larger aquageoponics cages and five smaller cages, the Small Group had five larger cages and ten small cages and the Medium Group had only ten aquageoponics larger cages with no small cages.

In one cubic meter small cages and nine cubic meter larger aquageoponics cages mono sex Tilapia and Climbing perch (Koi-Bangla name of the fish) was stocked at 200 per cubic meter in two cycles. In larger nine cubic meter aquageoponics cages mono sex Tilapia (in separate cages) was stocked at 200 fish/cubic meter in 1st cycle which was adapted to 150/cubic meter in the second cycle along with Koi. Mega grower floating feed was applied at 3% of the fish body weight two times daily which was adapted as per feeding need. The first cycle was between July to October and the second cycle was between November to February 2017. It was found that within three months’ farmers can harvest 114 kg of climbing perch (koi fish) worth 17700 BDT (221 USD) from a nine cubic meter cage and for tilapia 133 kg of fish worth 9542 BDT (119 USD) which was highest 182 kg of fish per larger cage. The cost benefit ratio was 1:1.75 for both fish. It was higher in case of climbing perch (Koi).
Total 120 sponge gourds and bottle gourd saplings were planted in 40 tubs floated with 20 larger cages (two tubs per cage) in 1st cycle. In the second cycle, only 120 bottle gourds were planted in 40 tubs. Two kg of vermi-compost was applied per two tubs in a cage in each cycle, which was same for both cycles. Additionally, 25 g urea per tub was applied only in second cycle. No significant irrigation effort was required as the roots touched the cage water. At harvest, bottle gourd was found suitable for both summer and winter; sponge gourd was suitable for only in summer. Average vegetable production per cage was 16 kg per cycle where bottle gourd was more than two third. Produced vegetables were considered fresh and pesticide free and mostly consumed by the households.

**Our pilot investigation confirmed that the business case was profitable with in two cycles where the 1st cycle was the breakeven point.** Once the system is installed only around 9000 BDT (115 USD) was required for running each cycle of a unit. If entrepreneurs can manage year round water in deeper canals 3 cycles of production is possible. The option has greater benefit compare to other options in terms of accessing water body for the poor, quick return and maximum utilization of available space. It was recommended that the options can be replicated in other suitable polders in an appropriate scale without interrupting water flow in the canal. It has also potential to scale in water logged areas. Access to commercial finance from Banks can be further investigated. Main challenges experienced were getting year-round water availability, reducing feed and cage construction cost to get higher profit. Providing protection from crab, finding cheaper and stronger cage construction materials and security issues also can be investigated further.
1. Background

Coastal area of Bangladesh covers 32% of the country and accommodates more than 35 million people. We have got 139 polders in 60’s while constructing coastal embankments. A polder is a low-lying tract of land enclosed by embankments. These polders are supporting the livelihoods of around 8 million people – an important resource base for integrated aquaculture-agricultural production and business, need better management.

A significant proportion of soil and water in the entire coastal belt is affected by different degree of salinity. Salinity causes unfavourable environment that restrict the normal crop, vegetable and freshwater fish production in these areas. It also limits the access to waterbodies for the poor. Due to salinity, shrimp farming increased but farmers are struggling to farm other diversified fish species like tilapia, climbing perch, sea bass etc. In some places, low land goes under water, and vegetable can only be grown in raised dykes or floating beds. In such context, aquageoponics and floating cage aquaculture can bring a new hope for entrepreneurs to farm fish and vegetable together in such marginal environment.

Aquageoponics and similar other techniques like hydroponics, aquaponics have great potential for sustainable farming in such areas. The aquageoponics system is a remarkable innovation which allows to farm fish and vegetable together. A cage is constructed under this system where the vegetable is planted in an attached floating tub and the fish is farmed inside the cage in water. The vegetable cultivation process purifies water and the waste produced by farmed fish, supplies nutrients for the vegetable. Many of the development effort failed in the past without having clear idea on its business proof. Therefore, the current pilot aimed to investigate the business model of the floating cage aquageoponics solution in salinity affected polder areas.

The main researchable issues were:

- Does IFCAS system is economically viable in salinity affected coastal areas?
- What would be the risk mitigation strategies for entrepreneurs?

