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Competitive Research Grant

Sub-Project Completion Report

On

Adoption of Culture Technologies of Short Cycle Fish Species in the Semi-arid Zone of Bangladesh

Project Duration
May 2017 to September 2018

Bangladesh Fisheries Research Institute
Freshwater Sub-Station, Saidpur, Nilphamari

Submitted to
Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Project Implementation Unit
National Agricultural Technology Pgrogram-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka-1215
Bangladesh

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Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka-1215
Bangladesh

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Acronyms

BBS = Bangladesh Bureau of Statistics

BCR= Benefit Cost Ratio

BFRI = Bangladesh Fisheries Research Institute

DoF = Department of Fisheries

FCR= Food Conversion Ratio

FSS = Freshwater Sub-Station

GDP = Gross Domestic Product

GIFT= Genetically Improved Farmed Tilapia

GO = Government Organization

NGO = Non-Government Organization

SGR= Specific Growth Rate

SUFO= Senior Upazila Fisheries Officer

UFO = Upazilla Fisheries Officer

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Executive Summary

The study was carried out in farmers' ponds located at the northern region of Bangladesh during May 2017 to September 2018 to observe the growth and yield of Shing, *Hetetopneustes fossilis* and Tengra, *Mystus vittatus* under polyculture system and to find out the most suitable combination of Shing/Tengra with other short cycle fish for the semi-arid zone of Bangladesh. With that view, two different patterns *viz*; Shing+Pabda+Rajpunti+GIFT (pattern-I) and Tengra+Magur+Rajpunti+GIFT (pattern-II) were used for trails including three treatments and two replications of each in seasonal farmer ponds at the adjacent areas of BFRI substation, Saidpur during mid July 2017 to mid December 2017 to evaluate the growth and yield performance of Shing, *H. fossilis* and Tengra, *M. vittatus* under polyculture system. Three different stocking densities (individuals decimal^{-1}) of Shing *viz.,* 400 Shing (+100 Pabda+10 Rajpunti+5 GIFT); 500 Shing (+100 Pabda+10 Rajpunti+5 GIFT) and 600 Shing (+100 Pabda+10 Rajpunti+5 GIFT) were treated as T_1, T_2 and T_3 respectively in pattern-I. In case of pattern-II, three different stocking densities (indi. dec.$^{-1}$) of Tengra *viz*; 500 Tengra (+100 Magur+10 Rajpunti+5 GIFT); 600 Tengra (+100 Magur+10 Rajpunti+5 GIFT) and 700 Tengra (+100 Magur+10 Rajpunti+5 GIFT) were treated as T_1, T_2 and T_3 respectively. After 5 months of culture period, the combination (T_2) of 500 Shing+100 Pabda+10 Rajpunti+5 GIFT (indi. dec.$^{-1}$) showed significantly higher (P<0.05) weight gain of Shing (g) 50.3±5.5^a, production of Shing (kgha^{-1}) 5080±75^a, total production (kgha^{-1}) 6,331±211^a, total production cost (Tk.ha^{-1}) 12,32,875±2281^b, gross return (Tk.ha^{-1}) 18,77,570 ±400^a, gross margin (Tk.ha^{-1}) 6,44,570 ±8886^{a}and benefit cost ratio (BCR) 1.52^a among three treatments in pattern-1. Similarly, the combination (T_1) of 500 Tengra+100 Magur+10 Rajpunti+5 GIFT (indi. dec.$^{-1}$) also showed significantly higher (P<0.05) weight gain of Tengra (g)16.2±1.1^a, production of Tengra (kgha^{-1}) 2,035±5.0, total production (kgha^{-1}) 5,592±8.0^a, total production cost (Tk. ha^{-1}) 10,09,167±2602^c, gross return (Tk.ha^{-1}) 16,04,987 ±1273^a, gross margin (Tk.ha^{-1}) 5,95,820 ±3259^a and benefit cost ratio (BCR) 1.60^a among the treatments in pattern-II. These two best combinations were chosen for multi location testing (MLT) program in different locations of northern region of Bangladesh during May 2018 to September 2018 to verify the previous results. A total of 06 (six) different locations (upazila) were selected from northern region and 2 (two) seasonal ponds from each upazila were selected on a random basis. Of them, three locations such as Saidpur (Niphamari); Hatibanda (Lalmonirhat) and Dimla (Niphamari) were selected for demonstrating the combination of 500 Shing (+100 Pabda+10 Rajpunti+5 GIFT) indi. dec.$^{-1}$ and another three locations such as Domar (Niphamari); Kaligonj (Lalmonirhat) and Niphamari Sadar were selected for demonstrating the combination of 500 Tengra (+100 Magur+10 Rajpunti+5 GIFT) indi. dec.$^{-1}$. After 5 months of multi-location testing with Shing as the main species, the highest weight gain of Shing (g) 57.38±0.9^a, production of Shing (kgha^{-1}) 5,828±3.1^a, total production (kgha^{-1}) 7352±2.5^a, total production cost (Tk.ha^{-1}) 12,29,000±10, gross return(Tk.ha^{-1}) 21,35,000±7.6^a, gross margin (Tk.ha^{-1}) 9,06,000±10.4^a and benefit cost ratio (BCR) 1.73^a were found in Dimla with significant difference (P<0.05) among three locations. In similar trials with Tengra as the main species, the highest weight gain of Tengra (g) 16.20±0.40^a, production of Tengra (kgha^{-1}) 2252±3.5, total production (kgha^{-1}) 5656±70.3, total production cost (Tk.ha^{-1}) 10,12,000±15, gross return (Tk.ha^{-1}) 16,65,400±5.7, gross margin (Tk.ha^{-1}) 6,53,400±18.5 and benefit cost ratio (BCR) 1.65 were found in Kaligonj with significant difference (P<0.05) among three locations excepting the value of total Tengra production found higher in Domar. Thus, the results of multi-location trials clearly authenticated the previous findings rather demonstrated higher growth performance, production and BCR compared to that of previous on station trials in both of the culture patterns. Therefore, the technologies of short cycle fish species such as Shing, *H. fossilis* and Tengra, *M. vittatus* should be disseminated to fish farmers and entrepreneurs throughout the semi-arid zone of Bangladesh for enhancing fish production and livelihoods.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project**: Adoption of Culture Technologies of Short Cycle Fish Species in the Semi-arid Zone of Bangladesh

2. **Implementing organization**: Bangladesh Fisheries Research Institute (BFRI)

3. **Name and full address with phone, cell and E-mail of PI/Co-PI (s):**

Principal Investigator: Dr. Khondaker Rashidul Hasan
Principal Scientific Officer and Sub-Station Chief
BFRI, FSS, Saidpur, Nilphamari
Cell: 01714337502
Email: rashidulbfri@yahoo.com

Co-Principal Investigator: Mr. Saokat Ahamed
Scientific Officer
BFRI, FSS, Saidpur, Nilphamari
Cell: 01751256234
Email: saokat.sau04@yahoo.com

4. **Sub-project budget** (Tk):29,95,495/-
Totalreceived (Tk): 29,95,495/-
Revised (if any) (Tk): 29,95,495/-

