A Final Report on

Aquaculture Intervention in Seasonal Waterlogged Areas in Southwest Region of Bangladesh

Department of Fisheries Biology & Aquatic Environment
Bangabandhu Sheikh Mujibur Rahman Agricultural University
Gazipur- 1706, Bangladesh

Blue Gold Programme in Bangladesh

Innovation Fund

Final Repot

Aquaculture Intervention in Seasonal Waterlogged Areas in Southwest Region of Bangladesh

By

Professor Dr. Md. Jahangir Alam
Department of Fisheries Biology & Aquatic Environment
Bangabandhu Sheikh Mujibur Rahman Agricultural University
Gaziour-1706, Bangladesh

March 2018

Acknowledgement

This research was made possible with a financial contribution of the Innovation Fund of the Blue Gold Programme and the Government of the Netherlands.

The author gratefully acknowledges support of the Department of Fisheries (DoF), Bangladesh Water Development Board (BWDB), and the Blue Gold Programme for making this research programme a success. The assistance of officials and field staff of the Blue Gold Satkhira, members of the Jordia-Erukhal and Degur Beel Water Management Groups was enormous from the very beginning to end of the project implementation period. Thanks to them.

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.

Table of Contents

1			General project information	1
2			Introduction/background	1
3			Project objectives	2
4			Approach and methodology	3
	4.1		Approaches	3
	4.2		Methodologies	4
		4.2.1	Site selection	4
		4.2.2	Farmer selection	4
		4.2.3	Design of the study	6
		4.2.4	Fish pen construction and preparation	7
		4.2.5	Fish stocking	9
		4.2.6	Post-stocking management	9
5			Results	10
	5.1		Chaler beel (Degur beel WMG)	11
	5.2		5.2 Kachur beel (Jordia Erukhal WMG)	13
6			Skill and awareness building activities	19
	6.1		Farmers training	19
	6.2		Farmers' day	20
	6.3		Publicity and documentation	20
7			Stakeholder workshop	21
8			Challenges and mitigation measures	22
9			Lesson learnt	23
10			Conclusion	23
			Reference	24

List of Tables

Table #	Title	Page
1	List of beneficiary farmers in Chaler Beel site	5
2	List of beneficiary farmers of in Kachur Beel site	6
3	Pen area, fish species and stocking number for the pen culture intervention in Polder 2	7
4	Mean length and weight of fish at stocking	9
5	Fish harvesting details of Chelar Beel (as of 18 September 2017)	12
6	Growth of different fish species in three pen compartments in Kachur beel	14-15
7	Production (kg/ha) of different fish species in three pen compartments in Kachur beel	17
8	Simple cost benefit analysis (per ha) of pen fish culture in Kachur beel	19

List of Figures

Fig. #	Title	Page
1	Selected pen culture intervention sites	4
2	Pen construction layout of the (a) Chaler Beel and (b) Kachur Beel	8
3	Variations in water depth in Chaler beel.	11
4	Variations in water temperature in Chaler beel	11
5	Variations in dissolved oxygen (DO) level in Chaler beel	12
6	Growth of tilapia (GIFT) in Chaler beel up to 30 August 2017 (29 days of culture period)	13
7	SGR of tilapia (GIFT) in Chaler beel up to 30 August 2017 (29 days of culture period)	13
8	Variations in water depth in Kachur beel	13
9	Variations in water temperature in Kachur beel	13
10	Variations in dissolved oxygen (DO) level in Kachur beel	14
11	Pen-wise incremental growth of tilapia (GIFT) in Kachur beel during the culture period	15
12	FCR of tilapia (GIFT) in different pen compartments in Kachur beel	18

Final Report of Innovation Funded Project

1. General project information:

Title of the innovation project	**:**	**Aquaculture intervention in seasonal waterlogged areas in southwest region of Bangladesh**
Thematic area	**:**	Fish & shrimp production
Project coordination institution	**:**	Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur 1706, Bangladesh
Project leader	**:**	**Dr. Md. Jahangir Alam** Professor Dept. of Fisheries Biology & Aquatic Environment Faculty of Fisheries, BSMRAU, Gazipur- 1706 *E-mail*: mjalam.bsmrau@gmail.com *Cell*: +88 01715 143521
Location of the project	**:**	Polder-2, Satkhira Sadar, Satkhira
Duration of the project	**:**	June 2017 – January 2018

2. Introduction/background:

According a report of FAO (2015), three south western coastal districts (Jessore, Satkhira and Khulna) have been experiencing problems of waterlogging since the early 1980s affecting over 50,000 ha of land, resulting in devastating effects on livelihoods and quality of life. Among the three districts, Satkhira holds the highest waterlogged areas. The waterlogged areas in Satkhira was estimated as 15,281 ha in 2006, which is increased to 34,366 ha and 33,470 ha 2009 and 2013, respectively (FAO, 2015). The main cause that has been resulting in the increased waterlogging in the areas is the poor drainage system due to increased siltation in the Betna, Marirchap, Shalikha, Parulia-Sapmara and Kobadak rivers.

The Bangladesh Water Development Board (BWDB) and Department of Agriculture Extension (DAE) have been implementing “Blue Gold Programme” in Bangladesh, which is jointly funded by the the Government of Bangladesh and Government of the Netherlands, with the objective of “Improvement of living condition for coastal people through integrated water resource management aimed to enhanced production and business linkages". Among the Blue Gold intervention areas, Polder 2 in Satkhira district is one which consists of 57 mouzas with 9 Unions under the upazila of Satkhira sadar, Ashasuni, and Tala (part), where a part of areas are using only one crop of rice in winter leaving the fields inundated with monsoon rain for 4-5 months. In the waterlogging affected areas, all categories of farmers (landless, marginal, small and even the rich) are greatly affected economically at different dimensions due to no crop production activities (Bluegold, Masterfile Polder 2). The research and development question, therefore, arouse whether this seasonally stagnant water could be productively used that may hold great promise in food production and livelihood improvement of farming community in the areas.

It has been recognized that waterlogged areas could often contribute a much larger potential for aquaculture development (Das et al., 2009), adopting scientific methods of fixing enclosure, often termed as ‘pen fish culture’, in which the bottom is the bed of the part of waterlogging area. Constructing pen using locally available materials like knotless polythene net and bamboo for fish polyculture in floodplain area has shown a great potential for increasing fish production in Bangladesh (Haque et al., 2006). A development project of the Department of Fisheries (DoF) has successfully operated pen fish culture in 57.40 ha of water area in the river Boral of Bagatipara upazila in Natore, stocking with larger sized carp species (0.5-1kg) and rearing them during January to May (http:\\en.bdfish.org/2010/10/pen-culture-boral-river-bagatipara-natore/). While polyculture of carps has been reported for pen culture in floodplains and river waters, Das et al. (2009) suggested culturing of tilapia and silver barb in waterlogging areas where water depth remains 1.0-1.5 m for a duration of 3-5 months. However, no attempt has so far been made for aquaculture in waterlogged areas of southwest region. In this context, upon an invitation from Blue Gold progamme, the present project on “Aquaculture intervention in seasonal waterlogged areas in southwest region of Bangladesh” was undertaken with an intention of looking for a viable aquaculture intervention so that the waterlogging conditions can be utilized productively for improved livelihoods of the affected farmers.