The goal, purpose and outcomes of the project was (Box1):
2. Methods and Approach

2.1 Applying a business development lens:

A cluster based group approach was followed in two canal and few pond sites where participants had their designated individual cages (large and small cage). All the members of the pilot were from Blue Gold Water Management Group of the polder canals. They were grouped in three as Micro, Small and Medium Group. Each group had 5 male and 5 female members. The Micro Group started the enterprise with five larger aquageoponics cages and five smaller cages, the Small Group had five larger cages and ten small cages and the Medium Group had only ten aquageoponics larger cages with no small cages.

The investigations framework followed a business development approach, which focused key aspects of business such as - 1) clear understanding on cost structure and revenue of the product and services 2) strong validation of the business action 3) team building and partnership 4) business model thinking 5) finding entrepreneurial leadership. While investigating business proof key areas such as – key business functions, any change in value propositions, customer segment, customer relationship, cost structure & revenue has been investigated (Figure 1).
2.2 Project location:

The project was implemented at two unions in Satkhira district under one polders i.e. polder no-02 (Figure 2, Figure 3).

Figure 1: Business model of Aquageoponics system

Figure 2: Canal selection discussion under polder 2
2.3 Site selection process in brief

Participatory process was followed which includes representatives from Blue Gold Component staff, Union Council Chairman, secretary and general members of the respective Water Management Groups (WMGs) and Practical Action experts for the selection of the projects sites. Common water bodies e.g. like canals, river, big ponds, community owned ponds have been investigated. Associated factors like - salinity, water availability, scope of irrigation, distance of water bodies from the community residences.
2.4 Business grouping:
A group or cluster approach was followed keeping individual responsibility. The participants were selected in consultation with Blue Gold staff and local Water Management Groups. All participants were poor and the member of Water Management Group. All groups were equally encouraged to choose canals and ponds but due to crab attack risk it was amalgamated in ponds and canals.
35 cages were installed in ponds and canals within polder based aquatic system of Satkhira district with 30 participants in three business groups (Table 1). In business modelling there was different combination between aquageoponics larger cages (9M$^3$) and non-aquageoponics smaller cages (1M$^3$).

Table 1: Business Model Approach

<table>
<thead>
<tr>
<th>Choice 1</th>
<th>Choice 2</th>
<th>Choice 3 (medium/ME)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(micro/MI)</td>
<td>(small/ SM)</td>
<td></td>
</tr>
<tr>
<td>Five entrepreneurs in a group with five aquageoponics cage + five smaller fish cage</td>
<td>Five entrepreneurs in a group with five aquageoponics cages + ten smaller fish cage</td>
<td>Five entrepreneurs in a group with ten aquageoponics cages + With no smaller fish cage</td>
</tr>
</tbody>
</table>

2.5 Cage construction: Two types of cages (9 cubic meter iron famed cage and 1 cubic meter bamboo made cage) were used. Twenty (20) iron made big cages and 15 bamboo frame made smaller cages were installed in canals and ponds. One local metal workshop was taught on the measurements and materials to supply the frame to the farmers. Black polyethylene net was used for the cages. Farmers themselves constructed the bamboo frame cages. Previous researcher’s (Bangladesh Agricultural University, Faculty of Fisheries) guideline was applied in selecting materials and measurements.

2.6 Fish stocking: From previous research recommendation we have considered 200 fish per cubic meter both for Tilapia and Climbing perch. Fish seeds were sourced locally.

2.7 Vegetable planting: Total 120 sponge gourds and bottle gourd saplings were planted in 40 tubs floated with 20 larger cages (two tubs per cage). In the second cycle, only 120 bottle gourds were planted in 40 tubs of 20 cages. Two kg of vermi-compost was applied per two tubs in a cage in each cycle, which was same for both cycles. Additionally, 25 g urea per tub was applied only in second cycle. No significant irrigation effort was required as the roots touched the cage water.

2.8 Feeding fish: Considering the food competition Mega grower floating feed (code: 102) was applied 3 kg for 100 kg body weight of fish, twice a day. Floating feed was chosen so that it does not create sediment in the bottom of the cage and water body.

2.9 Water quality monitoring: Water quality monitoring was done periodically. We measured water Salinity, pH, Dissolved Oxygen, Nitrate, Nitrite, Ammonia inside the cage water.
2.10 Other monthly monitoring and harvesting of fish and vegetables: Monthly and issue based discussion was arranged with the groups throughout the cycle and recorded and finally fishes, vegetables were harvested after three months and sold in local market. Fish consumption was allowed and farmers were encouraged to save money for next seasons.