5. **Duration of the sub-project**:May 2017-September 2018

Start date (based on LoA signed): 08 May 2017
End date: 30 September 2018

6. **Justification of undertaking the sub-project:**

Bangladesh is ranked fourth position in Inland fishery production just after China, India, and Myunmar and fifth position in marine water. Fisheries sector is inseparable from the life and lifestyle of the people of Bangladesh which contributes 4.37% to the national GDP and almost one-fourth (23.37%) to the agricultural GDP (DoF, 2013). About 1.5 million people are directly employed by this sector (DoF, 2012). The rich aquatic biodiversity of the country has been attributed to the world's one of the largest wetlands (Bengal Delta) and three large river systems (Brahmaputra, Ganges and Jamuna) that flow from the Himalayan Mountains into the Bay of Bengal. A Huge inland fisheries resource has been supplying fish and other aquatic animals and plants to millions of people living in the Delta (Hossain, 2014). But the Northern region (Rangpur division) of Bangladesh is known as drought and river bank erosion prone area. Most of the districts under this division have been experiencing frequent natural disasters and adverse impacts of climate change and surface water is almost disappeared from ponds and canals, even major rivers have reduced water volume for 6-8 months. As a result the number of seasonal waters (BBS. 2000) is increasing and about 55% ponds are seasonal of which 60% retained water for 4-6 months while 40% retained for 6 to 9 months in a year and even more in some areas.

These small water bodies are being used mainly for household activities but some are still abandoned due to their derelict and marshy nature. In this semi-arid zone, fish farmers are lacking appropriate fish culture techniques as a result most of the farmers practice traditional way of fish culture. The polyculture attempts on short cycle species such as Tengra (*Mystus vittatus*), Shing (*Hetetopneustes fossilis*), Magur (*Clariasbatracus*), Pabda(*Ompuk Pabda*), Rajpunti (*Barbodesgonionoutus*) and GIFT (*Oreochromis*sp) etc. might have potential in those seasonal waters. But Tengra, Shing, Magur, Pabda were hardly attempted for polyculture in greater northern region. To ensure proper utilization of seasonal ponds, the culture of short-cycle species should be introduced in the semiarid zone for enhancing fish production. These species have high demand throughout the country due to their taste and medical values. The popular belief is that there is special nutritive and medicinal quality in those fish which are good for patients and convalescents (Mookerjee and Mazumder, 1950). But lack of knowledge of appropriate culture techniques and unavailability of quality fish seed of candidate species at required time are found to be some of the major constrains at present time to disseminate the BFRI evolved culture technologies in the northern parts of Bangladesh. Unfortunately the proper culture technologies of these species have yet not been optimized and evaluated specially in Northern part of the country. Northern region is such an area where this culture technique will be the most suitable and effective for all types of fish farmers for increasing fish production and income generation. In this context, culture techniques of these species are to be disseminated in this region. Hence, the present project had been proposed to demonstrate the research findings at farmer's ponds as well as to validate the technologies of commercially important short cycle fish species prior to large scale dissemination in the semiarid zone of Bangladesh.

7. **Sub-project goal:** To disseminate a sustainable culture pattern of short cycle fish species in the semi-arid zone for enhancing fish production and as well as to improve farmer's livelihood status.

8. **Sub-project objective (s):**
   To adopt the culture technologies of short cycle fish species; and
   To disseminate the culture technologies in different parts of semi-arid zone of Bangladesh

9. **Implementing location** (s):BFRI, Freshwater Sub-Station, Saidpur, Nilphamari

10. Methodology:

10.1 Adoption of the culture technologies of short cycle fish species in the semi-arid zone of Bangladesh (2017)

10.1.1 Pond selection and experimental design: Two experiments were conducted in farmer's ponds located at the Nilphamari district of Bangladesh for a period of 5 months during mid July to mid December 2017 to observe the growth and yield performance of Shing, *Hetetopneustes fossilis* and Tengra, *Mystus vittatus* under polyculture system. For this reason, six seasonal ponds (7-15 decimal) were selected for each experiment. Six ponds were divided into three groups. Each group was used for a treatment. Ponds were selected with the concern of relevant Upazilla Fishery Officer (UFO/SUFO).The experimental designs are described as follows in Tables 1 and 2.

Table 1. Polyculture of Shing, *H.fossilis*(pattern-1)under different stocking densities infarmer's pond

Treatments	Species wise stocking size (cm)	Stocking density (indi. dec^{-1})			
		Shing	Pabda	Rajpunti	GIFT
T_1	Shing(7-10)	400	100	10	05
T_2	Pabda (5-7)	500	100	10	05
T_3	Rajpunti (7-8)	600	100	10	05
	GIFT (5-6)				

Table 2. Polyculture of Tengra, *M.vittatus*(pattern-2) under different stocking densities in farmer's pond

Treatments	Species wise stocking size (cm)	Stocking density (indi. dec^{-1})			
		Tengra	Magur	Rajpunti	GIFT
T_1	Tengra(5-7)	500	100	10	05
T_2	Magur(7-10)	600	100	10	05
T_3	Rajpunti(6-7)	700	100	10	05
	GIFT (6-7)				

10.1.2 Pond preparation: The selected ponds were prepared by dewatering and drying. Aquatic weeds were removed from the ponds manually. And then, lime was applied @ 1.0 kg decimal^{-1}. After 7 days of liming, urea @100 g decimal^{-1} and TSP @75 g decimal^{-1} were applied at initial stage of pond preparation.

10.1.3 Stocking of fingerlings: The hatchery produced fingerlings (5-10cm) of selected fish were stocked as per experimental design (Tables 1 and 2)

10.1.4 Feeding regime: Commercially available fish feed (containing 30-35% protein) were fed @15-5% BW day^{-1} of the fish.

10.1.5 Sampling: Length and weight data were collected fortnightly in the morning at 8.00 am to 9.00 am. Samplings were done by cast net. Fish length was measured using a measuring meter scale (cm) and weight was taken by a precision weighing balance (measuring range from 1.0 g to 1.0 kg).

10.1.6 Water quality parameters: Water quality parameters such as water temperature (^{0}C) by Celsius thermometer, transparency (cm) by secchi disc, water pH by digital pH meter (Hanna Co. Japan),dissolved oxygen (DO) (mg l^{-1}) by digital DO meter (Lutron PDO-519, Taiwan) and ammonia (NH_3) (mg l^{-1}) by ammonia test kit (Hanna Co. Japan) of the experimental ponds were monitored fortnightly.

10.1.7 Harvesting and estimation of growth parameters and BCR analysis: The ponds were completely dewatered and harvested all the fish at the end of the experiment and counted species wise. Then the final length-weight of each species was recorded. The parameters such as length gain, weight gain, % weight gain, SGR, FCR and survival rate (%) and also benefit cost ratio (BCR) were calculated and evaluated on the growth and yield of fish.

10.2 Dissemination of suitable polyculture patterns of short cycle fish species in different part of semi-arid zone (northern part) of Bangladesh (2018)

Polyculture of *H. fossilis* and polyculture of *M. vittatus* were tested under different treatments in seasonal farmer's ponds at the adjacent areas of FSS, Saidpur during mid July to mid December 2017. Of them, 500 Shing+100 Pabda+10 Rajpunti+5 GIFT(indi. dec.$^{-1}$) from Shing polyculture (pattern-1) and 500 Tengra+100 Magur+10 Rajpunti+5 GIFT(indi. dec.$^{-1}$) from Tengra polyculture (pattern-2)were selected due to technically sound, socially acceptable and economically viable polyculture patterns. These two combinations were disseminated in different aqua-ecological zones of northern region of Bangladesh during May to September 2018 through multi location testing (MLT) program.