3. Project objectives:

The goal of the project is to explore the utilization of seasonally waterlogged rice fields for fish production and income generation through practicing appropriate aquaculture system. The specific objectives are to –

- establish pen fish culture system in three selected waterlogged areas in Polder 2;

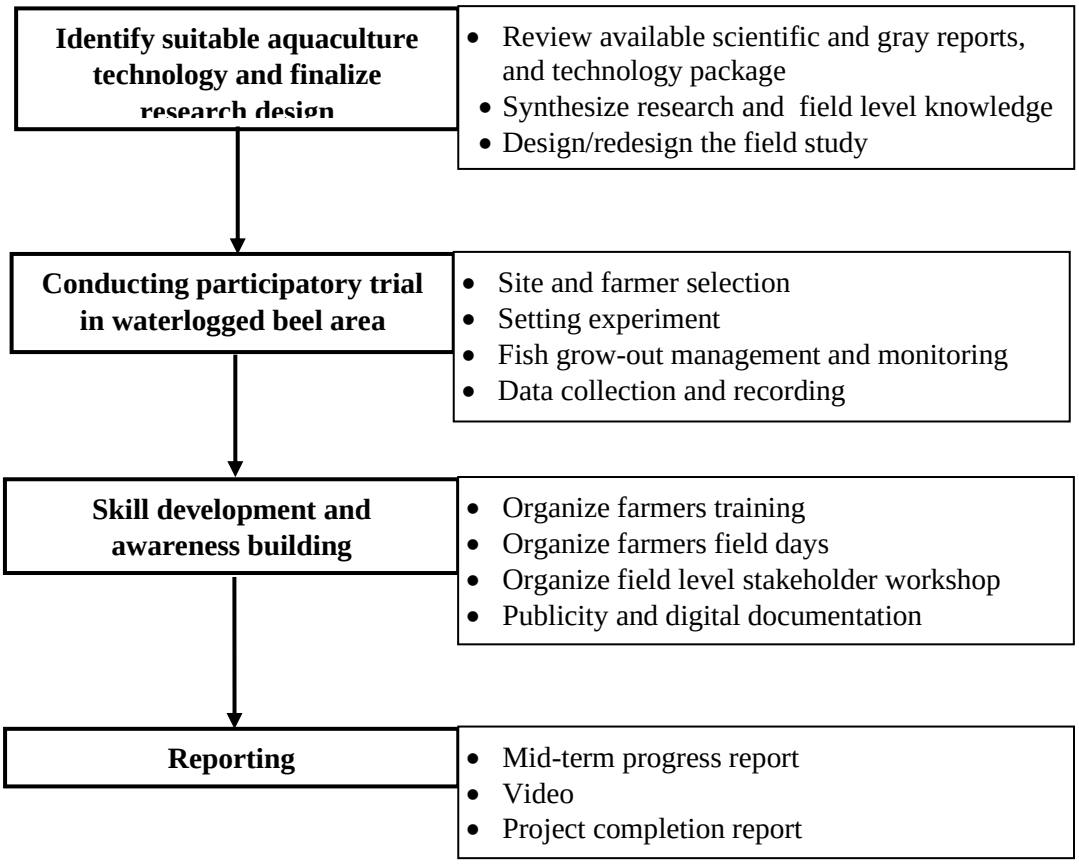
- assess the effects of addition of carps at different stocking rate on growth and production of tilapia in pen culture system in waterlogged environment; and
- engage Blue Gold WMG in the R&D process of fish culture in waterlogged rice fields in Polder-2.

4. Approach and methodology:

4.1 Approaches

Upon the approval of the Concept Note by the Blue Gold and signing of a contract agreement between Euroconsult Mott Macdonald and Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), the field study was implemented by BSMRAU in direct participation with selected members of two Water Management Groups (WMG), *viz*., Degur Beel WMG and Jordia Erukhal WMG in Polder 2, Satkhira sadar. Blue Gold Satkhira office assisted in selecting study site, organizing farmers groups and in other activities. A memorandum of understanding was developed and signed by Blue Gold Programme, Satkhira and each of the WMGs.

The overall approach that was followed in implementation of the field study is presented below:



4.2 Methodologies

4.2.1 Site selection

The process that was followed to select the study sites is field visits and informal discussion with local people, members of different water management group (WMG) and Blue Gold local officials. The main focus of site selection was that the areas have been affected by waterlogging in the past consecutive years due to monsoon rain, with a water depth of 2.5 – 4.0 feet for a period of 4-5 months.

Initially three beels viz., (i) Chaler Beel (Dagur Beel WMG), (ii) Ghoshkahil beel (Ghoshkhali WMG), and (iii) Kachur beel (Jordia Erukhal WMG) under the Polder 2 in Fingri union, Satkhira sadar, Satkhira were selected, considering the locations, past history of waterlogging condition and willingness of concerned WMG members to participate in the study programme (Fig. 1). Unfortunately, almost at the end of preparation phase, Ghoshkhali WMG members suddenly declined to offer their land and participate in the programme. We had to drop the Ghoskhali Beel site and limit the study to other two sites at Chaler Beel and Kachur beel to conduct the study.

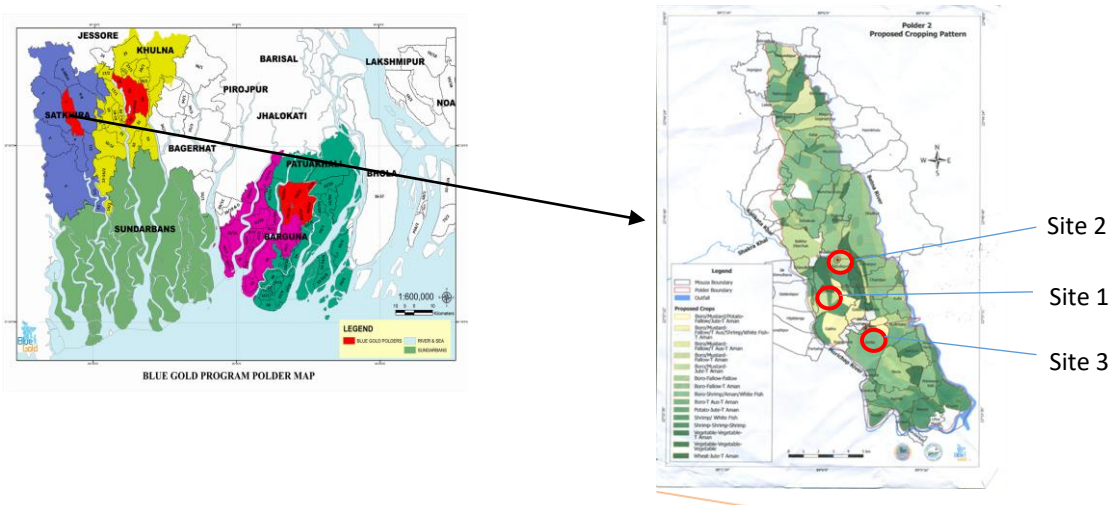


Fig. 1. Selected pen fish culture intervention sites.