3. Results and discussions:
3.1 Business aspects:

3.1.1 Value proposition: Why aquageoponics?
The participants and stakeholders found three clear reasons for doing aquageoponics in a coastal district like Satkhira:

- This can give higher production using a small water area in a marginal aquatic environment. An entrepreneur can definitely get a quick and good return of investment within 6 months, which require less hard work.

- This can give better access to water resources to many entrepreneurs in such polder and other canals.

- Supplementary production of vegetables (10-15%) with fish in the floating containers is necessary to reduces chance of water pollution while intensified it at commercial scale. This can give extra benefit and increase fresh safe vegetable consumption of the households. Such vegetable production is even more demandable in water-logged areas.

Tilapia fish has been chosen; as this is a freshwater fish can tolerate moderate salinity. This is one of the fast growing species suitable for the poor farmers. Mono-sex Tilapia has the advantage to manage stocking density as it will not breed and overpopulate the lake to interrupt lake ecology. Tilapia farming has great potential in Bangladesh. Tilapia promises to become a primary cultured species for freshwater and brackish water ecosystems, and therefore may be a major source of employment. Bangladesh could become one of the leading Asian countries for tilapia seed production and grow-out farming (The Fish Site 2014). Tilapia are labelled as being very "disease-resistant."(http://americulture.com/tilapia-diseases/; Americulture, 2016).
3.1.2 Key business activities
Over the period of one year during the pilot, main business activities for the aquageponics found were –

1) Verification and selection of a suitable site or canal for the business which requires sufficient water availability for 2-3 cycle of production and no conflict or having mutually negotiated water ownership. One of the main lesson was checking presence of crab in the canals.
2) Finding and building local capacity of making suitable cage frame of iron and bamboo and managing net materials and suitable fish species (Figure 4)
3) Securing quality seed supply of mono sex tilapia and climbing perch (Koi fish),
4) Protecting cages from crab attack and manmade water pollution (jute retting),
5) Vegetable plant growth monitoring and adding extra manure as needed
6) Selecting right time of fish sale so that should not overlap with shrimp gher harvest time.

3.1.3 Customer segments
Shrimp gher farmers, villagers, polder based water management groups and trader, retailers and local market consumers were found as the main customers of this business. In the supply chain, seed suppliers, cage construction metal workshops, net suppliers, feed suppliers, vermi-compost producers and vegetable seed suppliers were closely linked with the business. With the increased salinity, there was a demand for fresh water fish like tilapia and climbing perch in
local market. Crab farmers were also found as customers for small tilapia as they fed crabs with small tilapia.

Women were integral part of cage aquageoponics farming (Figure 5). They helped in preparing the soil for vegetable planting, feeding, selling fish, looking after the cages etc. The cage ownership was jointly offered to husband and wife under a group and cluster.

**Figure 5: Participation of women in learning water quality**

**Box2: Socio-economic general overview**

**Socioeconomic profile of participants and villagers**

Aa a whole nearly half of the villagers were fish farmers (39%) and the rest are van pullers and day labours (51%), around 10% people were engaged with some kind of trading and business in surrounding 3-4 villages.

Among the participants most of them were day labours earning below 2USD per day. Out of 15 households participating in the intervention, 6 of the HH head has no formal education and 9 of them below class V.

**3.1.4 Customer relationship lessons**

Apart from fish vegetable producer, buyer, and consumer, the business operation attracted various interest groups such as – canal management authority, Union council those who own some other canals, Water Management Group leaders, other polder inhabitants, net suppliers and poor people in water logged and flood affected areas (Figure 6). This also attracted
commercial bank such as Bank Asia, global net distributes, net makers and local fish seed, feed suppliers. It was realised that a local autonomous business environment is essential driven by identified stakeholders.

Figure 6: Stakeholders and producers in Satkhira shared the learning and decide for future actions to scale it up

Entrepreneurs found that they should be more aware of sale and distribution of their fish to get better price. They have tried to link with the local fish market but opportunity of getting higher price was yet to be explored. Relationship with financial institutions like Bank Asia was found useful to access credit for business in future (Figure 7).