10.2.1 Multi location testing (MLT) program: Multi location testing program was conducted in different Upazilaof northern region of Bangladesh to verify the research results of previously tested suitable culture patterns and exchanged views among the researcher, extension people (DoF) and farmers. A total of 06 (six) seasonal ponds were selected in 06 (six) different Upazila of Rungpur region (Table 3). The six Upazila or ponds divided into two groups. Each group was considered as one pattern e.g. pattern-I and pattern-II and each pond or Upazila considered as one replication. The areas of ponds ranged between 10 and 15 decimal. The on-farm ponds were selected with the concern of relevant Senior Upazila Fishery Officer (SUFO/UFO).

10.2.2 Pond preparation: The selected ponds were prepared by drained and drying. Aquatic weeds were removed from the ponds manually and harmful and undesirable fish species removed by using rotenone 25-35 g dec^{-1} ft^{-1} if necessary and ponds were limed @1 kg dec^{-1}. After 5 days of liming, cow-dung 6 kg dec^{-1}, urea 100 g dec^{-1} and TSP 75 g dec^{-1} were applied at initial stage during pond preparation.

10.2.3 Stocking, feeding and data collection: About 7-10 cm fingerlings of those fish were stocked as per experimental design (Table 3). Fish were fed commercially available fish feed 10-5% BW day^{-1} (containing 30-35% protein). Length-weight data and water quality parameters *viz.*, temperature, pH, DO, CO_2, NH_3 etc. were collected fortnightly. The experimental design is presented in Table 3.

Table3. Experimental design of pattern-1 and pattern-2in different Upazila of Rungpur region

Culture pattern	Replication (one pond/Upazila)	Species combination	Stock. density (indi. decl^{-1})
Pattern-1	Saidpur, Niphamari+Hatibanda, Lalmonirhat+Dimla,Niphamari	Shing+Pabda+Rajpunti+GIFT	500+100+10+5
Pattern-2	Domar, Niphamari+Kaligonj, Lalmonirhat+NiphamariSadar	Tengra+Magur+Rajpunti+GIFT	500+100+10+5

10.2.4 Harvesting and growth parameters/BCR analysis: The ponds were completely dewatered and harvested all the fish at the end of the experiment and counted species wise. Then the final length-weight of each species was recorded. The parameters such as length gain, weight gain, % weight gain, SGR, FCR, survival (%) and benefit cost ratio (BCR) were calculated.

10.3 Data analysis: Data were analyzed using MS Excel and **o**ne-way analysis of variance (ANOVA) (Duncan, 1993) and SPSS 20 (Chicago, USA) to detect significant differences among the treatments at 5% level. The values were given with means ±SD, and differences were considered significant at subset for alpha = 0.05 ($p \leq 0.05$).

11. Results and discussion:

11.1 Polyculture of Shing, *H. fossillis* (pattern-1) under different stocking densities in farmer's pond

To evaluate the growth and production of *H. fossillis* nder polyculture system, an experiment was conducted under 3 treatments (T_1-400 Shing+100 Pabda+10 Rajpunti+5 GIFTindi. dec.$^{-1}$; T_2-500 Shing+100 Pabda+10 Rajpunti+5 GIFT indi. dec.$^{-1}$ and T_3-600 Shing+100 Pabda+10 Rajpunti+5 GIFTindi. dec^{-1}) in the earthen mini ponds for a period of 05 (five) months. The growth parameters of candidate fish and water quality parameters of experimental ponds were studied. The results are presented in Tables 4 and 5.

11.1.1 Growth performances of Shing,*H. fossillis* under polyculture in farmer's pond

The growth parameters such as weight gain, SGR, survival rate (%), production of Shing and total production of candidate species were studied and presented in Table 4. In this experiment, the final weights of Shing were 55.5, 52.3 and 42.2 g in T_1, T_2 and T_3 respectively. The highest weight gain (53.5 g) was found in T_1 and the lowest (40.2 g) was found in T_3. The weight gain of Shing were found significantly identical ($P<0.05$) in T_1 and T_2 but higher than T_3. More or less similar growth pattern was observed by Kohinoor *et al*. (2012) who stated the growth of Shing varied between 49.5 and 69.4 g from six months. The growth performances of Shing were found inversely related with the stocking density might be due to competition of food and habited. The SGR of Shing was 2.21, 2.17 and 2.03 %day^{-1} respectively in T_1, T_2 and T_3. On the basis of analysis, the SGRs were found significantly ($P<0.05$) similar in T_1 and T_2 but lower in T_3. The FCR values were higher in T_3 (2.65) and lower in T_1 (2.51). Analytical results showed, the FCR values were directly related with the stocking density. Overall the FCR values were acceptable level and indicated utilization of food soundly, which is agreed by Islam (2002).The survival rate was estimated after harvesting of fish by dewatering the ponds. The survival (%) values of Shing were 84, 80 and 73, respectively in T_1, T_2 and T_3. The survival of Shing was found significantly ($P<0.05$) different among three treatments and inversely related with the stocking density might be the reason of space and food competition among the individuals. The production of Shing was recorded 4,620, 5,080 and 4,599, respectively in T_1, T_2 and T_3. On the basis of analysis, the production (kg ha^{-1}) of Shing in T_2 showed significantly ($P<0.01$) higher value, followed by T_1 and T_3. The total fish production (Kg ha^{-1}) was recorded 5,896, 6,331 and 5894 in T_1, T_2 and T_3 respectively. The total production was also significantly ($P<0.05$) higher in T_2 than those of T_1 and T_3. The production was directly related with stocking density, survival and also individual growth. Although individual growth and survival of Shing was higher in T_1 but higher production was obtained from T_2. The higher production in T_2 was due to dense population than T_1, because individual weight and survival of Shing was not found significantly ($P<0.05$) different between T_1 and T_2. In the present study, the values of survival and individual growth of Shing were relatively sensible impact on the production in T_2 than that of T_1 and T_3. The present findings with the supported by the findings of Narejo*et al.* (2005) who obtained the higher production from higher stocking density at the certain level but individual growth was inversely related with the stocking density.

Table 4. Growth performances of *H. fossillis* under polyculture in farmer's pond

Parameters	Treatments		
	T_1	T_2	T_3
Stock. dens. of Shing (indi. dec^{-1})	400	500	600
Culture period (months)	05	05	05
Initial weight (g)	2.0±.01	2.0±.01	2.0±.01
Final weight (g)	$55.5±5.2^a$	$52.3±6.5^a$	$42.2±7.5^b$
Weight gain (g)	$53.5±4.1^a$	$50.3±5.5^a$	$40.2±6.7^b$
SGR (% day^{-1})	$2.21±0.03^a$	$2.17±0.03^a$	$2.03±0.02^b$
FCR	$2.51±0.01^c$	$2.55±0.01^b$	$2.65±0.01^a$
Survival (%)	$84±1.0^a$	$80±2.6^a$	$73±2.6^{ab}$
Production of Shing (kg ha^{-1})	$4620±30^b$	$5080±75^a$	$4599±20^b$
Total production(kg ha^{-1})	$5,896±87^b$	$6,331±211^a$	$5894±100^b$

Within rows values with different superscripts are significantly different (P<0.05)