4.2.2 Farmer selection

Basically WMG members of the respective beels who own the lands were the beneficiary farmers. However, farmers in the project area, who does not belong to WMG, were also involved in the beneficiary farmers group. The list of selected farmers in each study site is given in Table 1 and Table 2.

Photo 1. Field visit for site selection.

Photo 2. Discussion with WMG in Blue Gold office to finalize site selection.

Table 1. List of beneficiary farmers in Chaler Beel site

SL. No.	Name	Designation	Village
01.	Mr. Ronjon Mondol	President, Degur Beel WMG	Foyjullahpur
02.	Mr. Mijanur Rahman	Vice-President, Degur Beel WMG	Foyjullahpur
03.	Mr.Thakur Das Bosak	General Secretary, Degur Beel WMG	Foyjullahpur
04.	Mr. Roshid Morol	Joint Secretary, Degur Beel WMG	Foyjullahpur
05.	Mr. Ebadad Karigor	Member, Degur Beel WMG	Foyjullahpur
06.	Mr.Abhilas Mondol	Member, Degur Beel WMG	Foyjullahpur
07.	Mr. Gopal Mondol	Member, Degur Beel WMG	Foyjullahpur
08.	Mr. Profullo Biswas	Member, Degur Beel WMG	Foyjullahpur
09.	Mr. Anisur Karigor	Member, Degur Beel WMG	Foyjullahpur
10.	Mr. Hojrot Mukti	Member, Degur Beel WMG	Foyjullahpur
11.	Mr. Romakanto Mondol	Member, Degur Beel WMG	Foyjullahpur
12.	Mr. Rofiqul Mollah	Member, Degur Beel WMG	Foyjullahpur
13.	Mr. Abdullah Sordar	Member, Degur Beel WMG	Foyjullahpur
14.	Mr. Ajed Sordar	Member, Degur Beel WMG	Foyjullahpur
15.	Mr. Dhiren Sen	Member, Degur Beel WMG	Foyjullahpur
16.	Mr. Shofiqul Sordar	Member, Degur Beel WMG	Foyjullahpur
17.	Mr. Afasar Sordar	Member, Degur Beel WMG	Foyjullahpur
18.	Mr. Sulekha Bosak	Member, Degur Beel WMG	Foyjullahpur
19.	Mr. Owajed Sordar	Member, Degur Beel WMG	Foyjullahpur
20.	Mr. Kader Mollah	Member, Degur Beel WMG	Foyjullahpur

Table 2. List of beneficiary farmers of in Kachur Beel site

SL. No.	Name	Designation	Village
01.	Sheikh Monayem	President Jordia Eru Khal WMG	Jordia
02.	Sheikh Asad	Vice-President, Jordia Eru Khal WMG	Jordia
03.	Sheikh Ajmir Hossain Babu	Member, Jordia Eru Khal WMG	Jordia
04.	Sheikh Romimul	Member, Jordia Eru Khal WMG	Jordia
05.	Sheikh Ekramul	Land owner/shareholder	Jordia
06.	Sheikh Jiyad Ali	Member, Jordia Eru Khal WMG	Jordia
07.	Sheikh Abdul Momin	Member, Jordia Eru Khal WMG	Jordia
08.	Sheikh Ataur Rahman	Member, Jordia Eru Khal WMG	Jordia
09.	Sheikh Basharul Islam	Member, Jordia Eru Khal WMG	Jordia
10.	Sheikh Ajijul Islam	Member, Jordia Eru Khal WMG	Jordia
11.	Sheikh Doulat Hossain	Land owner/shareholder	Jordia
12.	Sheikh Liakat Ali	Land owner/shareholder	Jordia
13.	Mr. Tarikul Islam	Land owner/shareholder	Jordia
14.	Sheikh Abdul Kashem	Member, Jordia Eru Khal WMG	Jordia
15.	Sheikh Najrul Islam	Member, Jordia Eru Khal WMG	Jordia
16.	Sheikh Habib	Land owner/shareholder	Jordia
17.	Md. Abdul Mannan	Land owner/shareholder	Jordia
18.	Md. Yousuf	Land owner/shareholder	Jordia
19.	Md. Selim	Land owner/shareholder	Jordia
20.	Md. Mohinur	Land owner/shareholder	Jordia

4.2.3 Design of the study

To achieve the objectives, the study was designed with three stocking rates (treatments), replicating each in two experimental sites. Keeping a total fish stocking biomass of about 750-800 gm per decimal similar, the treatments were: (i) tilapia (GIFT strain of *Oreochromis* sp.) at a stocking density of 180/decimal (1 decimal = 40 m2) and grass carp (Ctenopharyngodon idella) at 1.5/decmal ; (ii) tilapia at 150/decimal and carps (ruhu Labeo ruhita, catla Gibelion catla, mrigal Cirrhinus cirrhosus and grass carp) at 6/decimal; and (iii) tilapia at 120/decimal and carps at 9/decimal). The stocking rates were determined, calculating the individual stocking weight of 4-5 gm and 45-50 gm for tilapia and carp, respectively. Due to any variation in available stocking size, the stocking biomass of fish was determined near to similar by recalculating the stocking number. The study design with stocking protocol is shown in Table 3.