Figure 7: Primary discussion with Bank Asia (having local such Branch in Satkhira) for access to finance in future

3.1.5 Cost structure, revenue and cost benefit of the business
The business start-up cost of the aquageoponics in saline/brackish environment was funded by Blue Gold Innovation Fund to build the capacity of local farmers and entrepreneurs. Fifteen farming families under the Water Management Group of Polder canals in Fingri union of Satkhira Sadar upazila, Satkhira district have practiced aquageoponics technology in canals and some larger ponds and confirmed that the business case was profitable with in two cycles. 1\textsuperscript{st} cycle was the breakeven point. The investment was \textbf{118 USD} to construct a nine cubic meter iron frame cage and around \textbf{114 USD} was spent for fish seed, feed and others (total \textbf{18,000 Taka}) and harvested fish was around 133-180 kg of Tilapia fish within 3 months. Additionally, average 16 kg of vegetables was harvested from a large cage per cycle. For the second cycle they spent only \textbf{9000 Taka per cage for feed and seed}. They found that cage construction cost of larger ones can be reduced to \textbf{90 USD} using bamboo or other materials. Even they have thought on the prospect of low cost HDPE (High Density Poly Ethylene) net available in the local and global market. Fibre made frame can be used but current cost in the market is high need further investigation to find cheaper fibre frame material.

The investment structure is described in the Table 2 below:

\textbf{Table 2:} Business Proof of the aquageoponics practiced in Satkhira in 2016-17

<table>
<thead>
<tr>
<th>Investment</th>
<th>Return</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• A nine cubic meter aquageoponics cage made of iron frame and net cost 9250 BDT (a fixed investment)

• Depreciation cost per cycle is around 578 BDT/cycle.

• Feed and fish seed cost is 8915 BDT/cycle of 3-4 months

• Plus minimal labour cost

• The fixed cost can be reduced to 7000 BDT if we design the cage frame using bamboo or other suitable materials

• Within 3 months’ farmers can harvest 114 kg of koi fish worth 17700 BDT from a nine cubic meter cage.

• For tilapia, it will be 133 kg fish/cycle worth 9542 BDT.

• It is possible to harvest 16 kg of vegetables worth 320 BDT from a nine cubic meter cage in 3-4 months.

• Farmers will be in a breakeven point in the first cycle. They can easily do two cycles but can run 3 cycles in some areas where water is available round the year.

The aquageoponics system was found an economically viable and environmentally responsible solution for sustainable farming to ensure food production in the salinity affected coastal areas. Some farmers think that it has great potential to scale it up in flood affected and water logged areas too including large water basin areas. Our trial on business proof (Figure 8) confirmed that it can be replicated in other suitable polders.

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**Aqua geoponics Business Model**

**Customer Segment**
15 Poor farming household, Male & female, water user groups,

**Value proposition**
New farming option, alternative option when they cannot farm vegetable in the crop filed or homestead for salinity & water logging, freshwater fish and vegetable.

**Key investment**
Iron frame cage construction fixed cost 118 USD (can be reduced 90 USD using bamboo), Depreciation cost 7.4 USD/cycle, Fish seed, feed cost 114 USD,

**Channels**
Water user group, local NGO, Union Digital Centre, input supplier, market

**Cost benefit**
Fish production worth 210-226 USD/cycle for Tilapia or Climbing perch, vegetable production

**Key activities**
Suitable waterbody selection, Cage/farm construction, training, Fish seed stocking, feeding, vegetable and fish growing, fish selling

**Customer relationship**
Relation exist with pond, gher fish

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Feed, fish seed and cage construction were the three big investment areas (Figure 9), which could be reduced. If farmers were taught local nursing of tilapia in ponds, they can reduce the cost of fish seed. By using bamboo, frame farmers can reduce 2000-3000 BDT per nine cubic meter cage. Locally made feed or combination of high commercial feed and locally produced feed can be applied to reduce feed cost, as price of fish did not increase that much compared to the increase of fish feed cost. Investment in all inputs and return displayed in Table 3 and Figure 10.