11.1.2 Physiochemical parameters of the experimental ponds

The water quality parameters *viz.*, temperature (^oC), transparency (cm), water pH, DO(mg l^{-1}) and ammonia(mg l^{-1}) of experimental pond under 3 different treatments were monitored and presented in Table 5. The water temperature varied between 27.8^{0}C and 28.5^{0}C during the experiment and there were no significant difference among the treatments but the range was suitable for fish culture. Similar results were observed by Akhteruzzaman (1988) and Rahman *et al.* (1982) they stated that 25.5^{0}C to 30.0^{0}C is favorable for fish culture. The values of water transparency were 26.5, 26.6 and 27.1 cm respectively, in T_1, T_2 and T_3. The present results were relevant with the results of Kohinoor *et al.* (2016) who recorded 26.8 to 30.4 cm transparency in successful Koi culture pond. The mean values of pH were 7.8, 7.7 and 7.6 in treatment T_1, T_2 and T_3 respectively. According to Boyd (1982), the pH values of water ranging from 7.3 to 9.0 indicated that the experimental ponds were suitable for fish culture. This finding agrees well with the present study. The DO concentration ranged from 5.4 to 6.0 mg l^{-1} during the experiment and no significant difference was observed among the treatments. DoF (1996) reported that dissolved oxygen content for fish culture should be maintained from 5.0 to 8.0 mg l^{-1}. So, it is to be assumed that the dissolved oxygen level was suitable for fish culture in the present study. The ammonia varied from 0.08 to 0.12 mg l^{-1} among the treatments. Rana (2017) stated that ammonia level varied between 0.16 and 0.24mg l^{-1} in Shing polyculture pond at the northern region of Bangladesh. This finding agrees with the finding of present study. Based on experimental results and above discussion it can be concluded that the water quality parameters of present study were congenial for fish culture.

Table 5. Physiochemical parameters of the experimental ponds of *H. fossillis*polyculture

Water quality parameters	T_1	T_2	T_3
Water temperature (^oC)	28.0±2.5	27.8±3.0	28.5±2.0
Water transparency (cm)	26.5±1.5	26.6±2.0	27.1±1.0
Water pH	7.8±1.0	7.7±1.5	7.6±1.0
DO (mg l^{-1})	6.0±0.5	5.5±0.6	5.4±0.5
NH_3 (mg l^{-1})	0.08±0.01	0.10±0.01	0.12±0.01

11.1.3 Economic analysis

A simple economic analysis was made to estimate the benefit cost ratio (BCR) of Shing polyculture (Table 6). The total production (kg ha^{-1}) of fish was recorded as 5,896, 6,331 and 5,894, respectively in T_1, T_2 and T_3. The results were similar with the findings of Ahamed *et al.* (2017) who stated that the production range from 6981 to 7793 kg ha^{-1} where the stocking density of Shing ranged from 500 to 700 indi. $dec.^{-1}$ in polyculture during 05 months culture. The highest production cost (Tk. ha^{-1}) was recorded inT_3 (1362392) and the lowest was T_1 (1159508) (Table 6). The expenditures in three treatments varied significantly ($P<0.05$) among themselves. On the basis of analysis, the gross return (Tk. ha^{-1}) was found significantly ($P<0.05$) highest in T_2(1877570) followed by T_3 (1736143) and T_1(1731253). In case of gross margin (Tk. ha^{-1}), significantly ($P<0.05$) highest in T_2 (644570) followed by T_1 (571828) and T_3(373752). Furthermore, significantly ($P<0.05$) higher BCR were recorded in T_2 (1.52) followed by T_1 (1.48) and T_3 (1.27).The BCR in the present study was similar with the findings of Ahamed *et al.* (2017) who stated that the BCR range from 1.69 to 1.32 where the stocking density of Shing range from 500 to 700 indi. $dec.^{-1}$ in polyculture during 05 months culture. The findings agree with the findings of present study and the results indicated that improvement of growth, survival and production of Shing through polyculture was possible in seasonal waters. Besides the economical aspect and species combinations were also considered as the important factors for large scale production. On the basis of discusses results and considering economic aspect it can be concluded that T_2 (500 Shing+100 Pabda+10 Rajpunti+5 GIFT indi. $dec.^{-1}$) was found as the best combination for Shing polyculture in seasonal ponds at the Semi-arid zone of Bangladesh.

Table 6 Benefit and cost analysis of Shing under polyculture in three treatments

Item wise expenditure	**T_1**	**T_2**	**T_3**
Pond preparation (Tk. ha^{-1})	25,000	25,000	25,000
Fingerling cost(Tk.ha^{-1})	2,71,500	3,29,000	4,04,583
Lime and fertilizer (Tk.ha^{-1})	12,500	12,500	12,500
Feed costs(Tk.ha^{-1})	8,00,258	8,16,375	8,88,391
Transport, labor etc.(Tk.ha^{-1})	50,000	50,000	50000
Total production costs (Tk. ha^{-1})	11,59,508±4409^{c}	12,32,875±2281^{b}	13,62,392±12291^{a}
Income and output			
Total production (kg ha^{-1})	5,896±87^{b}	6,331±211^{a}	5894±100^{b}
Gross return (Tk. ha^{-1})	17,31,253±1397^{b}	18,77,570±400^{a}	17,36,143±3755^{b}
Gross margin (Tk. ha^{-1})	5,71,828±3402^{b}	6,44,570±8886^{a}	3,73,752±2558^{c}
Benefit cost ratio (BCR)	1.48^{b}	1.52^{a}	1.27^{a}

Within rows values with different superscripts are significantly different ($P<0.05$)

11.2 Polyculture of Tengra, *M.vittatus*(pattern-2) under different stocking densities in farmer's pond

To find out the growth and production of *Mystus vittatus* under polyculture system, an experiment was conducted under 3 treatments (T_1-500 Tengra+100 Magur+10 Rajpunti+5 GIFTindi. dec^{-1}; T_2-600 Tengra+100 Magur+10 Rajpunti+5 GIFT indi. $dec.^{-1}$ and T_3-700 Tengra+100 Magur+10 Rajpunti+5 GIFTindi. dec^{-1}) in the farmer`s ponds. The growth parameters of candidate fish and water quality parameters of experimental ponds were studied and the results are presented in Tables7 and 8.