Table 3. Pen area, fish species and stocking number for the pen culture intervention in Polder 2

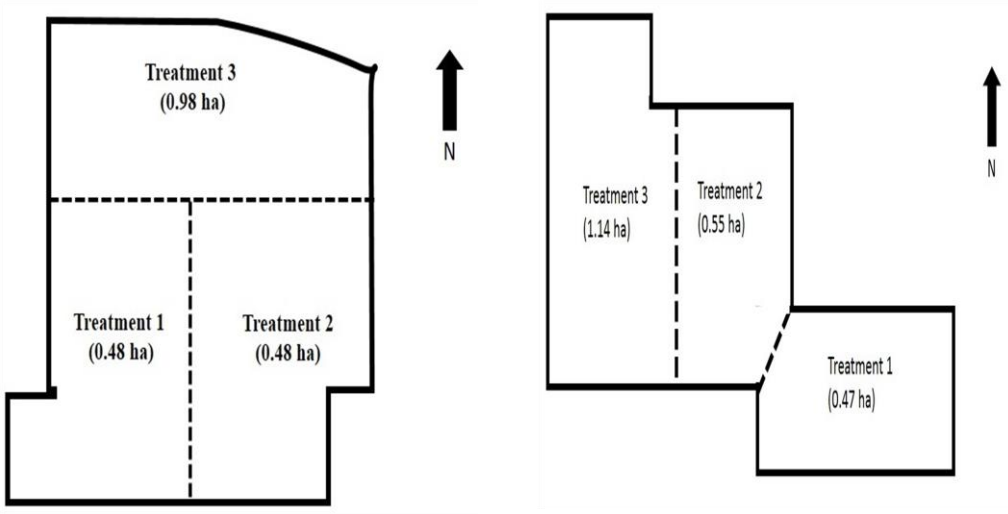
Study site	Pen area In ha (decimal)	Treatment	Stocking density (indv/decimal)	Total number of fish stocked
Chaler Beel (Dagur Beel WMG)	0.47 (116.82 decimal)	T1	Tilapia: 180	21028
			Grass Carp: 1.5	176
	0.47 (116.82 decimal)	T2	Tilapia: 150	17523
			Ruhu: 3	351
			Catla: 1	117
			Mrigal: 0.5	59
			Grass Carp: 1.5	176
	0.97 (239.45 decimal)	T3	Tilapia: 120	28734
			Ruhu: 5	1198
			Catla:1.5	360
			Mrigal: 1	240
			Grass Carp: 1.5	360
Kachur beel (Jordia Erukhal WMG)	0.46 (114.51)	T1	Tilapia: 180	20612
			Grass Carp: 1.5	172
	0.54) (134.31)	T2	Tilapia: 150	20147
			Ruhu: 3	403
			Catla: 1	135
			Mrigal: 0.5	68
			Grass Carp: 1.5	202
	1.13 (278.55)	T3	Tilapia: 120	33426
			Ruhu: 5	1393
			Catla: 1.5	418
			Mrigal: 1	279
			Grass Carp: 1.5	418

4.2.4 Fish pen construction and preparation

A part of each selected beel was demarked for pen construction. The total pen area in Chaler beel was 1.94 ha and that in Kachur beel was 2.16 ha. Each of the demarked area for pen was enclosed and divided into three compartments to assign each treatment (Fig. 2). Polyethylene knotless net (Photo 3) of Spider brand (ASM Industries Ltd, Narayangonj, Bangladesh) was used to construct the fish pen in both the experimental sites. The net was fixed to 30 cm beneath the mud, tied with bamboo spilt that resisted the net to come out of the cervices once it is filed up with soil, and

fetched with bamboo poles in the surrounding areas. The height of the pen was at least 3 meters to prevent fish escaping from any overflow and/or jumping. The fish pen area was almost dry for nearly about one month that helped for entrapping any predator inside the pen during construction.

Photo. 3. Polyetylene net (spider brand), ASM Industries Ltd., Narayongonj



(**a**) (**b**)

Fig. 2. Pen construction layout of the (**a**) Chaler Beel and (**b**) Kachur Beel


Photo 4 & 5. Pen construction

4.2.5 Fish stocking

Tilapia (GIFT strain) fingerlings were collected from local hatchery through a supplier. Prior to transportation, the fishes were caught from hatchery ponds and kept overnight starved. The fishes were then loaded in oxygenated plastic drum and transported to experimental sites. Consulting with the contract WMG members, carp fishes were collected directly from local fish farm. The number of tilapia fingerling in one kilogram was estimated for the required number of fish to stock in each treatment. Fish stocking in each site was completed within 30 July 2017 - 3 August 2017. Prior stocking to pen compartments, fishes were acclimatized with the prevailing conditions of beel water. Average initial length (cm) and weight (g) of stocked fish were recorded (Table 4). Both tilapia and carp fishes were stocked to respective treatment pen compartment according to the study design (Table 3).

Table 4. Mean length and weight of fish at stocking

	Chaler Beel		**Kachur beel**	
Species	**Length (cm)**	**Weight (gm)**	**Length (cm)**	**Weight (gm)**
Tilapia	5.43±0.73	5.00±1.00	5.69±0.71	5.5±1.00
Ruhu	50.21±8.90	14.7±2.50	15±3	53.10±10.21
Catla	50.30±7.60	14.3±3.00	14.6±2.7	51.20±8.24
Mrigal	52.30±9.50	14.4±2.30	14.4±2.1	50.10±7.40
Grass carp	54.30±10.70	15.2±3.30	15.2±3.3	54.00±8.10

Photo 6 & 7. Fish stocking

4.2.6 Post-stocking management

"Mega Floating Fish Feed for Tilapia" from Spectra Hexa Limited was selected for feeding tilapia. For the 1st week, "Pre-starter" (protein level 32%) feed was applied thrice a day at the rate of 7% body weight for tilapia. For the 2nd to 4th week, "Starter" (protein level 30%) was applied at 6% of body weight. For the 5th to 9th week onwards "Grower" (protein level 28%) was applied at 5-4% body weight. For the 10th week onwards Finisher (protein level 26%) was applied at 4-2.5% body weight. Daily feed amount was adjusted at weekly basis by calculating the tilapia biomass during fish growth sampling. No extra feed was being applied for carps. Feed was applied to fish twice a day, dividing the daily required amount, by broadcasting using boat.

Photo 7 & 8. Fish growth monitoring and sampling

Growth of fish was monitored weekly through random sampling of fish (n ≈ 25) and measuring individual length (cm) and weight (gm), using measuring scale and digital balance, respectively. Health condition of fish was also observed during sampling. Depth, temperature, dissolved oxygen (DO) and pH of water were monitored at weekly interval, using wooden scale, thermometer, portable DO Meter (Lutron DO-5519) and pH Meter (Milwaukee pH 55), respectively. Fishes were harvested by repeated netting and draining the water. All data were compiled and analyzed using Microsoft Excel 2013.

5. Results

5.1 Chaler beel (Degur beel WMG)

At the time of fish stocking (31 July 2017), average water depth of the entire pen area was 77.50 cm (53 - 104 cm). After the stocking, a gradual decline in water depth was noticed and reduced to an average of 30.04 cm (16 – 47 cm) in 30 August 2017. Unexpectedly the reduced water depth resulted in trapping the fish in upper parts of pen area, increased water temperature (34^0C) and decreased dissolved oxygen (DO) concentration (4.0 mg/l). The fish started to die. As there was no alternative to increase the water depth, farmers started to harvest, upon the consent of Blue Gold, and the inner net walls were removed on 30 August 2017 to allow the fish to move to comparatively deeper parts of the pen area. As the fishes were undersized and market price was low, farmers wanted to keep fish, hoping the more rain to fall and an increase in water depth, but that did not ultimately happened rather there was further decrease in average water depth of 14.50 cm (Fig. 3), increase in temperature of 35^0C (Fig. 4) and decrease in DO level of 2.5 mg/l (Fig. 5). Though there was low rainfall during the period, but the main reason of reduced water depth was the drainage of beel water through the nearby Amadkhali canal, which has been re-excavated under the Blue Gold programme in the last year. This was the opinion of the Blue Gold and that was endorsed by the local people.

