

Sub-Project ID: 011

Program Based Research Grant (PBRG)

Sub-project Completion Report
on

**Food Based Initiative for Improving Household
Food Security, Income Generation and
Minimizing Malnutrition**

Sub-project duration
5 April 2018 to 13 January 2022

Coordinating Organization

Nutrition Unit
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215



Project Implementation Unit
National Agricultural Technology Program Phase II Project
Bangladesh Agricultural Research Council
Farmgate, Dhaka 1215

November 2021

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Food Security, Income Generation and
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Implementing Organization



Goat and Sheep Production Research Division
Bangladesh Livestock Research Institute
Savar, Dhaka-1341



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Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

November 2021

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Abbreviation and Acronyms

a.m.	:	Ante meridiem	USD	:	United States Dollar
%	:	percentage	viz	:	Namely
µm	:	Micrometre	yr	:	Year
BARC	:	Bangladesh Agricultural Research Council	BCC	:	Behavioural Change Communication
BDHS	:	Bangladesh Demographic and Health Survey	BMI	:	Body Mass Index
BDT	:	Bangladeshi Taka	DOC	:	Day-Old Chick
BLRI	:	Bangladesh Livestock Research Institute	EU	:	European Union
cm	:	Centimetre	FCR	:	Feed Conversion Ratio
dec	:	Decimal	FAO	:	Food and Agricultural Organization
et al.	:	And others	FAME	:	Fatty Acid Methyl Ester
g	:	Gram	IGA	:	Immunoglobulin A
ha	:	Hectare	ICP-OES- MS	:	Inductively Coupled Plasma-Optical Emission Spectrometry-Mass Spectrometry
IMCs	:	Indian major carps	IMC	:	Integrated Market Communication
Ind.	:	Individual	PP	:	Project Proposal
Kg	:	Kilogram	PRA	:	Participatory Research Appraisal
L	:	Litre	UK	:	United Kingdom
L ⁻¹	:	Per litre	AOAC	:	Association of Official Agricultural Chemist
m ²	:	Square meter	AAS	:	Atomic Absorption Spectroscopy
mg	:	Milligram	SBCC	:	Social and Behavioural Change Communication
mg/L	:	Milligram per litre	SGS	:	Socitete Generale Surveillance
ml	:	Millilitre	SGR	:	Specific Growth Rate
mm	:	Millimetre	MUAC	:	Mid Upper Arm Circumference
p.m.	:	Post meridiem	Hb	:	Haemoglobin
Tk	:	Taka	WHO	:	World Health Organization

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Executive Summary

The sub-project was designed to identify the present socio-economic situations and livelihood pattern of the ethnic and coastal people and using pattern and biological productivity of homestead resources with a view to increase food security and adequate dietary intake in terms of energy, protein, fat, vitamin and other micronutrients. To achieve the target of the sub-project, implementation of the specific activities at field level were done by two components, namely Bangladesh Livestock Research Institute (BLRI, component 1) and the Noakhali Science and Technology University (NSTU, component-2). The sub-project activities of BLRI component was implemented in different topographic locations i.e. Kalapani and Kaminipara (both sites called as panchmile) under 4 no. Perachara union and another in Munigram, Robijoy Para, Chittaranjan Para and Porchim Muslim Para under 5 no. Vaibonchara union of Khagrachori Sadar Upazila of Khagrachari district. In Khagrachari, on the basis of the PRA result, total number of 60 households were selected purposively from two locations of which 30 households from each. A short PRA and baseline survey of the household was conducted. To achieve the goal and objectives of the sub-project whole activities of the BLRI Component was divided into two parts: one was Component Research Programme and another was Component Development Programme. The Component Research Programme was focused on two issues (a) household food security and (b) dietary intake status of selected households. The Component Development Programme was emphasis on technology dissemination through technological intervention on the basis of the resources allocation of selected households' technological intervention was developed.

The average farm size of marginal, small, medium farms and all farms were 0.18, 0.62, 1.79 and 0.76 ha, respectively in 5 no. Vaibonchara union. Average gross margin farm⁻¹ year⁻¹ of marginal, small and medium farms were increased 341%, 96% and 261%, respectively over inception year. Average gross margin increased 119% over initial year. The results revealed that BCR increased after intervention because of intensification of enterprises which indicated the household security increased over initial year. While The average farm size of marginal, small, medium and all farm were 0.12 0.57, 1.29 and 0.68 ha, respectively in Panchmile. Average gross return after intervention was Tk 138637.50, 190086.05 and 283835.71 in marginal, small and medium, respectively those were higher than that of before intervention. Gross margin increased significantly in different farm category after intervention which was 248%, 118% and 58% for marginal, small and medium, respectively. Overall findings indicated that efficiency of productivity increase was the highest in medium sized farms.

The level of food security was secured on the basis of consumption of cereals and the percentages were 171.34 and 162.52, respectively in both before and after intervention. The level of food security of cereal was decrease 20.35 % after intervention due to increase the consumption of other food items specially vegetables. It was also found that 78 percent farmers produced rice of which 45 percent farmers were secured in terms of production. It indicated that the level of food security of the majority farmers (55 percent) was not secured on the basis of production. The study also revealed that findings of the level of food security of vegetables, fish, potato and spices were secured and their percentage were 218.38, 103.45, 122.75 and 168.35, respectively while the level of food security of other food items such as pulses, milk, meat, egg, oil and sugar/gur were not secured though after intervention it was increased.

The interventions were increased cropping intensity, crop diversification, number of homestead plantation, and productivity of all systems in the both sites. Interventions also change the cropping

pattern in the farms and other farms of the village. It was also indicated that some socio-economic impact was resulted in some farms. The additional income was spent for purchases food, health care, education, repayment of loan, land rent, inputs for farming activities etc. The impact of intervention on farming created very positive response among the farmer of the study area.

The NSTU component conducted investigation to (1) uncover the present status of carp polyculture and biological productivity of homestead ponds, (2) to assess the nutritional and health status of coastal rural people, (3) to know the fish diversity and determine the nutritional value of fishes available in the homestead ponds for estimating the contribution of fish in family nutrition, and (4) to develop a modified carp-based polyculture system suitable for homestead ponds for introducing fish as the major sources of dietary protein to the coastal community.

To uncover the present status of carp polyculture system, a baseline survey was conducted and revealed that the average stocking density in homestead pond was about 11,122 fingerlings/ha that was similar to the recommendation of the Department of Fisheries, Bangladesh. The average fish production was approximately 2350 kg/ha that was lower than the other areas (2900 kg/ha). For assessing the nutritional and health status of coastal communities, the data was collected through questionnaire survey and found that the households with homestead pond consumed 1.2 times more fish (121.13 g/person/day) than that of the households with no ponds (99.82 g/person/day). To estimate the contribution of fish in family nutrition, 30 marginal families with homestead ponds had been provided fish seed, feed and other materials continuously for 3 years. Fish consumption (g/person/day) was almost doubled after completion of three culture cycles with a gradual increase from 59.57 g to 120.10 g. Body mass index (BMI) also increased in normal health condition from 42% to 58% among men, 36% to 68% among women and 48% to 55.5% among children. The prevalence of mild anaemia decreased from 79% to 47% among men and 93% to 79% among women of beneficiary families. It proved that fish culture greatly impacted the nutritional and health status of homestead pond farmers of Noakhali by reducing malnutrition.

To develop a modified carp-based polyculture system, two separate experiments were carried out with four advanced carp fingerlings (weighting 150 – 250 g) e. g. *Gibilion catla*, *Labeo rohita*, *Cirrhinus cirrhosis*, and *Labeo calbasu*. First experiment was carried out with different stocking densities and the specific growth rate was revealed highest at low stocking density (370 kg/ha). An inverse relationship was detected between fish growth, survival and stocking density where lower fish growth and survival rate were documented at higher stocking density in the case of all species. Besides, the highest net benefit (2788.35 ± 10.26 USD) and cost-benefit ratio (1.22 ± 0.01) also proved that carp polyculture at 370 kg/ha stocking density is more viable for coastal homestead ponds. Based on the findings of previous experiment, seed from two local hatcheries and wild sourced (Halda River) were stocked. Though the wild sourced seeds had lower FCR (1.65±0.10) and higher production (2687.07±140.68 kg/ha/6 month) than the hatchery seeds, but due to the higher price of wild seed and transportation cost, the CBR was recorded lower in case of wild seed. The present study revealed that the farming of Indian major carp species from hatchery seeds is more viable and profitable in the coastal homestead ponds, Bangladesh.

Key words: Ethnic people, Household food security, Homestead ponds, Body mass index.

PBRG Sub-Project Completion Report (PCR)

A. Sub-project Description

- 1. Title of the PBRG sub-project: Food Based Initiative for Improving Household Food Security, Income Generation and Minimizing Malnutrition**
- 2. Implementing organization (s):** Bangladesh Agricultural Research Council, Bangladesh Livestock Research Institute, Savar, Dhaka and Noakhali Science and Technology University, Sonapur, Noakhali.
- 3. Name and full address with phone, cell and E-mail of Coordinator, Associate Coordinator and PI/Co-PI (s)**

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4. Sub-project budget (Tk) : 3,31,16,009.00

4.1 Total (in Tk as approved)

BARC component (TK) : 42,80,000.00

BLRI component (TK) : 1,89,98,780.00

NSTU component (TK) : 95,10,540.00

4.2 Latest Revised (if any)

BLRI component (TK) : 2,04,28,780.00

NSTU component (TK) : 84,07,229.00

5. Duration of the sub-project

5.1 Start date (based on LoA signed) : 05/04/2018

5.2 End date : 13/01/2022

6. Background of the sub-project

Malnutrition is truly the “hidden disaster” which continues to hold back economic development in Bangladesh. In Bangladesh about 31.5% of the population is living below the poverty line and a big portion of them is also below the “hardcore” poverty line that is called ultra poor and the rate of it is 7.7%. More than 60% of all children are either undernourished or malnourished, and the average height of the population in Bangladesh is decreasing. Thus nutritional intake is even more important. The big task ahead is to make food available in sufficient quantities and with sufficient nutritional value. Malnutrition reduces physical and mental growth, adversely affects health and productivity, impacting on the economic development of families, the society and the nation as a whole.

We need food for living and for good health. We should have nutritious food. Though it is unfortunate, it is true that majority of the people have little knowledge about nutritious food. Besides, most of the people do not have the ability to take adequate nutritious food. Thus the problem of malnutrition is increasing day by day (Chowdhury, 1999). Realizing the situation, the government of Bangladesh has given highest priority on nutrition.

Nutrition is pre-requisites utilization. The concern is whether the food available is nutritious or not. Cereals provide calories needed for energy, and some protein, but they fail to provide the balanced diet needed to eliminate malnutrition. Availability of other foods such as fruits and vegetables, fish, pulses, oilseeds, poultry and livestock needs to increase and to provide balance to Bangladesh diets. In Bangladesh about 20% of the people fully and 75% of the rural people partially depend on livestock to some extent for their livelihood (BBS, 2009). In this country, about 80% of the total cultivable land is used for cultivation of cereal crops and only 0.03% for

cultivation of fodder crops and rest for other crops (BBS, 2009). Scarcity of animal feeds and fodder has been identified as a major constraint for the development of livestock in Bangladesh (Kanak *et al.*, 2012)

Significant improvements in food consumption and behavior have also been observed since 1992, with per capita daily calorie intake rising (from 2266 Kcal in 1991-92, to 2318 Kcal in 2010), as well as increases in the consumption of protein (from 62.72 g in 1991-92 to 66 g in 2010). Dietary diversity has improved, along with a significant reduction of rice intake from 478.8 g in 1992 to 416 g in 2010 (though still higher than the desirable FAO/WHO normative standards. Fish intake is near to the desirable dietary intake pattern (FAO 2021). However, consumption of pulses, meat, egg and milk are still below the desirable dietary pattern. Consumption of pulses has declined from 17.9g in 1992 to 14.3g in 2010. Though, the intake of fruits and vegetables has increased since 1992, it (211g in 2010) it is half of the FAO/WHO recommendations (400 g per day). The difference between average daily per capita intake and recommendation scenario is only 5% but the actual scenario of the rural areas especially ethnic and *charland* people is different. The food security-availability, utilization and access of the ethnic and *charland* people is not easy due to food production.

The long-term solution to this problem is a food-based approach. Pills and supplements are helpful as short- and medium-term interventions but for long-term sustainable food security, the food-based approach offers the most promise. It is better to take food-based measures, because food is the source for living and economic well being. It plays an important role in social, economic, political, and national development. Only food can ensure protection against malnutrition and quality improvement. The very reason behind it is that the malnutrition originated from the insufficient intake of nutritious food.

Therefore, a food-based initiative to improving nutrition for household food security in Bangladesh was undertaken with a long-term goal for sustainable improvement of food and nutrition of the rural poor.

Considering the above issues, the sub-project was designed to implement in Khagrachari and Noakhali district. The eastern hill district Khagrachari and the southern coastal *charlands* of Noakhali district are comparatively less developed area due to natural position and agro-ecosystem, low level of management in agriculture, migratory nature of people and distance from headquarters of development agents. Modern agricultural technological intervention with adequate input and effective management through crop diversification and intensification would create opportunities for higher productions and income. Similarly, diversification and integration of livestock and fisheries enterprises would give higher production and income with modern breeds/species, inputs and management practices.

The sub-project activities of BLRI component were implemented in different topographic locations one is Kalapani and Kaminipara (both sites called as panchmile) under 4 no. Perachara union and another is Munigram, Robijoy Para, Chittaranjan Para and Porchim Muslim Para under 5 no. Vaibonchara union of Khagrachori Sadar Upazila of Khagrachari district. In Khagrachari, on the basis of the PRA result total number of 60 households was selected purposively from two locations of which 30 households from each. A short PRA and baseline survey of the household was conducted. To achieve the goal and objectives of the sub-project

whole activities of the BLRI Component was divided into two parts: one was Component Research Programme and another was Component Development Programme. The Component Research Programme was focused on two issues (a) household food security and (b) dietary intake status of selected households. The Component Development Programme was emphasis on technology dissemination through technological intervention on the basis of the resource's allocation of selected households' technological intervention was developed.

The greater Noakhali is situated in the central coastal zone of Bangladesh along the north-eastern coast of the Bay of Bengal. Therefore, aquaculture practices in the new settlement area like the news chars are complex. This area characterized by seasonal water logging and which remain dominate about six month and considerable potentials for the development of aquaculture. Therefore, short-term culture with high yielding native carp varieties will ensure successful aquaculture in this region. Traditional carp poly culture in this area through native carp fry and fingerlings does not ensure sufficient economic production because of short culture period. So, development of modified polyculture or composite culture system (model) suitable for coastal region of Bangladesh using native species can increase fish production, income and reduce or remove malnutrition.

The NSTU component conducted investigation to (1) uncover the present status of carp polyculture and biological productivity of homestead ponds, (2) to assess the nutritional and health status of coastal rural people, (3) to know the fish diversity and determine the nutritional value of fishes available in the homestead ponds for estimating the contribution of fish in family nutrition, and (4) to develop a modified carp-based polyculture system suitable for homestead ponds for introducing fish as the major sources of dietary protein to the coastal community.

7. Sub-project general objective (s)

Identify the present socio-economic situations and livelihood pattern of the ethnic and coastal people and using pattern and biological productivity of homestead resources (livestock and fisheries) with a view to increase food security and adequate dietary intake in terms of energy, protein, fat, vitamin and other micronutrients.

8. Sub-project specific objectives (component wise)

Coordination component (BARC)

Under the principal objective of the NATP, the coordination unit of BARC sub-project shall have the following specific objectives to achieve the sub-project goal. In addition to the above, the coordination unit also performs limited research activities under the broad objective of the sub-project to mitigate contaminants and adulterants in food chain and awareness building of producers, traders, processors and consumers with the following specific objectives:

- i) To develop /produce BCC/SBCC tools to disseminate it to the children's, adolescent girls, lactating mothers and pregnant women for up-scaling malnutrition

- ii) To analyze the micro-nutrient (Fe, Ca,) content of different variety of rice and fermented rice.
- iii) To analyse the heavy metals content of selective rice.
- iv) Co-ordination and monitoring of the component sub-project activities to facilitate smooth implementation.
- v) Development of communication materials for wide awareness building to the stakeholders
- vi) Organize disseminating training workshop/seminar and capacity building on food safety and quality.

Component-1 (BLRI)

- i) To improve household food security, income generation and nutrition for the rural poor.
- ii) To improve household agro-processing, preservation, value addition and marketing optimizing income.
- iii) To ensure awareness building on nutrition, environment conservation and gender issues among the poor.
- iv) To ensure improved capability in developing technology and research/extension on balanced dietary intake, eradication of nutritional deficiency diseases and generation of nutritional database.

Component 2 (NSTU)

- i) To assess current nutritional status of coastal household's families and facilitate them to better nutrition standard in family-based diet.
- ii) To enhance income generating capacity of housewife through whole family approach by opportunistic employment.
- iii) To convert under-utilized water bodies to productive aquaculture and enhance community-based fish farming in coastal floodplain as a source of nutrition.

9. Implementing location(s)

The sub-project activities of BLRI component implemented in entirely two different topographic locations of Khagrachori Sadar Upazila of Khagrachari district. One is Kalapani and Kaminipara (both sites called as panchmile) under 4 no. Perachara union and another is Munigram, Robijoy Para, Chittaranjan Para and Porchim Muslim Para under 5 no. Vaibonchara union. Four no. Perachara union is far about 5 km from northeast side of District headquarters beside the Khagrachori-Dighinala highway while of 5 no. Vaibonchara union is far about 15 km from north side of District headquarters beside the Khagrachori-Panchari highway.

The implementation location of the NSTU component is greater Noakhali (Noakhali, Feni, Lakshmipur districts).

10. Methodology in brief

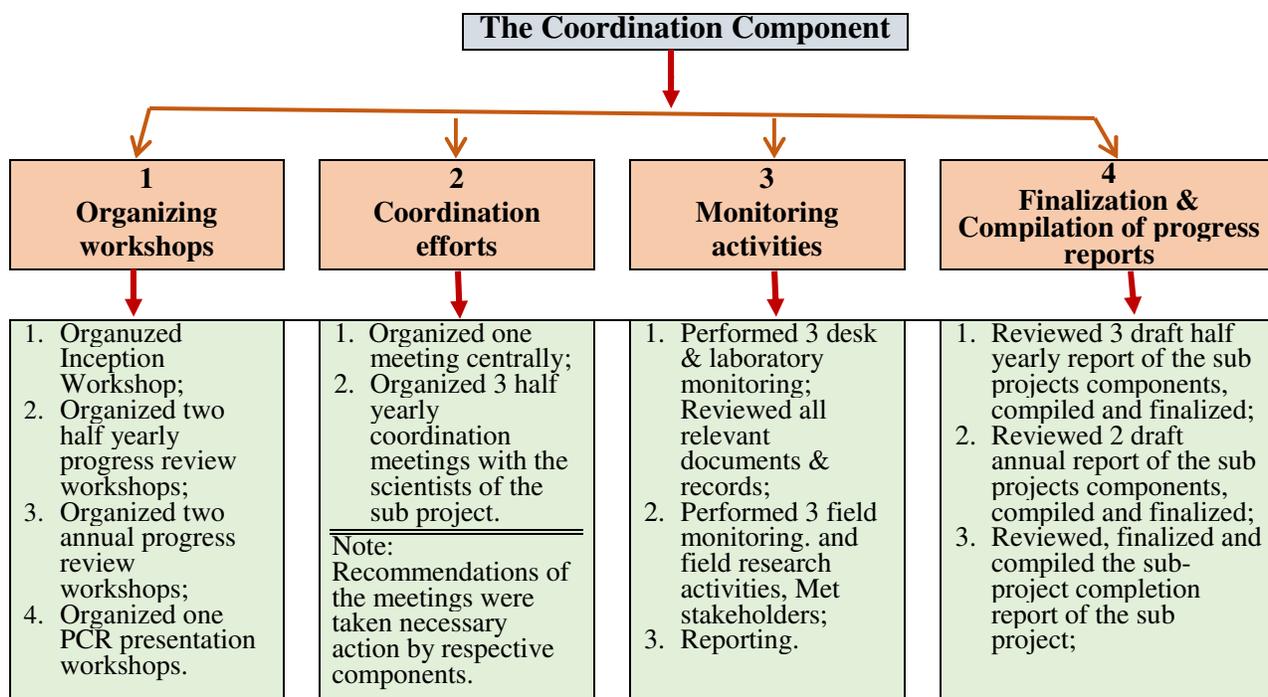
10.1 Approach

10.1.1. Implementation approach for the Coordination Component

The Coordination component as the responsible unit of the sub-project to initiate all potential efforts in the process of implementation of each component under the sub-project so that the general objectives and goal of the sub-project can be achieved through smooth and successful completion of each of the specific objectives as per activity time plan of the sub-project document. To ensure that, the Coordination component, taken into consideration its own activity and objectives and duration of the sub-project, thus accordingly designed its own plan of activity (approach) for the proposed period. Followings are the major activities carried out by the Coordination component under the plan:

- a. Organizing seminars/workshops.
- b. Monitoring the sub-project activities (specifically financial and research activities).
- c. Coordination activities within the component of the sub-project.
- d. Review and compilation of half yearly and annual research progress reports.

The implementation approach and activities thereunder for the Coordination component of the sub-project shown in the following diagram:



Recommendations of the inception workshop, half yearly and annual research progress review workshops and different coordination meetings are furnished hereunder in **Appendices- BARC: A – D.**

Following table represents the summary statement of achievements performed by the Coordination component of the sub project.

Summary statement of achievements		
Name of activities	Performance against each activity	Remark
Inception workshop	Organized centrally at BARC in November' 2018	Attended all PI, Co-PI & expert members.
Revision of PP	Done as per recommendations of Inception Workshop	
H-Y-prog. Review Workshop (Date)	Organized centrally at BARC in March' 2019, January' 2020.	Attended all PI, Co-PI & expert members
Ann. Prog. review Workshop (Date)	Organized centrally at BARC in July' 2019 & in September' 2020	Attended all PI, Co-PI & expert members.
Coordination meeting (No)	03 07.02.19, 19.10.19 & 25.06.20	One Coordination meeting held centrally.
Monitoring of field and Lab activities	04 (BLRI & NSTU)	Covered all components under sub-project.
Financial achievement	Approx. 99.6% of total approved budget and 100% of the released amount	Delay in proc. plan approval and Covid-19 incidence hampered desired progress
Reporting performance	Provided project inception reports, SoE, Half yearly and Annual compiled progress reports of all sub project components as per planned time frame.	<u>Major reports are:</u> <ul style="list-style-type: none"> • Inception report (1 no); • Compiled half yearly progress report (3 no); • Compiled annual progress report (2 no); • Monitoring reports (3 no);

Pictorial views of different workshops, coordination meetings and field monitoring activities



Plate 1. Inception and review workshops at BARC conference room.



Plate 2. Field visit by PIU-BARC team.



Plate 3. Coordinator of the sub-project at farmers house.

10.2 Research Methodology

10.2.1 Coordination component

Information generation on development of BCC tool : Generation and gathering of information done through survey research by using a structured questionnaire and review of literatures for development of nutrition information rich BCC/SBCC tools for disseminating information to the children's, adolescent girls, lactating mothers and pregnant women for up-scaling malnutrition.

Micronutrient study of rice varieties : Micro-nutrients compositions of 11 normal and fermented rice varieties like BRRI dhan 28, Najir, Pari, Miniket, Biroi, Aush, Tepi Boro, Guti, Swarna, Aman and Red Balam were analysed for Calcium (Ca), Iron (Fe), Potassium (K) and Sodium (Na) and to understand the level of contents under the changing fermentation process. All the analysis were done in triplicate in the accredited lab of SGS Bangladesh. Test method followed as per AOAC (16th Edt. 2016) by ICP-OES/MS considering an amount sample quantity of 300gm in each case.

Heavy metal analysis of rice varieties : Locally available thirteen varieties of rice samples were collected from different retail and wholesale markets of Dhaka city for detection and quantification of selected heavy metals such as As, Cd, Cr and Pb. Sample preparation and analysis were conducted in the laboratory of SGS Bangladesh following the standard methods. List of rice varieties are shown in Table 2.

10.2.2. Physical characteristics of Khagrachari Sadar

Khagrachari Sadar upazila area is 297.92 sq km, located in between 23°00' and 23°21' north latitudes and in between 91°55' and 92°00' east longitudes. It is bounded by Panchari upazila on the north, Mahalchhari upazila on the south, Dighinala and Langadu upazilas on the east, Matiranga upazila on the west (Fig 1).

Khagrachari district belong to agro ecological zone (AEZ) 29. Hill areas of this district relief are complex. Hills have been dissected to different degrees over different rocks. In general, slopes are very steep and few low hills have flat summits. The major hill soils are yellow-brown to strong brown permeable friable loamy, very strongly acidic and low in moisture holding capacity. However, soil patterns generally are complex due to local differences in sand, silt and clay contents of the underlying sedimentary rocks and in the amount of erosion that has occurred. Brown Hill soils are the predominant general soil type of the area having low organic matter and general fertility level.

10.2.2.1. Topography & configuration of land

The area is hilly covered with thick vegetation. It is physically constituted with earthen & rocky hills, forests, waterfalls, rivulets (chara) and river valleys. Alongside the hill ranges, small & thin plain strips run. The river, namely Chengi, in the middle rich the soil, is flowing across this district. 5 no. Vaibonchara union is blessed by the river Chengi with fertile soil and water also

with some places with low hilly portion with acidic soil. Whereas 4 no. Perachora union with high hilly to medium hilly land cover with mostly Teak and other forest species.

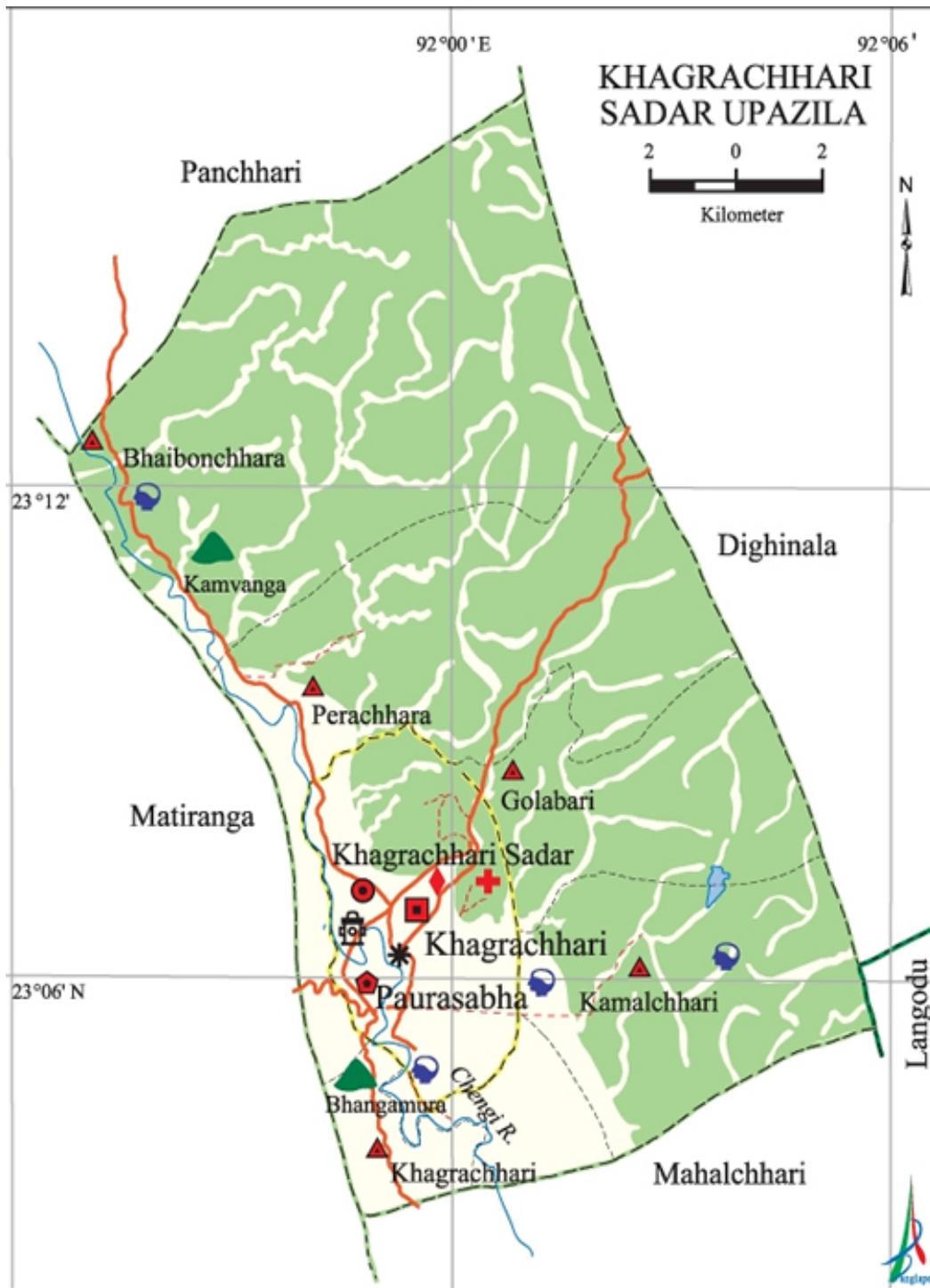


Fig 1. Map of Khagrachhari Sadar Upazila.

10.2.2.2. PRA findings

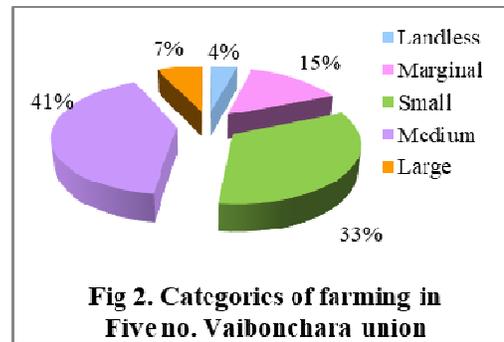
Initially a short PRA was conducted for selection of area and households for implementing the sub-project. Regarding the selection procedure the landless, marginal and small households was get priority. On the basis of the PRA result total number of 60 households was selected purposively of which 30 households from each location. Some of the major PRA tools such as Demographic information, farming category, Transect (resource map, House infrastructure, Land use pattern), Venn diagram, Seasonal calendar, Rainfall, Labor wages, Cropping pattern, Crop calendar, Seed source, Farming system, etc. were discussed in the PRA session. The PRA findings were as follows:



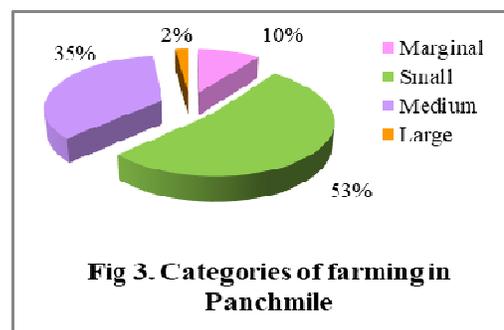
Plate 4. PRA study at different research sites.

10.2.2.3. Socioeconomic characteristics of the selected location

a) **Five no. Vaibonchara union :** The villages consist of approximately 328 households with more than 1352 people. The male and female population is approximately 48:52. The average literacy rate is 67.04 percent. All most of the people are ethnic group belong to Chakma tribe and they are Buddhist. A few numbers of people are Hindu and Muslim in this area. Most of the households have farming (68 percent) as major occupation while 8, 8 and 16 percent, respectively as small business, service and day labour. The farmers of the village belong to five farm categories viz. landless, marginal, small, medium and large farms. The medium farms were highest (41 percent) while small, marginal, large and landless farms were 33, 15, 7 and 4 percent, respectively (Fig 2).



b) **Panchmile :** The villages consist of approximately 102 households with more than 523 people. The male and female population is almost equal (49:51). The average literacy rate is 65.50 percent. In Panchmile villages people belongs Tripura ethnic community believe in Hindu religion, very few of some follow Baptist Church. Most of the households have farming (64 percent) as major occupation followed by small business (18 percent),



service (11 percent) and day labour (7 percent). The farmers of the village belong to four farm categories viz. landless, small, medium and large farms. The small farmers belong to high portion (53 percent) category followed by medium (35 percent), marginal (10 percent) and large (2 percent) respectively (Fig 3). No landless category farmer was found in this site.