11.2.1 Growth performances of Tengra, *M.vittatus* under polyculturein farmer's pond

The results of growth parameters such as weight gain, SGR, production of Tengra and total production of experimental fish are presented in Table 7. In this experiment, the final weight of Tengra was 18.5, 16.2 and 14.2 g in T_1, T_2 and T_3, respectively. The highest weight gain (16.2 g) was found in T_1 and the lowest (11.9 g) was found in T_3. The weight gain of Tengra were found significantly ($P<0.05$) higher in T_1 followed by T_2 and T_3. The SGR (%day^{-1}) of Tengra was 1.38, 1.30 and 1.21 respectively in T_1, T_2 and T_3.On the basis of analysis, the SGR found significantly ($P<0.05$) higher in T_1 followed by T_2 and T_3. The survival was estimated after harvesting of fish by dewatering of ponds. In case of Tengra, the values of survival were 88, 87 and 85%, respectively in T_1, T_2 and T_3. The survival rate of Tengra was found significantly ($P<0.05$) different among three treatments. The results revealed that the final weight, weight gain, SGR and survival were inversely related with stocking density. Stocking density is known to be one of the important parameters in the fish culture, since directly effects on growth and survival (Backiel and ED, 1967).Haylor (1992) revealed that the growth and survival of African catfish was significantly influenced by the stocking density. The findings agree with the findings of present study. The FCR values were higher in T_3 (2.70) and lower in T_1 (2.15). Analytical results showed, the FCR values were directly related to the stocking density. However, the FCR values in the present study were acceptable level and indicated better food utilization, which is agreed by Islam (2002). The production (kg ha^{-1}) of Tengra was recorded 2,035, 2,114 and 2,112, respectively inT_1, T_2 and T_3 and there was no significantly ($P<0.05$) different among three treatments. On the other hand, the total production (kg ha^{-1}) was 5,592, 5,391 and 5,245 respectively in T_1, T_2 and T_3. On the basis of analysis, the production of Tengra in T_2 were found higher than that of T_1 and T_3 but total the production was obtained significantly ($P<0.05$) higher in T_1 followed byT_2 and T_3 (Table 7). Hence, the higher growth observed in lower density could be due to space limiting effect, stressful situation caused by supplementary feed, some variations in environmental parameters and less availability of natural food. The present results agreed with the findings of Mollah (1985) who obtained the highest production from higher stocking density but individual growth higher in lower density.

Table 7. Growth performances of *M.vittatus* under polyculture in the farmer's pond

Parameters	**Treatments**		
	T_1	**T_2**	**T_3**
Stock. dens. of Tengra (indi. dec^{-1})	500	600	700
Culture period (months)	05	05	05
Initial weight (g)	2.3±.02	2.3±.02	2.3±.02
Final weight (g)	18.5±1.2^{a}	16.2±1.5^{b}	14.2±1.7^{c}
Weight gain (g)	16.2±1.1^{a}	13.9±1.5^{b}	11.9±1.7^{c}
SGR (% day^{-1})	1.38±0.02^{a}	1.30±0.01^{b}	1.21±0.02^{c}
FCR	2.15±0.01^{c}	2.51±0.01$_{a}$	2.70±0.02^{a}
Survival (%)	88.0±2.0^{a}	87.0± 1.5^{ab}	85.0±1.5^{ab}
Production of Tengra (kg ha^{-1})	2,035±5.0	2,114±14.0	2,112±92.0
Total production(kg ha^{-1})	5,592±8.0^{a}	5,391±91.0^{b}	5,245±45.0^{c}

Within rows values with different superscripts are significantly different ($P<0.05$)

11.2.2 Physiochemical parameters of the experimental ponds

The water quality parameters *viz.*, temperature (^oC), transparency (cm), water pH, DO(mgl^{-1}) and ammonia($mg\ l^{-1}$) of experimental pond under 3 different treatments were studied and presented in Table 8. The water temperature varied between 28.0 and 28.6^0C during the experiment and there was no significant ($P<0.05$) difference among the treatments. The findings agreed with the findings of Monir and Rahman (2015) who stated that the temperature ranged between 28.0 and 32.0^0C in the nursery pond of Shing (*H. fossillis*). The present findings also agreed with the findings of Kohinoor *et al.* (1998). The water transparency was 26.5, 27.0 and 28.0 cm respectively, in T_1, T_2 and T_3. Boyd (1982) reported that the range of transparency from 15 cm to 40 cm is suitable for fish culture. Thus the transparency was found to be suitable ranges in the present study. The pH was 7.7, 7.8 and 7.6 in T_1, T_2 and T_3 respectively. According to Swingle (1995), pH range from 6.5 to 9.0 is suitable for pond culture. However, the pH range was found to be suitable in the present study that agrees well with the findings of Rahman *et al.* (2005) and Kohinoor *et al.* (2012). The DO concentration ranged from 5.5 to 5.7 $mg\ l^{-1}$ during the experiment and no significant ($P<0.05$) difference was observed among the treatments. Kohinoor *et al.* (2012) stated that dissolved oxygen varied between 4.23 and 5.32 $mg\ l^{-1}$ in *H. fossillis* cultured pond. However, the DO levels were within the acceptable ranges in all the experimental ponds. Analytical results showed the pH and DO values were inversely related with the stocking density. The ammonia was found varied from 0.10 to 0.13$mg\ l^{-1}$ among the treatments and bit higher level might be due to higher stocking density. This findings with agrees with the findings of Kohinoor *et al.* (2012) who stated that the ammonia ranged between 0.01 $mg\ l^{-1}$ and 1.55 $mg\ l^{-1}$ in monoculture of *H. fossillis* in pond condition. On the basis of observation and discussion, the water quality parameters were found quite friendly for fish culture.

Table8. Physiochemical parameters of the experimental ponds under polyculture of *M.vittatus*

Water quality parameters	T_1	T_2	T_3
Water temperature (^oC)	28.6±3.0	28.0±3.5	28.5±3.2
Water transparency (cm)	27.0±1.0	26.5±2.5	28.0±1.0
Water pH	7.7±0.2	7.8±0.1	7.6±0.1
DO ($mg\ l^{-1}$)	5.7±0.2	5.7±0.1	5.5±0.2
NH_3 ($mg\ l^{-1}$)	0.10±0.01	0.12±0.02	0.13±0.01

11.2.3 Economic analysis of polyculture of *Mystusvittatus*:

Economic analysis was performed to estimate the benefit cost ratio from different treatments of the Tengrapolyculture system (Table 9).The production in present study was more or less similar with the findings of Kohinoor and Rahman (2014) who stated that the production ($kg\ ha^{-1}$) of Gulsha, *Mystus cavacious* in polyculture varied between 4050 and 4650 in 06 months culture. The production costs (Tk. ha^{-1}) were 1009167, 1182167 and 1271125 in T_1, T_2 and T_3 respectively. The gross return values (Tk. ha^{-1}) were 1604987, 1550656 and 1531610 respectively in T_1, T_2 and T_3 with significant difference ($P<0.05$) among the treatments. Furthermore, the gross margins (Tk. ha^{-1}) were 595820,368490 and 260485 respectively in T_1, T_2 and T_3 and the gross margin was found significantly higher in T_1 followed by T_2 and T_3. The highest BCR was achieved in T_1 (1.60) followed by T_2(1.31) and T_3(1.20). The BCR was found significantly difference ($P<0.05$) among the three treatments. The BCR in present study was more or less similar with the findings of Ahamed *et al.* (2018) who stated that the BCRof Vietnamese koi in polyculture varied between 1.64 and 1.40 where the stocking density of koi ranged from 300 to 500 indi.

dec.$^{-1}$ in polyculture during 04 months culture. On the basis of discusses results and economic point of view it can be concluded that T_1 (500 Tengra+100 Magur+10 Rajpunti +5 GIFT indi. dec.$^{-1}$) was the best combination for Tengra polyculture in seasonal ponds at the Semi-arid zone of Bangladesh.