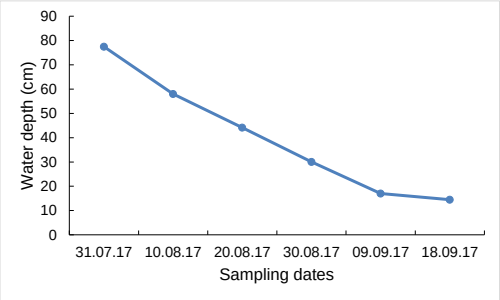


Fig. 3. Variations in water depth in Chaler beel.

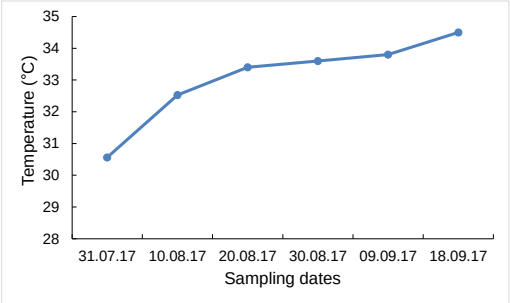


Fig. 4. Variations in water temperature in Chaler beel.

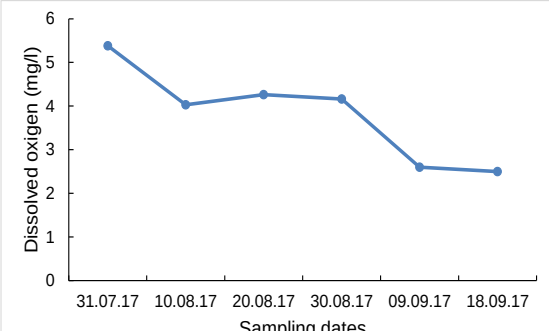


Fig. 5. Variations in dissolved oxygen (DO) level in Chaler beel.

Under this unexpected circumstances, mortality in fishes continued. At the face of continued high mortality in fish, farmers started partial harvesting in the 1st week of September 2017 and completed harvesting by the 18th September 2017. The details of fish harvesting record are given in Table 5. The recovery rate of carp fishes was higher than that of tilapia.

Table. 5. Fish harvesting details of Chelar Beel (as of 18 September 2017)

Fish	Number of stocked fish	Number of fish harvested	Average weight (gm) at harvest	Total weight at harvest (kg)	Recovery rate (%)
Tilapia	67285	11149	106.75	1190.12	17
Rui	1549	516	292.26	150.81	33
Catla	477	224	282.18	63.21	47
Mrigal	299	135	237.35	32.04	45
Grass carp	712	351	428.95	150.56	49

Due to circumstantial removal of inner partition of the pen compartments, it was not possible to record the treatment-wise growth data at harvest. However, data that were recorded before removal of net partition (30 August 2017, i.e. 29 days of culture period) reveals that the lowest stoking density of 120 tilapia/decimal resulted in higher average individual body weight of 68.25 gm than that of 150/decimal (47.47 gm) and of 180/decimal (31.02 gm) (Fig. 6). The specific growth rate (SGR) of fish was also as high as 9.01%/day for tilapia with the stocking density of 120/decimal (Fig. 7).

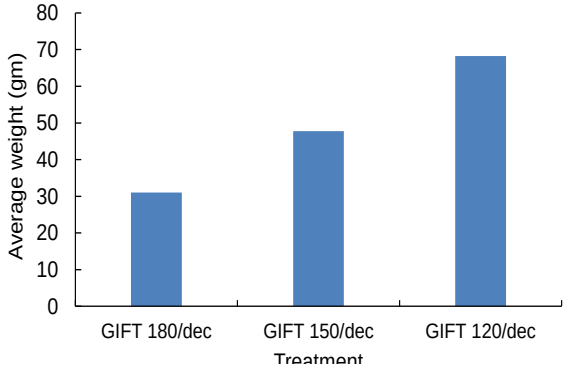


Fig 6. Growth of tilapia (GIFT) in Chaler beel up to 30 August 2017 (29 days of culture period).

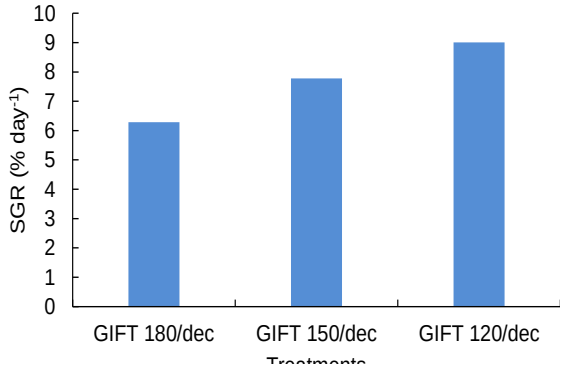


Fig 7. SGR of tilapia (GIFT) in Chaler beel up to 30 August 2017 (29 days of culture period).

5.3 Kachur beel (Jordia Erukhal WMG)

As was happened in Chaler beel, the water depth in Kachur beel was not affected by any drainage of water, but by variations in rainfall and evaporation, during the fish culture period. Variations in average water depth, temperature and DO level are presented in Fig. 8, Fig 9 and Fig 10, respectively. The average water depth varied from 49 to 95 cm, with a higher depth of 109 cm at stocking of fish. The intensity of rainfall in the locality resulted in the gradual increase and decrease in water depth. The water temperature varied from 27 – 33^{0}C, with the highest in the month of September 2017. The DO level varied from 4.06 – 6.11 mg/l. An increase and a decrease of both temperature and DO level were recorded with a decrease and an increase od water depth (Fig. 8, Fig. 9 and Fig. 10). However, the variations in in values of water quality parameters were within the fish culture limit and did not cause any mortality of cultured fish.

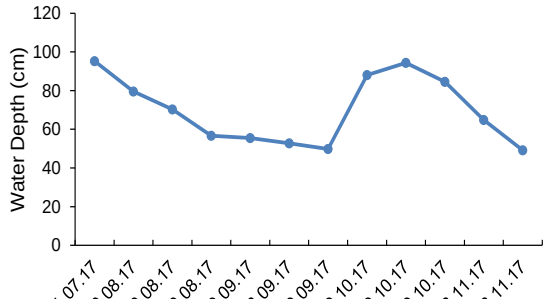


Fig. 8. Variations in water depth in Kachur beel.