10.2.2.4. Biological characteristics of the selected location

Both of the selected location located in the hilly area, most of the land is hilly, Jhum cultivation and homestead gardening is the main sources of agricultural products. Only 10 % lands were plain in Five no. Vaibonchara union while in Panchmile it is below 5%. Jhum cultivation is done once in a season. Land use patterns of plain land in Five No. Vaibonchara union is covering mono cropped T. Aman rice and a few areas covering double and triple cropped area. Rice is grown in two seasons by most of the farmers mainly in rainy season and some of them grown in rabi season also. Most of farmers collect seed from local market. Most popular and available varieties are Sonalipaijam, Chokkapanja and BRRI dhan 2828. But In Panchmile Sonalipaijam and Chokkapanja varieties are most popular among farmers to cultivate in plain land area one's a year. Besides theses the major rice varieties are BR3, BR11, BR14, BR6, Lakhai(L), Bogra(L), BRRI dhan 29, BRRI dhan 36, Binadhan 5, Binadhan 6, BADC 1, Amarsree(L), Manik 6(L), Sonarbangla(L) and Tepi boro(L). ginger, turmeric, banana and sugarcane are the major cash crops in the two locations.

Now-a-days horticultural crops especially fruit orchards becoming popular among farmers and in Vaibonchara union it cover about 30% while in Panchmile it is more than 60%. The area is scatteredly covered by various fruit, timber and fuel tree species like banana, litchi, mango, jackfruit, ber, malta, lemon, segun and mahogany.

The livestock are cattle, goat and pig while the domestic birds are chicken, ducks and pigeons. The animal breeds are local with few crossbred cows but the chicken and ducks breeds are almost local. There is prevalence of seasonal diseases of livestock and poultry in the area. There is little number of seasonal ponds or ditches with traditional fish culture with major carps like Catla, carpio, mrigel etc.

10.2.2.5. Baseline survey

Before starting of the sub-project activities a baseline survey was conducted among the selected 60 households to get the details information. Major focus of the baseline survey of the selected household was socio-economic status and resource allocation, food security, food intake and dietary pattern, agricultural production and practices, homestead and forestry system, employment, organizational training and communication, market and marketing, labour and wages, income and expenditure. On the basis of the information implementation strategy was finalized.

10.2.2.6. Implementation procedure

To achieve the goal and objectives of the sub-project whole activities of the BLRI component was divided into two parts: one was Component Research Programme and another was

Component Development Programme. The Component Research Programme was focused on two issues (a) household food security and (b) dietary intake status of selected households. The Component Development Programme was emphasis on technology dissemination through technological intervention like a) diversified of rice and non-rice crops i.e. vegetables, lean season minor fruits, oil seed, spices, roots and tubers; b) livestock and poultry i.e. goat, sheep, hilly chicken, turkey, duck and pigeon: c) fisheries and d) off-farm activities. Technological intervention was provided in terms of training and technology transfer, demonstration, building farmer's motivation, advice, field visits, market linkage development, etc. which was very much relevant to the sub-project objectives and activities. On basis of the resource's allocation of selected households' technological intervention was developed.

10.2.2.7. Evaluation procedures

The component technologies were used for intervention according to farmers' felt need, problem solving, resource potential and management. However the decision was taken by the farmers. The impact of the sub-project interventions was evaluated on the basis of bio-economic performance and improvement of social status.

10.2.2.8. Biological performance

The biological performance was measured in terms of productivity of crop, livestock and poultry, fishes and biomass fuel including timber. The crop data were collected through seasonal (after harvesting) monitoring while those of livestock and poultry; fisheries and agroforestry were collected through every day or six monthly monitoring. The homestead production data were collected through yearly monitoring. The collected data were analyzed on yearly basis and the average of all years' data was presented in the respective household component wise.

10.2.2.9. Economic performance

Economic performance was measured with respect to land holding, labour utilization, gender participation, labour potentiality, labour productivity and energy status. The economic analysis of various components of the household was done on the basis of local market price of inputs and products. The Benefit-cost ratio (BCR) was calculated on the basis of total annual gross return divided by total annual cost of the farmers. The contribution (Tk.) of each component was calculated as percentage of total taka of a farm⁻¹.

10.2.2.10. Monitoring of dietary status

Improvement of dietary intake was monitored in terms of food consumption, change of food consumption habit, household food production and consumption. The monitoring process was started 24 months after the intervention of sub-project inputs and continued upto four months. The monitoring process was examined the following issues:

- i) Annual availability of different food items in the farm families
- ii) Consumption of specified food items and level of household food security.

10.2.2.11. Social change

Social change was evaluated on the basis of improvement of livelihood in terms of nutrition, housing, education, communication, saving and diversification of occupation.

10.2.2.12. Component Development Programme (by BLRI)

a) Agro-economic performance of transplant aman rice varieties

Rice is the staple food and its production plays an important role in the economy of the country. In Bangladesh, rice alone constitutes 92 percent of the total food grain production annually. It provides about 80 percent of the people's energy intake (Tetens et al. 2003), the majority of their protein intake, and a considerable proportion of several micronutrients in their average daily diet (Hels et al. 2003). The transplanted aman rice is the main crop of both sites. Farmers generally grow transplant aman rice under rainfed condition. The usual phenomenon is that a farmer wishes to have a number of varieties of rice for a particular season. The Bangladesh Rice Research Institute and Bangladesh Institute of Nuclear Agriculture have developed some short duration modern varieties recommended for season. Farmers are getting higher yield by the introduction of these modern varieties. But realization of potential yield depends on various factors like locality, soil, climate and management. The study was undertaken to observe the economic performance of four varieties for both sites.

The experiment was conducted at 5 no. Vaibonchara union and Panchmile during 20 June 2020 to 18 October 2020. Four varieties such as BRRRI dhan-71, BRRRI dhan-75, Binadhan-16 and Binadhan-17 were tested in the experiment. Two farmers were selected from each site. Each farmer's plot was divided into three plots of 30 sq m each and used for transplanting each variety. Date of seed sowing was 20-23 June 2020. The land was ploughed with power tiller followed by laddering. Weeds were cleaned and rice stubble was allowed to rot before puddling. Fertilizers were applied as per recommended dose of BRRRI and BINA. Whole amount of PKSZn was applied during final land preparation. The puddling was done and 12-21days old seedlings were transplanted during 3-14 July 2020. Urea was applied in three equal splits as top dressing at 15, 30 and 45 days after transplanting. Harvesting was done at full maturity and date of harvesting of BRRRI dhan-71 was 3-17 October 2020, BRRRI dhan-75 was 6-17 October 2020, Bibadhan-16 was 3-17 October 2020 and Binadhan-17 was 17-18 October 2020. The data were analyzed in terms of total variable cost, gross return, gross margin and BCR.

b) Varietal performance of mustard

Mustard (*Brassica* spp.) is one of the first domesticated crops which has wide dispersal, and has been grown as herb in Asia, North Africa and Europe for thousands of years (Oplinger et al., 2016). It ranks world's third important oil crop in terms of production and area, and in Bangladesh, it is the first in ranking. Among the three species of brassica, *Brassica napus* and *Brassica campestris* are regarded as rape seed and *Brassica juncea* is regarded as mustard. Mustard oil is one of the healthiest edible oils as it has no trans fat, has low saturated fats, high mono-unsaturated and poly-unsaturated fats like omega-3 (Das et al., 2009). There is a possibility of growing short duration mustard after harvesting of early varieties of aman rice.

Thus single or double cropped area may be converted into double cropped or triple cropped area and farmers would get more return from the same land.

There is a possibility of growing short duration mustard after harvesting of early varieties of aman rice. Thus single or double cropped area may be converted into double cropped or triple cropped area and farmers would get more return from the same land. Thus the experiment was conducted to see agro-economic performance and popularize the improved variety BARI Sarisha-14 and BARI Sarisha-17.

The study was conducted at 5 no. Vaibonchara union from 10 November 2020 to 02 February 2021. Two varieties - BARI Sarisha-14 and BARI Sarisha-17 were grown in three farmers' fields. The plot size of each farmer was 10 decimals. The field was pulverized through two ploughing followed by laddering. Seeds were broadcast on 10 November 2020 at the rate of 8 kg ha⁻¹. Fertilizers were used @ 100, 100, 50 and 30 kg ha⁻¹ of N, P, K and S as urea, triple super phosphate, muriate of potash and gypsum, respectively. Economic analysis was done on the basis of local market prices of input and output.

c) Varietal performance of potato

Potato is one of the most important vegetables of Bangladesh, which can be stored and consumed throughout year. The experiment was undertaken to study the performance of BARI released varieties of potato and to give an exposure to the farmers for evaluating and selecting varieties in their own environment.

The experiment was conducted at 5 no. Vaibonchara union and Panchmile Site from 28 November 2020 to 05 March 2021. Six varieties of BARI potato viz. BARI Alu 36, 46, 49, 53, 62 and 63 were set up in 15 farmer's field in this trial. The plots were pulverized through ploughing, laddering and cleaning weeds by 15 November 2020. The sprouted tubers were planted into 70cm x 20cm spacing on 28 November to 6 December 2020. The total amount of triple super phosphate (200 kg ha⁻¹) and muriate of potash (250 kg ha⁻¹), gypsum (100 kg ha⁻¹), Boron (5 kg ha⁻¹) was applied during final land preparation. The urea was applied at the rate of 300 kg ha⁻¹ in equal two splits at land preparation and 30-35 days of planting. Two weeding and two earthing up were done during growth period. The plots were harvested on 26 February to 05 March 2021. The samples were collected from 1.5m x 1.5m of each varietal plot randomly to record tuber yield. Economic analyses were done on the basis of local market prices of inputs and outputs. The yield of local varieties is much lower than that of modern varieties. The cultivation of BARI potato varieties has a good scope in the hilly area.

d) Performance of papaya

Papain is the dried latex from the fruit, containing a protein hydrolyzing enzyme which has a number of specific technological functions viz., food and beverage preparations, pharmaceutical applications, textile industries and garment cleaning (Kumar and Saha, 1997). Although climatic conditions of Bangladesh topapaya production. It is cultivated on large scale in Jashore, Rajshahi, Kustia, Tangail, Khulna and hill tracts. The national production of papaya is 332093 metric tons with an area of 14547 acres in 2015-2016 (BBS, 2016). Usually, farmers are grown papaya as vegetable. But also ripe papaya is consumed as fruits and market price of ripe papaya is high. Generally, farmers are planting 1-3 number of local varieties in their homestead area for

their own consumption and sometimes they sale it in a limited scale in the local market. There is an opportunity to produce ripe papaya as commercially due to high demand and high market price regarding tourist area it's sweetness and color and this might be due to the congenial micro-climatic conditions maintained in poly house which influenced the production of more photosynthates that might resulted in sweeter fruits with maximum TSS. These finding are also in line with the results of Reddy and Gowda (2014) in papaya cv. Red Lady 786.

Red Lady variety was used for producing of sapling and 2365 saplings were distributed among the 60 farmers of which 15 farmers were selected for established orchard and 80-500 saplings were planting in each orchard. At initial stage saplings were planting in February to March 2019 and the planting process was continued upto March 2021. Before transplanting of sapling 60cm × 60cm × 45cm hole was prepared filled with 10 kg cow dung, 500gm TSP, 250gm Gypsum, 20gm Boron and 20gm zinc sulphate. 30-40 days old saplings were transplanted with 180cm × 180cm spacing. Every month 50gm urea and 50gm muriate of potash (MoP) was applied. Irrigation and weeding was done as when necessary. Harvesting was started after 5-6 month later of transplanting.

e) Performance of brinjal at farmers' fields

Brinjal is the year-round vegetable in Bangladesh. Some varieties are grown in specific season and some are grown over the year. The Bangladesh Agricultural Research Institute has developed some brinjal varieties. Among them 3 number of varieties were selected to observe the performance at 5 no. Vaibonchara union Site.

The field trial was conducted in three farmers' fields during September 2019 to January 2020. BARI Begun-4, 6 and BARI BT Begun-4 were selected for this trial. Seeds were sown on 25 August 2019 in farmer's house to raise seedlings for the trial. Fertilizers were applied at the recommended rate of BARI. P, K Zn and S were applied during final land preparation. Seedlings were transplanted on 16-19 September 2019 with 60cm × 50cm spacing. Urea was applied in three equal splits. Weeding was done during growth period of brinjal. Harvesting was done from December to February 2020. Yields were recorded from five sample plants.

f) Performance of some winter vegetables

Ideal method of growing homestead vegetables in the area was a prime need. On the other hand, newly released variety should also be introduced for higher production. In 5 no. Vaibonchara union and Panchmile Site farmers' are reluctant to produce homestead vegetable although most of the households have homestead area. The programme was initiated to see the performance of some modern varieties of vegetables developed by BARI as well as marketed by private organization.



Plate 5. Field visit by Field Assistant.

The study was carried out in the village in 5 no. Vaibonchara union site during 2019 to 2021. Most of the farmers of Panchmile do not produce winter vegetables due to water scarcity. Brief methodologies of different vegetables are given below:

- a) **Tomato** : Five farmers were selected to cultivate the varieties of BARI Tomato 14 and 17. Land was prepared during first week of December 2020. Fertilizers were applied at the recommended dose. Thirty days old seedlings were transplanted on 15-20 December 2020 with 50cm × 50cm spacing. Urea was applied in two equal splits at 20 and 35 days after planting the seedlings. Irrigation and weeding was done as when necessary. Harvesting was done during February to March 2021.



Plate 6. Farmer's potato plot.

Yields were recorded from five sample plants. On the average, benefit cost ratio was found to be 4.19 on full cost basis and 5.09 on cash cost basis, which was almost similar with karim *et al* (2009).

- b) **Broccoli** : Broccoli was introduced as a new crop in the sub-project area. Early U (Hybrid) variety was used for broccoli cultivation. One farmer from 5 no. Vaibonchara union was selected for this trail. Seedling was transplanting on 08 November 2019. Harvesting was done from January 2020. Total production and gross return farm⁻¹ was recorded through monitoring. In fact, Those findings are in accordance with the findings of Nooprom *et al.*, (2013) in broccoli.



Plate 7. Roadside marketing by farmer herself

- c) **Capsicum** : Pepper (*Capsicum annum* L.) belongs to the family Solanaceae. It is a year round international vegetable crop used in variety of ways for home consumptions, catering and industries (Obidiebube *et al.* 2012). Capsicum was also introduced as a new crop in 5 no. Vaibonchara union. The variety Indra was used capsicum cultivation. One farmer from 5 no. Vaibonchara union was selected for this trail. Seedling was transplanting on 07 November 2019. Mulching and non-mulching management



Plate 8. Production of Cabbage & Chili.

technique was applied for capsicum cultivation. Harvesting was done from January to February 2020. Total production and gross return farm⁻¹ was recorded through monitoring.

- d) **Country bean** : Twenty farmers were selected to distribute the seeds. Variety of seeds was BARI Sheem-1, 5, 6, 9, 10, Rifa and Noldog. Seeds were sown on 25 September 10 October 2019. Harvesting was done from December 2019 to February 2020. Total production and gross return farm⁻¹ was recorded through monitoring.
- e) **Bottle gourd** : BARI Lau-3 and 5, Maria, Dayna and Niko (hybrid) seeds were distributed among 30 farmers of the Site. Seeds were sown on 10-25 October 2019. Improved management was made as per finding of baseline survey. Harvesting started from December 2019 and completed on February 2020. Total production and gross return farm⁻¹ was recorded through monitoring.
- f) **Sweet gourd** : Sweet gourd is an important vegetable which is rich in vitamin and minerals. Generally farmers are cultivating sweet gourd in jum. But to extend the sweet gourd cultivation the demonstration was undertaken in both sites through three hybrid variety of Sweety, Shuprima and Maya in 2018 in three farmer's field and during this period response of farmers was on sweety. On the basis of the farmers response in next year 2019 a trial was conducted in 5 no. Vaibonchara union and Panchmile. The variety was sweety. Twenty farmers were selected. The fertilizer rate was 250-100-50g pit⁻¹ of urea, triple super phosphate and muriate of potash, respectively.
- g) **Cabbage** : To popularize the cabbage cultivation 5 farmers was selected for this trial. Magic 65 and Ruby King variety was used for cabbage cultivation. Seedling was transplanting on 05 November 2019. Harvesting was done from January 2020. Total production and gross return farm⁻¹ was recorded through monitoring.



Plate 10. Farming of cabbage.

- h) **Jhar Sheem** : BARI Jhar Sheem-1, 2, 3 were distributed among the 15 farmers. Seeds were sown on 13-28 November 2019. Harvesting was done from January to February 2020. Total production and gross return farm⁻¹ was recorded through monitoring.



Plate 11. Distribution of HYV Jhar Sheem.

Performance of some summer vegetables

Vegetables are important food items for daily consumption. More number of vegetables is grown in winter than other seasons. But people taking less amount of vegetables comparing to their requirement. To overcome the situation, it is need to boost up the production of summer vegetables and create awareness to increase intake of vegetables. The present study was, therefore, undertaken to observe the performance of modern varieties of tomato, bitter gourd and red amaranth under improved management.

Materials and methods

The study was carried out in the both site during May 2019 to October 2020. Brief cultivation procedure of different vegetables is given below.

- a) **Tomato** : BARI Tomato-4 was provided one farmer field for the study. Land was prepared during last week of June 2019. Fertilizers were applied at the rate of 150-80-50-30 kg ha⁻¹ of NPKS as urea, triple super phosphate, muriate of potash and gypsum, respectively. PK and S were applied during final land preparation. Thirty days old seedlings were transplanted on 20 July 2019 with 50c m × 50 cm spacing. Urea was applied in two equal splits at 20 and 35 days after planting the seedlings. Irrigation and weeding was done as when necessary. Harvesting was done during 25 September to October 2019. Yields were recorded from five sample plants. The average yield of summer tomato was 46.45 t/ha and gross return was 1380200 tk/ha. On the average, benefit cost ratio was found to be 2.35 on full cost basis and 2.98 on cash cost basis, P. Hajong *et al* (2018) also found the same result.



Plate 12. Tomato harvesting by farmer.

- b) Bitter gourd :** Moyna variety was distributed among the 20 farmers. Seeds were shown on 10 April 2019. Recommended cultural practices and plant protection measures were done according to need. Harvesting was started from 25 May 2019.



Plate 13. Vegetables production (corolla-local name).

- c) Red amaranth and coriander :** Red amaranth is also especially nutritious, rich in easily digestible minerals i.e., iron and calcium, as well as protein, vitamin C, and beta-carotene (Islam et al., 2003) The vitamins and minerals present in plants as natural or synthetic antioxidants have been linked to removing harmful molecules called free radicals in the body to help fight against infection and other conditions, including cancer, coronary artery disease, muscular degeneration, and serious eye diseases (Dasgupta and De, 2007). Fifteen farmers were selected for the study. The trial was conducted at homestead of the farmers. Land was prepared during first fortnight of September 2020. Fertilizers were applied at the rate of 170-100-80 kg ha⁻¹ of NPK as urea, triple super phosphate and muriate of potash, respectively. PK and half of urea were applied during final land preparation. Seeds were sown on 20-30 September 2020. Rest half of urea was applied at 20 days after sowing of seed. Harvesting was done during October 2020. Yields were recorded from one sqm area.



Plate 14. Production of Lal & data shak.

Goat and sheep rearing under improved feeding

Goats and sheep are mainly raised by the landless and small farmers who cannot afford to keep cows and whose per capita income is low. Goats and sheep are reared by women in the villages. People rear goat and sheep mainly for meat purpose. Black Bengal goats of Bangladesh demands less care and kids twice in a year. The present programme aimed to develop management practices of goat and sheep under homestead condition to make an additional income source. To see the performance of goat and sheep in hilly area mostly based on natural source in farming household.

The programme was conducted with 6 different farmers in 5 no. Vaibonchara union and 8 different farmers in Panchmile. 3 adult goats of which 1 male and 2 female were distributed to each farmer. Same type of sheep was supplied among the 7 different farmers in 5 no. Vaibonchara union and 8 different farmers in Panchmile. Duration of the study was 180 days. Each adult goat and sheep was supplied concentrate mixture (50 % bran, 30% grain, 19% oil cake, 1% salt) @ 150-200 g/kg body wt. The feed was supplied from sub-project fund. The goats and sheep were free access to grazing. The goat and sheep were dewormed for internal parasites before the commencement of the study. Records were kept on grazing hours and fortnightly body weight of goats and sheep during the experimental period.

Hilly chicken rearing under scavenging condition

Poultry rearing is one of most popular supplementary income generating activity in mixed farming systems in Bangladesh. Millions of farmers especially women in rural areas of Bangladesh are involved traditionally rear indigenous chicken for meat and egg purpose under scavenging condition as a supplementary enterprise. Though the non-descriptive type local chicken is very low producers but its egg and meet market price is higher than others. Considering the facts sub-project was attempt to rear hilly chicken at village condition under scavenging cum supplementary feeding condition as an income generating activity for women. Thus the study was undertaken to disseminate the supplementary cum scavenging technology for hilly chicken.

The trial was conducted with 10 different women of 8-10 hilly chicken day old chicks. The programme was lasted for 8 months. All the birds were supplied balanced diet d^{-1} . The balanced diet was supplied from sub-project. The birds were allowed to go for scavenging during daytime.

Rearing of turkey under improved management practice

Turkey farming is a new entrepreneurship in Bangladesh and the young entrepreneurs from different parts of Bangladesh are trying to adopt turkey farming. The density of turkey farms is not same in all regions. Therefore, farmers were chosen based on the interest and availability of area of turkey farming. Thus, appropriate ten farm households from each site were selected. The study was conducted to know the existing turkey production system, supply chain mapping and identifying the prospects and problems of turkey rearing in hilly area under homestead condition.

Vaccination of livestock and poultry against different diseases

A large number of cattle, goat, sheep and poultry die in the rural areas of Bangladesh every year due to outbreak of different infectious and contagious diseases. The most common diseases are Anthrax, PPR, Black quarter, Haemorrhagic septicemia, Gumboro, Ranikhet, Fowl pox, Fowl cholera, Duck plague etc. Regular vaccination reduced mortality of cattle, goat, sheep and poultry. Thus the objectives of the attempt was to reduce mortality of cattle, goat, sheep and poultry and to increase livestock and poultry production.

Vaccination of cattle, goat, sheep and poultry has been started by field assistants at 5 no. Vaibonchara union and Panchmile site since November 2018. Vaccines were collected from Bangladesh Livestock Research Institute, Savar, Dhaka.

Economics performance of indian major carps and exotic species in perennial ponds under farmers management

Bangladesh is very rich in her inland fisheries resources in the form of capture fisheries and culture fisheries. The fish production from capture fisheries has been declining day by day due to over fishing and changes in fish habitat. Therefore, culture fisheries, specially the pond fish culture have become one of the most important alternate means for increasing fish production in the country. Adoption of improved fish culture technologies could increase fish production. In study area a few number of pond is available and the farmers' culture fish under traditional practice. In that case the production of fish is very low. Thus the study was undertaken to see yield and economic performance of Indian major carps and exotic species of fishes.

The experiment started in 2 perennial ponds of one farmer in each site. The size of the ponds varied from 25-30 decimal. The fish species stocked were Catla, Sarputi, Carpio, Grass carp, Rui and Mrigal. The ponds were prepared before stocking the fish and lime was applied at the rate of 200 kg ha^{-1} . After 10 days of liming, urea and triple super phosphate were applied at the rates of 40 kg ha^{-1} , respectively. Supplementary ready feed was given to fish everyday at the rate of 3% of the body weight of the fish. The fishes were stocked during the last week of July 2019 and harvested during the month of February 2020. Final body weights of the fishes were recorded at harvesting period.

Soil nutrient status of the farmers homestead and crop land

Maintenance of soil fertility is essential for sustainable agriculture. This requires that soil organic matter levels be maintained, supply of nutrient to the crops is sufficient and soil structure is conserved. The unbalance and continuous fertilizers in intensive cropping often leads to imbalance of nutrient and finally decreased in crop yields (Ramteke *et al.* 1997). Chemical fertilizers used in combination with bulky organic manure can meet the nutrient needs of crops. Plant cannot uptake soil nutrient by root zone without available form of soil nutrient in the soil profile. Soil nutrient be available in presence of sufficient soil water. For efficient use of chemical fertilizers a reasonably high level of organic matter in the soil is always desirable. For sustained crop productivity on long term basis plant nutrient status in the soil must have to know. Therefore, an attempt has been made to determine the physico-chemical properties of the soil of the study area.

The experiment was conducted in both 5 no. Vaibonchara union and Panchmile during February 2020. 31 soil samples were collected from 30 farmers land covering the entire study area. Soil samples were collected from a depth of 18 to 20 cm in polythene bags and transferred to Soil Resource and Development Institute, Dhaka for determining the physico-chemical properties of soil viz. pH, Organic matter, N, P, K, S, B, Mg and Zn.

10.2.3. Assessment of present status of homestead pond polyculture system

Aquaculture status of the study area was determined through personal interview supplemented by multiple methodological Participatory Research Approach (PRA) tools such as Focus Group Discussion (FGD) and Crosscheck Interviews (CI) with key informants. Data were collected face to face by pre-coded structured questionnaire interview through randomly selected homestead pond farmers from five upazilas of Noakhali. Among the 110 respondent farmers, 27 of Noakhali Sadar, 20 of Kabirhat, 23 of Companiganj, 20 of Subornochar and 20 of Hatiya were selected. For questionnaire interview, simple random sampling method was followed for fish farmers. In order to collect valid and reliable information from the homestead pond owner, a direct interview schedule was developed considering the objectives of the study by making question to the fish farmers. At the beginning of the interview a brief introduction about the purposes of the study was given to each of the farmers and each question was explained clearly and asked systematically for their sound understanding. The people living in the coastal region of Noakhali having a pond adjacent to their house were surveyed.



Plate 15. Assessment of present status of homestead pond polyculture system through questionnaire survey.

10. 2.3.1. Estimation biological productivity of homestead pond

a. Phytoplankton

Samples were drawn from five upazilas of Noakhali for collecting data on the phytoplankton community of the homestead ponds. Ten litres (10 L) of water was collected and passed through a 20 µm meshed phytoplankton net to concentrate. Each concentrated water sample was then transferred to a glass bottle and diluted to 100 ml with formalin to obtain a 5% buffered formalin solution for analysis. About 250 ml of filtered water was collected, kept in a cooled ice box in field and preserved at refrigerator in lab for nutrient analysis. The samples were analysed within 48 hours after sample temperature increase to room temperature following standard method (APHA, 1992). Enumeration of density of phytoplankton was done using a Sedgwick–Rafter (S-R) cell and the abundance was expressed as cells L⁻¹. A 1 ml sample was put in the S-R cell and left 5 min to allow phytoplankton to settle down. The phytoplankton in 10 randomly selected fields in the S-R cell was counted and plankton density was calculated using the formula (Pitchaikani and Lipton, 2016):

$$N = (P \times C \times 1000)/L.$$

Where, N = the total number of phytoplankton per litre of sample water; P = the average number of phytoplankton counted in 1 ml of sample water; C = the volume of the concentrated sample water (100 ml); L = the total volume of the filtered sample water (10 L). The identification of phytoplankton was done up to genus level using a Carl Zeiss axiostar microscope and Euromax (EC 1152) microscope with the help of Bellinger and Sigiee, 2015; Van Vuuren et al., 2006; Belcher and Swale, 1976.



Plate 16. Phytoplankton sample collection and identification.

b. Zooplankton

Three upazilas of Noakhali coast namely Noakhali Sadar, Subornochar, and Hatiya were chosen for conducting the zooplankton study. Samples were collected by a conical shaped monofilament nylon net (zooplankton net) from three corners of the pond. The mesh size of the plankton net was 90 μm and the diameter of the net at mouth was 9 inch. The water was passed down through the net for 5 minutes and the plankton condensed at the lower end of the plankton net then it was collected into plastic container. After collection, the samples were preserved with 5% formalin. Then the plankton samples were carried out to the laboratory of Fisheries and Marine Science department, Noakhali Science and Technology University for further analyses. For efficient sorting, a small amount of ‘‘Rose Bangle’’ was added within the formalin solution of the plastic containers and left for overnight. All the zooplankton attained pink color rendering easy identification. Zooplankton was separated manually putting the collected organisms with other residues on a tray. The stained plankton was stored out from debris with fine brush, needle, forceps and microscope. The sorted organisms were preserved in 70% ethanol in the small vials. 1 ml sample was poured on an S-R (Sedgwick Rafter) cell. Then it had been set up with luminous stereoscopic microscope (model: XSZ21-05DN and made in China) to identify different species of zooplankton. Thus, a series of photographs of the species was taken to identify the organisms. For identification, monographs, text book, journal articles was followed (Ali and Chakraborti, 1992; Battish, 1992; Phan et al., 2015; Needham and Needham, 1962; Sahu et al., 2013). For quantitative study of zooplankton, Sedgwick-Rafter cell was used which are approximately 50 mm long, 20 mm wide and 1 mm deep. Before filling the S-R cell with sample, the cover glass was diagonally placed across the cell and then 1 ml of zooplankton sample was transferred with a micro pipette so that no air bubbles in the cell covers were formed. The Sedgwick Rafter (S-R) cell was let standard for at least 15 minute to settle plankton. Then plankton on the bottom of the S-R cell was counted enumerated by luminous stereoscopic microscope (model: XSZ21-05DN and made in China). The plankton in 20 randomly selected fields in the S-R cell was identified and counted. The zooplankton concentration was calculated at ind/L where total volume of water (m^3) filtered through the net was calculated by using the following formula: $V = \pi r^2 d$. Where V = Volume of water filtered by the plankton nets, $\pi = 3.1416$, r = Radius of the mouth of the net, d = Distance through which the plankton net is towed.

The zooplankton abundance was calculated using the following formula: **No (per L) = x/v.**
Where x = Total counts of the specimens, v = Volume of water filtered.



Plate 17. Zooplankton sample collection and preserve for identification.

c. Benthos

Sediment samples were collected from Noakhali region namely Noakhali Sadar, Hatiya and Subarnochar by using a hand mud spade (10cm×10cm×10cm) with an area of 0.01 m² with three replicates. The collected samples were washed through a 0.5 mm mesh hand sieve with filtered water at collection point to separate animals from the sediments. The materials retained on the sieve were taken in plastic vials and labelled, to which 70% alcohol were added for killing and fixing the organisms. To increase the visibility of benthic infauna a small amount of “Rose Bengal” was added within the formalin solution of plastic container in the laboratory. Benthic infauna was separated manually putting the collected organisms with the other residues on a tray under enough light availability and evaluated under major taxa. Then the enumerated infaunas were preserved in small vials using small forceps. To identify the benthic infauna, the benthos samples were taken into a round transparent Petri Dish (diameter 15 cm and depth 2 cm) and placed on white paper background for easy contrast of vision. The organisms were counted and calculated for total amount in ind./m². Then it had been set up with luminous stereoscopic microscope (model: XSZ21-05DN and made in China) to identify different species of macrobenthos. Thus, a series of photographs of the species was taken to identify the organisms. For identification, monographs, text book, journal articles was followed (Ali and Chakraborti, 1992; Battish, 1992; Phan et al., 2015; Needham and Needham, 1962). Then, the benthic samples were presented in 70% ethanol (Alcohol) for future evidence. On the data available after total number of infauna counting in a sample, number per square meter occurrence of infauna was then estimated by using the following formula formulated by Welch (1948).

$$N = O \times 1000 / (A \times S).$$

Where, N = Number of infauna 1 sq. m of profoundal bottom, O = No. of infauna (actually counted) per sampled area, A = Transverse area of Mud spade in sq. cm, S = No. of sample taken at one sampling site.