Table 9. Benefit and cost analysis of Tengra under polyculture in three treatments

Item wise expenditure	T_1	T_2	T_3
Pond preparation (Tk. ha^{-1})	25,000	25,000	25,000
Fingerling cost(Tk.ha^{-1})	3,03,750	3,73,750	4,03,750
Lime and fertilizer (Tk. ha^{-1})	12,500	12,500	12,500
Feed cost(Tk. ha^{-1})	6,17,916	7,40,916	7,79,875
Transport, labor etc.(Tk.ha^{-1})	50,000	50,000	50,000
Total production costs (Tk. ha^{-1})	10,09,167±2602^{c}	11,82,167±1774^{b}	12,71,125±944^{a}
Income and output			
Total production (kg ha^{-1})	5,592±8^{a}	5,391±91^{b}	5,245±45^{c}
Gross return (Tk. ha^{-1})	16,04,987±1273^{a}	15,50,656±558^{b}	15,31,610±348^{c}
Gross margin (Tk. ha^{-1})	5,95,820±3259^{a}	3,68,490±1360^{b}	2,60,485±883^{c}
Benefit cost ratio (BCR)	1.60^{a}	1.31^{b}	1.20^{c}

Within rows values with different superscripts are significantly different (P<0.05)

11.3 Dissemination of the best polyculture patterns in different Semi-arid zones in the Northern part of the country (2nd year)

11.3.1 Polyculture of Shing, *H. fossilis* and polyculture of Tengra, *M.vittatus*in multi location testing

Polyculture of *H. fossilis* and polyculture of *M.vittatus* were carried out under different treatments in seasonal farmer's mini ponds at the adjacent areas of FSS, Saidpur during first year of the project. Of them, 500 Shing+100 Pabda+10 Rajpunti+5 GIFT (indi. dec-^{1}) combination from Shing polyculture and 500 Tengra+100 Magur+10 Rajpunti+5 GIFT (indi. dec-^{1}) combination from Tengra polyculture were selected for multi locations testing due to the highest yield and economic viability. For this reason, the two combinations were demonstrated in different upazilla of northern region of Bangladesh as per methodology during May 2018 to September 2018.

11.3.1.1Polyculture of Shing, *H. fossilis* in multi location testing

After the culture tenure, growth parameters and production of Shing, the total production of cultured fish and the economics of multi location trials are presented in Table 10. The initial weight (g) of Shing was 1.90, 1.87 and 1.92 respectively in Saidpur, Hatibandha, Dimla. The highest final weight of Shing was recorded (59.3 g) in Dimla upazila. The final weight gain (g) of Shing varied in different locations and the value of Dimla(57.38) was found higher compared to Saidpur (54.33)and Hatibandha upazila (52.33). The highest SGR (2.29) was in Dimla among the locations. The survival (78%) was significantly($p<0.05$) higher in Saidpur followed by Hatibandha and Dimla upazila. The production of Shing (5828kgha-^{1}) and the total production of fish(7352 kgha-^{1}) found highest in Dimla upazila followed by Saidpur and Hatiandha. The gross return (Tk. ha^{-1}) 2135000, gross margin (Tk ha^{-1})906000 and benefit cost ratio (1.73) were significantly ($p<0.05$) higher in Dimla Upazila compared to Saidpur and Hatibandha. According to multi location results, the production of Shing, total production of fish and the BCR were found higher and satisfactory than that of 1st year, which might be due to suitable stocking density and appropriate culture period. Therefore, the combinations including 500 Shing+100 Pabda+10 Rajpunti+5 GIFT

indi.dec.$^{-1}$ can be recommended for culture in the northern region of Bangladesh. It also can be remembered that this type of culture pattern is appropriate in seasonal water bodies and there is no requirement of additional water supply during the culture period ranging from May to October.

Table 10. Growth and yield performances of *H. fossilis* under polyculture in multi-location of northern part of Bangladesh

Parameters	Multi-location			**Avrage**
	Saidpur	Hatibandha	Dimla	
Stock. dens of Shing (indi. dec^{-1})	500	500	500	500
Culture period (months)	05	05	05	5
Initial weight (g)	1.9±0.0	1.87±0.0	1.92±0.0	1.9±.03
Final weight (g)	56.3±0.9^{b}	54.2±0.3^{c}	59.30±0.9^{a}	56.6±2.6
Weight gain (g)	54.3±0.9^{b}	52.3±0.3^{c}	57.38±0.9^{a}	54.66±2.6
SGR (% day^{-1})	2.25±0.02^{ab}	2.24±0.02^{b}	2.29±0.02^{a}	2.26±.03
FCR	2.63±0.01	2.64±0.02	2.62±0.01	2.63±.01
Survival (%)	78±1.5^{a}	75± 1.0^{b}	74±1.5^{b}	75.67±2.1
Production of Shing (kg ha^{-1})	5476±2.0^{b}	5351±3.5^{c}	5,828±3.1^{a}	5552±247
Total production(kg ha^{-1})	7039±70.3^{b}	6766±40^{c}	7352±2.5^{a}	7052±193
Total cost (Tk. ha^{-1})	1221500±15.3	1221650±10	1229000±10	1224050±4287
Gross return (Tk. ha^{-1})	2040850±5.7^{b}	1976375±5.0^{c}	2135000±7.6^{a}	2050742±79773
Gross margin (Tk. ha^{-1})	819350±18.5^{b}	759875±8.1^{c}	906000±10.4^{a}	826692±73482
BCR	1.67^{b}	1.62^{c}	1.73^{a}	1.67

Within rows values with different superscripts are significantly different (P<0.05)

11.3.1.2 Polyculture of Tengra, *M. vittatus* in multi location testing

After the culture of 05 months, the growth parameters and production of Tengra; the total production of cultured fish and their economics in different locations are presented in Table 11.The final growth (18.2g) was found significantly (p<0.05) higher in Kaligonj upazila followed by Nilphamari sadar and Dumar upazila. The weight gain (16.2 g) and SGR (1.47) were also significantly (p<0.05) higher in kaligonj followed by Nilphamari sadar and Dumar. The highest survival (86%) was recorded in Nilphamari sadar but there was no significant difference among the three locations. Similarly, the production of Tengra(kg ha^{-1}), the total production (kg ha^{-1}) of cultured fish, gross return (Tk. ha^{-1}), gross return (Tk. ha^{-1}) and BCR were found identical in three locations. On the basis of multi locations results, the production of Tengra, total fish production and BCR were higher and found satisfactory than that of 1st year, which may be due to suitable stocking density and as well as suitable culture period. Thus, it can be concluded that the combination of 500 Tengra+100 Magur+10 Rajpunti+5 GIFT indi. dec.$^{-1}$ is suitable for dissemination in northern region of Bangladesh. Moreover, this type of polyculture combination is appropriate for utilizing the seasonal mini ponds during May to October. It is concluded that these fish culture technologies can ensure the best utilization of the semi-arid zone in southern Bangladesh for enhancing fish production and as well as to improve farmer's livelihood status.