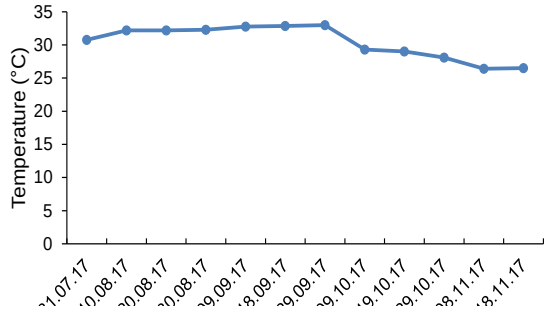


Fig. 9. Variations in water temperature in Kachur beel.

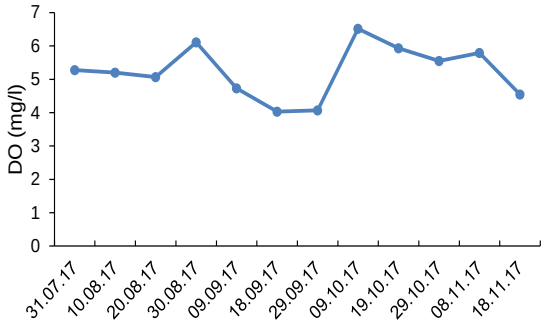


Fig. 10. Variations in dissolved oxygen (DO) level in Kachur beel.

The growth of cultured fish in three pen compartments are given in Table 6. In about 130 days of culture period, tilapia attained higher average weight of 239.10 gm with the stocking density of 120/decimal (Table 6), though statistical analysis could not be done due to lack of replications. Among the carp species, grass carp attained the higher body weight of 356.12 gm and 534.89 gm in Pen-2 (GIFT 150/dec) and Pen-3 (GIFT 120/dec) compared to that of 376.22 gm in Pen-1, where the tilapia (GIFT) were stocked at the higher density of 180/dec. Among the three species of Indian major carps, average weight gain in catla was higher compared to that in mrigal and rui. The SGR (% per day) of tilapia was similar (3.26-3.28) irrespective of stocking densities (Table 6).

Table 6. Growth of different fish species in three pen compartments in Kachur beel

Fish Species	Growth Parameters	Treatment		
		Pen-1 (GIFT 180/dec)	Pen-2 (GIFT 150/dec)	Pen-3 (GIFT 120/dec)
Tilapia	Final length (cm)	22.59±3.89	22.62±4.23	22.63±3.21
	Final weight (gm)	232.65±40.53	235±52.1	239.1±20.32
	Length gain (cm)	16.9±3.95	16.93±4.29	16.94±3.28
	Weight gain (gm)	227.15±40.54	229.5±52.11	233.6±20.34
	SGR (% per day)	3.26	3.27	3.28
Rui	Final length (cm)		26.4±6.34	26.5±6.72
	Final weight (gm)		355±50.8	352.02±53.2
	Length gain (cm)		11.4±7.06	11.5±7.36
	Weight gain (gm)		301.9±51.82	298.92±54.17
	SGR (% per day)		1.65	1.64
Catla	Final length (cm)		32.1±11.22	32.15±10.51
	Final weight (gm)		407.22±60.32	408.3±67.76
	Length gain (cm)		17.5±11.54	17.55±10.85
	Weight gain (gm)		356.02±60.88	357.1±68.26
	SGR (% per day)		1.80	1.81

Fish Species	Growth Parameters	Treatment		
		Pen-1 (GIFT 180/dec)	Pen-2 (GIFT 150/dec)	Pen-3 (GIFT 120/dec)
Mrigal	Final length (cm)		27.91±7.36	27.88±8.1
	Final weight (gm)		395.21±40.21	395.02±45.88
	Length gain (cm)		13.51±7.65	13.48±8.37
	Weight gain (gm)		345.11±40.89	344.92±46.47
	SGR (% per day)		1.68	1.68
Grass Carp	Final length (cm)	30.2±8.9	32.3±2.8	32.07±5.3
	Final weight (gm)	430.22±100.21	590.12±30.67	588.89±40.34
	Length gain (cm)	15±11.39	17.1±4.33	16.87±6.24
	Weight Gain (gm)	376.22±100.54	536.12±31.72	534.89±41.15
	SGR (% per day)	1.8	2.1	2.1

The harvesting of fish was started on 23 November 2017 and completed on 8 December 2017. After completion of total harvesting, per ha production (species-wise and total) of cultured fish was estimated and is presented in Table 7. While per ha production of tilapia was 6.47 t/ha in Pen 1, with the stocking density of 180 tilapia/dec, that of tilapia in Pen 2 and Pen 3 were much lower. However, the lowest production of 1.35 t/ha of tilapia was obtained from Pen 3, with the stocking density 120/decimal, but the individual growth rate was higher throughout the culture period (Fig. 11) and at harvest (Table 7) as well.

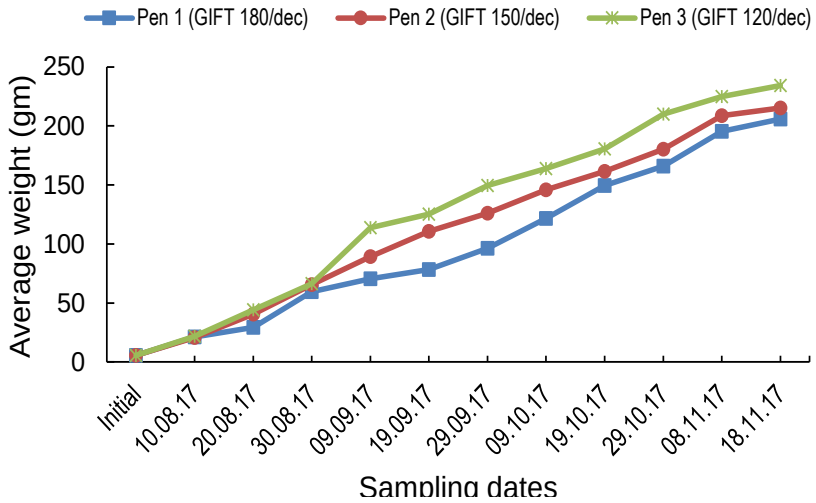


Fig. 11. Pen-wise incremental growth of tilapia (GIFT) in Kachur beel during the culture period.

The lower production of tilapia in Pen 2 (2.44 t/ha) and in Pen 3 (1.35 t/ha) was due to corresponding low recovery rate of 28.01% and 19.03%, compared to that of 62.46% in Pen 1

(Table 7). The lower recovery rate in Pen 2 and Pen 3 also resulted in higher FCR of 2.86 and 2.98. The FCR of 1.35 for tilapia in Pen 1 was quite optimum (Fig. 12). In some other pen fish culture on open waters the low rate of recovery (32 -65%) has been identified due to improper maintenance, escaping through crab holes, jumping over dike during heavy shower, poaching and predation (Haque et al., 2006).