Table 3: Input and output of the business case in two cycles
<table>
<thead>
<tr>
<th>Cycle</th>
<th>Mean initial individual wt. Tilapia (g)</th>
<th>Mean initial individual wt. Koi (g)</th>
<th>Mean, highest, lowest harvest wt. Tilapia (g)</th>
<th>Mean, highest, lowest harvest wt. Koi (g)</th>
<th>Mean survival rate Tilapia (%)</th>
<th>Mean survival rate of Koi (%)</th>
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<tbody>
<tr>
<td>1st</td>
<td>5.5</td>
<td>-</td>
<td>122.00</td>
<td>-</td>
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<td>-</td>
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<td>98.61</td>
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<td></td>
<td></td>
<td>053.00</td>
<td>73.17</td>
<td></td>
<td>90.24</td>
</tr>
</tbody>
</table>

**Figure 10:** Investment vs return in three business groups

Small group having 2 small cages & 1 large aquageoponics cage performed better (Figure 10, 11). This might be because of productivity of type of water body (those cages were mostly in canals, got better water flow, DO) and type of cages (in small cages water flow was better) and group understanding and management efforts.
Figure 11: Two cycle fish production rate by business groups

3.2. Technical Aspects:

3.2.1 Lessons on water body selection

Figure 12: Lessons on water body selection

Waterbody selection was a critical part of the business (Figure 12). Finally, we got two canals and few ponds. Regarding water body selection criteria main lessons were as follows:

- There were existing water user’s groups in Blue Gold supported polders whose interest for the intervention was higher. Excavated canals need to be identified.
- Water availability round the year or maximum time of the year
- Not close to a crab fattening farm
• Security issues and input transportation road facility need to be considered
• Not in a jute retting area of the canal
• There should not be conflicts with other users and water users
• Interest of the canal authority to use it for aquageoponics
• Canals were better than ponds. Small ponds not suitable at all.

3.2.2 Working with groups and individuals
Though they managed the business function in a group, individual ownership of large and small
cages within a group was found effective in such small scale. There was no conflict in fish
distribution, sale and consumption. Three groups were formed based on their choice of options
and large small cage combination. Groups and cluster based approach was needed for better
management of inputs, fish rearing and security issues. Their house location was close to each
other. The group members were from the same social class which was useful.

3.2.3 Cage construction adaptation

3.2.4 Adapting stoking density and choice of fish
Initially stocking density was 200/cubic meter; however, it was reduced to 150/cubic meter in
large aquageoponics cages considering available water area for fish. But for smaller cages it was
remain same in both cycles. Tilapia and climbing perch was stocked in separate cages not mixed
in a same cage. Although they stoked perch in second cycle they thought it would be better if
they could stock perch in first cycle (Figure 14).
3.2.5 Vegetable production results
We found sponge gourd and bottle gourd grown well in the cage pots. We tried for bitter gourd and bean but due to insect and disease attack the growth and production was not satisfactory. Bottle gourds and sponge gourds were found pest tolerant so the production was higher. Bottle gourd was suitable for both summer and winter, sponge gourd for summer only. Average vegetable production per cage was 16 kg. Local market price rate was 20 Tk/kg and 15 Tk/Kg for bottle gourd and sponge gourd which slightly higher in district market as 30 Tk and 25 Tk per kg. It was learnt to avoid late planting which may affect the production. Vegetables grown were mostly eaten by the households as these are very organic and without any pesticide. Some women opined that the vegetable planted in the floating tubs were protected from cows and goats as it was in water (Figure 14).

![Figure 14: Production of fish and vegetables](image)

3.2.6 Food Conversion Ratio:
The Mega Grower Floating Feed was used for tilapia in cages under SHIREE project funded by DFID (by Practical Action), was our reference. The FCR (Food Conversion Ratio) mentioned in the feed was 1:1.3. Framers used mainly mega grower feed along with some kitchen waste, rice bran and duck weed for tilapia in the cages. Tilapia also eaten natural food (as omnivorous) from the pond and canal. This was the context. From our analysis of first cycle the Food
Conversion Ratio we found - the mean was 1:1.41, which is good in such context. For this type of fish, average FCR 1.4 – 1.8 range is acceptable.

3.2.7 Water quality results
Salinity was found higher in canal water than pond. Average salinity in pond was 0.55 ppt and in canal was 0.85 ppt. Pond water salinity was highest 0.65 ppt and in canal was 1.63 ppt. However, salinity did not kill fish or vegetables (Figure 15).