Table 11. Growth performances, production and economic analysis of *Mystusvittatus* under polyculture in multi-location of northern part of Bangladesh

Parameters	Multi-location			Average
	Kaligonj	Domar	Sadar, Nilphamari	
Stock. dens of Tengra (indi. dec^{-1})	500	500	500	500
Culture period (months)	05	05	05	5
Initial weight (g)	2.0±0.0	2.0±0.0	2.0±0.0	2
Final weight (g)	18.20±0.40^{a}	15.76±0.32^{b}	15.77±0.40^{b}	16.58±1.4
Weight gain (g)	16.20±0.40^{a}	13.76±0.32^{b}	13.77±0.51^{b}	14.58±1.4
SGR (% day^{-1})	1.47±0.02^{a}	1.38±0.01^{b}	1.37±0.02^{b}	1.41±0.1
FCR	2.20±0.01	2.21±0.015	2.19±0.01	2.2±0.01
Survival (%)	84.00±1.0	85.00± 1.0	86.00±2.5	85±1
Production of Tengra (kg ha^{-1})	2,250±2.0	2,252±3.5	2,240±3.1	2247.3±6.4
Total production(kg ha^{-1})	5,656±70.3	5,625±40.0	5,650±2.5	5643.7±16.4
Total cost(Tk ha^{-1})	10,12,000±15	10,30,000±10	10,09,870±10	1017290±11059
Gross return (Tk ha^{-1})	16,65,400±5.7	16,58,750±5.0	16,63,000±7.6	1662383.3±3368
Gross margin (Tk ha^{-1})	6,53,400±18.5	6,28,750±8.1	6,53,130±10.4	645093.3±14154
BCR	1.65	1.61	1.64	1.63

Within rows values with different superscripts are significantly different (P<0.05)

12. Research highlight/finding:

- Polyculture of Tengra (*Mystus vittatus*) and Polyculture of Shing (*Heteropneustes fossilis*) in seasonal waters at the semi-arid zone are economically viable;
- Considering the growth and survival, 500 indi. dec.$^{-1}$ Tengraor Shing was found as the most suitable stocking density for polyculture system;
- Fish farmer can be suggested to follow the combination of 500 Tengra+100 Magur+10 Rajpunti+5 GIFT indi. dec.$^{-1}$ in case of Tengra polyculture and 500 Shing+100 Pabda+10 Rajpunti+5 GIFT indi. dec.$^{-1}$ in case of Shing polyculture;
- In context to fish production; Shing polyculture was found bit higher than the Tengra polyculture;
- On the basis of economic aspect; Tengra polyculture and Shing polyculture were identical;
- Appropriate culture period during April to August and over wintered fingerlings were identified as the key to successful fish culture in seasonal ponds ;
- Water quality parameters were found suitable for fish culture;
- Fish farmers were very much interested in Tengra polyculture due to new and modern technology; and
- The study explored new culture technologies for the Northern semiarid region of Bangladesh.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	Laptop - 1	60,000.00	100%	100%	
(b) Lab &field equipment	Water quality inst. 1 set	40,000.00	100%	100%	
(c) Other capital items	Furniture – 1 set	157,550.00	95%	95%	

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Pond preparation, repair and maintenance	40,000.00	100		100	

3. Training/study tour/seminar/workshop/conference organized:

Description	Number of participant			Duration (days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	N/A	N/A	N/A	N/A	
(b) Workshop	N/A	N/A	N/A	N/A	

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	2,36,485	2,36,485	2,29,385	0	97	
B. Field research/lab expenses and supplies	18,90,000	17,86,797	17,89,751	-2954	95	
C. Operating expenses	2,75,000	2,69,382	1,50,027	1,19,355	56	
D. Vehicle hire and fuel, oil & maintenance	1,90,000	1,70,095	1,66,714	3,381	88	
E.Training/workshop/seminar etc.	90,000	85,500	-	85,500	0	
F. Publications and printing	1,00000	85,000	-	85,000	0	
G. Miscellaneous	50,000	47,750	26,173	21,577	52	
H. Capital expenses	1,65,000	1,65,001	1,57,550	7451	95	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	**Major technical activities performed in respect of the set objectives**	**Output(i.e. product obtained, visible, measurable)**	**Outcome(short term effect of the research)**
To adopt the culture technologies of short cycle fish species	1.Polyculture of *H. fossillis* in farmers pond 2. Polyculture of *M. vittatus* in farmers pond	1.Fish production increases 2. Opportunity the polyculture of *H. fossillis* and *M. vittatus* with short cycle fishin seasonal waters of semi-	1. Utilization of unused seasonal ponds 2. 40% fish production increases than previous method 3. possibility of culture of indigenous and

		arid zone of Bangladesh 3. More profit in short time	endangered short cycle fish species
To disseminate the culture technologies in different part of semi-arid zone of Bangladesh	1. Multi-location Testing of the best pattern, 2. Training, field day, preparation of booklets, media coverage etc.	1. Increased awareness 2. Motivated fish farmers 3. Technologically trained 4. Obtained appropriate stocking density for the culture system	1. Farmers get direct technological support and inputs of fish farming 2. Increasing short cycle fish culture practices in northern region

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.	01	-	-
Journal publication	02	-	-
Information development	-	-	-
Other publications, if any	-	-	-

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

Polyculture of Shing and polyculture of Tengra were developed in the semi-arid zone of Bangladesh

ii. **Generation of new knowledge that help in developing more technology in future**

To develop breeding and culture technique of endangered others short cycle fish species *viz*; *Barilus*spp, *Labeoangra*, Ghutum and Kholisha in the Northern region of Bangladesh

iii. Technology transferred that help increased agricultural productivity and farmers' income

The technologies should be transferred to DoF and NGOs in order todisseminate among fish farmers for higher fish production and as well as to improve farmer's livelihood status.

iv. Policy Support

Seasonal waters should be utilized mainly for fish culture in the northern region of Bangladesh for enhancing fish production and livelihoods.

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring (monitoring workshops):

- CRG Sub- Project Implementation Progress Workshop/Seminar held in BARC, Farmgate Dhaka on 21 December 2017. Advised for minor changes.
- CRG Sub-Project Final output Workshop held in BARC, Farmgate Dhaka on 19-20 September 2018. Found satisfactory

ii) Field Monitoring (time& No. of visit, Team visit and output):

Monitoring Team	Time & No. of visit	No. of visit	Output
PIU-BARC, NATP-2	6-7 January 2018	1	Satisfaction of research works
Internal Monitoring	DG and CSO	2	Satisfaction of research works
Others(BTV), Mati O Manus	03 June 2018	1	TV channel facilitators visited the farms and interviewed concerned scientists and fish farmers in live program.

H. Lesson Learned

i) Stocking of overwintered fingerlings might give higher yieldin short cycle fish culture;
ii) Unpredicted water flash and
iii) High water temperature in April-October and insufficient rainfall.

I. Challenges (if any)

i. Motivating fish farmers for adopting the technologies
ii. Disseminating technologies to fish farmers in the remote areas.

Signature of the Principal Investigator
Date …….
Seal

Counter signature of the Head of the organization/authorized representative
Date ……..
Seal

Reference:

Ahamed S, Hasan KR, Hossain M, Mahmud Y, Rahman MK. 2017: Adaptability of polyculture of stinging Catfish (*Heteropneustes fossilis*) in seasonal water bodies of greater northern region, Bangladesh. *International Journal of Fisheries and Aquatic Studies*, 5(1): 433-439.

Ahamed S, Hasan KR, Hossain M,Mursalin MI. 2018: Polyculture of Vietnamese koi (*Anabas testudineus*): Emphasis on Seasonal Mini Water Ponds in Semi-arid Zone of Bangladesh. *J. Annu.Res.and Rev. Bio*., 27(6):1-7

BBS. 2000:Bangladesh Bureau of Statistics (BBS), 2000.

BorthakurS, Goswami UC. 2007: Cage culture of Magur, *Clariasbatrachus* (Linnaeus) with selected non-conventional diets in a floodplain wetland of Assam. *Indian J. Fish.,* 54(4):357-363.

Boyd CE. 1982: Water quality management for fish culyure. *Elsevier Science publisher*, the Netherlands. 318.

DoF.1996: National Fish Week-1996 Compendium (In Bangla). Department of Fisheries (DoF), Ministry of Fisheries and Livestock, Bangladesh, 140 p.