However, neither any adverse environmental condition nor any mortality of fish was observed during the fish culture period of the present study. The reason that was identified for low recovery rate was escaping a huge number of fish, particularly tilapia, from the Pen 2 and Pen 3. At the end of harvesting period, large areas of net wall along with the open beel side of Pen 2 and Pen 3 were found cut. A large number of people were found to catch fish from the outside bee area. Though it was not possible to quantify the escaped fish, personal interview of local people indicated that nearly nearly 4000-5000 kg of fish were caught by the neighbours.

Photo 8 & 9. Fish harvesting

Table 7. Production (kg/ha) of different fish species in three pen compartments in Kachur beel

Fish Species	Pen-1 (GIFT 180/dec)			Pen-2 (GIFT 150/dec)			Pen-3 (GIFT 120/dec)		
	Av. weight (gm)	Survival (%)	Production (kg)	Av. weight (gm)	Survival (%)	Production (kg)	Av. weight (gm)	Survival (%)	Production (kg)
Tilapia	232.65	62.46	6462.80	235.00	28.01	2444.47	239.10	19.03	1351.31
Rui	-	-		355	65.32	173.05	352.02	61.33	266.14
Catla	-	-		407.22	50.51	51.43	408.3	50.42	76.10)
Mrigal	-	-		395.21	65.08	32.39	395.02	65.13	63.52
Grass carp	430.22	74.34	119.58	590.12	59.13	130.53	588.89	61.28	133.50
Total production			**6582.38**			**2831.87**			**1890.57**

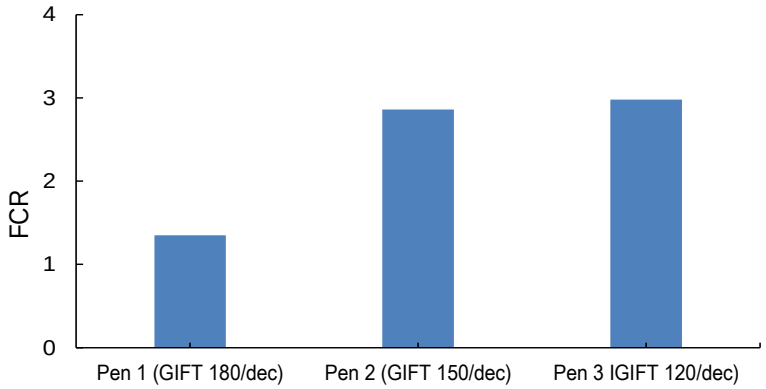


Fig. 12. FCR of tilapia (GIFT) in different pen compartments in Kachur beel.

With the obtained fish growth, survival and production rate in Kachur beel, a simple cost benefit analysis per ha is shown in Table 8. Pen 1, where the stocking density of tilapia was 180/decimal, resulted in a net benefit of Tk. 1,37,037 in four months investing a total of Tk. 3,92,003 (Table 8). Due to the unexpected early closure of the pen fish culture in Chaler beel and very low recovery rate of fish in Kachur beel, as have been mentioned earlier, it is easily understood that there was no overall profit from the fish culture. However, the final production data of Kachur beel pen culture indicate that final growth of tilapia and carp species was similar irrespective of different stocking densities, but indifferent stocking biomass. As there is evidence of forced escaping of fish at the end of fish rearing period, It could be assumed that the addition of carps had no effects on growth and survival of tilapia. So, if we consider the highest production rate of tilapia (6,463 kg/ha in Pen 1) and of carp fishes (532 kg/ha in Pen 3) that has been recorded in Kachur beel study site, the pen fish culture might be profitable.

In early 90's, several attempts for pen culture were made in Chandpur Irrigation Project (CIP) canal with varying level of stocking density, ranging from 12000 - 24000 fish/ha, and production, ranging from 812 kg/ha/crop - 3841 kg/ha/crop with recovery rate of 28% - 65% (Akhter and Halder,1996). A 7-month study on pen culture of silver carp (*Hypophthalmicthus molitrix*), catla (*Catla catla*), rohu *(Labea rohita*), common carp (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*) at a stocking density of 16000/ha with the ratio of 31:12:12:12:31 in a flood plain in Dhaka resulted in a total production of 2742 kg/ha with 37% recovery rate and the net profit of Tk. 86320/ha (Haque et al., 2006). In spite of facing natural and social problems, the growth and production of fish has shown a great promise of utilizing the seasonal waterlogged areas, while a comparison is made with above study results of pen culture in open water.

Table 8. Simple cost benefit analysis (per ha) of pen fish culture in Kachur beel

Cost				
Item		**Treatment**		
		T-1 (GIFT 180/m^2)	**T-2 (GIFT 150/m^2)**	**T-3 (GIFT 120/m^2)**
Preparation cost	Net	16000	16000	16000
	Labour	5000	5000	5000
	Bamboo	4000	4000	4000
	Total	**25000**	**25000**	**25000**
Seed Cost	Tilapia	58474	48841	39095
	Carp	1830	7345	11000
	Total	**60303**	**56186**	**50095**
Feed Cost		**301700**	**263454**	**50094**
Maintenance Cost		**5000**	**5000**	**5000**
Total		**392003**	**349641**	**302989**
Production				
Tilapia		**6463**	**2444**	**1351**
Carp Fish		**120**	**387**	**532**
Income				
Tilapia (@80 tk/kg)		517040	195520	108080
Carp Fish (@100 tk/kg)		12000	38700	53200
Total		**529040**	**234220**	**161280**
Net Benefit				
Income		529041	234221	161280
Cost		392003	349641	302989
Net Benefit (Tk)		**137037**	**-115420**	**-141709**

It is to note that, though was no market study activity under the project, there are a number of fish wholesale markets in the locality where the farmers sold their fishes.

6. Skill and awareness building activities

6.1 Farmers training

Day-long training programme on different aspects of pen fish culture was organized on separate days for the farmers of each beel. The local DoF officials were invited and participated in each training programme as trainer. Besides the technical aspects of pen fish culture, Blue Gold experts were participated as trainer, particularly for the subject of value chain and marketing.

Photo 10 & 11. Farmers training

6.2 Farmers day

One farmers' day was organized in Kachur beel site. More than 100 farmers of the locality observed the fish at site and then participated in a discussion meeting that was organized at a nearby school field. Among the participants, there were local leaders, journalists and members of different WMGs. Different aspects of pen fish culture and its potential application in waterlogged areas were discussed. The farmers were also shared their positive views and expressed their interest to practice pen fish culture, if they are provided with technical as well as financial supports from Blue Gold or any other organizations.