Figure 15: DO, salinity, ammonia and nitrite in pond

Figure 16: DO, salinity, ammonia and nitrite in canal
No major conflict was found with DO, pH, salinity, ammonia and nitrite. However, DO was found less in ponds than canal (Figure 15, 16).

**Figure 17:** Temperature and pH in canal, pH didn’t fluctuate in canals and ponds was favourable for farming

4. Challenges, risk and risk mitigation efforts

Use of a combination of smaller non-aquageoponics smaller cage with aquageoponics larger cage was beneficial as growth was better in smaller cages due to better water flow and useable volume of water. If the iron made cage is not affordable for poor individual owners, they can try with bamboo frame cages or (Figure 18)

**Figure 18:** Risk mitigation efforts by the farmers

use double layer net tightly fitted in a bamboo frame and fibre mother de cage frame materials can be searched. If not possible to get crab free canals, farmers learnt to use bamboo fence
surrounding the net with an extra cost of 40 USD per nine cubic meter cage. In economic and technical term this was not a very good strategy as it inhibits water flow into the cage and need frequent cleaning effort. Two catch three cycle in a year farmers must start the cycle by the end of May if water is available.

Farmers learnt to aware of the following risks – 1) presence of crab in the canal which can damage net, 2) water availability and security issues to protect the fish 3) quality fish seed availability 4) conflict with water user groups and others.

These were low to moderate type of risks and appropriate mitigation measures can reduce the likelihoods of occurring those risks. For better vegetable production vermi-compost was used to increase organic content in the soil. To protect crab attack carb free water body can be selected. A one cubic meter small cage can be installed with some tilapia fish to check presence of carb in a waterbody. It was experienced that crab cannot damage net if that was tightly placed in the frame, it can easily attack loosely covered net in the frame. Canals near crab fattening farm had the in big risk. Bamboo fence can protect crab but it increases cage construction cost of around 40 USD per 9 cubic meter cage. Other alternative arrangement for crab protection need to be applied. In regard to maintain enough oxygen flow inside the cages water needed to be splashed into cages and nets to be cleaned regularly. The vegetable shade above the cage need to be modified so that enough sunlight is ensured in the cage water. An agreement among the water users group, entrepreneurs, investors and water canal authority would be necessary to avoid any conflicts of interest.

4.1 What is needed to further develop it?
Three things can be further improved as – 1) diversification of fish and vegetable species 2) reducing cage construction cost with more strong, cheap materials 3) access to commercial finance (interest rate, period, repayment schedule etc.)

We need to ensure availability of good quality cage net and improve the cage construction material with more cheaper and durable materials. Practical Action already communicated with
global, local net suppliers on availability of **High Density Poly Ethylene** (HDPE) net which is costly (initially three times higher than current iron made structure which could be

**Main recommendations from stakeholders & farmers of Satkhira were:**

- As farmers got quick return of their investment within 3-4 months and this was not very labor intensive business it should be continued. It can be expanded both in Water Development Board and non-Water Development Board operated canals
- An agreement between cage entrepreneurs and canal authorities would be useful for scaling the business into a scale.
- Building local technical capacity/confidence to expand the operation is a key driver
- We need bank loan trial for a season to look at access to finance for small entrepreneurs. We may further investigate on net and cage frame materials to reduce cost and making it crab protected.
- It has potential to expand in other excavated canals where more or year round water is available (mentioned by local Chairman).
- Water flow should not be interrupted in the canals while expanding operation
- Similar ideas like Hydroponics farming also could also be linked with such entrepreneurs, farmers

**Box 3: Stakeholder recommendations in Satkhira on aquageoponics promotion**

reduced) but carb resistant and also alternative cage frame materials. However, we need continuous search finding a cheaper and stronger net and frame (Figure 19). We will construct some cages using bamboo which will reduce 3000 BTD per 9 cubic meter cage. Easy harvesting techniques of fish from the floating cage will be ensured.

![Current and future options for cage materials](image)

**Figure 19:** Bamboo fence and other materials for cage construction to protect crab
4.2 How did we ensure value for money?
Having one-year experience in Satkhira, it can be mentioned that farmers can get higher return of investment considering the following aspects (Figure 20)

- Strengthening technical skills such as managing quality larger size fish seed, however they should know transportation mortality will be higher in larger size tilapia seed.
- For koi they need to confirm reliable source with same size fingerling to be supplied
- If they can manage a good canal with year-round water availability will get higher return,
- They should avoid jute retting nearby and ensure enough oxygen into the cages.