Plate 18. Benthos sample collection and sieving for identification.

10.2.3.2. Socio-economic status of coastal rural people

Mixed methods are referring to an emergent methodology for conducting research that involves collecting, analyzing and integrating quantitative (e.g., experiments, surveys) and qualitative (e.g., focus groups, interviews) research. In this study an exploratory sequential design has been used, where a primary qualitative phase influences the design of a secondary quantitative survey tool. This places an emphasis on the findings of the qualitative phase, with the quantitative phase being employed to test the generalizability of the qualitative findings. Socio-economic status of the study area was determined through personal interview supplemented by multiple methodological Participatory Research Approach (PRA) tools such as Focus Group Discussion (FGD) and Crosscheck Interviews (CI) with key informants. Data were collected from 100 homestead pond farmers by the pre-tested draft questionnaire from four upazila of Noakhali coast. The socioeconomic status such as age, religion, education, land ownership, occupation and annual income, were obtained mainly from the homestead pond fish farmers.



Plate 19. Assessment of socioeconomic status of coastal rural people by questionnaire survey.

10.2.3.3. Nutritional and health status of coastal rural people

Farmers of low-income and landless households, each own a homestead ponds in their households called “beneficiary farmers” were selected by union chiefs. The beneficiary farmers

were provided with aquaculture supplies (i.e. fish seed, fish feed, fertilizer, lime), technical supports, and management assistance for 3 years. Baseline data of the beneficiary farmers were collected in 2018 and end line data was collected in 2021 with two mid-term data after each culture cycle during 2019 and 2020. To cross-check our findings a survey was conducted in four upazilas (sub-district) namely Noakhali sadar, Subarnachar, Kabirhat, and Ramgati having similar socio-economic status called “control farmers”. About 80 controlled farmers (4 × 20) were randomly selected through a multi-stage cluster sampling divided into two groups— ‘having homestead ponds’ and ‘without homestead ponds’.

A draft questionnaire was developed and pre-tested with a few pond fish farmers before collecting primary data. The questionnaire included anthropometric characteristics (Height, weight, MUAC), anaemia prevalence (Hb level) and socio-demographic (Sex, age, religion, education, annual income) characteristics of the pond fish farmers. Secondary data on nutritional health were gathered from literatures like various published and unpublished relevant documents of various sources, Govt. and non Govt. organizations like as District Fisheries Office, Central Library of Noakhali Science and Technology University. Height and weight was measured using ideal height and weight measuring scale (H07, Zhongshan Dingheng Yipin Home Product Co. Ltd., China). During measuring the weight, each person was requested to bare footed and put off heavy cloths, and weight was logged in to the nearest 0.5 Kg. For height measuring, every farmer was positioned to stand on plain land, removing shoes and looking straight forward. Height was recorded to the nearest 0.1 cm. Nutritional health condition was calculated by Body Mass Index (BMI) through the following formula and classified according to “Asian criteria” (WHO, 2000; Lido and Mirasol, 2011).

$$BMI = \frac{\text{Weight in kilogram}}{\text{Height in sq. meter}}$$

MUAC value was calculated to the nearest 0.1 cm by using a tape, and the measurement was taken at theme-point of the upper left arm. After locating the mid-point, the subject was asked to keep arm extended with the palm facing inward. The tape was wrapped smoothly and gently around the mid-point of arm, and MUAC was classified according to James et al. (1994) and Tang et al. (2013). During the study, the blood sample was collected to know the anaemia prevalence by a nurse who was trained for two days. Anaemia prevalence was assessed by determining the haemoglobin level (gdl⁻¹) according to (WHO, 1992; WHO, 2001) using Hemoglobin analyzer (HemoCue Hb 201⁺, HemoCue AB, Sweden) to know the prevalence of anaemia among pond fish farmers.



Plate 20. Measurement of Haemoglobin level and MUAC.

10.2.3.4. Homestead ponds fish diversity of Noakhali

Fish samples were caught by means of the traditional fishing gears such as seine net (Sutar jal), cast net (jhaki jal), square lift net (tar jal), conical trap (dughair), fish angles (Borsi), monofilament fixed gill net (Current jal) and fish barrier (Thaga). All the fish samples are being preserved with 10% formalin in the plastic jars and identify by different taxonomic books e.g. An illustration guide to fishes of Noakhali (Hossain, 2013), Encyclopedia of Flora and Fauna of Bangladesh (Freshwater Fishes) (Siddiqui, 2007), Freshwater fishes of Bangladesh (Rahman, 1989), Bangladesher Matsya Shapad (Shafi and Quddus, 2004).



Plate 21. Collection of fish from the homestead ponds.

10.2.3.5. Nutritional value of fish available in the homestead ponds

Proximate composition

The fish samples were periodically collected from homestead ponds during culture periods. Immediately after caught the fish sample were carried to the laboratory of Department of Fisheries and Marine Science and preserved through freezing. Nutritional analysis was performed in the laboratory of the Faculty of Fisheries, Bangladesh Agricultural University

(BAU), Mymensingh, Bangladesh. The fish were carefully washed with cooled tap water. Fins, gills and viscera were removed and again washed with tap water to remove blood, slime and unnecessary flesh. After washing the fish sample cut into small pieces and finally ground with a blender for homogenous mixture. The prepared samples were used and each experiment was conducted with three replicates. The proximate compositions of each species were analysed by using conventional methods of Association of Official Analytical Chemists (AOAC, 1995).

Moisture: The moisture content was determined by drying the sample at 105 °C to a constant weight for 24 hours.

$$\text{Moisture (\%)} = \frac{\text{Weight loss}}{\text{Original weight of the sample taken}} \times 100$$

Ash: Total ash content was evaluated from weighed samples in a porcelain crucible placed in a muffle furnace at 600 °C for 6 hours.

$$\text{Ash (\%)} = \frac{\text{Weight of the dry sample}}{\text{Original weight of the sample taken}} \times 100$$

Crude Protein: The protein content of the fish was determined by micro-kjeldahl method. Samples (0.5 g) were digested in digestion unit for 45 minutes. The digest was then distilled in distillation unit. Finally it was titrated with 0.1 N HCl and crude protein was obtained by multiplying the total nitrogen by a conversion factor of 6.25.

N_2 (%) = (Titration reading–blank reading) × Strength of Acid × (100/5) × (100/weight of the sample).

$$\text{Protein content (\%)} = \% \text{ of total } N_2 \times 6.25$$

Crude Lipid: The estimation of fat content of experimental raw fish, smoke cured fish samples will be accomplished by Bligh and Dryer method:

$$\text{Fat (\%)} = \frac{\text{Weight of the residue}}{\text{Original weight of the sample taken}} \times 100$$

Total carbohydrate: Carbohydrate content was determined by-
= [100 – {moisture (%) + protein (%) + fibre (%) + lipid (%) + ash (%) }].

Minerals determination

The fish samples were collected from homestead ponds and the fish samples were stored at -4 °C until analysis. Before sampling the fish was weighed and the body length was measured. Then it was sun dried until the fish attained a constant weight. Then it was powdered in blender. Finally it was preserved in zipper bag before laboratory analysis. All chemicals used were of the highest purity and all solutions were prepared using double distilled water. Collected samples were analysed by the AAS (Model: is AA-700, SHIMADZU) using standard analytical procedure. Samples were carefully handled. Recommended clean powder free latex gloves and lab coats were used during the samples handling for avoiding contamination. Glassware was properly cleaned by chromic acid solution and distilled water. Analytical grade chemicals and reagents were used throughout the study. Blank determinations were used to get the correct instrument readings.

Fish sample (1.0 g) was placed in a 25 ml beaker. Afterwards, about 10 ml of concentrated HNO_3 (analytical grade, 69%w/w) was poured into the beaker. A watch glass was placed at the mouth of the beaker and the beaker was placed on a magnetic stirrer/hot plate. Initially, the temperature was kept at about 40 °C for one hour to prevent vigorous reactions. Then the temperature was maintained at 140 °C for another 3 hours. Once the digestion was completed all tissue samples were completely dissolved in the acid. Then the mixture was cooled to room temperature. After cooling, 5 ml of H_2O_2 was added and the mixture was boiled until a white fume was observed. The sample was filtered by filter paper (Whatman No.1 grade). The filtrates were stored at 4 °C until the metal determination by AAS.



Plate 22. Determination of nutrients, minerals and fatty acids.

Fatty acids determination

Relative concentration of fatty acid (FA) from oil samples were measured as their corresponding methyl esters according to the method described in IUPAC (1979) with a minor modification. 5-7 drops of oil was taken in 15 ml test tube and 3 ml of 0.5 M sodium methoxide (prepared by mixing metallic sodium in methanol) was added and digested by stirring in a boiling water bath for about 15 minutes. It was allowed to cool to room temperature and 1 ml of petroleum ether (40-60 °C) was added followed by 10 ml deionized water, mixed gently and allowed to settle for 5-6 minutes. The distinct upper layer of methyl ester in petroleum ether was separated carefully in a capped vial and used for analysis. 200 mg of different fatty acid standard in their respective methyl ester form were dissolved separately in 10 ml petroleum ether (b.p 40-60°C) in a series of screw-capped test tubes. Aliquots of 1 μ l fatty acid methyl ester (FAME) were injected and the peaks of fatty acids were recorded for their respective retention time and areas by the data processor unit of GC.

Fatty acid composition was analysed using gas chromatograph (Shimadzu GC-14B, Japan) equipped with flame ionization detector and fused silica capillary column (FAMEWAX, Crossbond® polyethylene glycol, 15m \times 0.25mm \times 0.25 μ m film thickness, Restek; Pennsylvania, USA). Split less injection technique with nitrogen as carrier gas at a constant flow rate of 20 ml/min was used. Injector temperature was 250°C, initial oven temperature was 150°C and held for 5 minutes. Temperature was increased at a rate of 8 °C/min to 190 °C and then increased to 200 °C at a rate of 2°C/min and held for 10 minutes. The fatty acids were identified by using

respective fatty acid methyl ester standards (FAME mix) and presented as relative percentage done by the automated GC software (Class GC-10, version-2.00).

10.2.3.6. Development of a modified carp-based polyculture technology suitable for the homestead ponds of Noakhali

Pond preparation

All of the aquatic weeds were removed manually before the research starting. Use of repeated netting (seine net, mesh size of 12.5 mm) undesirable fish species and other species were removed from the pond. In addition, liming (CaO at the rate of 247 kg/ha as base dose and 120 kg/ha/month as periodic dose) was done to sustain good water quality. Composted was also applied to increase the natural feed production, fertilization (basal dose, 2470 kg/ha; periodic dose, 1235 kg/ha/month), urea (basal dose, 50 kg/ha; periodic dose, 25 kg/ha/month) and Triple Super Phosphate (TSP; basal dose, 50 kg/ha; periodic dose, 25 kg/ha/month).

Carp-based polyculture for homestead ponds with different stocking density : This experiment was performed on optimization of stocking density and feeding ration for polyculture in homestead ponds of Noakhali district, Bangladesh between August 2019 and December 2019. Four advanced fingerlings of carps viz. Catla (*Gibelion catla*), rohu (*Labeo rohita*), Mrigal (*Cirrhinus cirrhosus*), and Kalbasu (*Labeo calbasu*) were used as experimental species and stocked at 825 kg (T₁), 560 kg (T₂) and 370 kg (T₃) fish seed per hectare in nine earthen ponds. The mean stocking weight of *G. catla*, *L. rohita*, *C. cirrhosus*, and *L. calbasu* was 243 ± 1.87 g, 223.56 ± 2.35 g, 155.89 ± 1.69 g, and 158.72 ± 1.35 g, respectively.

Carp-based polyculture for homestead pond stocked with wild and hatchery seed : This study was conducted on growth performance and fish yield in polyculture systems from hatchery and wild sources in homestead ponds of Noakhali, Bangladesh between July 2020 and December 2020. Four species of IMCs viz. Catla (*Gibelion catla*), Rohu (*Labeo rohita*), Mrigal (*Cirrhinus cirrhosus*), and Kalbasu (*Labeo calbasu*) were stocked in three different treatments (T₁–T₃) from two hatcheries (T₁ & T₂) and Halda River (T₃). The mean stocking weight of *G. catla*, *L. rohita*, *C. cirrhosus*, and *L. calbasu* were 134.93 ± 3.85 g, 115.85 ± 5.02 g, 119.09 ± 1.27 g, and 118.17 ± 1.62 g, respectively.

Feeding management

Feeding began immediately after stocking and supplementary feed (dietary protein content of 24.25%) was used twice daily at 8:00 am and 5:00 pm with a mixture of rice bran (25%), wheat bran (25%), fish meal (25%), and mustard oil cake (25%). Supplementary feeding was done at the rate of 2 to 6% of fish body weight (6% for the first month, 5% for the next three months, and 2% for the last two months). The quantity of feed was adjusted every month according to the total biomass of fish obtained from the sampling as part of monitoring fish growth.

Water quality monitoring

The important physico-chemical parameters of water viz., pH, salinity (psu), dissolved oxygen (mg/L), and water temperature (°C) were monitored every seven days interval using Hannah Multi-parameters (Model: H198194). Water transparency (cm) was measured using a Secchi-disc. Nitrates (NO_3^-), phosphates (PO_4^{3-}), sulphates (SO_4^{2-}) were also determined monthly by using a Spectrophotometer (Model: UV 1800, Shimadzu Europa).



(a) Stocking of fish seeds



(b) Feeding of fish



(c) Growth monitoring of fish



(d) Water quality monitoring

Plate 23. Development of a modified carp-based polyculture systems.

Survival rate, weight gain and feed conversion ratio

The fish were sampled monthly intervals to assess the growth of fish in the experimental ponds. A cast net was used for sampling in ponds. At least 10% of the stocked fishes were caught for each sampling in each experimental pond. The survival rate, specific growth rate (SGR), feed conversion ratio (FCR), and gross yield (GY) were measured at the end of the experiment as:

$$\text{Survival rate (\%)} = [\text{Number of fish harvested} / \text{Number of fish stocked}] \times 100$$

$$\text{Weight gain (g)} = [\text{Mean final weight (g)} - \text{Mean initial weight (g)}]$$

$$\text{SGR (\%/day)} = [\ln(\text{Final weight}) - \ln(\text{Initial weight})] / [\text{Culture period in days}] \times 100$$

$$\text{FCR} = [\text{Feed given (dry weight)} / \text{Body weight gain (wet weight)}]$$

$$\text{GY} = [\text{Average final weight} \times \text{total number of survivors}]$$

Economics of homestead pond carp polyculture

An elementary cost-benefit analysis was followed to disclose the economics of carp polyculture under diverse treatments. At the termination of the experiment, fishes were harvested and sold to the local market. Cost-benefit analysis of different treatments was figured based on variable costs (the cost of lime, organic and inorganic fertilizer, fish seed, and feed) and the revenue from the sale of fishes. The prices were expressed in the US currency (84 BDT = 1 USD). Total return determined from the market price of the fish sale was expressed as USD ha⁻¹. Prices of inputs and fish resembled to wholesale market prices in 2019 of Noakhali, Bangladesh. Net benefit and cost-benefit ratio (CBR) were reckoned as:

$R = I - V_c$. Where R, net benefit; I, total income from fish sold, and V_c for variable costs.

Cost-Benefit Ratio (CBR) = Net benefit/ total investment.

11 Results and discussion

11.1. Coordination component (BARC)

11.1.1. Development of BCC tool

The nutrition information rich BCC tool developed by the Nutrition Unit (Coordination component of the sub project) covered various categories of food items from energy provider to growth and development accelerator to disease resistance/immunity developer food items for all categories of age group people. Viewers can easily understand the food and nutrition value of each item under different categories from the pictures plate in addition to gathering a nutritional guideline and information



Plate 24. BCC tool.

11.1.2. Nutrient composition study of rice samples

Increase in Ca content was observed higher in fermented BRRI dhan 28, Pari, Miniket and in Balam Red samples. Highest amount of increase in Ca concentration (352%) recorded in Miniket. While for all other samples of rice, fermented samples exhibit decreasing values (from 4.25 -63.74%). In case of Fe, increased amount was recorded for BRRI dhan 28, Pari, Miniket and Gutti fermented rice samples (4.35-55.83%). While the other fermented rice samples showed decrease in Fe content that varied from 5.67 – 64.49%. Potassium (K) content in all the fermented rice samples showed decreasing concentration than in normal rice samples. The value for fermented samples were varied between 34.40 -89.58%. Except for BRRI dhan 28, Miniket and Aush rice all other fermented rice samples exhibits decreasing tendency for Na content in fermented form and the values varied between 5.91 – 295.43% (Table I)

Table 1. Nutrient composition of normal and fermented rice

Sample code & Rice variety	Unit (mg/kg)											
	Calcium (Ca)			Iron (Fe)			Potassium (K)			Sodium (Na)		
	N	F	% increase (g)	N	F	% increase (g)	N	F	% increase (g)	N	F	% increase (g)
BRRi dhan-28 NN-2.8-101a (N) NG-2.8-101b (F)	369.60	492.0		3.26	5.08	(+) 55.83%	215.05	117.69	(-) 45.27%	26.56	36.94	(+) 39.08%
Najir NN-NJ-102a (N) NG-NJ-102b (F)	327.87	313.93	(-) 4.25%	2.47	2.33	(-) 5.67%	201.88	73.04	(-) 63.82%	25.40	23.90	(-) 5.91%
Pari NN-PR-103a (N) NG-PR-103b (F)	206.35	355.94	(+) 72.49%	1.38	1.44	(+) 4.35%	163.43	99.10	(-) 39.36%	21.47	16.36	(-) 23.80%
Miniket NN-MNK-104a (N) NG-MNK-104b (F)	69.29	313.15	(+) 351.94%	1.63	1.82	(+) 11.66%	114.78	75.29	(-) 34.40%	14.18	20.92	(+) 47.53%
Biroi Rice NN-BRO-105a (N) NG-BRO-105b (F)	474.08	171.88	(-)63.74%	5.88	5.09	(-)13.44%	254.69	78.10	(-)69.34%	(+) 33.12%	15.01	(-)55.19%
Aush NN-AS-106a (N) NG-AS-106b (F)	550.47	231.66	(-)57.91%	5.33	4.02	(-)24.58%	278.58	141.58	(-)49.18%	21.45	84.82	(+)295.43%
Tepi Boro NN-TPB-107a NG-TPB-107b	419.72	318.30	(-)24.16%	3.63	1.18	(-)67.49%	168.08	17.52	(-)89.58%	28.13	7.95	(-)71.74%
Guti Swarna NN-GTSR-108a NG-GTSR-108b	438.33	235.96	(-)46.17%	2.25	2.87	(+)27.56%	204.82	21.91	(-)89.30%	22.27	11.52	(-)48.27%
Aamon Rice NN-AMN-109a (N) NG-AMN-109b (F)	519.36	132.38	(-)74.51%	4.14	2.06	(-)50.24%	230.18	53.00	(-)76.97%	22.57	18.39	(-)18.52%
Balam Red Rice 111NM-BLM-001 (N) 111GN-BLM-005 (F)	198.22	241.99	(+22.08%	6.51	5.66	(-)13.06%	569.74	500.32	(-)12.18%	146.37	169.17	(+)15.58%

Test Method: AOAC 20th Edition (2016) by ICP-OES/MS; Sample quantity: 300grm

11.1.3. Heavy metals in rice samples

Results of various rice samples for heavy metal concentration are presented in Table 2. Findings revealed the presence of heavy metals (As, Cd and Cr) concentration of in all the sampled varieties are below the recommended level of FAO/WHO/EU. In case of Pb, only one sample of rice (Kohinoor Bashmati Rice) showed higher concentration (0.48 ppm) than the recommended level (0.20 ppm) of WHO. Concentration of Pb was also found below detectable level for other rice samples.

Table 2. Test results of heavy metals in different rice samples

Sl. No.	Rice Variety/Sample	Results of Heavy Metals Parameters (ppm)			
		Arsenic	Cadmium	Chromium	Lead
1	BRR1 Dhan-28	ND	ND	ND	ND
2	Guti/gudi Rice	ND	ND	ND	ND
3	Pizaam Rice	ND	ND	ND	ND
4	Pizaam Aatop Rice	ND	ND	ND	ND
5	Aamon Rice	ND	ND	ND	ND
6	Miniket Rice	ND	ND	ND	ND
7	Bashmati Rice (loose)	ND	ND	ND	ND
8	Bashful (Tapi boro) Rice	ND	ND	ND	ND
9	Nazir-shail Rice	ND	ND	ND	ND
10	Tilda Bashmati Rice	ND	ND	ND <td ND	
11	Fortune Bashmati Rice	ND	ND	ND	ND
12	Kohinoor Bashmati Rice	ND	ND	ND	0.48
13	Birooi Rice	ND	ND	ND	ND

MRL: As-1.00ppm; Cd-0.20 ppm; Pb-0.20 ppm; Cr-1.0 ppm (source: FAO/WHO/EU)



Plate 25a. Fresh rice samples.



Plate 25b. Normal and fermented rice samples collected for analysis.

11.2. Component 1 (BLRI)

11.2.1 Component research Programme

11.2.1.1 Household food security

a) Five no. Vaibonchara union

The sub-project activities in Munigram Site were performed with 30 farms. Among them, 28 farms were documented, of which 2 marginal, 22 small and 4 medium farms. Performances of farm household under marginal, small and medium farm categories in 5 no. Vaibonchara union site have been summarized in Table 3. The average farm size of marginal, small, medium farms and all farms was 0.18, 0.62, 1.79 and 0.76 ha, respectively (Fig 4). It is difficult to find out the impact of intervention in

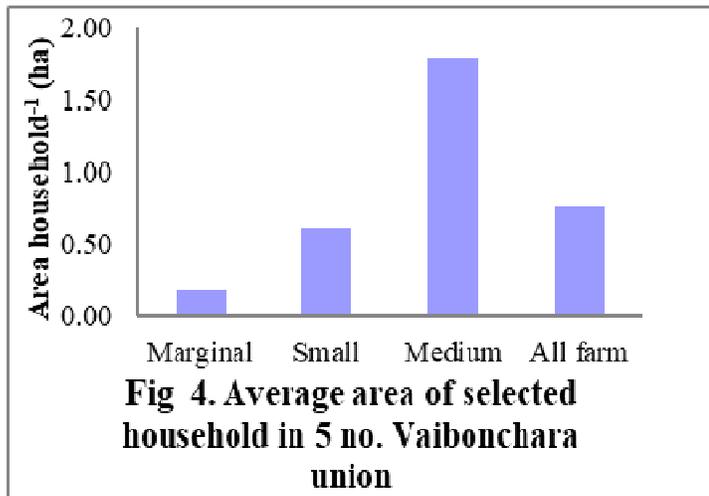
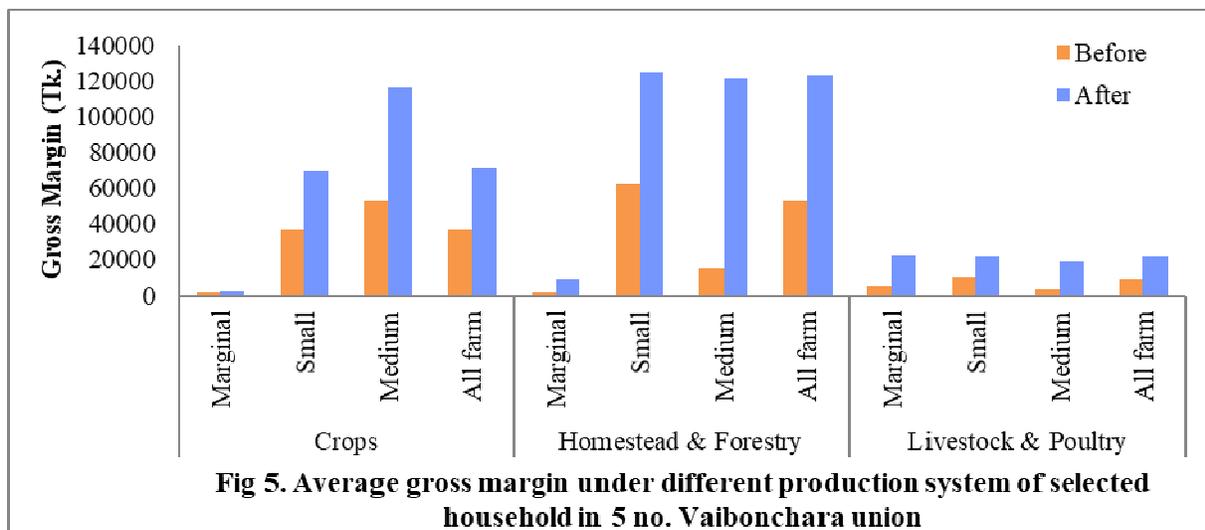


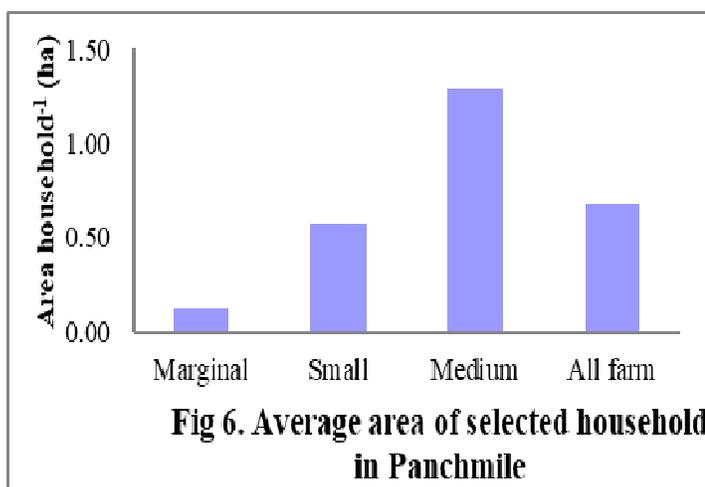
Fig 4. Average area of selected household in 5 no. Vaibonchara union

short time. The previous experiences of different research activities show that it needs at least 3-5 years for visible impact. Present findings indicated that after two and half year intervention, the annual income increased in each category of farm. Average gross margin farm⁻¹ year⁻¹ of marginal, small and medium farms were increased 341%, 96% and 261%, respectively over inception year. Average gross margin increased 119% over initial year. Before and after interventional effect on gross margin of crops, homestead and forestry, and livestock production showed in Fig 5. The results revealed that BCR increased after intervention because of intensification of enterprises which indicated the household security increased over initial year.



b) Panchmile site

The development of integration of farm household was done through intervention of technology, management and addition of enterprises. The summary performance of farming in Panchmile Site is presented in Table 4. The sub-project started its activities with 30 farms of which 4 marginal, 19 small and 7 medium farms. The average farm size of marginal, small, medium and all farm were 0.12 0.57, 1.29 and 0.68 ha, respectively (Fig 6).



Average gross return after intervention was Tk 138637.50, 190086.05 and 283835.71 in marginal, small and medium, respectively those were higher than that of before intervention. Fig 7 showed that the gross margin increased significantly in different farm category after intervention and the gross margin increased by 248%, 118% and 58% for marginal, small and medium, respectively. Overall findings indicated that efficiency of productivity increase was the highest in medium farm.

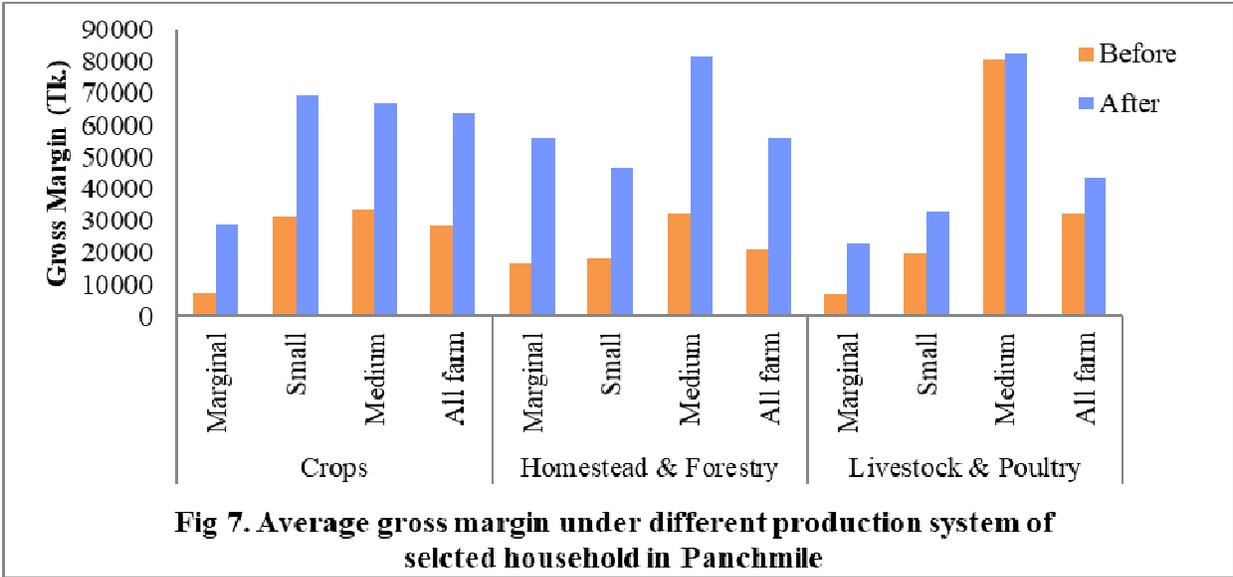


Table 5 to 10 showed also total cost, gross return and gross margin of crop production, homestead and forestry production, and livestock production of 5 no. Vaibonchara union and Panchmile. The interventions were increased cropping intensity, crop diversification, number of homestead plantation, and productivity of all systems in the both sites. Interventions also change the cropping pattern in the farms and other farms of the village. It is also indicated that some socio-economic impact also observed in some farms. The additional income was spent for purchases food, health care, education, repayment of loan, land rent in, inputs for farming activities etc. The impact of intervention on farming created very positive response among the farmer of the area.