Photo 12 & 13. Farmers' day

6.3 Publicity and documentation

The pen fish culture activities were broadcasted in Mati O Manush programme of BTV and in other television channels (Banglavision and Channel 9). One 10-12 minutes length video has also been prepared.

7 Stakeholder workshop

A day-long local stakeholder workshop on "Pen Fish Culture in Waterlogged Areas" was organized at the Digital Conference Room of Satkhira Sadar Upazila Parishad on 22 January 2018. The District Fisheries Officer, Satkhira and the Executive Engineer, Bangladesh Water Development Board (BWDB), Satkhira were present in the workshop respectively as the Chief Guest and Special Guest. The Upazila Nirbahi Officer, Satkhira Sadar presided over the workshop. The Chairman of Fingri Union Parishad was also present in the workshop as an invited guest. Officials from Blue Gold Dhaka office and Satkhira office were present in the workshop. Representatives from the local public extension (DoF, DAE) and research (BFRI - Bangladesh Fisheries Research Institute) organizations, BWDB, fish hatchery owners, fish feed suppliers, WMGs, fisheries entrepreneurs and farmers actively participated in the workshop. The main purpose of the workshop was to present and discuss the results of the project for future application of the pen fish culture technique in waterlogged areas.

In the workshop, Dr. MJ Alam presented the results that have been obtained from two study sites of pen fish culture. The president of Jordia Erukhal WMG and Degur Beel WMG shared their experience that their groups have gained during the implementation pen culture activities. Both the Presidents expressed satisfaction with growth of fish and potential of pen culture in waterlogged conditions, but they failed to get the full benefit of fish culture due to either of shut down the fish culture for unexpected water drainage (Chaler beel) or of escape of fish form the pen. The Chairman of Fingri UP, expressed his own views on the completed pen culture project that he has observed closely. He admitted, he has the authentic information that some local people intentionally cut the net at the beginning of harvesting and a huge quantity of fish has been caught from the open beel area. But he marked the pen culture a very successful, pointing that 20 farmers of Kachur beel (Jorida Erukhal WMG) did not get profit but other farmers around earned a huge through catching the escaped fish. This means that there was a good production of fish in pens. The Chief Guest requested Blue Gold to replicate the pen culture in other suitable areas. He assured that the DoF will be providing all possible supports in the implementation process of such an

Photo 14 &15. Workshop

innovative project. The Chairman of the workshop thanked Blue Gold and BSMRAU for undertaking the project and also expressed its wider adoption in the areas. The important recommendations of the workshop are given below:

- Blue Gold and BSMRAU should repeat the study, taking precautionary measures to risks encountered, for further validation and documentation of results.
- Alternate hardy materials like bamboo or plastic split, which could not be intentionally cut easily, may be used for pen construction.
- Freshwater prawn (Golda Chingri) may be a suitable species for pen culture in waterlogged areas.
- Bagda chingri at very low stocking density can also be cultured along with freshwater fish.
- As the price of fish is lower in December (harvesting time of pen culture), research works should find how the production cost would be reduced.
- Site should be selected where water remains up to January. As feed cost covers 70 -75% of the total operational cost, there is need to enhance natural food and find alternative feed for fish.
- Different innovative ideas of cultivating fish and crop together should be developed.

8 Challenges and mitigation measures

- Proper site selection appears to be a major challenge what happened in case of Chaler beel. Prior to selection of a site, a detailed survey should be done to identify any probability of water drainage due to any development works around.
- The starting and duration of pen culture in the area largely depend on the onset of monsoon and intensity of rainfall. The stocking of fish in the pen delayed almost a month due to late rainfall. It may not be that every year the waterlogging will occur in a particular area with a desired level for pen fish culture. Relying on weather forecast and monsoon behaviour, farmers in the locality may prepare the pen for fish culture.
- There is a challenge of group formation of all the land owners. Farmers might have reluctance to go for pen fish culture due to confusion regarding the initial cost involvement and expected benefit. An awareness building programme through pilot scale demonstration and training to farmers may result in motivation of farmers to pen fish culture practice.
- Another major challenge might be protecting fish from escaping due to intentional damage of net enclosure by others. Besides guarding, selection of wider area and involving almost all land owners of the waterlogged beel may help to solve this social problem to a great extent.

9 Lesson learned

- Seasonal waterlogging in all areas may not recur every year to an extent that would be sufficient for fish culture.
- A mistake in selecting Chaler Beel without assessing re-excavation of Amodkhali khal under the Blue Gold programme, as it had caused rapid water drainage and failure of fish culture in Chaler Beel.
- Social mobilization as well as wider participation is required to protect cultured fish from illegal loss.
- Framers are interested to pen fish culture, but lacks appropriate technical know-how and financial support.

10 Conclusion

There are areas in Polder 2 in Satkhira and in other areas of southwest part of Bangladesh those remain unproductive during most of the period of a year due to seasonal waterlogging. These untapped waterlogged areas, where the water depth remains at least 80-100 cm for 4-5 months, could be potentially utilized for overall economic upliftment of the local farming community through adoption of pen fish culture technology. The target fish to culture would preferably be the short grown species like tilapia (GIFT), but the major carps (viz., catla, ruhu and mrigal) may be stocked as secondary fish species. Though it is clear that pen fish culture in the waterlogged areas may be an excellent example to stimulate income generation and employment opportunity for sustainable rural livelihood, there have been a number of challenges like water drainage and pouching of fish to get expected results. Prior to select an area, a thorough assessment should be done on the development works that may cause rapid water drainage. Community based participatory aquaculture should be in the place to achieve good harvest by overcoming any social problem like intentional cutting of nets and pouching of fish. The WMGs (and the rural communities as well) need to be trained on location specific fish culture management and empowered economically to ensure their participation in planning and execution of their future programme. Further study on fish feeding management (both feeding rate and frequency) may be conducted to minimize the production cost for covering the as usual lower market price of fish in the locality during November-December, which would be the fish harvesting period of pen culture.

References

Akhter, J.N. and G.C Haldar, 1996. Culture of fish in pens. Technical report-12. Riverine Station, Bangladesh Fisheries Research Institute, Chandpur-3602, Bangladesh. 42 pp.

Das, N.G., M.S. Hossain and M.S. Islam. 2009. Waterlogged area as new horizon for aquaculture development: a golden dream to the rural communities of Begumgonj, Noakhali. Bangladesh J. Mar. Sci. Fish., 1(1): 47-62.

FAO, 2015. Mapping exercise on water-logging in south west of Bangladesh. Draft for Consultation, Food and Agriculture Organization of the United Nations, March 2015, 160p.

Haque, W., S. Sharmin and G.B. Sufi. 2006. Feasibility study of fish culture in pen in a flood plain area in Dhaka. Bangladesh J. Zool., 34(2): 247-256.

.