![Figure 20: Recommendations of Dhaka Learning haring Workshop April 2017](image)

4.3 Comparison of aquageponics with other options available in the area:

<table>
<thead>
<tr>
<th>Other reference</th>
<th>CB ratio</th>
<th>Compare with our aquageponics option in cages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production performance of mono-sex tilapia was assessed in the marginal farmer’s pond in South-central Bangladesh (Nabi et al., 2017), With commercial pellet feed, 4 months culture</td>
<td>BCR(benefit cost ratio) was 1.41</td>
<td>150 fish/m2, with commercial floating feed BCR in cage aquageponics was 1.75. Which was higher than pond. Dam and flood protection embankments in</td>
</tr>
</tbody>
</table>
Period, average pond size was 30 decimals, stocking density followed was 200 fish seed/decimal (around 5 fish/m²).

<table>
<thead>
<tr>
<th><strong>Mono-sex tilapia was grown in brackish water pond (average size 25 decimal) in South-west region of Bangladesh, culture period 3 months, With floating commercial feed, Stocking density was 5/m²</strong></th>
<th>BCR was 1.28</th>
<th><strong>In cage system farmers will get higher economic return than pond. With mega expansion of shrimp in coastal areas, cage can open up new opportunity for poor entrepreneurs who can farm fish in cages which require small area, less labour and can give better economic return than pond or open canals.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(Khatun et al., 2017)</td>
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<tr>
<th><strong>Vietnami Koi/Climbing perch was grown in fresh water pond (average size 33 decimal) with commercial pellet feed, culture period was 3 months following a stocking density of 150-350 fish seed/decimal.</strong></th>
<th>BCR was 1.63</th>
<th><strong>Our CB ratio for Vietnami Climbing perch in floating cage was better in cage, which was well protected from predators and flooding.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(Gias et al, 2014)</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Cage aquaculture reference: Cage and pond aquaculture performance was evaluated in an experiment where they used Tilapia, and Thai Climbing perch in cage and pond system (Modal et al., 2010)</strong></th>
<th>Higher cost benefit was obtained in cage system with climbing perch than in open pond system.</th>
<th><strong>They have recommended integrated system of pond and cage and recommended perch in cage and tilapia in pond in a integrated way. Economic return was higher in cages.</strong></th>
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<thead>
<tr>
<th><strong>Dike cropping vs aquageponics vegetable production: Farmers using</strong></th>
<th>If a farmer invests 22</th>
<th><strong>Amount of vegetable production in Cage aquageponics was not huge,</strong></th>
</tr>
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</table>
shrimp gher dikes for vegetable growing but in low lying areas there is a threat of flooding and increased salinity in dry season. The area of shrimp gher dike is also not accessible for poor women farmers those who want to grow some vegetables.

| shrimp gher dike | USD for dike vegetable cropping in a 33 decimal gher, She/he may get a return of around 45 USD from vegetables in 3 months (Practical Action experience, 2017). That means double return. | but it can expand the scope of vegetable production in water areas, create extra opportunity for the poor women to grow vegetables they need for their home consumption. However, in suitable areas such as water-logged areas, it can be a great and only opportunity to grow vegetables in floating beds or cages. |

From the above references we can claim cage aquageoponics has advantages over open pond system in the salinity and coastal flood affected vulnerable areas can be considered as an option to diversify conventional aquatic system. In a floating cage condition, the farm units can be moved from one place to another suitable place responding to water availability and other security issues (higher adaptability). Poor farmer are getting extra space for an integrated system. Particularly considering the issue of limited water access for the poor water user groups and women this type of system has great potential for scale and adjusting farming period to catch better market price of fish and vegetables. Apart from Tilapia and climbing perch there is also opportunity for sea bass to grow with tilapia both in ponds and cages in the coastal areas. In future, they can do canal fishery, pen culture, cage aquageoponics, only cage fish culture and dike cropping (shrimp gher dike) in an integrated manner. As an expanded idea of growing vegetables in floating vegetable tubs, farmer in the area already found to diversify vegetables farming using sack gardening techniques. Therefore, it was clear that as a response to climate and economic shock farmers in the area will continue such systems and diversify their ideas to grow fish and vegetables.
4.4 Environmental, social and gender related benefits