Table 3. Performance of farming in 5 no. Vaibonchara union, Khagrachari Site after two and half years of intervention

Sl. No.	Name of the farmers	Farm size (ha)	Before intervention				After intervention				Socio-economic impact
			Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR	Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR	
1	Marginal Farm Sukra Maya Chakma	0.20	4800	43821	39021	9.13	23000	250940	227940	10.91	Ensuring food security, extension house Increase food consumption
2	Jubamita Chakma	0.16	6350	24250	17900	3.82	16750	40100	23350	2.39	
	Average	0.18	5575	34036	28461	6.11	19875	145520	125645	7.32	
3	Small Farm Surovi Chakma	0.89	49300	169140	119840	3.43	55425	313425	258000	5.65	Constructed semi pacca house and installed sanitary latrine Ensuring food security Improved household food consumption Ensuring food security Ensuring food security Built a tin Roof semi pacca house Purchased an auto Rickshaw and build a semi pacca tin shed house. Leased in betel nut garden and act as a bapari of betel nut Ensuring food security Invest in commercial papaya cultivation Ensuring food security Ensuring food security Ensuring food security Established Multa Orchard Ensuring food security Improved household food consumption Ensuring food security Ensuring food security Ensuring food security Leased in 0.16 ha crop land for crop cultivation Constructed a semi pacca house. Marriage ceremony of her daughter.
4	Geeta Chakma	0.97	38200	113975	75805	2.98	87950	318500	230550	3.62	
5	Manashi Chakma	0.60	15750	47780	32030	3.03	28400	102900	74500	3.62	
6	Birala Chakma	0.80	37490	88630	51140	2.36	86440	256225	169785	2.96	
7	Prakash Mitra Chakma	0.84	46900	139575	92675	2.98	79750	280100	200350	3.51	
8	Nirupa Chakma	0.89	21600	98010	76410	4.54	65050	313420	248370	4.82	
9	Sagorika Chakma	0.48	36700	298000	261300	8.12	58500	620000	561500	10.60	
10	Varot Chakma	0.56	38700	280500	241800	7.25	36800	509300	472500	13.84	
11	Ujjola Chakma	0.60	106900	532000	425100	4.98	128650	783750	655100	6.09	
12	Joytika Chakma	0.73	20250	142470	122220	7.04	10000	241500	231500	24.15	
13	Nayoan Chakma	0.81	53950	242100	188150	4.49	53050	243100	190050	4.58	
14	Tisha Chakma	0.32	9300	64100	54800	6.89	9000	136000	127000	15.11	
15	Basona Chakma	0.40	41650	154300	112650	3.70	45250	218000	172750	4.82	
16	Jharna Debi Chakma	0.89	19150	69125	49975	3.61	62600	222125	159525	3.55	
17	Manju Rani Chakma	0.40	10000	53875	43875	5.39	21500	124000	102500	5.77	
18	Jupee Chakma	0.60	7570	26275	18705	3.47	28350	114125	85775	4.03	
19	Bimolendu Chakma	0.72	21560	79675	58115	3.70	23000	190700	167700	8.29	
20	Supta Chakma	0.89	25200	101825	76625	4.04	54700	200650	145950	3.67	
21	Nejam Uddin	0.21	24000	122000	98000	5.08	44500	163000	118500	3.66	
22	Nazrul Islam	0.48	33700	115000	81300	3.41	52800	175000	122200	3.31	
23	Nashir Uddin	0.24	32500	93000	60500	2.86	55800	153500	97700	2.75	
24	Radhika Rani Nath	0.40	49000	130000	81000	2.65	45200	208000	162800	4.60	
	Average	0.62	33608	143698	110092	4.28	51487	267605	216118	5.20	
25	Medium Farm Manik Baran Chakma	2.20	32250	120800	88550	3.75	79200	280500	201300	3.54	
26	Preety Chakma	1.78	31000	107660	76660	3.47	90685	490050	399365	5.40	
27	Rekhona Chakma	2.02	48900	112335	63435	2.30	74000	307050	233050	4.15	
28	Tuntuni Chakma	1.17	32550	92850	60300	2.85	36890	246760	209870	6.69	
	Average	1.79	36175	108411	72236	3.00	70194	331090	260896	4.72	
	All Farm										
	Average	0.76	31972	130824	98853	4.09	51901	267954	216053	5.16	

Table 4. Performance of farming in Panchmile, Khagrachari Site after two and half years of intervention

Sl. No.	Name of the farmers	Farm size (ha)	Before intervention				After intervention				Socio-economic impact	
			Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR	Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR		
	Marginal Farm											
1	Lalindra Tripura	0.20	12350	31400	19050	2.54	16950	78650	61700	4.64	Ensuring food security Ensuring food security Ensuring food security Purchased an Auto Rickshaw, leased in 20 decimal land for cultivation, Re-structure and extended the house by tin	
2	Jibika Tripura	0.06	1390	5500	4110	3.96	3900	19000	15100	4.87		
3	Ajit Mohan Tripura	0.10	47925	130160	82235	2.72	75050	332950	257900	4.44		
4	Sohen Tripura	0.12	6950	26000	19050	3.74	26000	123950	97950	4.77		
	Average	0.12	17154	48265	31111	2.81	30475	138638	108163	4.55		
	Small Farm											
5	Poten Kumar Tripura	0.40	45300	123785	78485	2.73	69200	269040	199840	3.89	Ensuring food security Ensuring food security	
6	Koren Kumar Tripura	0.32	32200	194300	162100	6.03	52400	271000	218600	5.17		
7	Umaboti Tripura	0.67	17000	46400	29400	2.73	32000	118600	86600	3.71		
8	Upen Tripura	0.56	18000	61400	43400	3.41	29900	121000	91100	4.05		
9	Rano Bikash Tripura	0.56	24940	110200	85260	4.42	44200	149560	105360	3.38		
10	Naro Vushon Tripura	0.80	26770	78200	51430	2.92	42500	151075	108575	3.55		
11	Gajon Mohan Tripura	0.48	50900	126600	75700	2.49	31200	142350	111150	4.56		
12	Aortho Mohan Tripura	0.40	9700	53200	43500	5.48	19800	67000	47200	3.38		
13	Shanti Tripura	0.72	21500	57700	36200	2.68	20500	65400	44900	3.19		
14	Montu Bikash Tripura	0.98	118500	214700	96200	1.81	53000	256100	203100	4.83		
15	Olen Debi Tripura	0.40	10000	28800	18800	2.88	13000	80000	67000	6.15		
16	William Tripura	0.81	46250	151200	104950	3.27	77800	713600	635800	9.17		
17	Aonkey Roy Tripura	0.32	18075	71480	53405	3.95	44750	133560	88810	2.98		
18	None Ranjan Tripura	0.40	22200	41400	19200	1.86	37300	83800	46500	2.25		
19	Roti Kumar Tripura	0.80	13200	37100	23900	2.81	26100	108700	82600	4.16		
20	Khanjan Rani Tripura	0.22	32600	176400	143800	5.41	45300	223400	178100	4.93		
21	Mojamohan Tripura	0.89	24030	128700	104670	5.36	50000	166200	116200	3.32		
22	Nirobala Tripura	0.76	22400	111000	88600	4.96	25900	291000	265100	11.24		
23	Tholen Tripura	0.40	14750	70175	55425	4.76	36400	200250	163850	5.50		
	Average	0.57	29911	99092	69180	3.31	39539	190086	150547	4.81		
	Medium Farm											
24	Biplob Voshan Tripura	1.25	26200	161900	135700	6.18	62000	358450	296450	5.78		Ensuring food security Ensuring food security Ensuring food security Ensuring food security Ensuring food security Ensuring food security Ensuring food security
25	Real Tripura	1.13	21400	63250	41850	2.96	27100	95700	68600	3.53		
26	Dipeen Bala Tripura	1.25	85700	396540	310840	4.63	117500	650800	533300	5.54		
27	Probir Tripura	1.11	26900	135700	108800	5.04	29300	155200	125900	5.30		
28	Barendra Lal Tripura	1.70	15000	64800	49800	4.32	29200	112300	83100	3.85		
29	Khanjan Mohan Tripura	1.17	64450	385900	321450	5.99	90000	440100	350100	4.89		
30	Olen kumar Tripura	1.45	12000	68000	56000	5.67	14300	174300	160000	12.19		
	Average	1.29	35950	182299	146349	5.07	52771	283836	231064	5.38		
	All Farm											
	Average	0.68	29619	111730	82110	3.77	41418	205101	163683	4.95		

Table 5. Total cost, gross return and gross margin of crop production in 5 no. Vaibonchara union, Khagrachari site

Sl. No.	Name of the farmers	Before intervention				After intervention			
		Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR	Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR
	Marginal Farm								
1	Sukra Maya Chakma	300	2821	2521	9.40	500	3390	2890	6.78
2	Jubamita Chakma	350	1650	1300	4.71	250	3100	2850	12.40
	Average	325	2236	1911	6.88	375	3245	2870	8.65
	Small Farm								
3	Nejam Uddin	24000	122000	98000	5.08	44500	163000	118500	3.66
4	Nazrul Islam	33700	115000	81300	3.41	52800	175000	122200	3.31
5	Nashir Uddin	32500	93000	60500	2.86	55800	153500	97700	2.75
6	Radhika Rani Nath	34000	80000	46000	2.35	28200	103000	74800	3.65
7	Sagorika Chakma	6200	29000	22800	4.68	28500	200000	171500	7.02
8	Varot Chakma	12500	41000	28500	3.28	13500	56000	42500	4.15
9	Ujjola Chakma	34000	88000	54000	2.59	51950	168250	116300	3.24
10	Joytika Chakma	5500	13750	8250	2.50	6500	18000	15000	2.77
11	Nayoan Chakma	5500	19000	13500	3.45	7000	20000	13000	2.86
12	Tisha Chakma	3500	12500	9000	3.57	3500	20000	16500	5.71
13	Basona Chakma	34250	75000	40750	2.19	14250	53500	39250	3.75
14	Jharna Debi Chakma	14950	54625	39675	3.65	38200	100125	61925	2.62
15	Manju Rani Chakma	5500	12875	7375	2.34	6500	24000	17500	3.69
16	Jupee Chakma	5950	17475	11525	2.94	19000	59125	40125	3.11
17	Bimolendu Chakma	12750	21150	8400	1.66	14500	28000	13500	1.93
18	Supta Chakma	15950	57825	41875	3.63	23500	73100	49600	3.11
19	Nirupa Chakma	12000	58050	46050	4.84	26750	127870	101120	4.78
20	Prakash Mitra Chakma	11500	36475	24975	3.17	36550	117800	81250	3.22
21	Birala Chakma	32500	70900	38400	2.18	63100	157175	94075	2.49
22	Manashi Chakma	11750	25900	14150	2.20	12650	45900	33250	3.63
23	Geeta Chakma	25850	70845	45025	2.74	56950	171350	114400	3.01
24	Surovi Chakma	30800	102750	71950	3.34	44500	139250	94750	3.13
	Average	18416	55324	36909	3.00	29486	98816	69329	3.35
	Medium Farm								
25	Manik Baran Chakma	30400	115800	85400	3.81	67200	234500	167300	3.49
26	Manik Baran Chakma	12000	60060	48060	5.01	52000	137050	85050	2.64
27	Preety Chakma	42850	87635	44785	2.05	56000	165050	109050	2.95
28	Rekhona Chakma	28200	62800	34600	2.23	20340	124260	103920	6.11
28	Tuntuni Chakma	30400	115800	85400	3.81	67200	234500	167300	3.49
	Average	28363	81574	53211	2.88	48885	165215	116330	3.38
	All Farm								
	Average	18545	55282	36738	2.98	30178	101475	71297	3.36

Table 6. Total cost, gross return and gross margin of homestead and forestry production in 5 no. Vaibonchara union, Khagrachari site

Sl. No.	Name of the farmers	Before intervention				After intervention			
		Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR	Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR
Marginal Farm									
1	Sukra Maya Chakma	4500	41000	36500	9.11	15000	200000	185000	13.33
2	Jubamita Chakma	4000	10000	6000	2.50	15000	30000	15000	2.00
	Average	370	2217	1848	6.00	1304	10000	8696	7.67
Small Farm									
3	Nejam Uddin	0	0	0	0.00	0	0	0	0.00
4	Nazrul Islam	0	0	0	0.00	0	0	0	0.00
5	Nashir Uddin	0	0	0	0.00	0	0	0	0.00
6	Radhika Rani Nath	0	0	0	0.00	0	0	0	0.00
7	Sagorika Chakma	30500	269000	238500	8.82	30000	420000	390000	14.00
8	Varot Chakma	18800	208500	189700	11.09	20800	432800	412000	20.81
9	Ujjola Chakma	48500	360000	311500	7.42	64500	575000	510500	8.91
10	Joytika Chakma	9750	113720	103970	11.66	3500	223500	220000	63.86
11	Nayoan Chakma	45300	213100	167800	4.70	41550	208100	166550	5.01
12	Tisha Chakma	2600	35600	33000	13.69	5500	116000	110500	21.09
13	Basona Chakma	6200	66300	60100	10.69	27000	152500	125500	5.65
14	Jharna Debi Chakma	2700	11500	8800	4.26	5900	60000	54100	10.17
15	Manju Rani Chakma	4500	41000	36500	9.11	15000	100000	85000	6.67
16	Jupee Chakma	1620	8800	7180	5.43	2500	28000	25500	11.20
17	Bimolendu Chakma	5610	54070	48460	9.64	4500	146200	141700	32.49
18	Supta Chakma	9250	44000	34750	4.76	23500	105100	81600	4.47
19	Nirupa Chakma	9350	36880	27530	3.94	20000	111850	91850	5.59
20	Prakash Mitra Chakma	33200	71000	37800	2.14	32500	132000	99500	4.06
21	Birala Chakma	4740	13330	8590	2.81	22900	93100	70200	4.07
22	Manashi Chakma	3500	16880	13380	4.82	12550	40000	27450	3.19
23	Geeta Chakma	9350	36880	27530	3.94	20000	111850	91850	5.59
24	Surovi Chakma	9200	30800	21600	3.35	825	44750	43925	54.24
	Average	11576	74153	62577	6.41	16047	140943	124897	8.78
Medium Farm									
25	Manik Baran Chakma	1850	5000	3150	2.70	12000	46000	34000	3.83
26	Preety Chakma	19000	47600	28600	2.51	31810	317000	285190	9.97
27	Rekhona Chakma	6050	24700	18650	4.08	9500	122000	112500	12.84
28	Tuntuni Chakma	350	12650	12300	36.14	5900	60500	54600	10.25
	Average	6813	22488	15675	3.30	14803	136375	121573	9.21
	All Farm								
	Average	10372	63297	52925	6.10	15794	138438	122643	8.77

Table 7. Total cost, gross return and gross margin of livestock production in 5 no. Vaibonchara union, Khagrachari site

Sl. No.	Name of the farmers	Before intervention				After intervention			
		Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR	Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR
Marginal Farm									
1	Sukra Maya Chakma	0	0	0	0.00	7500	47550	40050	6.34
2	Jubamita Chakma	2000	12600	10600	6.30	1500	7000	5500	4.67
	Average	1000	6300	5300	6.30	4500	27275	22775	6.06
Small Farm									
3	Nejam Uddin	0	0	0	0.00	0	0	0	0.00
4	Nazrul Islam	0	0	0	0.00	0	0	0	0.00
5	Nashir Uddin	0	0	0	0.00	0	0	0	0.00
6	Radhika Rani Nath	15000	50000	35000	3.33	17000	105000	88000	6.18
7	Sagorika Chakma	0	0	0	0.00	0	0	0	0.00
8	Varot Chakma	7400	31000	23600	4.19	2500	20500	18000	8.20
9	Ujjola Chakma	24400	84000	59600	3.44	12200	40500	28300	3.32
10	Joytika Chakma	5000	15000	10000	3.00	0	0	0	0.00
11	Nayoan Chakma	3150	10000	6850	3.17	4500	15000	10500	3.33
12	Tisha Chakma	3200	16000	12800	5.00	0	0	0	0.00
13	Basona Chakma	1200	13000	11800	10.83	4000	12000	8000	3.00
14	Jharna Debi Chakma	1500	3000	1500	2.00	18500	62000	43500	3.35
15	Manju Rani Chakma	0	0	0	0.00	0	0	0	0.00
16	Jupee Chakma	0	0	0	0.00	6850	27000	20150	3.94
17	Bimolendu Chakma	3200	4455	1255	1.39	4000	16500	12500	4.13
18	Supta Chakma	0	0	0	0.00	7700	22450	14750	2.92
19	Nirupa Chakma	250	3080	2830	12.32	18300	73700	55400	4.03
20	Prakash Mitra Chakma	2200	32100	29900	14.59	10700	30300	19600	2.83
21	Birala Chakma	250	4400	4150	17.60	440	5950	5510	13.52
22	Manashi Chakma	500	5000	4500	10.00	3200	17000	13800	5.31
23	Geeta Chakma	3000	6250	3250	2.08	11000	35300	24300	3.21
24	Surovi Chakma	9300	35590	26290	3.83	10100	129425	119325	12.81
	Average	3616	14222	10606	3.93	5954	27847	21893	4.68
Medium Farm									
25	Manik Baran Chakma	0	0	0	0.00	0	0	0	0.00
26	Preety Chakma	0	0	0	0.00	2000	14500	12500	7.25
27	Rekhona Chakma	0	0	0	0.00	8500	20000	11500	2.35
28	Tuntuni Chakma	4000	17400	13400	4.35	10650	62000	51350	5.82
	Average	1000	4350	3350	4.35	5288	24125	18838	4.56
All Farm									
	Average	3055	12246	9190	4.01	5755	27274	21519	4.74

Table 8. Total cost, gross return and gross margin of crop production in Panchmile, Khagrachari site

Sl. No.	Name of the farmers	Before intervention				After intervention			
		Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR	Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR
	Marginal Farm								
1	Lalindra Tripura	6850.00	16700.00	9850.00	2.44	7500.00	29450.00	21950.00	3.93
2	Jibika Tripura	500.00	2000.00	1500.00	4.00	600.00	4000.00	3400.00	6.67
3	Ajit Mohan Tripura	7000.00	16800.00	9800.00	2.40	15000.00	53200.00	38200.00	3.55
4	Sohen Tripura	2100.00	10800.00	8700.00	5.14	4900.00	56500.00	51600.00	11.53
	Average	4112.50	11575.00	7462.50	2.81	7000.00	35787.50	28787.50	5.11
	Small Farm								
5	Poten Kumar Tripura	24000.00	85000.00	61000.00	3.54	37000.00	145600.00	108600.00	3.94
6	Koren Kumar Tripura	14000.00	52400.00	38400.00	3.74	19000.00	60800.00	41800.00	3.20
7	Umaboti Tripura	5000.00	12000.00	7000.00	2.40	5500.00	14000.00	8500.00	2.55
8	Upen Tripura	10000.00	26350.00	16350.00	2.64	18000.00	56500.00	38500.00	3.14
9	Rano Bikash Tripura	18740.00	66700.00	47960.00	3.56	35200.00	98800.00	63600.00	2.81
10	Naro Vushon Tripura	13500.00	50400.00	36900.00	3.73	22000.00	85575.00	63575.00	3.89
11	Gajon Mohan Tripura	37200.00	83000.00	45800.00	2.23	15000.00	59200.00	44200.00	3.95
12	Aortho Mohan Tripura	9700.00	53200.00	43500.00	5.48	19800.00	67000.00	47200.00	3.38
13	Shanti Tripura	5000.00	20000.00	15000.00	4.00	8000.00	40000.00	32000.00	5.00
14	Montu Bikash Tripura	6000.00	17200.00	11200.00	2.87	18500.00	52500.00	34000.00	2.84
15	Olen Debi Tripura	5000.00	20000.00	15000.00	4.00	6000.00	40000.00	34000.00	6.67
16	William Tripura	42000.00	138700.00	96700.00	3.30	68300.00	577600.00	509300.00	8.46
17	Aonkey Roy Tripura	15000.00	60800.00	45800.00	4.05	40500.00	115600.00	75100.00	2.85
18	None Ranjan Tripura	8000.00	18000.00	10000.00	2.25	9000.00	30000.00	21000.00	3.33
19	Roti Kumar Tripura	6000.00	14000.00	8000.00	2.33	12000.00	37500.00	25500.00	3.13
20	Khanjan Rani Tripura	9000.00	39200.00	30200.00	4.36	18500.00	75200.00	56700.00	4.06
21	Mojamohan Tripura	6950.00	35700.00	28750.00	5.14	13250.00	48200.00	34950.00	3.64
22	Nirobala Tripura	7000.00	19000.00	12000.00	2.71	8000.00	28500.00	20500.00	3.56
23	Tholen Tripura	7200.00	33175.00	25975.00	4.61	29000.00	91500.00	62500.00	3.16
	Average	13120.53	44464.47	31343.95	3.39	21186.84	90740.79	69553.95	4.28
	Medium Farm								
24	Biplob Voshan Tripura	6200.00	30000.00	23800.00	4.84	13000.00	38450.00	25450.00	2.96
25	Real Tripura	5500.00	14000.00	8500.00	2.55	15500.00	54000.00	38500.00	3.48
26	Dipeen Bala Tripura	24500.00	93400.00	68900.00	3.81	42500.00	167000.00	124500.00	3.93
27	Probir Tripura	9700.00	53200.00	43500.00	5.48	19800.00	65000.00	45200.00	3.28
28	Barendra Lal Tripura	6000.00	27000.00	21000.00	4.50	17500.00	53300.00	35800.00	3.05
29	Khanjan Mohan Tripura	18000.00	59800.00	41800.00	3.32	52000.00	200500.00	148500.00	3.86
30	Olen kumar Tripura	6500.00	32400.00	25900.00	4.98	7700.00	56800.00	49100.00	7.38
	Average	10914.29	44257.14	33342.86	4.05	24000.00	90721.43	66721.43	3.78
	All Farm								
	Average	11404.67	40030.83	28626.17	3.51	19951.67	83409.17	63457.50	4.18

Table 9. Total cost, gross return and gross margin of homestead and forestry production in Panchmile, Khagrachari Site

Sl. No.	Name of the farmers	Before intervention				After intervention			
		Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR	Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR
	Marginal Farm								
1	Lalindra Tripura	5500.00	14700.00	9200.00	2.67	2750.00	24000.00	21250.00	8.73
2	Jibika Tripura	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	Ajit Mohan Tripura	21300.00	77360.00	56060.00	3.63	41350.00	216000.00	174650.00	5.22
4	Sohen Tripura	1050.00	2000.00	950.00	1.90	3100.00	32200.00	29100.00	10.39
	Average	6962.50	23515.00	16552.50	3.38	11800.00	68050.00	56250.00	5.77
	Small Farm								
5	Poten Kumar Tripura	10000.00	19400.00	9400.00	1.94	15000.00	68000.00	53000.00	4.53
6	Koren Kumar Tripura	15400.00	128000.00	112600.00	8.31	28000.00	175000.00	147000.00	6.25
7	Umaboti Tripura	12000.00	34400.00	22400.00	2.87	20000.00	90200.00	70200.00	4.51
8	Upen Tripura	3000.00	15750.00	12750.00	5.25	7000.00	36000.00	29000.00	5.14
9	Rano Bikash Tripura	600.00	2500.00	1900.00	4.17	3000.00	17400.00	14400.00	5.80
10	Naro Vushon Tripura	11000.00	23000.00	12000.00	2.09	8000.00	29500.00	21500.00	3.69
11	Gajon Mohan Tripura	6900.00	10600.00	3700.00	1.54	8800.00	26550.00	17750.00	3.02
12	Aortho Mohan Tripura	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	Shanti Tripura	4000.00	11300.00	7300.00	2.83	12000.00	17000.00	5000.00	1.42
14	Montu Bikash Tripura	102000.00	178000.00	76000.00	1.75	16500.00	119300.00	102800.00	7.23
15	Olen Debi Tripura	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	William Tripura	3700.00	7500.00	3800.00	2.03	9500.00	136000.00	126500.00	14.32
17	Aonkey Roy Tripura	2825.00	8000.00	5175.00	2.83	2750.00	9000.00	6250.00	3.27
18	None Ranjan Tripura	7200.00	11700.00	4500.00	1.63	6300.00	15800.00	9500.00	2.51
19	Roti Kumar Tripura	7200.00	23100.00	15900.00	3.21	7600.00	44200.00	36600.00	5.82
20	Khanjan Rani Tripura	10200.00	36000.00	25800.00	3.53	11600.00	116000.00	104400.00	10.00
21	Mojamohan Tripura	13950.00	28000.00	14050.00	2.01	31750.00	65000.00	33250.00	2.05
22	Nirobala Tripura	6000.00	19000.00	13000.00	3.17	8000.00	30500.00	22500.00	3.81
23	Tholen Tripura	1050.00	2000.00	950.00	1.90	3000.00	91500.00	88500.00	30.50
	Average	11422.37	29381.58	17959.21	2.57	10463.16	57207.89	46744.74	5.47
	Medium Farm								
24	Biplob Voshan Tripura	8000.00	105500.00	97500.00	13.19	26000.00	243000.00	217000.00	9.35
25	Real Tripura	6000.00	8000.00	2000.00	1.33	6600.00	21500.00	14900.00	3.26
26	Dipeen Bala Tripura	34500.00	92640.00	58140.00	2.69	46000.00	156200.00	110200.00	3.40
27	Probir Tripura	6000.00	24000.00	18000.00	4.00	3000.00	33600.00	30600.00	11.20
28	Barendra Lal Tripura	3500.00	22800.00	19300.00	6.51	9700.00	47000.00	37300.00	4.85
29	Khanjan Mohan Tripura	7200.00	22800.00	15600.00	3.17	22000.00	108000.00	86000.00	4.91
30	Olen kumar Tripura	1500.00	17500.00	16000.00	11.67	1900.00	79000.00	77100.00	41.58
	Average	9528.57	41891.43	32362.86	4.40	16457.14	98328.57	81871.43	5.97
	All Farm								
	Average	9528.57	41891.43	32362.86	4.40	16457.14	98328.57	81871.43	5.97

Table 10. Total cost, gross return and gross margin of livestock production in Panchmile, Khagrachari site

Sl. No.	Name of the farmers	Before intervention				After intervention			
		Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR	Total cost farm ⁻¹ (Tk)	Gross return farm ⁻¹ (Tk)	Gross margin farm ⁻¹ (Tk)	BCR
	Marginal Farm								
1	Lalindra Tripura	0.00	0.00	0.00	0.00	6700.00	25200.00	18500.00	3.76
2	Jibika Tripura	890.00	3500.00	2610.00	3.93	3300.00	15000.00	11700.00	4.55
3	Ajit Mohan Tripura	19625.00	36000.00	16375.00	1.83	18700.00	63750.00	45050.00	3.41
4	Sohen Tripura	3800.00	13200.00	9400.00	3.47	18000.00	35250.00	17250.00	1.96
	Average	6078.75	13175.00	7096.25	2.17	11675.00	34800.00	23125.00	2.98
	Small Farm								
5	Poten Kumar Tripura	11300.00	19385.00	8085.00	1.72	12200.00	24840.00	12640.00	2.04
6	Koren Kumar Tripura	2800.00	13900.00	11100.00	4.96	5400.00	35200.00	29800.00	6.52
7	Umaboti Tripura	0.00	0.00	0.00	0.00	6500.00	14400.00	7900.00	2.22
8	Upen Tripura	5000.00	19300.00	14300.00	3.86	4900.00	28500.00	23600.00	5.82
9	Rano Bikash Tripura	5600.00	41000.00	35400.00	7.32	6000.00	33360.00	27360.00	5.56
10	Naro Vushon Tripura	2270.00	4800.00	2530.00	2.11	12500.00	36000.00	23500.00	2.88
11	Gajon Mohan Tripura	6800.00	33000.00	26200.00	4.85	7400.00	56600.00	49200.00	7.65
12	Aortho Mohan Tripura	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
13	Shanti Tripura	12500.00	26400.00	13900.00	2.11	500.00	8400.00	7900.00	16.80
14	Montu Bikash Tripura	10500.00	19500.00	9000.00	1.86	18000.00	84300.00	66300.00	4.68
15	Olen Debi Tripura	5000.00	8800.00	3800.00	1.76	7000.00	40000.00	33000.00	5.71
16	William Tripura	550.00	5000.00	4450.00	9.09	0.00	0.00	0.00	
17	Aonkey Roy Tripura	250.00	2680.00	2430.00	10.72	1500.00	8960.00	7460.00	5.97
18	None Ranjan Tripura	7000.00	11700.00	4700.00	1.67	22000.00	38000.00	16000.00	1.73
19	Roti Kumar Tripura	0.00	0.00	0.00	0.00	6500.00	27000.00	20500.00	4.15
20	Khanjan Rani Tripura	13400.00	101200.00	87800.00	7.55	15200.00	32200.00	17000.00	2.12
21	Mojamohan Tripura	3130.00	65000.00	61870.00	20.77	5000.00	53000.00	48000.00	10.60
22	Nirobala Tripura	9400.00	73000.00	63600.00	7.77	9900.00	232000.00	222100.00	23.43
23	Tholen Tripura	6500.00	35000.00	28500.00	5.38	4400.00	17250.00	12850.00	3.92
	Average	5368.42	25245.53	19877.11	4.70	7626.32	40526.84	32900.53	5.31
	Medium Farm								
24	Biplob Voshan Tripura	12000.00	26400.00	14400.00	2.20	23000.00	77000.00	54000.00	3.35
25	Real Tripura	9900.00	41250.00	31350.00	4.17	5000.00	20200.00	15200.00	4.04
26	Dipeen Bala Tripura	26700.00	210500.00	183800.00	7.88	29000.00	327600.00	298600.00	11.30
27	Probir Tripura	11200.00	58500.00	47300.00	5.22	6500.00	56600.00	50100.00	8.71
28	Barendra Lal Tripura	5500.00	15000.00	9500.00	2.73	2000.00	12000.00	10000.00	6.00
29	Khanjan Mohan Tripura	39250.00	303300.00	264050.00	7.73	16000.00	131600.00	115600.00	8.23
30	Olen kumar Tripura	4000.00	18100.00	14100.00	4.53	4700.00	38500.00	33800.00	8.19
	Average	15507.14	96150.00	80642.86	6.20	12314.29	94785.71	82471.43	7.70
	All Farm								
	Average	7828.83	40180.50	32351.67	5.13	9260.00	52423.67	43163.67	5.66

11.2.1.2 Dietary intake status and level of food security

Khagrachari is one of the three hill districts of Bangladesh and a part of the Chattogram Hill Tracts. Majority of the tribal communities of the country live in this area and depend on the plant resources for their food, fuel, fruit, vegetables and medicine. This is a diverse system specific to the ecosystem and ethnic community. The use of wild plants forms part of their traditional or indigenous systems of knowledge and practice that have accumulated (Rahman and Fakir, 2015) and developed over generations. They live in close contact with nature and largely dependent on best for their livelihood (Sawian et al. 2007). Their forest dependency is reflected in their food habits, which include several non-conventional plants or plant parts collected from the forest. Rashid (1996) listed 98 species of vegetables that are grown in Bangladesh but the real number maybe more. The subsistent farming system which is a characteristic phenomenon of Bangladesh could play a leading role in achieving sustainable food production as well as national and household level food security. At present Bangladesh has achieved food security at national level by producing above 60 million metric ton of cereals food grain. In achieving household food security, agriculture or more importantly, sustainable agriculture plays a very important role. Integrated farming system is a great approach in sustainable agriculture. Few available research work that was conducted on minor fruit diversity tin Khagrachari district (Khatun et al. 2015) but not with specific locations. This work aims to create information minor fruits available and consume by the two local tribes which will help in sustainable conservation of these wild genetic resources also fulfill the need for sustainable forest management. The potential role of farming systems could achieve the goal of household food security in Bangladesh. To observe the improvement of dietary intake and consequent nutrition, household food allocation (among male, female and children), relation between food production and consumption, income and nutrition of the selected households due to intervention of sub-project activities was monitored regular basis. The monitoring process was conduct 24 months after intervention of inputs. The monitoring process was examined the following issues:

- i) annual availability of staple food items in the farm families
- ii) annual consumption of specified food items and level of food security

Annual requirements and consumption of Cereal, vegetables, pulses, fish, milk, meat, egg, potato, oil, spices, salt and sugar/gur and their level of food security were presented in Table 11. Data of cereal, vegetables, fish, milk, meat and egg were calculated on consumption $\text{g capita}^{-1} \text{ day}^{-1}$ basis. The level of food security of selected food items was measured on the basis of requirements and consumption of food items over six months. The level of food security of was secured on the basis of consumption of cereals and the percentages were 171.34 and 162.52, respectively in both before and after intervention. The level of food security of cereal was decrease 20.35 percentage after intervention due to increase the consumption of other food items specially vegetables.

Table 11. Requirements and dietary intake of selected food items and level of food security of the selected household in the study area

Food items	Recommended food intake ($\text{g capita}^{-1} \text{ day}^{-1}$)	Consumption ($\text{g capita}^{-1} \text{ day}^{-1}$)		Level of food security on the basis of consumption (%)		
		Before Intervention	After intervention	Before Intervention	After intervention	Increase or decrease
Cereal	375	642.52	609.45	171.34	162.52	-20.35
Vegetables	200	282.07	436.75	141.04	218.38	70.83
Pulses	60	11.72	16.43	19.53	27.38	17.20

Food items	Recommended food intake (g capita ⁻¹ day ⁻¹)	Consumption (g capita ⁻¹ day ⁻¹)		Level of food security on the basis of consumption (%)		
		Before Intervention	After intervention	Before Intervention	After intervention	Increase or decrease
Fish	55	49.46	56.90	89.93	103.45	7.19
Milk	75	7.11	7.92	9.48	10.56	7.67
Meat	35	25.86	34.48	73.89	98.51	8.75
Egg	15	2.98	8.99	19.87	60.00	10.03
Potato	60	52.71	73.65	87.85	122.75	17.06
Oil	40	7.82	15.78	19.55	39.45	20.18
Spices	20	27.43	33.67	137.15	168.35	3.71
Salt	-	5.62	5.21	-	-	-
Sugar/gur	18	3.07	4.08	17.06	22.67	4.46

Source: Dietary Guidelines of Bangladesh, BIRDEM.