DoF. 2012: National Fish Week-2012 Compendium (In Bangla). Department of Fisheries (DoF), Ministry of Fisheries and Livestock, Bangladesh, 142 p.

DoF. 2013: National Fish Week-2013 Compendium (In Bangla). Department of Fisheries (DoF), Ministry of Fisheries and Livestock, Bangladesh, 144 p.

Gupta MV.1991: Low input techniques for rural aquaculture development in Bangladesh. In: Aquaculture schistosomiasis: 26-35. Proceeding of network meeting in Manila, Philippines, August 6-11, 1991. National Academy Press, WaShington, D.C.

Haroon AKY, Pittman KA. 2000: Niche measures and feeding strategies of *Barbodesgonionotus* Bleeker and *Oreochromis* spp. from a rice field in Bangladesh. *Bangladesh J. Fish. Res*., **4**(1): 13-26.

Hossain MAR. 2014: Habitat and fish diversity: Bangladesh perspective, pp 1-26. In: Wahab MA, Shah MS, Hossain MAR, Barman BK, Hoq ME (eds.), Advances in Fisheries Research in Bangladesh: I. Proc. of 5th Fisheries Conference & Research Fair 2012. 18-19 January 2012, Bangladesh Agricultural Research Council, Dhaka, Bangladesh Fisheries Research Forum, Dhaka, Bangldesh.

Huque SHE, Hossain GS, Huq KA. 2008: Effect of stocking density on growth Performance of Thai koi (*Anabas testudineus*) monoculture. Bangladesh Fisheries Research Forum (BFRF).Abstracts Book.3rd Fisheries Conference and Research Fair 2008. Bangladesh Agricultural Research Council, Dhaka, Bangladesh. 170p.

Hussain MG, Rahman MA, Akhteruzzaman M, Kohinoor AHM. 2000: Study on the production of *Oreochromisniloticus* under semi-intensive culture system in Bangladesh. *Bangladesh J. Fish.* 12(1)59-65.

Islam MS. 2002: Evaluation of supplementary feeds for semi intensive pond culture of Mahaseer, *Tor putitora* (Hamilton). *Aquaculture*. 212: 263-276

Kohinoor AHM, Rahman MA. 2014: Fry production and culture management of gulsha, *Mystuscavasius,* Bangladesh Fisheries Research Institute, leaflet No.14.

Kohinoor AHM, Khan MM, Yeasmine S, Mandol P, Islam MS. 2012: Effect of stocking density on growth and production performance of indigenous stining catfish, *Heteropneustes fossilis* (Bloch), *Int.J Agril. Res. Innov. and Tech.*, 2(2): 09-14

Kohinoor AHM, Islam ML, Wahab MA, Thilsted SH.1998: Effect of mola, *Amblypharyngodonmola*Ham, on the growth and production ofcarps in polycultue, Bangjadesh J Fish. Res., 2(2): 111-126

Mazid MA, Janssen J. 2005: Preface. *Bangladesh J. Fish.Research***.** Special IssueVol.**9**(1).

Mookerjee HK,Mazumdar SR. 1950: Some aspect of the life history of *Clariasbatrachus* (Linn.) *Proc. Zool. Soc. Bangal*., **3**: 71-84.

Mollah MFA. 1985: Effects of stocking density and water depth on the growth and survival of Mahaseer, *Tor putitora* (Hamilton). *Aquaculture*. 212: 263-276

Mostakim M, Islam MS, Rahman MK, Rahmatullah SM. 2001: Size related feeding patterns and electivity indices of silver barb (*Barbodesgonionotus* Bleeker) from a pond, Bangladesh. *Bangladesh J. Fish. Res*., **5**(2): 105-114.

Monir MS, Rahman S. 2015: Effect of stocking density on the growth, survival and production of Shing *Heteropneustes fossilis* fingerlings under nursery ponds in Northern region of Bangladesh. Int. *J fish.*andAqu. Studi., 37(1): 49-52

Narejo NT, Salam MA, Sabur MA, Rahmatullah SM. 2005: Effect of stocking density on the growth and survival of indigenous catfish, *Heteropneustesfossilis* (Bloch) reared in the cemented cistern fed on formulated feed. *Pakistan J Zool*., 2(3): 81-86

Samad MA, Islam MA, Khaleque MA. 2005: Effect of stocking density on the growth and survival rate of Magur (*Clariasbatrachus*) fry in laboratory and nursery ponds. *Pakistan J. Biol. Sci*, **8(2)**:338-344.

Sevilleja RC. 1985: Tilapia Production in freshwater fish ponds of Central Luzon, Philippines. *In* SmithIR, Torres EB, Tan EO (eds.), Philippines tilapia economics, ICLARM conference proceedings 12, 261 p. Philippines Council for Agriculture Research and Development Loss Banos, Laguna and International Center for living Aquatic Resource Management, Manila.

Shah MM, Mia R, AlamMJ.2008: Performance of genetically improved farmed tilapia (GIFT) under mono and mixed culture with silver barb (*Barbodesgonionotus*) in south-west Bangladesh. *Bangladesh J. Fish Res*., **12**(1) 2008:75-80.

Sidthimunka A, Ekura P. 1959: Breeding and cultivation of PlaDuk in pond. Thai Fish Gazette 1959; 12(3):253-260.

Swingle HS. 1969: Standardization of chemical analysis for water and pond mud. FAO Fisheries Res., 4(2): 397-421.

Appendix 1

Pictorial views of fish of research works, NATP-2, FSS, Saidpur, Nilphamari

a

b

c

d

e

f

Plate 1. Views of (a) selected pond in Nilphamar iSadar, (b) inputs distribution among the selected farmers, (c) stocking of fish fry in prepared pond, (d) netting of experimental pond in Dimla, Niphamari, (e) community awareness are increasing during sampling in Dimla and (f) fish farmers showing fish after netting in Dimla

Pictorial views of fish of research works, NATP-2, FSS, Saidpur, Nilphamari

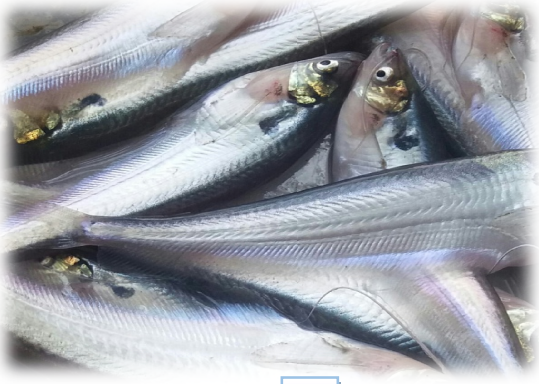
a

b

c

d

e



f

Plate 2. Views of (a-f) Length measurement, weighing and showing the growth performance of experimental fish of Dimla, Domar, Niphamari sadar, Kaligonj and Hatibandha, Lalmonirhat

Pictorial views of fish of research works, NATP-2, FSS, Saidpur, Nilphamari

a

b

c

Plate 3. Views of (a) Visited the Consultant of PIU-BARC, NATP-2, (b-c) Mrs. KadorBanu, Shingpolyculture farmer, NATP-2, Saidpur and Mr. Barek Shah, Tengrapolyculture farmer, NATP-2, Nilphamari Sadar were giving an interview on BTV about possibility of Shing/Tengrapolyculture in Nilphamari district