The main environmental challenge was responding to limited water access, limited water availability and combating salinity for fish and vegetable farming. When we take any fish farming options to business and commercial scale there is threat for water pollution. The aquageponics system is an environmentally responsible system which is capable to control pollution as a result of suing commercial fish feed in the cages for fish. The vegetable roots are open to cage water purifies the water. We have monitored water quality in a limited scale which didn’t record any threat of water pollution. On the other hand, if they farm fish in canals they were found to be more responsible to pollute water by any other practices such as jute retting. Some experts raised the concern of sedimentation in the canals. But because of the floating design (water can flow underneath) it was not found to inhibit water flow (as water flow is needed for the system) in such a small and even medium scale. Such type of systems in the rivers and canals have been practiced in other parts of Bangladesh also not reported on sedimentation.

All target beneficiaries under the project was mostly day labours and members of canal water user groups from the poorer section of the community. Husband and wife was equally treated as the owner of the cages which encouraged women to patriciate in such an economic activity which didn’t increased their work burden along with household works. Knowledge and capacity of women found to increase for such new systems. They were found to act as a trainer for others, were well linked with local Union Council Digital Centres and Krishi Call Centre (16123) for further assistance on such technical and business adventure. Giving them a medium-term asset (the iron framed cage, it works for 4-5 years) from the project was enough to cover risk of testing new thing and making new ways of business. It was found that if they make an agreement with the canal authorities or private owners in other cases, the business and water ownership is likely to be sustained. The women members of the households in future may become confident entrepreneurs of 1) aquageponisc, 2) floating garden, 3) sack vegetables in an integrated way where they can manage suitable water canals.
5. Conclusion and way forward:

- The business proof trial confirmed a CB ratio of 1.75 which shown greater opportunity of the option to scale up. Evidence from other research shown that doing fish and vegetables is cages has greater advantages than ponds in terms of fish escaping, protecting vegetables & fish, access to water and quick return of investment. Operation in cages has higher benefits than in ponds and canals to reduce risk. An integrated approach of canals fishery and such floating cage fish vegetables approach could be tried in future with further continued modification of the cage frame. The trial recommends it to scale up it to other polders and in other suitable canals both in polder and water-logged areas. However, while intensifying the system water follow in canals should not be slowed down to avoid sedimentation. Using excavated canals with year-round water is highly recommended. Local negotiation for water body access and an MOU with Water Board authority, farmer and entrepreneur is essential for large scale operation.

- It is better to avoid small ponds for a 9 cubic meter aquageoponics system. A combination of small one cubic meter normal cage and nine cubic meter aquageoponics cage is better to earn an attractive return.

- Entrepreneurs should try to start the 1st cycle in May to catch 3 cycle per year for higher return.

- Use both Tilapia and Climbing perch as candidate species and bottle gourd, sponge gourd for vegetables. The vegetable fences can be further designed in a way so that it do not protect sunlight to the fish cage water. Some other study recommends tilapia for ponds and climbing perch, sea bass for cages. In future, farmers can prioritise, diversify fish species comparing market demand.

- Search for alternative cage material to go for large scale (eg. HDPE net, fiber frame) and reduce cost in cage construction using bamboo and a combination of black polyethylene and other suitable net.

- Run a trial with access to finance from bank to define interest rate, payment schedule, guarantor etc.

- Both individual and group in cluster operation approach is recommended. Young entrepreneurs can come forward and work with village farmers. They can create strong input and output value chain linkage for fish and vegetables.
6. Annex:

6.1 Photos of beneficiaries:

Photos of micro group

Photos of medium group

Photos of Small group
### 6.2 List of Beneficiaries:

<table>
<thead>
<tr>
<th>SL</th>
<th>Beneficiary name</th>
<th>Beneficiary types</th>
<th>Father/Husband Name</th>
<th>Village</th>
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<tbody>
<tr>
<td>1</td>
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<td>Farmer</td>
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<td>Md. Sariful Morol</td>
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<td>Sabina yasmin</td>
<td>RTE</td>
<td>Mostafa Hossain</td>
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</tbody>
</table>
We have trained 12 Rural Technology Extensionists (RTE) on aqua geoponics system and vermicompost production from two unions.

6.3 Study Team:

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