It was also found that 78 percent farmers produced rice of which 45 percent farmers were secured in terms of production. It indicated that the level of food security of the majority farmers (55 percent) was not secured on the basis of production. The study also revealed that findings of the level of food security of vegetables, fish, potato and spices was secured and their percentage were 218.38, 103.45, 122.75 and 168.35, respectively while the level of food security the other food items such as pulses, milk, meat, egg, oil and sugar/gur were not secured though after intervention it was increased.

11.2.1.3 Household food diversity

a) Diversity of cereal intake

The main intake of cereal came from boiled rice (462.0 g) followed by flour (114.0 g), puffed rice (23.0 g), maize (7.0 g) and aromatic rice (2.45 g), respectively (Table 12) .

Table 12. Diversity of cereal intake of the selected household in the study area

Cereal	Intake (g capita ⁻¹ day ⁻¹)
Rice (boiled)	462.0
Aromatic Rice	2.45
Flour (Wheat)	114.0
Puffed rice	23.0
Maize	7.0
Total	609.45

b) Diversity of fish intake

Table 13 revealed that average capita⁻¹ day⁻¹ fish intake was 49.46g at starting period of sub-project while it was 56.90g at the end of the sub-project. Different dominant types of fish such as rhui, katla, pangash, puti, tilapia and small indigenous species of fish were found in the main menu of the farmers. They also intake dry fish and nappi as secondary source of fish food.

Table 13. Diversity of fish intake of the selected household in the study area

Fishes	Intake (g capita ⁻¹ day ⁻¹)
Fish	41.88
Dry fish	5.98
Nappi	9.04
Total	56.90

c) Diversity of meat intake

Meat intake was 34.48g capita⁻¹ day⁻¹ at the end of the sub-project period and mostly contributed by pork. The distributions of all the types were summarized below (Table 14).

Table 14. Diversity of meat intake of the selected household in the study area

Meat	Intake (g capita ⁻¹ day ⁻¹)
Chicken	2.09
Beef	5.23
Mutton	1.24
Pork	24.76
Duck	1.16
Total	34.48

d) Diversity of vegetables intake

During the starting period of the sub-project it was observed that both traditional and non-traditional vegetables were consumed by the farmers but traditional vegetables were less consumed due inadequate availability while they preferred non-traditional vegetables because of availability and low market price. Moreover, some seasonal common traditional vegetables such as brinjal, sweet gourd, potato, yard long bean, okra, arum stem, bottle gourd, radish, elephant apple, etc. were available which market price was high. It was also observed that both leafy and non-leafy vegetables were consumed by the farmers. Considering this situation different types of high yielding traditional vegetables seeds were distributed among the farmers to produce round the year in their homestead to fulfill their requirement as well as commercial purpose. At the end of the sub-project it was observed that the consumption pattern was diversified and level of traditional vegetables intake was increased because of own production. Moreover, they sold out their excess production to the neighbours of near local market. Table 15 showed the diversity vegetables intake in the study area.

Table 15. Diversity of vegetables intake of the selected household in the study area

Vegetables (Traditional)	Intake (g capita ⁻¹ day ⁻¹)	Vegetables (Non-traditional)	Intake (g capita ⁻¹ day ⁻¹)
Yard long bean	15.17	Dheki shak(fern)	7.37
Red amaranth	11.82	Marfa	7.53
Water spinach	9.32	Taro	15.02

Vegetables (Traditional)	Intake (g capita ⁻¹ day ⁻¹)	Vegetables (Non-traditional)	Intake (g capita ⁻¹ day ⁻¹)
Indian spinach	5.73	Chora kochu	11.13
Cucumber	14.00	Borna shak	0.94
Bean	5.45	Dew tara	3.04
Okra	5.03	Centella	1.21
Bottle gourd	32.87	Orol sim	5.68
Gourd leaf	9.12	Banana plant	6.30
Sweet gourd	14.60	Kona gula	0.92
Sweet gourd leaf	1.45	Amelia pata	3.85
Flower of sweet gourd	0.50	Flower of turmeric	0.98
Bitter gourd	5.40	Flower of ginger	0.90
Arum stem	2.90	Hilly brinjal	3.00
Green leaf of arum	3.64	Casaba	1.58
Green jackfruit	6.77	Casaba leaf	1.18
Radish	48.47	Bamboo shoot	28.65
Tamato	8.26	Tittol gula	0.36
Mustard (rai)	15.22	Teme titashak	1.22
Broccoli	0.11	Batabotte shak	0.87
Cabbage	11.08	Khatal dhaki	0.94
Cauliflower	17.98	Ozone shak	1.01
Plantain flower	9.02	Amboss shak	0.15
Mushroom	2.30	cheong shak	1.77
Brinjal	42.83	Jongli alu	31.22
Elephant apple	1.46		
Green banana	4.33		
Bitter gourd leaf	0.38		
Snake gourd	4.00		
Teasle gourd	1.40		
Papaya	10.42		
Sweet potato	1.49		
Radish shak	5.58		
Wax gourd	2.15		
Ridged gourd	0.90		
Potato	42.43		

e) Diversity of egg intake

Capita⁻¹ day⁻¹ egg was found below the recommendation and it was only 8.99g (Table 16). Daily intake has increased as an interventional effect of hilly chicken rearing.

Table 16. Diversity of egg intake of the selected household in the study area

Meat	Intake (g capita ⁻¹ day ⁻¹)
Egg (farm)	7.98
Egg (Deshi)	0.35
Egg (Duck)	0.66
Total	8.99

f) Diversity of milk intake

Milk was taken as liquid form and intake was only 7.92g capita⁻¹ day⁻¹ which is far below the recommendation.

g) Diversity of pulses intake

Average pulse intake of the farmers was found 16.43g capita⁻¹ day⁻¹ at the end of the sub-project which is very poor than the requirement (Table 17). Create awareness of the farmers emphasizes was given to eat pulses as a plant protein source during the training and monthly meeting.

Table 17. Diversity of pulses intake of the selected household in the study area

Pulse	Intake (g capita ⁻¹ day ⁻¹)
lentil	3.00
Pea	1.53
Bean	1.77
Forash bean	10.13
Total	16.43

h) Diversity of spices intake

Onion and green chilli was the main spices of the daily food recipe and it was 14.87g and 10.65g, respectively out of total intake (33.67g) capita⁻¹ day⁻¹ (Table 18). Distributions of all the spice were summarized below.

Table 18. Diversity of spices intake of the selected household in the study area

Spices	Intake (g capita ⁻¹ day ⁻¹)
Onion	14.87
Garlic	2.98
Turmeric	1.48
Cumin	0.44
Ginger	1.37
Indian bay leaf	0.20
Chilli powder	0.65
Green chilli	10.65
Black pepper	0.04
Cardamom	0.23
Clove	0.06
<i>Sabarang</i>	0.23
Cinnamon	0.27
Coriander	0.20
Total	33.67

i) Diversity of oil intake

Average oils intake was 15.78g capita⁻¹ day⁻¹ at the end of the sub-project. Soybean oil was consumed commonly as edible oil (Table 19). Often they used mustard oil.

Table 19. Diversity of meat intake of the selected household in the study area

Oil	Intake (g capita ⁻¹ day ⁻¹)
Mustard oil	0.87
Soybean oil	14.91
	15.78

11.2.1.4 Component development programme

Bangladesh has a wide range of diversity of vegetables; especially in the CHTs. Abdullah et al. (2017) recorded 36 traditional leafy vegetables from native tribal villages of Rangamati while Rahim et al. (2009) recorded about 49 underutilized vegetables grown in Bangladesh. Rashid (1996) listed 98 species of vegetables that are grown in Bangladesh but the real number maybe more. Khatun et al. (2015) identified 186 taxa used as leafy vegetables in the country, of which 140 taxa are wild and 46 are cultivated. Non-conventional vegetables have played a key role in the daily life of the tribal people for nutritional need, medicinal use, cash income generation opportunity and poverty alleviation (Rahim et al. 2009). In general, the use of those non-conventional vegetables is confined to the remote population; their market availability becomes a constraint for the urban people. Traditional knowledge is fast changing due to some factors like lack of availability of NCVs, migration of villagers to cities, input of top-quality food in markets etc. Therefore, the study was undertaken to understand the range of non-conventional vegetables used by the Chakma and Tripura community within the Khagrachari Hill district.

a) Agro-Economic performance of transplant aman rice varieties

The yield, total variable cost, gross return, gross margin and BCR are shown in Table 20. The economic analysis revealed that cost of cultivation was Tk. 59768. The highest gross margin (Tk 39467 ha⁻¹) was recorded in BRRI dhan 71 and the lowest (Tk 15660) in BRRI dhan 75 (Table 20). Benefit cost ratio ranged from 1.6657 in BRRI dhan 71 to 1.26 in BRRI dhan 75. Farmers of the village were more interested to cultivate BRRI dhan 71 because of their short duration and earliness and it was related to Kader *et al* (2020) and BRRI dhan71 was finally released as a high yielding and drought tolerant rice variety for drought prone areas of Bangladesh.

Table 20. Economic performance of transplant aman rice varieties

Variety	Grain yield (t ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross return (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	Benefit-cost ratio
BRRI dhan 71	4.46	59768	99235	39467	1.66
BRRI dhan 75	3.39	59768	75428	15660	1.26
Bina dhan 16	3.73	59768	82993	23225	1.39
Bina dhan 17	3.93	59768	87443	27675	1.46



Plate 26. Farmer's Training on HYV rice production & monitoring of production plot.

Farmers' response : The farmers of the site are interested to grow BRRI dhan 71 due to yield and early maturity.

Conclusion : Early maturity and yield of BRRI dhan 71 is advantageous for short duration mustard and winter vegetable cultivation.

Recommendation : BRRI dhan 71 may be selected for mustard and winter vegetable cultivation after harvest transplant aman rice.

b) Varietal performance of mustard

Yield and economic performance of mustard are shown in Table 21. It was observed that the yield was 1.04 and 0.94 t ha⁻¹ in BARI Sarisha-14 and BARI Sarisha-17, respectively. Gross margin was higher in BARI Sarisha-14 (Tk 32694.00 ha⁻¹) than BARI Sarisha-17 (Tk 28694.00 ha⁻¹). Benefit-cost ratio was 4.67 and 4.22 for BARI Sarisha-14 and BARI Sarisha 17, respectively. But, the expected result was not up to the mark due to the environment of hills in that period and Dhaliwal et al. (2007) also stated that the incidence, growth and multiplication of mustard aphid are largely influenced by meteorological parameters like temperature, relative humidity, rainfall, wind speed and cloudiness.

Table 21. Economic performance of mustard varieties

Variety	Tuber yield (t ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross return (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	Benefit-cost ratio
BARI Sarisha-14	1.04	8906.00	41600.00	32694.00	4.67
BARI Sarisha-17	0.94	8906.00	37600.00	28694.00	4.22

**Plate 27.** Harvesting of BARI Shorisha.

Farmers' response : Farmers responded very positively with new high yielding variety BARI Sarisha-14. Farmers expressed their satisfaction with high yield. It is also good as leafy vegetable during stage. The farmers for growing in the next year have stored seeds.

Conclusion : BARI Sarisha-14 produced the higher yield over local varieties.

Recommendation : BARI Sarisha-14 is recommended for large scale extension to the farmers' fields in the medium high land hilly area with irrigation facilities after harvesting of short duration aman rice.

c) Varietal performance of potato

Tuber yield of six BARI potato varieties is presented in Table 22. Tuber yield (30.63 t ha⁻¹) was the highest in BARI Alu 53 followed by BARI Alu 36 (29.77 t ha⁻¹), BARI Alu 49 (29.72 t ha⁻¹), BARI Alu 62 (26.12 t ha⁻¹), BARI Alu 63 (24.70 t ha⁻¹), BARI Alu 46 (24.42 t ha⁻¹), respectively. From economic analysis it was found that gross margin were Tk 585825, Tk 564367, Tk 563256, Tk 437700, Tk 394840 and Tk 357367 ha⁻¹ for BARI Alu 53, BARI Alu 36, BARI Alu 49, BARI Alu 63, BARI Alu 62 and BARI Alu 46, respectively. The highest Benefit-cost ratio (4.26) was observed in BARI Alu 53 and the lowest (2.99) in BARI Alu 46. MAH Talukder *et al* (2021) found the associated result that the highest tuber yield (36.49 t/ha) was obtained from BARI Alu-41 followed by BARI Alu-36, BARI Alu-40 and BARI Alu-35. The lowest yield was obtained from BARI Alu-35 (31.86 t/ha) at Ajodhapur, FSRD site, Rangpur.

Table 22. Economic performance of the potato varieties

Variety	Grain yield (t ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross return (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	Benefit-cost ratio
BARI Alu 36	29.77	179800	744167	564367	4.14
BARI Alu 46	24.42	179800	537167	357367	2.99
BARI Alu 49	29.72	179800	743056	563256	4.13
BARI Alu 53	30.63	179800	765625	585825	4.26
BARI Alu 62	26.12	179800	574640	394840	3.20
BARI Alu 63	24.70	179800	617500	437700	3.43

Farmers' response : Farmers were satisfied with potato varieties especially of BARI Alu 36, BARI Alu 49 and BARI Alu 53 for their high yield.



Plate 28. BARI released variety potato (36, 49, 53) plot inspection by BARC Chairman.

Conclusion : Yield of BARI Alu 36, BARI Alu 49 and BARI Alu 53 is near to national average yield.

Recommendation : BARI Alu 36, BARI Alu 49 and BARI Alu 53 varieties are recommended for extension in the hilly area.

d) Performance of papaya

Agro-economic performance of Red Lady is presented in Table 23. Only orchard data and information were considered for analysis. Total production, total variable cost, gross return, gross margin was depended on farm size. Average yield was 2389 kg farm⁻¹ and gross margin was Tk 110219.00 farm⁻¹. Benefit cost ratio (BCR) was 9.96 and production was 41.27 kg/plant and the result was almost same with Kuljeet Kaur and Amarjeet Kaur *et al* (2017) and that was 45.39 kg/plant.

Table 23. Agro-economic performance of papaya in homestead.

Sample farms	Production farm ⁻¹ (kg)	Total variable cost (Tk farm ⁻¹)	Gross return (Tk farm ⁻¹)	Gross margin (Tk farm ⁻¹)	Benefit-cost ratio
1	2842	17500.00	142100.00	124600.00	8.12
2	960	4800.00	52800.00	48000.00	11.00
3	3280	17600.00	196800.00	179200.00	11.18
4	4268	26800.00	204864.00	178064.00	7.64
5	1345	7500.00	67250.00	59750.00	8.97
6	435	2650.00	22620.00	19970.00	8.54
7	1790	14300.00	98450.00	84150.00	6.88
8	1800	12200.00	90000.00	77800.00	7.38
Average	2389	14764.00	124983.00	110219.00	9.96

Farmers' response : Farmers are interested and inspired to cultivate Red Lady variety of papaya for high profit.

Conclusion : Red Lady papaya provides higher and additional income to the farmer. This variety is well accepted to the beneficiaries and non-beneficiaries farmers and rapidly extends around the sub-project location for cultivation.



Plate 29. Red Lady Orchard & successful beneficiary of Red Lady production.

Recommendation : Soil of Khagrachari is more suitable for Red Lady papaya cultivation with appropriate management.

e) Performance of brinjal at farmers' fields

Performance of brinjal is shown in Table 24. Results revealed that fruit yield was 43.27, 35.66 and 44.63t ha⁻¹ for BARI Begun-4, BARI Begun-6 and BARI BT Begun-4, respectively. The gross margin was Tk 1040514.00, Tk 786196.00 and Tk 1390358.00 ha⁻¹ for BARI Begun-4, BARI Begun-6 and BARI BT Begun-4, respectively. The benefit cost ratio was highest 3.87 for BARI BT Begun-4. Previous studies on the impact of using Bt brinjal (see introduction) have shown virtually complete control of EFSB in Bangladesh without any disruption of non-target arthropods (Prodhan et al. 2018). In the Philippines, a similar level of control (Hautea et al. 2016) and lack of effect on non-target arthropods (Navasero et al. 2016) was observed

Table 24. Performance of brinjal at farmers' fields

Variety	Fruit yield (t ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross return (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	Benefit-cost ratio
BARI Begun-4	43.27	690286.00	1730800.00	1040514.00	2.51
BARI Begun-6	35.66	568884.00	1355080.00	786196.00	2.38
BARI BT Begun-4	44.63	484102.00	1874460.00	1390358.00	3.87

Farmers' response : The farmers of the Site are interested to grow BARI BT begun-4 variety because of its high profit and diseases and pesticide preventive character.



Plate 30. Brinjal harvesting.

Conclusion : Brinjal is a profitable vegetable in the Site during winter season.

Recommendation : Training programme may be arranged for effective management and production technique.

f) Performance of some winter vegetables

Though the main agricultural commodities of Bangladesh are rice, wheat, pulse, jute but vegetables are considered as an essential part of agriculture by contributing 9.23% of the agricultural Gross Domestic Product (BBS, 2019). Vegetables can be identified as a significant one for this economy for its impressive contribution in raising the foreign exchange earnings and occupies an important position among the items exported from Bangladesh (BBS, 2019). Performance of winter vegetables is presented in Table 25. The yield of bottle gourd was highest

176.54 kg farm⁻¹ in Niko variety and gross margin was Tk 2048.10 farm⁻¹. Country bean variety BARI Sheem-1 yield was 97.32 kg farm⁻¹ which gross margin was Tk 1346.40. Though BARI Jhar Sheem -1 produced highest yield 76.70 kg farm⁻¹ but BCR was found highest 4.50 in BARI Jhar Sheem -3. Gross margin of BARI Tomato 14 and BARI Tomato 17 was Tk 16212.60 and Tk 14107.20, respectively farm⁻¹. Gross margin of Broccoli, Capsicum and Sweet gourd was Tk 10422.20, Tk 26144.00 and Tk 7201.20, respectively farm⁻¹.

Table 25. Agro-economic performance of some winter vegetables in the study area

Vegetables	Variety	Production farm ⁻¹ (kg)	Total variable cost (Tk farm ⁻¹)	Gross return (Tk farm ⁻¹)	Gross margin (Tk farm ⁻¹)	BCR
Bottle gourd	BARI Lau-3	137.24	600.00	2058.60	1458.60	3.43
	BARI Lau-5	112.72	600.00	1690.80	1090.80	2.82
	Maria	124.96	600.00	1874.40	1274.40	3.12
	Dayna	130.22	600.00	1953.30	1353.30	3.26
	Niko (hybrid)	176.54	600.00	2648.10	2048.10	4.41
Country bean	BARI Sheem -1	97.32	600.00	1946.40	1346.40	3.24
	BARI Sheem -5	74.30	600.00	1486.00	886.00	2.48
	BARI Sheem -6	84.66	600.00	1693.20	1093.20	2.82
	BARI Sheem -9	58.44	600.00	1168.80	568.80	1.95
	BARI Sheem -10	55.16	600.00	1103.20	503.20	1.84
	Rifa	82.88	600.00	1657.60	1057.60	2.76
Jhar Sim	Noldog	86.50	600.00	1730.00	1130.00	2.88
	BARI Jhar Sheem -1	76.70	300.00	1150.50	850.50	3.84
	BARI Jhar Sheem -2	70.42	300.00	1056.30	756.30	3.52
Tomato	BARI Jhar Sheem -3	33.72	300.00	1348.80	1048.80	4.50
	BARI Tomato-14	550.24	2400.00	16507.20	14107.20	6.88
	BARI Tomato-17	620.42	2400.00	18612.60	16212.60	7.76
Broccoli	Early U (Hybrid)	420.74	2200.00	12622.20	10422.20	5.74
Capsicum	Indra	141.72	2200.00	28344.00	26144.00	12.88
Cabbage	Magic 65	410.25	2200.00	6153.75	3953.75	2.80
	Ruby King	220.65	1600.00	4413.00	2813.00	2.76
Sweet gourd	Sweety	270.04	900.00	8101.20	7201.20	9.00

Farmers' response : Farmers are interested to cultivate the winter vegetables. Farmers' reactions were positive in favour of cultivating Niko, BARI Jhar Sheem-3, BARI Tomato-17, Early U, Indra and Sweety variety in future.

Conclusion : Growing of winter vegetables gave additional income to the farmer.

Recommendation : Training on technology and supply of quality seed in time is necessary to improve the present situation.

g) Performance of some summer vegetables

Performance of different summer vegetables is shown in Table 26. Yields of tomato, bitter gourd, red amaranth and coriander were 22.33, 12.58, 10.54 and 7.62 t ha⁻¹, respectively. Tomato was the most profitable over other vegetable. Gross return from tomato, bitter gourd, red amaranth and coriander were Tk 1674750.00, 377400.00, 84320.00 and 381000.00 ha⁻¹, respectively. Gross margin from tomato, bitter gourd, red amaranth and coriander were Tk

1581750.00, 314400.00, 56320.00 and 353000.00 ha⁻¹, respectively. Benefit cost ratio was the highest in tomato which is almost similar with Sultana and Ghosh (2020).

Table 26. Agro-economic performance of summer vegetables

Vegetable	Yield (t ha ⁻¹)	Total variable cost (Tk ha ⁻¹)	Gross return (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	Benefit-cost ratio
Tomato	22.33	93000.00	1674750.00	1581750.00	18.01
Bitter gourd	12.58	63000.00	377400.00	314400.00	5.99
Red amaranth	10.54	28000.00	84320.00	56320.00	3.01
Coriander	7.62	28000.00	381000.00	353000.00	13.61

Farmers' response : Farmers are interested to cultivate the summer vegetable.

Conclusion : Summer vegetable cultivation is a profitable practice in the site area.

Recommendation : Training on technology and supply of quality seeds in time is necessary to improve the present situation.

h) Goat and sheep rearing under improved feeding

Growth performances of adult goats and sheep are presented in Table 27. In present study, the average age at first lambing was 364.3±22.6 days in two regions. The present observation is similar in Barind sheep, 389.9±43.0 days and Jamuna basin sheep, 409.8±75.0 days (Hassan and Talukder, 2011). In other studies, the age at first lambing was 530.5±12.4 days in Munjal sheep higher than the present findings. The average age at first pregnancy was 201.4±20.0 days in two regions. There was no significant difference in age at first pregnancy between the ewes of two different areas. The present observation is similar with the age of first pregnancy in Jamuna basin sheep, 277.0±104.9 days, Barind sheep, 264.7±49.4 days and Coastal sheep, 292.3±47.5 days (Hassan and Talukder, 2011) performed in Bangladesh Livestock Research Institute (BLRI) research station. The reproductive parameters viz, duration of oestrus, gestation length, litter size, lambing interval and onset of post-partum oestrus were observed in two sites and also supported with Zohara et al., 2014. In traditional management system, the gestation length in ewes varied from 145 to 152 days. In the present study pooled over gestation length was 147.9±3.4 days in two regions. Similar with above parameters gestation length in ewes was also not significantly ($p>0.05$) different between two regions (148.7±3.4 vs. 147.1±3.2 days), respectively. The present study was supported by Zohara *et al.* (2014). These observations indicate that average litter size is more or less similar (1 or 2 commonly, rarely 3) among the sheep breeds of tropical countries in well managed condition. It is supported by Hassan and Talukder (2011) observed in Jamuna, Barind and Coastal sheep. Nimbkar *et al.* (2002) found in Deccani sheep in India that the average lambing interval was 264.0 ± 81.0 days, higher than the present findings. This could be due to differences in breed, nutrition and environment of the study region. Economic analysis revealed that the differences between feed cost, total variable cost and gross margin were large although the benefit-cost ratios were similar (Table 28 & 29). Average gross margin was Tk 3675 with benefit-cost ratio of 2.1, whereas Tk. 2650 with benefit-cost ratio of 1.96 in that of sheep which results related to Islam *et al* (2016).

Table 27. Production performance of goat and sheep

Site	Body weight (kg)				Weight gain (g d ⁻¹)	
	Goat (rearing for 6 month)		Sheep (rearing for 6 month)		Goat	Sheep
	Initial	Final	Initial	Final		
5 no. Vaibonchara union	11.64	21.56	10.47	21.48	55.11	64.66
Panchmile	10.87	21.80	10.78	22.56	56.34	65.44
Average	11.255	21.68	10.625	22.02	55.725	65.05

Table 28. Economic performance of goat rearing

Site	Cost items (Tk goat ⁻¹)			Total variable cost (Tk)	Gross return (Tk)	Gross margin (Tk)	Benefit-cost ratio
	Initial value	Feed cost	Medi. cost				
5 no. Vaibonchara union	2500	700	200	3400	7000	3600	2.05
Panchmile	2400	650	200	3250	7000	3750	2.15
Average	2450	675	200	3325	7000	3675	2.1

Table 29. Economic performance of sheep rearing

Site	Cost items (Tk goat ⁻¹)			Total variable cost (Tk)	Gross return (Tk)	Gross margin (Tk)	Benefit-cost ratio
	Initial value	Feed cost	Medi. cost				
5 no. Vaibonchara union	2000	600	200	2800	5500	2700	1.96
Panchmile	2000	500	200	2700	5300	2600	1.96
Average	2000	550	200	2750	5400	2650	1.96

Conclusion : Women were more interested in goat/sheep rearing. Goat/Sheep rearing with some supplementary feed may be an additional income generating activity among rural women as they were good scavenger and they can sale goat/sheep of any age and any time of the year as necessary, why goat/sheep are called money bank of the poor.

**Plate 31.** Distribution of Black Bengal Goat to the beneficiaries.

Farmers' response : Farmers' response was very positive.

Recommendation : Farmers are to be motivated to goat/sheep rearing with supplementary concentrate mixture (moringa might be used as alternative of concentrate feed).

i) Hilly chicken rearing under scavenging condition

Growth and production performances of 10 farms are mentioned in Table 30. Average weight at 10 weeks farm⁻¹ was 1.19 kg. Egg production farm⁻¹ year⁻¹ was 79 eggs. Results indicate that most of he produced eggs were sold for table purpose (65.35%) and the rest was set for hatching purpose (34.65%). The value of chicken sell, egg, chicks and gift etc. indicate the return items. The value of adult poultry was calculated on the basis of weight (kg.) of live birds sold, multiplied by the average prices of that birds prevailing in the market. The value of per adult chicken was sold body weight basis. The price of egg fluctuates with market price. Generally it varies from Tk. 32.00 Tk. 40 per hali (4 pcs). The average price of egg was Tk. 96 to 120 per dozen (12 pcs). Total return, total cost and net return for each family poultry farmer was mentioned in Table 31. Gross return was calculated by multiplying the numbers of poultry sold in a year with the average price of per poultry. The average value of Gross return was Tk. 6305 (Table 32). The gross margin was Tk. 3127.05. Benefit Cost Ratio (BCR) represents the financial feasibility of any farm. In the present study, the value of BCR was 1.98. So, the family poultry farming is profitable and financially efficient.

Table 30. Growth performance and egg production of hilly chicken

Location	No. of birds	Survivability (%)	Body weight (gm)		Weight gain (kg)	Egg production (No. hen ⁻¹ year ⁻¹)
			Initial	At 10 weeks		
5 no. Vaibonchara union	80	85	28.94	1240	16.82	86
Panchmile	80	78	29.4	1156	16.64	72
Average	80	81.5	29.17	1198	16.73	79

Table 31. Economic performance (Cost analysis) of hilly chicken rearing (/family/year)

Items of Cost (Taka)/ Location	DOC	Feed	Medicine	Transport & Marketing	Housing	Poultry Equipments	Total
5 no. Vaibonchara union	200	1500	400	200	550	300	3150
Panchmile	200	1500	400	160	700	300	3260
Average	200	1500	400	200	700	300	3205

Table 32. Economic performance (Return analysis) of hilly chicken rearing (/family/year)

Items of Return (Taka)/ Location	Chicken & egg sold	Chicken & egg con consumed	Present Stock price	Total Cost	Gross return	Gross margin	BCR
5 no. Vaibonchara union	3500	1200	2000	3150	6700	3550	2.12
Panchmile	2970	1340	1600	3205	5910	2705	1.84
Average	3235	1270	1800	3177.5	6305	3127.5	1.98



Plate 32. Hilly chicken rearing in homestead condition.

Conclusion : Improved chicken rearing under scavenging cum supplementary feeding condition created a positive impact among the farmers, specially landless women.

Farmers' response : Farmers' response was very encouraging.

Recommendation : Chicks should be made available to the rural women for better expansion of this programme.

j) Rearing of turkey under improved management practice

The mean body weights of adult female and male birds were 2129, 1786 and 1457g; and 2436, 2834 and 2249 g respectively. The age of first egg were 158, 147 and 140 days and hen-day egg production were 44.56 ± 0.5 , 46.15 ± 0.5 and 48.84 ± 0.7 percent respectively. The average egg weight were 43.05 ± 0.1 , 42.87 ± 0.1 and 41.79 ± 0.24 percent respectively and these results were related to Islam *et al* (2016). The average benefit-cost ratio was BDT 3.06 by homestead turkey rearing per year per family. In the study, turkey rearing found some comparative benefit over chicken and ducks e.g. higher weight gain, forage eater, lower diseases rate and suitability for the country. The main problem of turkey rearing identified as market instability, lack of quality turkey feed, higher feed price, lack of proper marketing facility, public misconception and training on turkey farming. But, there is a considerable scope of turkey rearing in Bangladesh, as turkey can be reared in free range farming system. It has a good prospects and new dimension in poultry sector. Suitability of climatic condition, availability of natural feed and manpower can make this sector profitable, especially for the poor and marginal farmers. Turkey farmers are facing some production and marketing related problems. Taking proper remedial steps, turkey rearing could be vital part in poultry sector by supplying nutritious food, generating income, creating employment opportunities and thus improving the living standard of the rural people.

Table 33. Costing of Turkey rearing under homestead condition

Items of Cost (Taka)/ Location	DOC	Feed	Medicine	Transport & Marketing	Housing	Equipments	Total
5 no. Vaibonchara union	700	3000	200	200	550	200	4850
Panchmile	700	3000	200	200	550	200	4850
Average	700	3000	200	200	550	200	4850

Table 34. Return of Turkey rearing under homestead condition

Items of Return (Taka)/ Location	Adult turkey & egg sold	Chicken & egg con consumed	Present Stock price	Total Cost	Gross return	Net Return	BCR
5 no. Vaibonchara union	5500	3560	8200	4850	17260	12410	3.55
Panchmile	3760	1890	6780	4850	12430	7580	2.56
Average	4630	2725	7490	4850	14845	9995	3.06

**Plate 33.** Turkey rearing in homestead condition.**k) Vaccination of livestock and poultry against different diseases**

Doses of vaccines applied against different infectious diseases of cattle, goat, sheep and poultry are presented in Table 35. No disease outbreak occurred against which vaccination is being done.

Table 35. Vaccines with doses applied to cattle, goat, sheep and poultry

Name of vaccines	Doses given
1. FMD	200
2. RDV	1250
3. PPR	
4. BCRDV	2000
5. Fowl cholera vaccine	1200
6. Duck plague vaccine	750

Conclusion : Consciousness about the vaccination against different infectious diseases has been developed among the people of the village. Availability of quality vaccines to the farmers and technical knowledge on mode of vaccine administration may make this process successful, which will prevent outbreak of infectious diseases as epidemic form.

Farmers' response : Farmers' response was very encouraging.

Recommendation : Farmers are to be trained on technical aspects of vaccination and mode of their administration.



Plate 34. Different activities under livestock vaccination program.

1) Economics performance of Indian major carps and exotic species in perennial Ponds under farmers management

The results of the studies have been shown in Table 36. The total production was 1875 kg ha⁻¹ and gross return was Tk 375000.00 and gross margin was Tk 323650.00. Benefit-cost ratio was 7.30.

Table 36. Economic performance of Indian major carps in perennial ponds

Species stocked	Production (kg ha ⁻¹)	Total variable cost (Tk. ha ⁻¹)	Gross return (Tk. ha ⁻¹)	Gross margin (Tk. ha ⁻¹)	Benefit-cost ratio
Catla	463		92500		
Sarputi	313		62500		
Carpio	563	51350	112500	323650	7.30
Grass carp	350		70000		
Rui	125		25000		
Mrigal	63		12500		
Total	1875	51350	375000	323650	7.30



Plate 35. Fish production, harvesting and marketing in homestead pond.

Conclusion : Culture of Indian major carps and exotic species of fishes in perennial pond under improve management gave higher production. Moreover, farmers were financially benefited due high market price.

Farmers' response : Farmers' response was positive for the improve management of fish culture.

Recommendation : The improve management practice may be recommended for perennial pond fish culture.

m. Soil nutrient status of the farmers homestead and crop land

The physico-chemical properties of soil are presented in Table 37. It was found from the analysis that pH, Organic matter, N, P, K, S, B, Mg and Zn varied from 4.60 to 8.10, 0.30 to 3.00%, 0.015 to 0.150%, 0.12 to 1.40 ppm, 0.38 to 7.17 ppm, 1.15 to 52.96 ppm, 3.73 to 23.73 ppm, 0.04 to 1.43 ppm and 1.23-13.18 ppm, respectively.

Conclusion : All parameters value of each soil sample was below than the recommended level in maximum cases which causes the low productivity of crops in the study area.

Recommendation : Farmers' are suggested to use the recommended doses of fertilizers for crops production.

Table 37. Physico-chemical properties of soil of crop land in the study area

Sl No.	pH	Organic matter (%)	Total N (%)	K (ppm)	Mg (ppm)	P (ppm)	S (ppm)	B (ppm)	Zn (ppm)
1	5.00	2.20	0.110	0.24	0.67	3.54	9.07	0.24	1.29
2	5.00	2.60	0.130	0.18	1.61	1.85	10.02	0.17	1.46
3	6.10	2.80	0.140	0.20	3.17	3.91	10.02	0.41	2.27
4	5.70	1.80	0.090	0.19	1.20	6.60	5.84	0.21	5.02
5	6.10	2.20	0.110	0.47	1.15	6.71	8.52	0.27	10.18
6	8.10	2.40	0.120	1.40	7.17	52.96	9.17	0.71	2.98
7	5.60	3.00	0.150	0.37	3.71	2.34	7.20	0.23	2.00
8	5.10	1.50	0.075	0.33	2.01	1.15	7.37	0.34	2.73
9	4.80	1.50	0.075	0.18	0.38	2.58	8.63	0.18	1.65
10	4.60	1.50	0.075	0.18	0.94	1.64	23.73	0.19	1.23
11	5.10	0.50	0.025	0.20	0.98	19.80	9.17	0.13	3.18
12	5.50	1.30	0.065	0.29	2.86	9.30	8.49	0.15	3.65
13	5.40	2.10	0.105	1.00	2.27	13.30	12.57	0.33	9.52
14	5.10	1.10	0.055	0.27	1.14	38.98	9.58	0.23	4.71
15	5.50	2.70	0.135	0.45	1.74	18.42	6.08	0.34	7.83
16	6.20	0.90	0.045	0.28	2.72	4.25	8.42	0.11	1.76
17	5.00	1.60	0.080	0.23	1.21	42.47	7.23	0.23	9.06
18	4.70	1.30	0.065	0.13	0.71	44.26	6.08	0.32	5.98
19	4.80	1.30	0.065	0.12	0.71	52.82	3.73	0.22	13.18
20	5.10	0.70	0.035	0.19	1.33	17.48	10.46	0.20	3.79
21	5.70	0.90	0.045	0.23	1.97	9.51	5.87	0.26	2.74
22	6.20	2.20	0.110	0.38	1.21	28.90	5.16	0.41	8.71
23	5.90	0.30	0.015	0.17	1.31	3.05	11.25	0.06	1.78
24	5.00	2.40	0.120	0.27	1.50	4.70	7.61	0.26	7.94
25	6.20	1.80	0.090	0.26	1.86	2.90	5.16	0.08	3.27
26	5.10	1.50	0.075	0.26	1.87	4.76	6.55	0.07	2.76
27	5.40	1.30	0.065	0.23	2.49	9.70	6.96	0.04	2.20
28	5.50	1.30	0.065	0.20	2.39	3.90	4.95	0.06	2.32
29	4.60	1.70	0.085	1.00	1.51	3.69	9.71	1.43	2.44
30	5.50	2.10	0.105	0.20	1.49	22.72	9.99	0.17	7.48
31	5.10	1.90	0.095	0.48	1.38	5.20	7.67	0.21	3.87
Mean	5.44	1.69	0.085	0.34	1.83	14.30	8.46	0.27	4.48
Range	4.60-8.10	0.30-3.00	0.015-0.150	0.12-1.40	0.38-7.17	1.15-52.96	3.73-23.73	0.04-1.43	1.23-13.18

n. Distribution of fruits and spices saplings and development of orchard

Fruits are one of the main sources of nutrition. The PRA and baseline survey findings revealed that different type fruits species are grown in the study area but farmers are preferred on mango and litchi due to commercial purpose. Duration of these fruits cover May to August. Beside, banana is available round the year. Some fruits species grow in a few number of household

which cannot fulfill nutritional requirement round the year. Considering this situation to ensure the year round nutritional source almost 5000 sapling of which 13 species of fruits and 3 species of spices such as papaya, lemon, malta, ber, bael, wood apple, bullock’s heart, burmese grape, safeda, plum, custard apple, golden apple, dragon fruit, betel nut, black pepper and cinnamon sapling were distributed among the 60 selected households on the basis of their land resource (Table 38). One to five of each species sapling was distributed among the farmers. On the basis of the land holding 10, 5, 6, 2, 2, and 1 orchard were established on papaya, lemon, malta, ber, dragon fruit and Cinnamon, respectively.

Table 38. Distribution of different fruits and spices sapling in the study area

SI No.	Name of the sapling	5 no. Vaibonchara union	Panchmile	Total
1	Papaya	1500	865	2365
2	Lemon	375	260	635
3	Malta	250	220	470
4	Ber	50	50	100
5	Bael	30	0	30
6	Wood apple	60	60	120
7	Bullock’s heart	90	60	150
8	Burmese grape	60	60	120
9	Safeda	100	30	130
10	Plum	240	100	340
11	Custard apple	30	30	60
12	Golden apple	120	0	120
13	Betel nut	45	45	90
14	Black pepper	60	30	90
15	Cinnamon	60	60	120
16	Dragon fruit	60	0	60
		3130	1870	5000



Plate 36. Distribution of different sapling to the beneficiaries.

o. Development of nursery in the homestead

Farmers are usually purchase the vegetables and fruits sapling from the local market. Quality of these saplings is very poor in most cases which cause low productivity of crops. As a part of Income IGA and endure quality sapling a nursery was develop in the homestead of a farmer in 5 no. Vaibonchara union. Mainly papaya and winter vegetables sapling were grown and sold.



Plate 37. Seedlings produced by farmers themselves in homestead.

p. Training

Training is one of the major parts and parcel to increase the productivity of any crops. It also develops the skill of a farmer. In view of this point a lot of training program was arranged on different issues like winter and summer vegetables production and management, papaya cultivation, rice production, potato production, seed processing and preservation, homestead gardening, fertilizer management, management of fruits orchard, livestock management, goat and sheep rearing, poultry rearing, bee keeping, etc. during the sub-project period. All the training program was conducted half-day long involving 5-15 male and female farmers in each batch at sub-project office premises, BINA and field level at both sites.



Plate 38. Distribution of different inputs to the farmers.



Plate 39: Distribution of different HYV seeds.



Plate 40. Program based training on Livestock (Uthan Boithok).

q. Awareness building on nutrition

Nutrition based knowledge and nutritional awareness related meeting and trainings were arranged with the selected households. The focus of awareness building meeting was nutrition, nutrient content, balanced diet, eradication of nutritional deficiency diseases, communicable diseases, personal hygiene, safe drinking water, housing and sanitation, etc. Every month awareness building meeting was held in each site in a fixed date with the presence of male, female and youth. Different types of communication materials like picture, leaflets, booklets, poster, bulletins, etc. related to the topic of the discussion was used in the meeting. Generally the Scientific Officer of the sub-project was conducted the meeting as a resource person. Beside, Coordinator of the sub-project, different related GOs and NGOs personnel, BARTAN Officials were also presence as resource personnel in the training and awareness building meeting.

At the initial stage of sub-project it was observed that farming community of the study area was very poor concept in terms of nutrition, nutrient content, balanced diet, health, hygiene. But after training and monthly meeting awareness regarding balanced diet, health, housing and sanitation, etc. issues certainly improved and nutritional status of the farming communities also improved to a satisfactory level.



Plate 41. Farmers Training on different topics.

r. Introduce drip irrigation system

Water scarcity is one of the main constrain both the sites especially in Panchmile. During November to April in most cases irrigation facilities cannot provide due to shortage of water. Therefore, it is not possible to produce any crops and planting any sapling. Considering this problem drip irrigation system was introduce in papaya orchard as sample basis. Initially 50 papaya sapling was covered under drip irrigation system successfully.



Plate 42. Introduction of new technology on irrigation (drip irrigation).

s. Development of market linkage

Based on the projection of population statistics, Bangladesh has a population of approximately 164.62 million, making it one of the world's heavily populated nations (Population Stat. 2020, June 14). Bangladesh Population). While Bangladesh is on track for achieving middle-income country status by 2021, agriculture remains by far the state's largest employer, and 41% of the population is employed directly in agriculture. Almost 70% depend on agriculture (BBS-2017a). Agriculture acts as the foundations of food supply for human beings through crops, livestock, fisheries, raw materials sources for industry, timber for construction and originator of foreign exchange for the country through the export of raw or processed agricultural commodities. It is the powerhouse of agro-industrial sector growth, including food processing, input production, marketing and related services. It plays a fundamental role in reducing poverty, which remains a predominantly rural phenomenon, as the primary source of economic linkages in rural areas. Agriculture also plays an essential role in boosting nutritious diets, especially in rural areas where production and consumption patterns are highly interlinked. In rural areas, 26.4% and 14.9% of the total populations live below upper and lower poverty line respectively (BBS-2017b).

This is a common problem of Bangladesh agriculture that farmers cannot get fair price for their products at farmgate level. Thus sometimes they are loser and the study area is not out of this scenario. Keeping this in mind, a strategy was undertaken to make a linkage between the producer with middleman, local traders or retailer. On the basis of the product nature and production effective linkage developed between the market operators and producers. The linkage between producers and retailers was developed in the case of that commodity which was harvest daily. Producer carried their commodity directly to the retailers. It was easier for the producer due to small scale production. In that case both producers and retailers were benefited. Beside, some of the producers sold their commodity directly to the consumers and marketing as a retailer in the near or local market. But for the bulk production of any commodity middleman like faria or bapari was called to purchase the commodity from farmgate level.





Plate 43. Marketing of homestead products by farmers themselves.

11.3. Component 2 (NSTU)

11.3.1. Assessment of present status of homestead pond polyculture system

11.3.1.1. Pond size, type and ownership

The average size of homestead pond was 26.84 decimal (0.108 ha) with a range from 3 decimal (0.012 ha) to 125 decimal (0.506 ha) in the Noakhali. Size of pond is an important factor for the production of fish (Islam and Dewan, 1987) and fish culture efficiency varied with the size of ponds (Khan, 1986). Similar observation was found by Rahman (2003), the average pond size was 0.12 ha in Gazipur. The average pond size was found as 0.17 ha in areas of Tarakanda of Mymensingh with a range from 2.50 to 15 ha (Ali et al., 2009), 82% pond were up to 0.20 ha in Chandpur (Hossain et al., 1992) and about 80% ponds in rural areas are less than 0.13 ha (BBS, 1984).

About 84% of homestead pond was perennial and 16% pond was seasonal in the Noakhali. Ali et al. (2008) reported that about 46% pond were seasonal and 54% pond perennial in Rajshahi. Saha, (2004) observed that 37% ponds were seasonal and 63% perennial in Tangail Sadar. Rahaman (2007) found that 42% pond were seasonal and 58% pond perennial in Kurigram. About 33.34% ponds were seasonal and 66.66% ponds were perennial in Tarakanda of Mymensingh (Ali et al., 2009). All the finding above were not similar with this study may be for its geographical position and ecological condition.

About 80% of homestead pond belonged to single ownership (80%) and remain 20% was multi ownership in Noakhali. Ownership of pond is a vital issue for making smooth decision. Sarker and Ali (2016) observed that the uppermost number of ponds (85%) was occupied by the single owners followed by multiple owners (15%) which was close to the present study. The ponds were under single ownership (70%) and multiple ownership (30%) in Tarakanda of Mymensingh (Ali et al., 2009). About 54% of the total pond were in single ownership, 34% were belongs to multi ownership and remaining 12% ponds were under public or organization property in Demra, Dhaka (Quddus et al., 2000). About 64% of farmers have own pond without partnership and 36% had leased pond in Trishal of Mymensingh (Zannath, 2011). Saha (2004) stated that 52% ponds were found under single ownership, 21% multiple ownership and the rest 27% as leased pond in Tangail sadar.

11.3.1.2. Culture method and species

Most of homestead pond farmers (98%) practiced polyculture of Rohu (*Labeo rohita*), Catla (*Gibelion catla*), Mrigal (*Cirrhinus cirrhosus*), Kalibaus (*Labeo calbasu*), Tilapia (*Oreochromis mossambicus*), Silver Carp (*Hypophthalmichthys molitrix*), Grass Carp (*Ctenopharyngodon idella*), Bighead Carp (*Aristichthys nobilis*), Koral (*Lates calcarifer*), Carpu (*Cyprinus carpio*), Sarpunti (*Puntius sarana*), Pangas (*Pangasius pangasius*). Farmers did not follow any scientific ratio of the species in the pond as they had no institutional knowledge about fish culture. However some homestead pond farmers (2%) were practiced monoculture of tilapia. Various self-recruiting species (SRS) were also occurred naturally in the homestead pond as they did not release the fry of Taki (*Channa punctatus*), Puti (*Puntius chola*), Mola (*Amblypharyngodon mola*), Darkina (*Esomus danricus*). The polyculture system can ensure the maximum utilization of a water bodies. Similar results also reported by Zannath (2011) that about 92% farmers carried out polyculture system Trishal of Mymensingh. Rahman (2006) showed that around 90% of the fish farmers cultured pagas with carps in Mymensingh. Akter et al. (2018) found that the main culture species were Catla, Rohu, Mrigal, Silver carp, Grass carp, Mirror carp, Calbaus and Bata at Paba of Rajshahi.

11.3.1.3. Pond preparation

Most of the homestead pond farmers (93%) used lime during their pond preparation. About 71% pond farmers were applied lime in the homestead culture ponds and 29% were did not used lime during fish culture period. In Trishal of Mymensingh about 86% farmer dried their pond and among them 54% and 46% owner applied lime during pond preparation (Sheheli et al., 2013). About 10% of farmers remove the aquatic weeds and vegetation and 5% farmers repaired pond dykes during pond preparation. To eradicate undesirable species, most of the farmers (83%) used netting method and remain of them (17%) used rotenone but did not follow any recommended dose. Besides, 45% fish farmers applied fertilizer and 55% fish farmers did not apply fertilizer in their homestead pond. The present carried out that the average dose of inorganic fertilizer such as urea and TSP was at the rate of 86.50 and 62 kg/ha respectively. Sarker and Ali (2016) found that the fish farmers generally used (kg/ha/yr) cow dung (2600), urea (300) and TSP (150) in Sreemangal of Moulvibazar. Saha (2004) reported that inorganic fertilizer such as urea (387 kg/ha/yr) and TSP (176 kg/ha/yr) were used in Tangail sadar. The doses of same organic and inorganic fertilizers were 11,075 and 739 kg/ha/yr, respectively (Rahman et al., 1998). Present

study was not similar with others and use of pond water in household and others activities were leading less application of fertilizer to their homestead pond.

11.3.1.4. Stocking and feeding management

The average stocking density was about 45 fingerlings/dec or 11,122 fingerlings/ha in the homestead ponds of Noakhali. Similar stocking density of carp was maintained 10,621-13,091 fry/ha (DoF, 2005). The average stocking density was determined as 15500 fingerlings/ha in Sreemangal of Moulvibazar (Sarker and Ali, 2016), and 14675 fry/ha at Shahrasti of Chandpur (Pravakar et al., 2013), 17262 fry/ha at Mithapuquur of Rangpur (Alam, 2006) and 25250 fry/ha in Gazipur (Rahman, 2003). However, it was observed a range of stocking density from 10000-31000 fry/ha in Mymensingh district (Hossain et al., 1992). About 95% homestead pond owner used feed and other 5% did not used feed in their homestead ponds. It was observed that 17.2% framers fed formulated feed, 92.7% farmers fed supplementary feed and 15.4% farmers used both supplementary and formulated feed. Whereas, 95% farmer used rice bran and mustard oil cake as supplementary feed in Shahrasti, Chandpur (Pravakar et al., 2013) and 80% farmer applied the similar feed in Mithanpukur, Rangpur (Alam, 2006). Sarker and Ali (2016) reported that 45% of the farmers applied farm made supplementary feed prepared with rice bran and mustard oil-cake (80% and 20% ratio) and 55% farmers used artificial pellet feed in Sreemangal of Moulvibazar.

11.3.1.5. Culture period and harvesting

April to December was appropriate season for fish farming in the Noakhali area. Fish fingerlings stocked in April to June when the seeds become available. The fish stocked for 7 to 8 months up to being 0.5 to 1 kg. The duration of fish farming from June to November was observed in case of seasonal ponds and March to November in case of perennial ponds at Sreemangal of Moulvibazar (Sarker and Ali, 2016). Rahman (2003) stated that the peak period of carp polyculture was observed from March to December which was similar with present findings. The best season of fish farming was reported to be started in May and end in January at Trishal of Mymensingh (Zannath, 2011). The cultured fishes were harvested during December to February. In this season around 60% fishes was harvested and remaining 40% was harvested during other season. The harvesting is done frequently round the year after stock fish. The similar peak harvesting season December to February (65%) and remaining 35% was harvested during another season was observed at Sreemangal of Moulvibazar (Sarker and Ali, 2016). Ahmed (2003) reported that harvesting season from December to March in Mymensingh. The peak harvesting season was observed from November to January in Tangail Sadar (Saha, 2004) and from October to January in Gazipur (Rahman, 2003).

11.3.1.6. Fish production, costs and profits

Fish production of homestead pond was poor as farmers were trained through hands-on experience only and most of farmer had no technical knowledge about the fish culture. It is very difficult to estimate the actual total production of the homestead pond as harvesting is done frequently for household consumption round the year after stock fish. In the present study the average fish production was 2350 kg/ha/yr. Similar production was reported by Akter (2001) that average production of was 2112 kg/ha/yr in Trishal upazila under Mymensingh district. Pravakar et al. (2013) found the average yield of fish was found to be 2900 kg/ha/yr in Shahrasti of

Chandpur. The average yield of fish was found 2945 kg/ha/yr in Sreemangal of Moulvibazar (Sarker and Ali, 2016) and 2925 kg/ha/yr in Gazipur respectively (Rahman, 2003).

The production cost of fish production is depended on the cost of fingerlings, supplementary feed, fertilizers, drugs, chemicals and labor cost. The average total cost of fish production in the study area was observed as Tk. 86,500/ha/yr. Production cost was spend for fish feed (30%) followed by fingerlings (43%) which was highest amount than another cost. Remaining cost was spend for fertilizers (3%), lime (7%), drugs/chemicals (3%) and miscellaneous (14%). Similar production cost was assessed in Shahrasti of Chandpur, where total cost of fish production was 80850 Tk/ha/yr and spend for fish feed (28%) followed by fingerlings (25%), water pumping and electricity (9%), labour (8%), lime (8%), fish marketing (7%), fertilizers (5%), miscellaneous (4%), fish harvesting (3%), cow-dung/organic manure (2%) and drugs/chemicals (1%) (Pravakar et al., 2013). Sarker and Ali (2016) found average total cost of fish production was 125940 Tk/ha/yr in Sreemangal of Moulvibazar.

The approximate annual income of the homestead pond farmer through fish culture was 40,000 to 55,000 BDT. Fairly similar result observed by Quddus et al. (2000) in Demra, Dhaka in case of extensive, improve extensive and semi-intensive culture net profit was from fish culture were 46600, 63000 and 92000 Tk/ha/yr, respectively. The double profit (94,935 Tk./ha/yr) than present study showed by Sarker and Ali (2016) in Sreemangal of Moulvibazar may be due to catching of fish for household consumption during culture period was the major causes for this less profit in the present study.

11.3.1.7. Women participation in fish culture

Traditionally, women help men mainly in feeding of fish and fertilization of homestead ponds and some women of poor households also support main in repairing of nets, making of fish basket, drying and processing of fish. Women involvement in fish culture in small homestead ponds has brought a new dimension in fish culture of Noakhali region. In which majority of the activities such as; building and setting of habitats, stocking of fry in ponds collecting from the fingerling traders, observation of fish in ponds, harvest of fish have carried out though active participation of women. It was found that 2% female were directly involved in fish culture. All activities related to fish farming was done by them as collected of fry to harvest.

11.4. Biological productivity of homestead pond

11.4.1 Phytoplankton

A total of 34 phytoplankton genera were identified from the homestead ponds of Noakhali, Bangladesh during the present study. Of these 34 genera, 5 belonging to Cyanophyceae, 4 belonging to Bacillariophyceae, 3 belonging to Dinophyceae, 4 belonging to Euglenophyceae and 18 belonging to Chlorophyceae (Table 39). The percent composition of Cyanophyceae was 9% in monsoon and 17% in winter, Bacillariophyceae was 8% in monsoon and 2% in winter, Dinophyceae was 7% in monsoon and 13% in winter, Euglenophyceae was 40% in monsoon and 43% in winter and Chlorophyceae was 36% in monsoon and 25% in winter. Out of 34 genus, 30 were occurred in monsoon of which 16 were dominant, 25 were occurred in winter of which 15 were dominant, 21 were common that occurred in both seasons of which 13 were dominant, 9

occurred only in monsoon of which 3 were dominant and 4 occurred only in winter of which 2 were dominant (Table 39).

Table 39. Phytoplankton genera recorded from the homestead ponds of Noakhali.

Cyanophyceae	Monsoon	Winter	Chlorophyceae	Monsoon	Winter
<i>Aphanizomenon</i> sp. ^a	+	+	<i>Actinastrum</i> sp.	+	-
<i>Aphanocapsa</i> sp. ^a	+	+	<i>Ankristodesmus</i> sp.	-	+
<i>Microcystis</i> spp. ^a	+	+	<i>Botryococcus</i> sp.	+	-
<i>Merismopedia</i> sp.	+	+	<i>Chlorella</i> spp. ^a	+	+
<i>Spirulina</i> sp.	-	+	<i>Coelestrum</i> sp.	+	+
Bacillariophyceae			<i>Crucigenia</i> sp.	+	+
<i>Aulacodiscus</i> sp.	+	-	<i>Crucigeniella</i> sp.	+	-
<i>Coscinodiscus</i> spp. ^a	+	+	<i>Haematococcus</i> spp. ^a	+	+
<i>Cosmarium</i> sp. ^b	+	-	<i>Oocystis</i> spp. ^b	+	-
<i>Cyclotella</i> sp.	+	+	<i>Pandorina</i> sp.	+	+
Dinophyceae			<i>Pediastrum</i> sp.	+	+
<i>Ceratium</i> sp.	+	+	<i>Pleurococcus</i> sp. ^a	+	+
<i>Peridinium</i> spp. ^a	+	+	<i>Scenedesmus</i> spp. ^a	+	+
<i>Sphaerodinium</i> sp. ^c	-	+	<i>Tetraedron</i> sp.	+	-
Euglenophyceae			<i>Tetrastrum</i> sp.	+	+
<i>Euglena</i> spp. ^a	+	+	<i>Ulothrix</i> spp. ^b	+	-
<i>Phacus</i> spp. ^a	+	+	<i>Uroglena</i> sp. ^a	+	+
<i>Strombomonas</i> spp. ^a	+	+	<i>Volvox</i> sp.	+	-
<i>Tracelomonas</i> spp. ^c	-	+			

^a dominant in both seasons; ^b dominant only in monsoon; ^c dominant only in winter; '+' present; '-' absent

Phytoplankton community and composition at different stations and seasons exhibited different trend may be due to variations in environmental parameters (Shah et al., 2008). Chowdhury et al. (2007) reported 40 phytoplankton genera of five groups as Cyanophyceae (10 genera, 11%); Bacillariophyceae (8 genera, 19%); Dinophyceae (1 genera, 7%); Euglenophyceae (4 genera, 32%) and Chlorophyceae (18 genera, 31%) which was conducted in Borobila beel, Rangpur. Khan and Bari (2019) recorded 29 phytoplankton genera in ancient ponds of Noakhali town included Cyanophyceae (5 genera), Bacillariophyceae (8 genera), Euglenophyceae (2 genera) and Chlorophyceae (14 genera); Khan and Bari (2019) found 40 genera of phytoplankton in a aquaculture farm of Noakhali comprised of Cyanophyceae (7 genera), Bacillariophyceae (9 genera), Dinophyceae (2 genera), Euglenophyceae (3 genera) and Chlorophyceae (19 genera); Hossain et al. (2013) identified 23 phytoplankton genera at a Government fish seed production farm, Natore Sadar included Cyanophyceae (6 genera), Bacillariophyceae (4 genera), Euglenophyceae (2 genera) and Chlorophyceae (11 genera); Begum et al. (2007) observed 37 genera of phytoplankton at field laboratory of Faculty of Fisheries, BAU, Mymensingh comprised of Cyanophyceae (8 genera), Bacillariophyceae (7 genera), Dinophyceae (2 genera), Euglenophyceae (3 genera) and Chlorophyceae (19 genera). Maximum number of genera (30)

recorded during monsoon and minimum number of genera (25) recorded during winter probably due to environmental parameters i.e. temperature, pH, DO and water nutrients as distributions of phytoplankton are primarily driven by environmental parameters (Al et al., 2019; Gogoi et al., 2019).

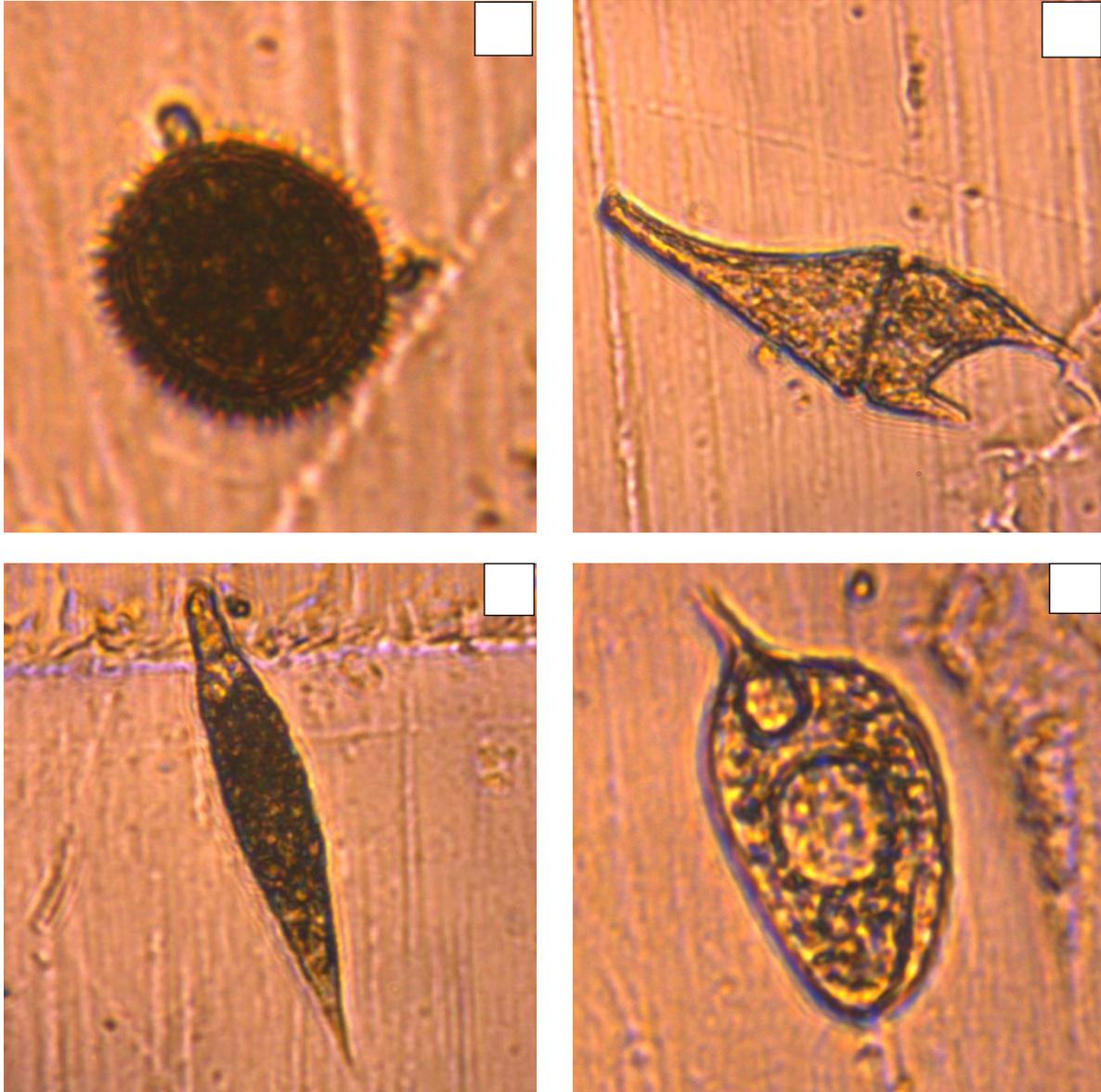


Plate 44. Some representative taxa of phytoplankton taxa recorded from the homestead ponds (a) *Aulacodiscus* sp., (b) *Ceratium* sp., (c) *Euglena* sp., (d) *Phacus* sp.

The highest abundance of phytoplankton was $405.00 \pm 116.66 \times 10^4$ cells L^{-1} and lowest was $67.33 \pm 15.31 \times 10^4$ cells L^{-1} with mean $186.13 \pm 129.34 \times 10^4$ cells L^{-1} in monsoon and higher abundance of phytoplankton was $422.00 \pm 48.50 \times 10^4$ cells L^{-1} and lower was $52.00 \pm 18.00 \times 10^4$ cells L^{-1} with mean $144.40 \pm 107.26 \times 10^4$ cells L^{-1} in winter (Table 39 Fig 8). The mean abundance of 18 dominant phytoplankton genera have presented in Fig 8. Similar results also reported by Khan et al. (2019), Hossain et al. (2013), Begum et al. (2007), Chowdhury et al.

(2007), Hossain et al. (2006) and Affan et al. (2005). Phytoplankton abundance at different stations exhibited different trend may be due to variations in environmental parameters. Mean abundance of phytoplankton was found highest ($186.13 \pm 129.34 \times 10^4 \text{ cells L}^{-1}$) in monsoon and lowest ($144.40 \pm 107.26 \times 10^4 \text{ cells L}^{-1}$) in winter which agrees with Affan et al. (2005). The seasonal variations of phytoplankton abundance may be attributed to environmental parameters (Shah et al., 2008) as higher concentration of nutrients accumulated from surface run-off due to heavy rainfall (Al et al., 2019) coupled with high temperature, pH, conductivity, TDS in monsoon while these parameters gradually decrease in winter (Chowdhury et al. 2007; Affan et al. 2005).

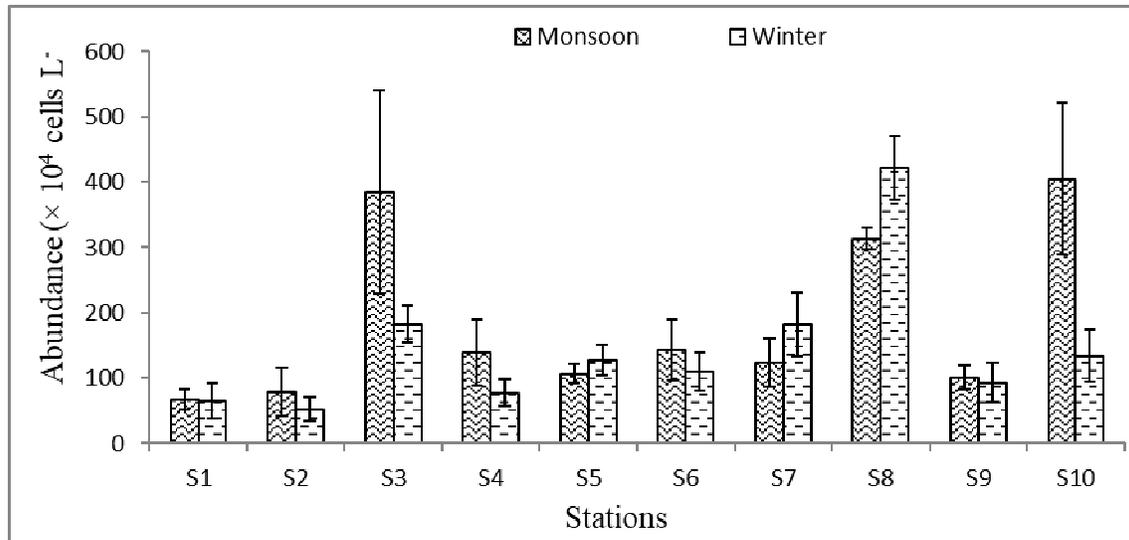


Fig 8. Mean abundance of phytoplankton among stations.

11.4.2 Zooplankton

Most of the zooplankton taxa of the present study were identified up to genus level. A total of 21 species of zooplankton were observed from the homestead ponds of Noakhali coast comprised of 6 major groups or classes. The groups include 6 species of Rotifera, 4 species of Copepoda, 2 species of Cladocera, 2 species of Crustacea, 5 species of Insecta and 2 species of Ichthyoplankton (Table 40). The present study found Copepoda as a dominant group among all the groups of zooplankton followed by Rotifera, Cladocera, Ichthyoplankton, Crustacea (Fig 9a). Similar result was observed by Hossain et al. (2007) and Rahman and Hussain (2008) and they found that Copepoda was a dominant group among zooplankton. Although a couple of research conducted by others (Akter et al. 2016; Akther and Hossain 2015; Basak et al., 2015; Roy et al., 2010) represented another group of zooplankton as a dominant group and this is due to the difference in study area.

Table 40. Density of zooplankton population (ind./L) in homestead ponds of Noakhali

Zooplanktom	Mean \pm SD	Total	Percentage (%)	Rank
Ritifera				
<i>Brachionus rubens</i>	9.09 \pm 1.82	81.5	18	1
<i>Brachionus quadridentatus</i>	1.26 \pm 1.26	11.5	2	11
<i>Brachionus calyciflorus</i>	1.32 \pm 1.18	11.1	3	10
<i>Brachionus</i> sp.	0.598 \pm 0.99	4.27	1	12
<i>Keratella</i> sp.	0.17 \pm 0.54	1.71	0	13
<i>Collotheca</i> sp.	0.0004 \pm 0.001	0.0004	0	21
Copepoda				
<i>Cyclops</i> sp.	7.68 \pm 1.26	70.9	15	3
<i>Mesocyclops</i> sp.	1.89 \pm 1.36	16.3	4	9
<i>Diaptomus</i> sp.	2.09 \pm 2.23	15.8	4	8
Harpecticoida	7.98 \pm 2.05	74.7	16	2
Cladocera				
<i>Diaphanosoma</i> sp.	4.99 \pm 1.04	44.4	10	5
<i>Bosmina</i> sp.	2.94 \pm 1.77	25.6	6	7
Crustacea				
Nauplius	4.99 \pm 2.55	45.2	10	6
<i>Caridean mysis</i>	0.005 \pm 0.007	0.04	0	15
Insecta				
<i>Chironomus</i> sp.	0.0007 \pm 0.001	0.01	0	20
<i>Ephemera</i> sp.	0.006 \pm 0.004	0.05	0	14
Hemiptera	0.002 \pm 0.003	0.02	0	16
Diptera larvae	0.002 \pm 0.002	0.02	0	17
<i>Neumania</i> sp.	0.0009 \pm 0.001	0.01	0	19
Ichthyoplankton				
Fish egg	6.06 \pm 3.53	53.8	12	4
Fish larvae	0.001 \pm 0.001	0.01	0	18
Total		457	100	

The standing stock of zooplankton during the present study is presented by the numerical abundance (ind./L). The current study yielded a total number of 456.953 ind./L with an average density 50.99 ± 6.91 ind./L from all stations. Zooplankton population density in homestead ponds ranged from 62.78 ± 10.24 ind./L to 42.297 ± 1.29 ind./L (Fig 9b). *Brachionus rubens* was dominant in all stations and ranked 1, having a mean of (9.09 ± 1.82) ind./L density of present study while Harpecticoida and *Cyclops* sp. were abundant in all stations, ranked 2 and ranked 3, having a mean of (7.98 ± 2.05) ind./L and (7.68 ± 1.26) ind./L with a total of 74.698 ind./L and 70.856 ind./L (Table 40). Fish egg ranked 4th, having a mean of (6.06 ± 3.53) ind./L and total density 53.7704 ind./L but it was not common in all stations. The dominant taxon *Brachionus rubens* contributes 18% while Harpecticoida and *Cyclops* sp. were abundant with 16% and 15%

of the total zooplankton. Fish egg contributes 12% of the total zooplankton. Few species like *Keratella* sp. (1.71 ind./L) and *Collotheca* sp. (0.004 ind./L) was found only two ponds and *Brachionus* sp also found in only three ponds. Similar finding was observed by Hossain et al. (2015); Akter et al. (2016) and Roy et al. (2010). Results observed by Rahman and Hossain (2008), Hossain et al. (2007), Basak et al. (2015) and Akther et al. (2015) was not consistent with the present study because of difference in study area.

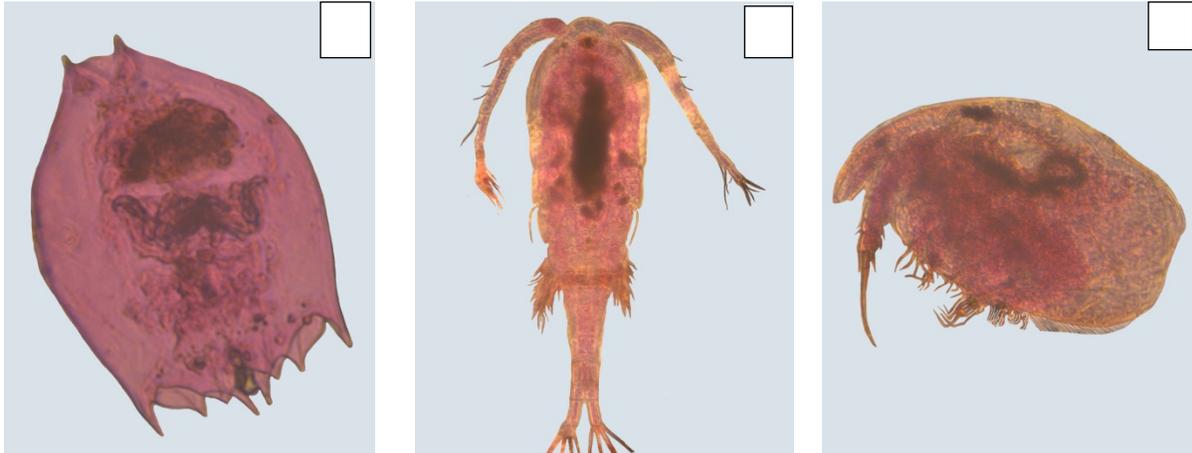


Plate 44. Some representative taxa of zooplankton recorded from the homestead ponds (a) *Brachionus rubens*, (b) *Cyclops* sp, (c) *Bosmina* sp.

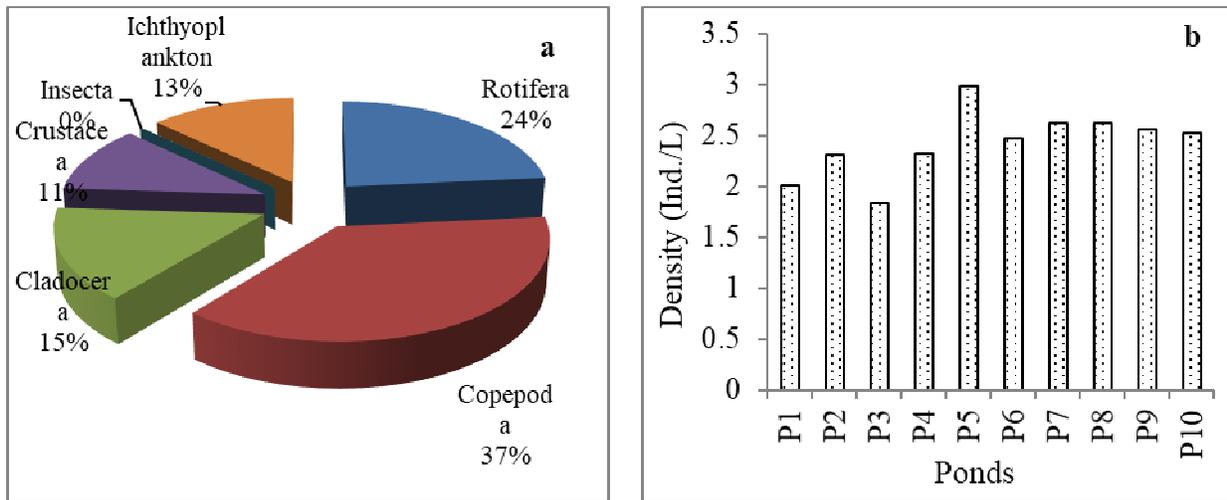


Fig 9. Zooplankton (a) composition and (b) abundance in homestead ponds of Noakhali.

11.4.3 Benthos

In present study, a total 7 taxonomic groups of benthic infauna namely Nematoda was 53200 ind./m², Gastropoda was 18300 ind./m², Diptera 28500 ind./m², Oligochaeta 4400 ind./m², Crustacea 2000 ind./m², Bivalves 1400 ind./m² and Polychaeta 1100 ind./m² were recorded from the homestead ponds. The highest number of benthic infauna was recorded in the group of Nematoda in each station which is available in all stations of the sampling areas and the 2nd highest was Gastropoda in the present study (Fig 10a). The Diptera found diversely in most of

the stations in the present study. The Oligochaeta was not much available in study sites. The Bivalves, Crustacea and Polychaeta were absent in most of the stations but present only in three, two and one stations respectively in the homestead ponds of Noakhali. Similar findings were observed by Traunspurger (2000) where Nematoda mentioned higher abundance. Bert et al.(2007) mentioned the total nematode density varied from 9000 to 411000 ind./m² which is moderately similar to present study. Results of previous studies have suggested that freshwater-nematodes proved to be indicators of aquatic pollution or eutrophication (Beier and Traunspurger, 2001; Prejs and Blaszczyk, 1977; Zullini, 1976).

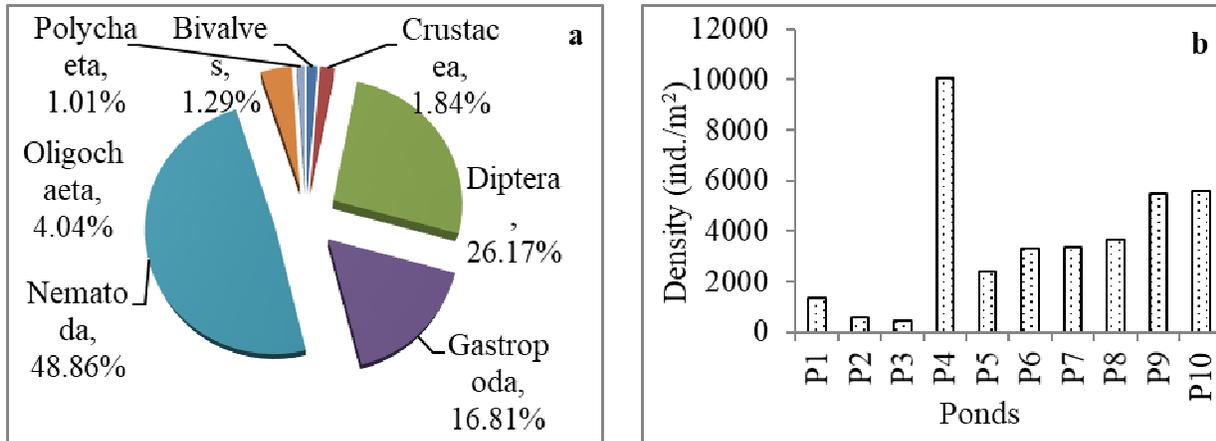


Fig 10. Benthos (a) composition and (b) abundance in homestead ponds of Noakhali.

The benthic infauna was identified up to the genus level which recorded a total of 15 taxa during the present study (Table 4I). The current study yielded a total number of 108900 ind./m² with a mean density of 3630 ± 2883 ind./m² from all stations of homestead ponds. The mean abundance of benthos in different homestead ponds have summarized in Fig 10b. *Prionchulus* sp. was dominant in all stations and ranked 1, having a mean density of 1113.34±827.04 ind./m² while *Chironomus* spp. and *Prismatolaimus* sp. were abundant in all stations, ranked 2 and ranked 3, having a mean density of 920±2387.3 ind./m² and 660±412.7 ind./m² with a total of 27600 ind./m² and 19800 ind./m² in the homestead ponds (Table 4I). Few species like *Pila globosa* (100 ind./m²) and *Clenchiella* sp. (200 ind./m²) was only found few stations. The present study has similarity with the findings of Ingels *et al.* (2011).



Plate 45. Some representative taxa of benthos recorded from the homestead ponds.

(a) *Prionchulus* sp., (b) *Chironomus* sp., (c) *Prismatolaimus* sp.

Table 41. Abundance of macrobenthic taxa (ind. /m²) recorded from the homestead ponds of Noakhali

Genus	Mean	Total	Percentage (%)	Rank
Nematoda				
<i>Prismatolaimus</i> sp.	660 ± 412.7	19800	18.18	3
<i>Prionchulus</i> sp.	1113.4 ± 827.04	33400	30.67	1
Gastropoda				
<i>Clenchiella</i> sp.	6.67 ± 21.08	200	0.18	16
<i>Melanoides</i> sp.	130 ± 265.95	3900	3.58	5
<i>Pila globosa</i>	3.34 ± 10.54	100	0.092	17
<i>Filopaludina</i> sp.	360 ± 759.6	10800	9.92	4
Bivalvia				
<i>Lamellidens</i> sp.	46.67 ± 93.23	1400	1.29	10
Crustacea				
<i>Thiane</i> sp.	110 ± 223.9	3300	3.03	6
Polychaeta				
<i>Lumbrineris</i> sp.	10 ± 22.50	300	0.28	15
<i>Nephtys</i> sp.	13.34 ± 23.31	400	0.37	13
<i>Cossura</i> spp.	13.34 ± 28.12	400	0.37	14
Oligochaeta				
<i>Limnodrilus</i> sp.	80.0 ± 74.04	2400	2.21	7
<i>Branchiodrilus</i> spp.	66.67 ± 103.04	2000	1.84	8
Diptera				
<i>Chironomus</i> spp.	920 ± 2387.3	27600	25.35	2
<i>Anopheles</i> sp.	30 ± 83.82	900	0.83	11
Total	3630 ± 2883.1	108900	100	

11.5. Socio-economic status of coastal rural people

11.5.1 Age, religion and education

Based on the age, the middle aged group was the maximum (38.8%) and old was the minimum (31.1%) considering all farmers (Table 42). This finding is somewhat in line with the findings Ali et al. (2009) conducted a study in Mymensingh and stated that most of the fish farmers (50%) belonged to age group of 31 to 40 years which agreed more with the present findings. In the study area, the absolute majority of the fish farmer was featured as Muslims 81.3% and 18.8% of the pond fish farmers was found to be Hindus (Table 42). Khatun et al. (2013) also reported that Muslims and Hindus comprised 82% and 18% of the pond fish farmers, respectively. Education is very important in the human existence because the education and society are interrelated and interdependent. Improvement and progress of an area depends greatly on the quality of education. The study revealed 10% had illiterate, 35% had only sign, 22.5% had primary education, 20% had secondary education, and the rest had higher secondary and bachelor level of education (Table 42). This finding was more or less similar with Khatun *et al.* (2013).

Table 42. Socio-demographic characteristics of pond fish farmers in the study area (N = 80)

Variables	Frequency		Percentage (%)	
Age (Year)				
20-35	16		20	
36-50	31		48.8	
51-70	33		41.2	
Religion				
Muslim	65		81.2	
Hindu	15		18.8	
Education				
Illiterate	8		10	
Only sign	28		35	
Primary	18		22.5	
Secondary	16		20	
Higher secondary	6		7.5	
Bachelor	4		5	
Land (Decimal)				
Small (≤ 10)	27		34	
(11–20)	39		49	
(≥ 21)	14		17	
Annual income (USD)				
365-845	7		8.8	
845-1,300	27		33.8	
1,300-1,785	31		38.8	
1,785-2,260	12		15	
2,260-2,500	3		3.8	
Occupation	Frequency		Percentage (%)	
	Primary	Secondary	Primary	Secondary
Fish culture	6	50	7.5	62.5
Agriculture	21	8	26.2	10
Business	24	10	30	12.5
Day labor	22	4	27.5	5
Poultry raising	5	6	6.3	7.5
Others	2	2	2.5	2.5

11.5.2. Land ownership and occupation

The present study revealed land ownership as small 34%, medium 49% and large 17% respectively. The primary and secondary occupation for their livelihoods of the homestead pond farmers have presented in Table 42. The main occupation of homestead pond fish farmers was considered from which most of the income was earned. Majority of the homestead pond fish farmers were involved in business including small trading and shop keeping as a principle occupation (30%), followed by agricultural farming (26.2%), day labour (27.5%) and poultry raising (6.3%) as their primary occupation. Only 7.5% of the homestead pond fish farmers were involved in fish farming as their principal occupation. The primary occupation was insufficient to provide adequate means of livelihood and so they involved into different occupation as secondary occupation. About 62.5% of homestead pond fish farmers stated that, they were

involved in fish farming as their secondary occupation to secure their livelihood in the year round. Momotaz (2009) found the highest number of fishermen (60%) had above 50 decimal lands which is different from the present study may be due to different region. Khatun et al. (2013) reported that majority of the fish farmers were involved in agricultural farming as a principal occupation (38%), followed by business including small trading and shop keeping (26%), fish farming (6%) in Noakhali district. About 36% of the respondents stated that, they were involved in fish farming as their secondary occupation while business (22%), agriculture (28%), services (8%) and poultry raising (6%) (Khatun et al., 2013). Sarkar and Ali (2016) found 17% agriculture, 52% fish culture, 3% business and 28% others as secondary occupation in Habigonj district. Ali et al. (2008) observed that almost all respondents (60%) reported agriculture is their primary occupation. However, 14% of respondents stated fish culture as their primary occupation, while 18% and 8% are occupied in business and service, respectively (Ali et al., 2008).

11.5.3. Annual income

Based on the level of annual income, pond fish farmers were classified into five categories. The highest percentage (38.8%) pond fish farmers earned USD 1300–1785 per year and higher (33.8%) earned USD 845–1300 per year (Table 42). When compared the findings the present study with that of Khatun et al. (2013), it was revealed that maximum (34%) fish farmers earned 892 to 1190 USD per year, which was lower than the current outcomes. The present study it revealed that, about 3.8% of homestead pond fish farmers had highest annual income (1788.47–2250.39 USD), 35% had moderate (840.93–1302.86 USD), and 40% had higher income (1314.70–1776.62 USD). Khan (2011) found that the highest income of fishermen was above 710.65 USD, moderate was 355.32–710.65 USD and lowest was 118.44–355.32 USD. Ali and Kausar (2013) found the highest annual income ranged from 61000–90000 TK and the lowest annual income ranged from 30000–40000 TK which was very similar to the present study.

11.6. Nutritional and health status of coastal rural people

11.6.1. Fish consumption

The consumption of fish is gradually increasing from baseline (59.57 g/ person/day) to end line (120.10 g/person/day) in the beneficiary homestead pond farmers (Fig 11a). The fish consumption (g/ person/day) of beneficiary homestead pond farmers range from 30.25 to 84.22 (mean = 59.57 ± 16.49) during baseline, 35.71 to 100 (mean = 72.43 ± 18.13) after 1st post cycle, 61.22 to 142.86 (mean = 99.07 ± 19.31) after 2nd post cycle and 81.63 to 166.67 (mean = 120.10 ± 18.43) in end line. In case of control farmers, people with homestead pond consumed 1.2 times more fish than without homestead ponds (Fig 11b). The fish consumption of without homestead pond range from 35.71 to 160 g/ person/day (mean = 99.82 ± 30.77) and control homestead ponds farmers varied from 35.71 to 190 g/ person/day (mean = 121.13 ± 46.46). The mean consumption of fish both in beneficiary farmers and control farmers of Noakhali revealed exceed the amount of fish intake compared to national fish consumption (62.58 g/person/day) of Bangladesh except during baseline (BBS, 2016). The higher fish consumption is attributed to the

availability and accessibility of fish both from aquaculture and coastal inland capture fishery in Noakhali.

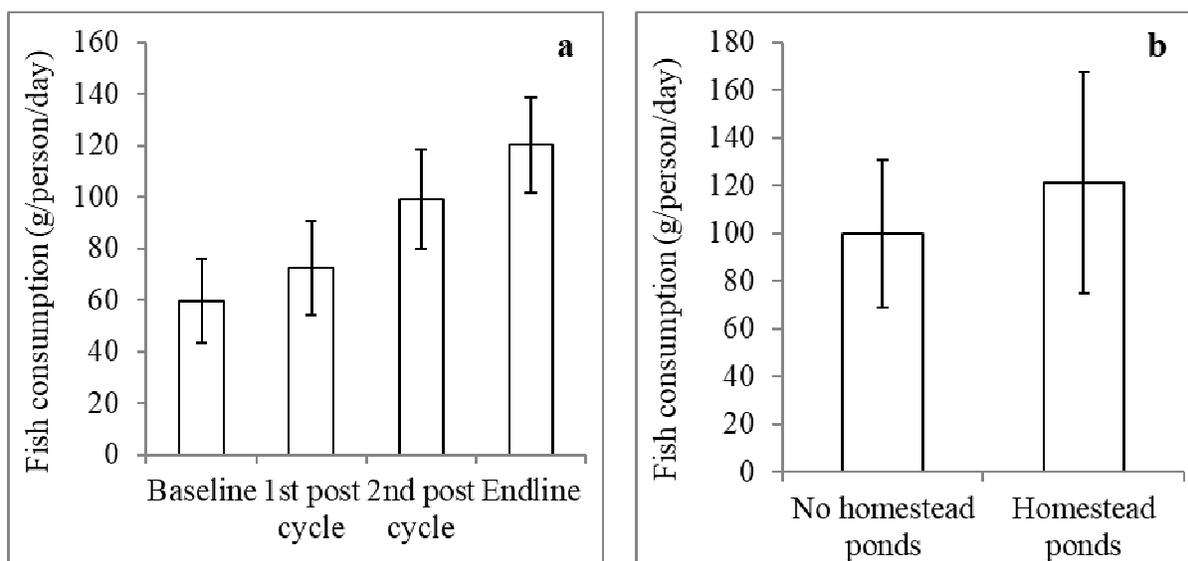


Fig 11. Fish consumption of (a) beneficiary farmers and (b) control farmers in Noakhali, Bangladesh.

11.6.2. Body mass index (BMI)

The nutritional status of beneficiary and control homestead pond farmers based on body mass index (BMI) has presented in Fig 12. BMI status of beneficiary farmers indicates the development of nutritional status e.g. decrease in moderate energy deficiency (CED₂) and increase in normal health status from baseline to end line (Fig 12a). The BMI value of beneficiary farmers stated a low standard of health condition during baseline and gradually increases in end line, nearly similar to others studies of Bangladesh (NIPROT and ICF: BDHS, 2020; Karim and Tasnim, 2015). The health condition of homestead pond farmers was better compared to without homestead pond in case of control farmers (Fig 12b). Severe energy deficiency (CED₃) was found among the children of both control homestead pond farmers (12.5%) and without homestead pond (27.5%). The BMI value of control farmers revealed a poor quality of health status compare to other studies of Bangladesh (NIPROT and ICF, 2020; Karim and Tasnim, 2015).

11.6.3. Mid-upper arm circumference (MUAC)

The health condition of beneficiary and control homestead pond farmers according to mid-upper arm circumference (MUAC) is presented in Fig I3a. MUAC status indicates the successive improvement of beneficiary farmers from baseline to end line e.g. increase in normal health status and decrease in under-nutrition status (Fig I3a). In the case of control farmers, the nutritional status of homestead pond farmers was better compared to without homestead pond farmers (Fig I3b).

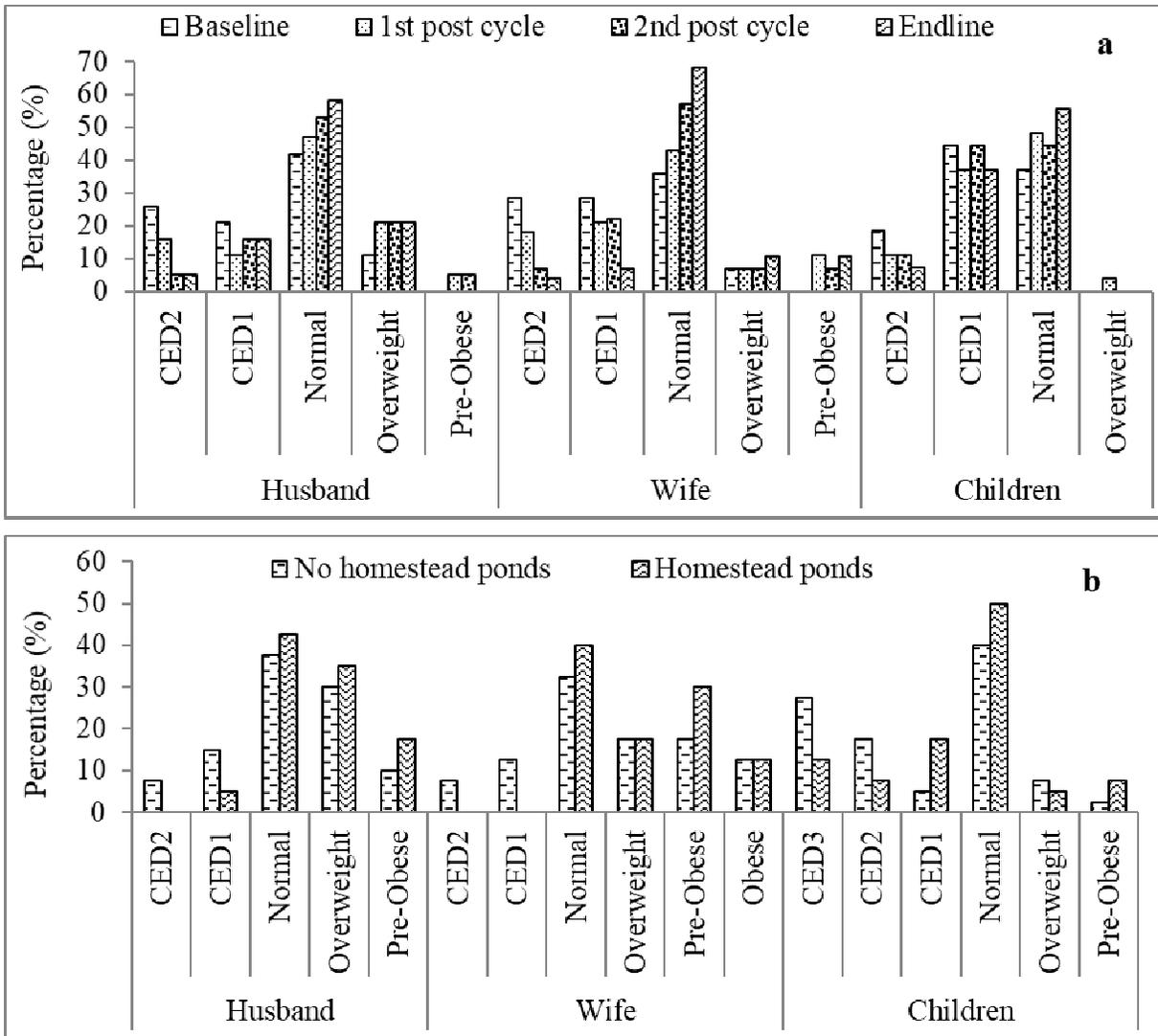


Fig 12. BMI status of (a) beneficiary farmers and (b) control farmers in Noakhali, Bangladesh.

11.6.4. Prevalence of anaemia

The anaemic status of beneficiary and control homestead pond farmers based on haemoglobin level has presented in Fig 14. The prevalence of malnutrition (mild anaemia) decreases from baseline to end line both in husband (79 to 47%) and wife (93 to 79%) in the beneficiary homestead pond farmers (Fig 14a). In the control farmers, the prevalence of malnutrition was higher in the family without homestead ponds compared to homestead pond farmers (Fig 14b). The prevalence of mild anaemia both in beneficiary and control farmers revealed a poor quality of nutritional status than the other studies of Bangladesh (Rahman et al., 2019; Hyder et al. 1998).

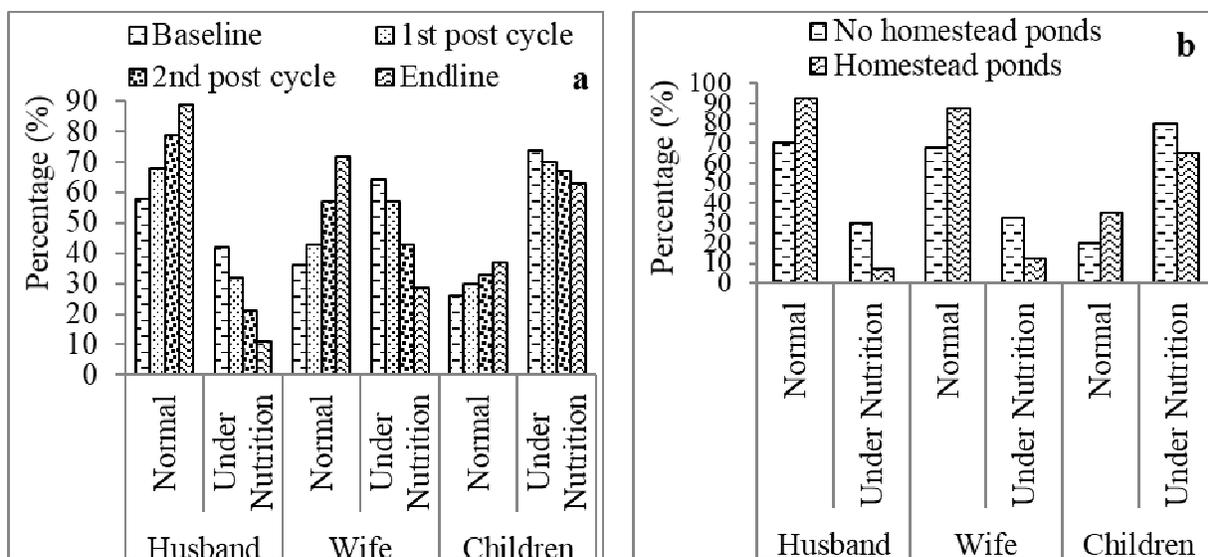


Fig 13. MUAC status of (a) beneficiary farmers and (b) control farmers in Noakhali, Bangladesh.

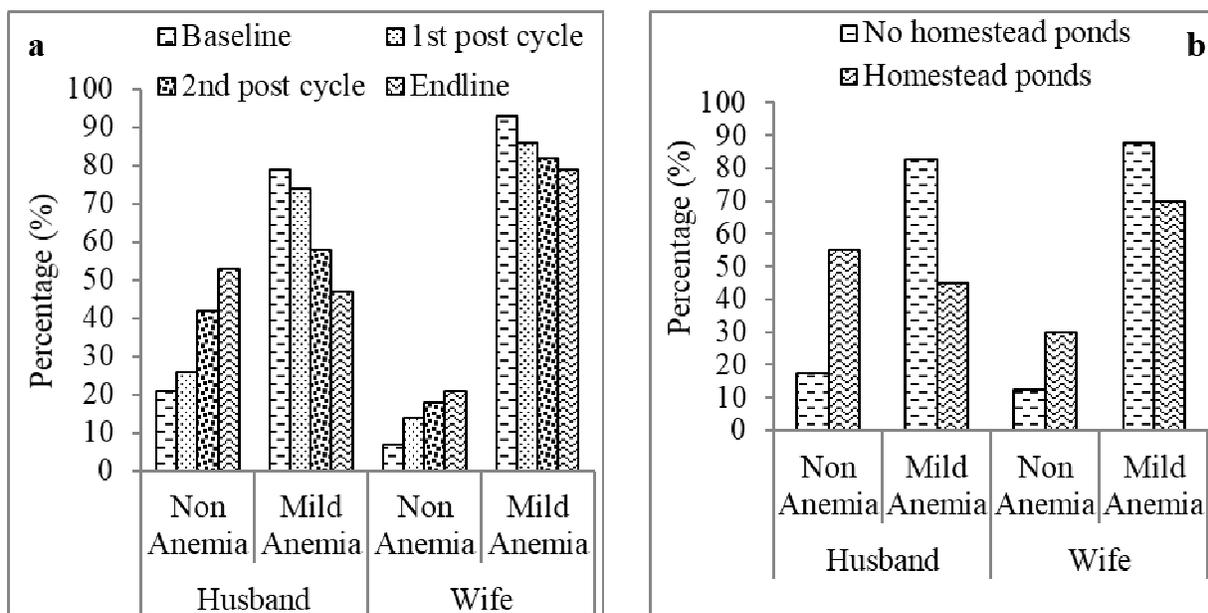


Fig 14. Anaemia prevalence of (a) beneficiary farmers and (b) control farmers in Noakhali, Bangladesh.

11.7. Homestead ponds fish diversity of Noakhali

A total of 52 fish species represented by 9 orders, 21 families, 11 groups and 35 genera were recorded from the homestead ponds of coastal area of Noakhali (Table 43). The fish species found from homestead ponds under 9 orders namely Osteoglossiformes (1, 2%), Clupeiformes (1, 2%), Channiformes (4, 7.5%), Cypriniformes (19, 36.5%), Siluriformes (7, 13.5%), Cyprinodontiformes (1, 2%), Synbranchiformes (1, 2%), Perciformes (16, 30.5%) and Beloniformes (2, 4%). A variety of 11 groups of fish species were recorded from the homestead ponds namely featherbacks (1, 1.9%), clupeids (1, 1.9%), snakeheads (4, 7.5%), carps (9,

17.5%), barbs and minnows (9, 17.5%), loaches (1, 1.9%), catfishes (7, 13.5%), killifishes (1, 1.9%), eels (4, 7.5%), perches (13, 25%) and halfbeaks (2, 4%).

Table 43. Fish species recorded from the homestead ponds of Noakhali

Order	Family	Scientific Name	Common Name	Local Name
Osteoglossi- formes	Notopteridae	<i>Notopterus notopterus</i>	Grey featherback	Hoilla, Foli
Clupeiformes	Clupeidae	<i>Corica soborna</i>	Ganges river spart	Kachki
Channiformes	Channidae	<i>Channa marulius</i>	Giant snakehead	Gajar
		<i>Channa orientalis</i>	Walking snakehead	Gaccha, Gachhua
		<i>Channa punctatus</i>	Spotted snakehead	Taki, Gori
		<i>Channa striatus</i>	Striped snakehead	Hoil, Shol,
Cyprini- formes	Cyprinidae	<i>Amblypharyngodon microlepis</i>	Indian carplet	Kachki, Mola
		<i>Amblypharyngodon mola</i>	Mola carplet	Kachki, Mola
		<i>Aristichthys nobilis</i>	Bighead carp	Bighead
		<i>Barbonymus gonionotus</i>	Java barb	Thai sarpunti
		<i>Gibelion catla</i>	Catla	Catla
		<i>Cirrhinus cirrhosus</i>	Mrigal carp	Mirka, Mrigal
		<i>Ctenopharyngodon idella</i>	Grass carp	Galas/grass curp
		<i>Cyprinus carpio</i>	Common carp	Carpu,
		<i>Danio dangila</i>	Flying barb	Daria boicha, Darkina
		<i>Esomus lineatus</i>	Striped flying barb	Daria boicha, Darkina
		<i>Hypophthalmichthys molitrix</i>	Silver carp	Silver cup
		<i>Labeo calbasu</i>	Kalbasu	Kali baus
		<i>Labeo rohita</i>	Rohu	Ruit, Rui
		<i>Puntius chola</i>	Swamp barb	Hudi, puti
		<i>Puntius sophore</i>	Pool barb	Jathudi/puti
		<i>Puntius ticto</i>	Ticto barb	Tithudi/puti
<i>Salmostoma bacaila</i>	Large razorbelly minnow	Chepli		
<i>Salmostoma phulo</i>	Finescale raz. min.	Phulchela		
	Balitoridae	<i>Schistura beavani</i>	Creek loach	Betta, gutum
Siluriformes	Bagridae	<i>Mystus gulio</i>	Long whiskers catfish	Gulla, Nuna tengra
		<i>Mystus tengara</i>	Striped dwarf catfish	Bojori tengra

Order	Family	Scientific Name	Common Name	Local Name
	Siluridae	<i>Ompok bimaculatus</i>	Butter catfish	Kani habda, pabda
	Pangasiidae	<i>Pangasius hypophthalmus</i>	Sutchi catfish	Thai hangaius, pangas
	Clariidae	<i>Clarias batrachus</i>	Walking catfish	Jagur, magur
		<i>Clarias gariepinus</i>	African catfish	African jagur,
	Heteropneustidae	<i>Heteropneustes fossilis</i>	Stinging catfish	Shing, Hing, Olijja
Cyprinodontiformes	Aplocheilidae	<i>Aplocheilus panchax</i>	Blue panchax	Choukkani
Synbranchiiformes	Synbranchiidae	<i>Monopterusuchia</i>	Cuchia, Swamp eel	Noaji mach, Kuiccha
Perciformes	Ambassidae	<i>Chanda nama</i>	Elongated glassy perchlet	Kada/Chanda
		<i>Pseudambassis baculis</i>	Himalayan glassy perchlet	Kada/Kata chanda
		<i>Pseudambassis lala</i>	Hifh fin glassy perchlet	Lal Chanda
	Nandidae	<i>Nandus nandus</i>	Mud perch	Bheda, Meni
		<i>Nandus meni</i>	Mud perch	Bheda, Meni
	Cichlidae	<i>Oreochromis mossambicus</i>	Mozambique tilapia	Tilapia
		<i>Oreochromis niloticus</i>	Nile tilapia	Nilotica
	Gobiidae	<i>Acentrogobius caninus</i>	Tropical sand goby	Baila, Bele
	Anabantidae	<i>Anabas testudineus</i>	Climbing perch	Bangla Koi
		<i>Anabas oligolepis</i>	Climbing perch	Thai Koi
	Osphronemidae	<i>Pseudosphromenus cupanus</i>	Spiktailed paradise fish	Koi bandi
		<i>Colisa fasciatus</i>	Giant gourami	Khoiya, kholisha
		<i>Colisa lalia</i>	Dwarf gourami	Teya/taka boicha
	Mastacembelidae	<i>Macragnathus aculeatus</i>	Lesser spiny eel	Tara baim
		<i>Macragnathus pancalus</i>	Striped spiny eel	Guchi baim
		<i>Mastacembelus armatus</i>	Tire-tack spiny eel	Bamosh, Salosh
Beloniformes	Belonidae	<i>Xenentodon cancila</i>	Freshwater garfish	Kaiya, kakila
	Adrianichthyidae	<i>Oryzias dancena</i>	Indian ricefish	Choukkani

11.8. Nutritional value of fish available in the homestead ponds

11.8.1. Proximate composition

Nutrient composition such as moisture, protein, lipid, ash and carbohydrate of 47 homestead ponds fish species were determined and summarized in Table 44. The moisture was found highest (83.77%) in *Corica soborna* and lowest (70.96%) in *Oreochromis mossambicus* with mean 75.65 ± 2.69 %. Maximum protein (17.30%) was found in *Macrogathus aculeatus* and minimum (11.00%) in *Corica soborna* with mean 14.70 ± 1.38 %. The lipid ranged between 5.20% in *Pangasius hypophthalmus* and 1.55 % in *Colisa fasciatus* with mean 2.39 ± 0.78 %. The fibre varies from 1.77% in *Mystus gulio* to 0.66% in *Acentrogobius caninus* with mean 0.91 ± 0.56 %. Higher ash (6.85%) was found in *Nandus meni* and lower (1.68%) was in *Heteropneustes fossilis* with mean 3.71 ± 1.22 %. The carbohydrate was found maxima (6.52%) in *Salmostoma bacaila* and minima (0.14%) in *Labeo calbasu* with mean 2.73 ± 1.41 %.

Table 44. Nutrient composition (%) of homestead ponds fish species.

Sl.	Local Name	Scientific Name	Moisture	Protein	Lipid	Fibre	Ash	Carbo-hydrate
01	Foli	<i>Notopterus notopterus</i>	74.62	15.00	2.02	0.98	4.36	3.02
02	Kachki	<i>Corica soborna</i>	83.77	11.00	1.90		1.70	1.63
03	Gajar	<i>Channa marulius</i>	74.33	16.22	2.15	1.50	4.28	1.52
04	Gachua	<i>Channa orientalis</i>	77.51	14.78	2.11		2.70	2.90
05	Taki	<i>Channa punctatus</i>	81.05	13.18	2.11		1.70	1.96
06	Shol	<i>Channa striatus</i>	74.30	16.53	2.45	0.87	4.09	1.76
07	Mola	<i>Amblypharyngodon microlepis</i>	75.67	15.46	2.88		2.77	3.22
08	Kachki	<i>Amblypharyngodon mola</i>	78.90	14.57	2.51		3.10	1.83
09	Bighead	<i>Aristichthys nobilis</i>	72.86	15.77	2.23	1.33	4.23	3.58
10	Thai Sarpunti	<i>Barbonymus gonionotus</i>	72.78	14.44	1.89	1.35	4.78	4.76
11	Catla	<i>Gibelion catla</i>	74.76	15.32	2.34	1.44	4.34	1.80
12	Mrigal	<i>Cirrhinus cirrhosis</i>	74.88	15.20	2.67	1.34	4.86	1.05
13	Grass carp	<i>Ctenopharyngodon idella</i>	76.56	14.56	1.90	1.43	4.67	0.88
14	Carpu	<i>Cyprinus carpio</i>	72.89	14.78	2.33	1.22	4.98	3.80
15	Darkina	<i>Danio dangila</i>	75.86	13.69	1.66	1.20	4.32	3.27
16	Darkina	<i>Esomus lineatus</i>	74.66	14.59	1.66	0.97	4.65	3.47
17	Silver carp	<i>Hypophthalmichthys molitrix</i>	75.23	14.45	2.34	1.45	4.66	1.87
18	Kalibaus	<i>Labeo calbasu</i>	75.21	15.66	2.77	1.55	4.67	0.14
19	Rui	<i>Labeo rohita</i>	73.67	15.56	2.56	1.41	5.44	1.36
20	Puti	<i>Puntius chola</i>	73.34	14.36	1.98	1.23	5.75	3.34

Sl.	Local Name	Scientific Name	Moisture	Protein	Lipid	Fibre	Ash	Carbo-hydrate
21	Jatputi	<i>Puntius sophore</i>	75.27	16.31	3.05		2.79	2.58
22	Titputi	<i>Puntius ticto</i>	77.29	14.39	2.14		3.72	2.46
23	Chepli	<i>Salmostoma bacaila</i>	72.22	14.22	1.76	1.10	4.18	6.52
24	Fulchela	<i>Salmostoma phulo</i>	70.53	15.72	2.40	1.16	4.28	5.91
25	Gulla	<i>Mystus gulio</i>	74.77	12.13	1.98	1.77	4.82	4.53
26	Tengra	<i>Mystus tengara</i>	78.17	13.73	1.67	1.83	2.54	2.06
27	Pabda	<i>Ompok bimaculatus</i>	74.43	12.95	4.80	1.45	2.05	4.32
28	Thai Pangas	<i>Pangasius hypophthalmus</i>	70.33	15.20	5.20	0.78	3.89	4.60
29	Magur	<i>Clarias batrachus</i>	74.40	17.15	3.11	0.86	2.15	2.33
30	Magur	<i>Clarias gariepinus</i>	74.15	16.35	3.70	0.70	2.25	2.85
31	Shing	<i>Heteropneustes fossilis</i>	79.89	14.11	2.51		1.68	1.81
32	Kata Chanda	<i>Chanda nama</i>	77.36	12.57	2.63	1.08	4.57	1.79
33	Kata Chanda	<i>Pseudambasis baculis</i>	78.26	12.37	2.23	0.98	5.22	0.94
34	Lal Chanda	<i>Pseudambassis lala</i>	78.82	13.77	2.65	1.18	4.89	1.69
35	Bheda	<i>Nandus nandus</i>	74.01	16.70	1.70	1.33	3.60	2.66
36	Meni	<i>Nandus meni</i>	73.52	14.02	1.87	1.26	6.85	2.48
37	Tilapia	<i>Oreochromis mossambicus</i>	70.96	14.23	4.23	0.97	3.44	6.17
38	Nilotica	<i>Oreochromis niloticus</i>	75.45	15.34	2.34	1.23	4.30	1.34
39	Baila	<i>Acentrogobius caninus</i>	79.43	13.77	1.83	0.66	2.87	1.44
40	Koi	<i>Anabas testudineus</i>	76.45	13.95	2.85	1.15	3.06	2.54
41	Thai Koi	<i>Anabas oligolepis</i>	78.11	12.25	2.55	1.10	2.66	3.33
42	Kholisa	<i>Colisa fasciatus</i>	78.32	14.51	1.55		3.43	2.19
43	Boicha	<i>Colisa lalia</i>	77.83	15.21	1.85		3.88	1.23
44	Baim	<i>Macrognathus aculeatus</i>	75.31	17.30	1.67		2.44	3.28
45	Guchi Baim	<i>Macrognathus pancalus</i>	76.47	15.41	1.76	0.89	2.87	2.60
46	Salosh	<i>Mastacembelus armatus</i>	75.52	16.97	1.79	0.97	1.87	2.88
47	Kakila	<i>Xenentodon cancila</i>	75.34	15.31	1.86	1.20	1.84	4.45

11.8.2. Minerals

Minerals like Calcium, Magnesium, Iron, Zinc, Potassium and Phosphorus of the 12 fish samples were determined (Table 45). Ca and P were found in highly rich among the analysed 12 fish species and varied 1663.39 to 3550.79 mg/100g and 1187.03 to 3713.38 mg/100g respectively. Mg ranged from 242.16 to 487.82 mg/100 g, Fe from 13.57 to 38.12 mg/100 g, Zn from 3.24 to 9.40mg/100 g and K from 438.75 to 1399.58 mg/100 g.

Table 45. Minerals contents of small indigenous fish species (mg/100 g of dry sample)

No	Local Name	Scientific Name	Ca	Mg	Fe	Zn	K	P
1	Khalisha	<i>Colisa fasciatus</i>	3026.6	290.5	35.65	6.38	705.85	2031.14
2	Mola	<i>Amblypharyngodon mola</i>	3035.68	325.68	33.63	9.4	438.75	2237.62
3	Punti	<i>Puntius sophore</i>	2792.3	285.01	20.93	8.6	495.91	3193.81
4	Sharpunti	<i>Puntius sarana</i>	2456.11	414.52	15.79	5.74	999.8	1694.66
5	Tarabaim	<i>Macragnathus aculeatus</i>	1764.16	274.84	25.2	4.37	1181.68	1477.1
6	Tengra	<i>Mystus tengara</i>	3381.89	422.22	28.8	7.54	1399.58	2214.34
7	Koi	<i>Anabas testudineus</i>	3550.79	357.73	31.22	4.85	986.29	3713.38
8	Taki	<i>Channa punctatus</i>	3000.6	281.77	16.73	4.67	1397.62	2316.06
9	Shing	<i>Heteropneustes fossilis</i>	2228.64	242.16	38.12	4.06	1397.48	1831.7
10	Magur	<i>Clarius batrachus</i>	2284	256.08	22.18	4.13	1390.68	1927.09
11	Meni	<i>Nandus nandus</i>	2862.19	487.82	13.57	5.83	1188	2366.1
12	Pabda	<i>Ompok pabda</i>	1663.39	341.85	14.26	3.24	798	1187.03

Ca: Calcium, Mg: Magnesium, Fe: Iron, Zn: Zinc, K: Potassium, P: Phosphorus

11.8.3. Fatty acids

The fatty acid profile documented that SIS contains a good source of Palmitic acid, Oleic acid, Linoleic acid, Myristic acid, Stearic acid, Palmitoleic acid and Linolenic acid apart from various others (Table 46).

Table 46. Fatty acids composition of small indigenous fish species

Fatty acid	<i>Colisa fasciatus</i>	<i>Amblypharyngodon mola</i>	<i>Puntius sophore</i>	<i>Puntius sarana</i>	<i>Macrogna- thus aculeatus</i>	<i>Mystus tengara</i>	<i>Anabas testud- ineus</i>	<i>Channa puncta- tus</i>	<i>Heterop- neustes fossilis</i>	<i>Clarius batra- chus</i>	<i>Nandus nandus</i>	<i>Ompok pabda</i>
Saturated Fatty Acid %	59.6951	63.3666	44.4938	43.6388	47.0367	49.8642	42.6560	47.9053	47.9696	45.4735	53.8977	51.1809
Myristic acid (C 14:0)	5.1015	9.5401	2.812	1.5586	2.3165	2.9678	1.3772	3.2635	2.9461	2.7935	4.6198	1.2789
Palmitic acid (C 16:0)	50.6128	52.0627	36.7169	36.3769	39.2524	42.0781	37.1274	40.1021	40.3226	38.1317	44.8383	46.2665
Stearic acid (C 18:0)	3.5584	1.5673	3.3353	4.2700	3.2154	2.9764	3.5777	3.5033	3.0169	3.1909	3.8348	3.0023
Arachidic acid (C 20:0)	0.1649	0.1965	0.9493	0.6928	1.5478	1.1173	0.1574	0.4704	1.0859	1.0245	0.0931	0.3316
Behenic acid (C 22:0)	---	---	---	0.0866	0.5621	0.4758	0.2686	0.2201	0.4053	0.2565	0.2129	---
Lignoceric Acid (C 24:0)	0.2575	---	0.0575	0.6539	0.1425	0.2488	0.1477	0.3459	0.1928	0.0764	0.2988	0.3016
Unsaturated fatty acids %	40.3049	36.6334	55.5062	56.3612	52.9633	50.1358	57.3439	52.0946	52.0303	54.5265	46.1022	50.1358
i) Monounsaturated fatty acids %	34.6018	26.4921	46.1181	46.1222	40.0382	41.6202	41.3308	40.4292	35.4909	41.3779	36.9642	40.3458
Myristoleic acid (C 14:1)	5.1329	2.6845	2.8565	0.6448	1.9853	2.2748	---	1.7927	2.8957	3.1257	3.1381	0.1759
Palmitoleic acid (C 16:1)	4.4635	1.0533	3.3353	5.2156	2.5390	2.8502	0.3592	2.2944	0.5183	2.9765	1.9950	0.2564
Oleic acid (C 18:1)	24.8893	22.7543	38.9012	39.5138	35.4265	36.4952	40.7929	36.3421	31.8508	35.0961	31.7403	39.7285
Eicosenoic acid (C 20:1)	0.1161	---	1.0251	0.7480	0.0875	---	0.1787	---	0.2261	0.1796	0.0908	0.1850
ii) Polyunsaturated fatty acids %	5.7031	10.1414	9.3881	10.2392	12.9251	8.5158	16.0131	11.6654	16.5394	13.1486	9.1380	8.4735
Linoleic acid (C 18:2)	3.7764	3.7554	8.4614	9.7211	11.1872	6.0303	15.1436	8.7753	8.0988	6.3432	6.7438	7.6000
Linolenic acid (C 18:3)	1.2166	5.2155	0.6421	0.1475	1.6109	1.8724	0.5059	1.1508	5.3832	3.3364	0.8192	0.0758
Arachidonic acid (C 20:4)	0.2505	0.3359	0.0580	0.2403	0.0608	0.1645	---	0.8039	1.8838	2.3570	0.7909	---
Eicosapentaenoic acid (EPA) (C 20:5)	0.2175	---	0.1885	0.0434	0.0093	---	---	0.1428	0.2009	0.5668	0.0748	0.1910
Docosahexaenoic acid (DPA) (C 22:6)	0.2415	0.3251	0.0381	0.0869	0.0569	0.4486	0.3636	0.7926	0.9627	0.5451	0.7093	0.6067

11.9. Development of a modified carp-based polyculture system suitable for the homestead ponds of Noakhali

11.9.1. Carp-based polyculture for homestead ponds with different stocking density

11.9.1.1 Fish growth assessment

Of the three treatments assessed, treatment T₃ had the highest carp production than in T₁ or T₂ (Table 47). In case of *G. catla*, fish production was maximum in T₃ (846.17 ± 18.32 kg/ Ha/ 5 month) which varied significantly ($p < 0.05$) from T₁ (658.16 ± 37.16 kg/ Ha/ 5 month) and T₂ (791.31 ± 28.56 kg/ Ha/ 5 month). In case of *L. rohita*, fish production was higher in T₃ (805.98 ± 11.16 kg/ Ha/ 5 month) which differ significantly ($p < 0.05$) from T₁ (623.1 ± 32.51 kg/ Ha/ 5 month). A similar trend was noticed in the production of *C. cirrhosus* and *L. calbasu* where T₃ had the highest carp production rate (Table 47). The species-wise growth trend curve under different treatments showed significant variations ($p < 0.05$) among the treatments at 30 days and thereafter (Fig 15). The maximum weight gain was found in *G. catla* (1313.0 ± 3.61 g) and then *L. rohita* (1252.0 ± 6.24 g) in T₃ and minimum weight gained in *C. cirrhosus* (322.00 ± 7.94 g) in T₁. Significant variation ($p < 0.05$) was found among the treatments in terms of final weight, SGR, and survival rate (Table 47). The trend of higher survival rate was found with decreasing stocking density. It was observed that the survival rates were significantly higher ($p < 0.05$) in treatment T₃ compared to treatment T₁ and T₂, which contributed to higher yield. The yield under treatment T₃ was 129.21% and 110.96% higher than yield under treatment T₁ and T₂, respectively. This study elucidated that the feed conversion ratio (FCR) followed the decreasing order of T₁ (2.81 ± 0.07) > T₂ (2.46 ± 0.1) > T₃ (1.82 ± 0.05) and significantly differ ($p < 0.05$) among the treatments.

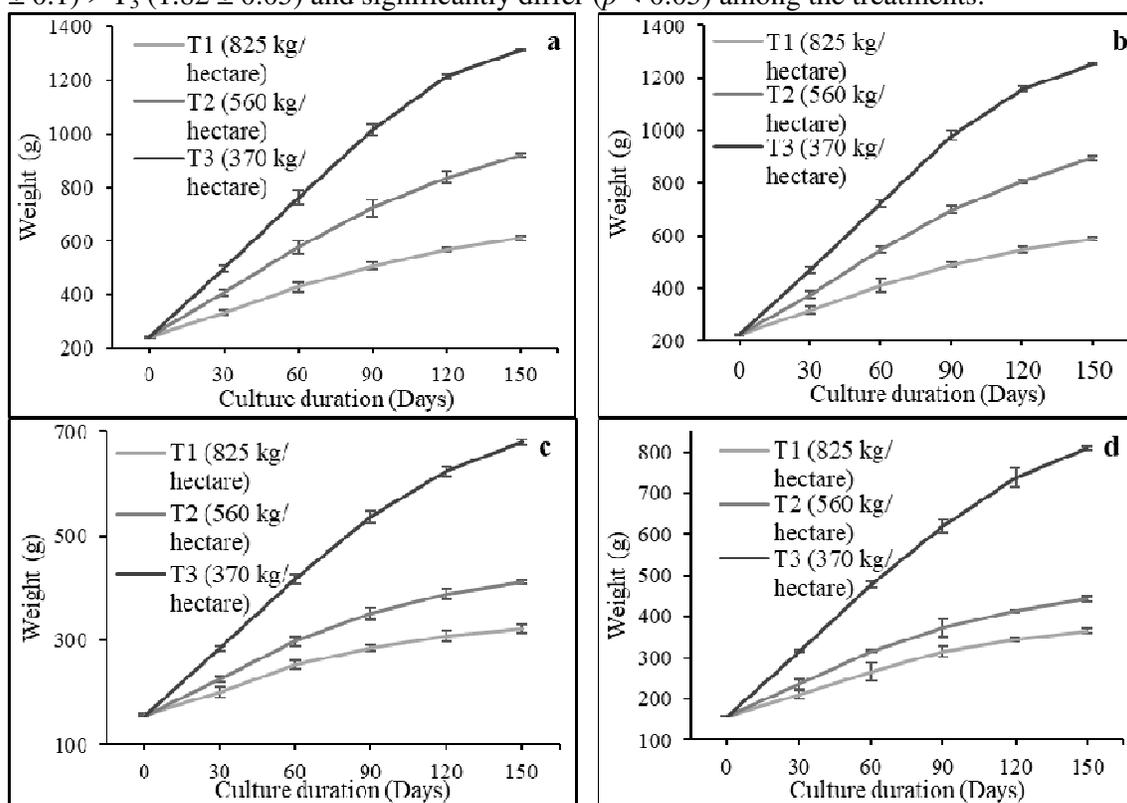


Fig 15. Growth trend of (a) *G. catla*, (b) *L. rohita*, (c) *C. cirrhosus*, (d) *L. calbasu* in different treatments.

Table 47. Growth and production of carp polyculture under different stocking density

Species	Treatment	Number of sp./ Ha	Average initial weight (g)	Average final weight (g)	SGR (%/day)	Fish production Kg/ Ha/ 5 month	Survival rate (%)
<i>G. catla</i>	T ₁	1300	242.00 ± 2.65 ^a	611.33 ± 9.45 ^a	0.62 ± 0.01 ^a	658.16 ± 37.16 ^a	82.78 ± 3.52 ^a
	T ₂	1000	243.67 ± 1.53 ^a	920.00 ± 7.00 ^b	0.89 ± 0.01 ^b	791.31 ± 28.56 ^b	86.02 ± 3.49 ^a
	T ₃	700	243.33 ± 1.53 ^a	1313.0 ± 3.61 ^c	1.12 ± 0.004 ^c	846.17 ± 18.32 ^c	92.07 ± 1.15 ^b
	<i>F</i>	-	0.6	7355	2224	37.14	7.729
	<i>P</i>	-	0.579	<0.001	<0.001	<0.001	0.022
<i>L. rohita</i>	T ₁	1300	222.67 ± 2.08 ^a	589.33 ± 6.03 ^a	0.65 ± 0.01 ^a	623.1 ± 32.51 ^a	81.31 ± 3.61 ^a
	T ₂	1000	224.67 ± 3.51 ^a	896.33 ± 8.08 ^b	0.92 ± 0.01 ^b	763.22 ± 51.45 ^b	85.19 ± 6.42 ^{ab}
	T ₃	700	223.33 ± 1.53 ^a	1252.0 ± 6.24 ^c	1.15 ± 0.01 ^c	805.98 ± 11.16 ^b	91.94 ± 1.21 ^{bc}
	<i>F</i>	-	0.4912	9174	1549	21.51	4.677
	<i>P</i>	-	0.635	<0.001	<0.001	0.002	0.06
<i>C. cirrhosus</i>	T ₁	650	156.67 ± 2.89 ^a	322.00 ± 7.94 ^a	0.48 ± 0.02 ^a	167.93 ± 2.8 ^a	80.25 ± 0.94 ^a
	T ₂	500	155.33 ± 0.58 ^a	411.89 ± 3.75 ^b	0.65 ± 0.004 ^b	170.5 ± 4.34 ^a	82.8 ± 2.33 ^a
	T ₃	350	155.67 ± 1.15 ^a	675.33 ± 4.51 ^c	0.98 ± 0.002 ^c	216.63 ± 1.63 ^b	91.13 ± 0.78 ^b
	<i>F</i>	-	0.433	3087	1889	230.7	42.16
	<i>p</i>	-	0.667	<0.001	<0.001	<0.001	<0.001
<i>L. calbasu</i>	T ₁	650	159.00 ± 1.73 ^a	365.67 ± 5.03 ^a	0.56 ± 0.01 ^a	200.91 ± 2.72 ^a	84.53 ± 0.87 ^a
	T ₂	500	158.67 ± 1.53 ^a	443.42 ± 7.42 ^b	0.69 ± 0.02 ^b	196.55 ± 18.78 ^a	88.58 ± 7.23 ^{ab}
	T ₃	350	158.50 ± 1.32 ^a	808.67 ± 3.51 ^c	1.09 ± 0.01 ^c	263.4 ± 2.63 ^b	93.07 ± 1.25 ^{bc}
	<i>F</i>	-	0.08235	5433	1990	34.29	3.003
	<i>P</i>	-	0.922	<0.001	<0.001	<0.001	0.125

Figures bearing common letter (a, b, c) in a column as superscript do not differ significantly (*p* <0.05)

In this study, an inverse relationship was detected between fish growth and stocking density. Overstocking density led to a reduction in average weight gain, thus a decrease in the final fish production. This happens due to a decrease in the availability of free space for the individual which causes trauma on fish and therefore increases energy expenditure. Besides, overstocking density can distress feed uptake as well as conversion efficiencies in fish (Ellis et al., 2002). These phenomena were also proven in the experiment of Chattopadhyay et al. (2013), Mane et al. (2019), Yengkokpam et al. (2020) which fully supported our findings. Maximum weight gain and survival rate was observed in lower stocking densities which might be due to less competition for feed and space among fishes. On the contrary, a lower survival rate was documented in T1 which also clarifies the effect of feed competition and stocking abundance on the survival percentage. These findings were supported by Mane et al. (2019), Marengoni (2006), Sharma and Chakrabarti (2003) where higher stocking density of carps showed lower SGR and survival rate. The survival percentage of this experiment was comparatively better than the study conducted by Kohli et al. (2002). Present findings specified that the value of FCR was increased with the increasing stocking density. Similar phenomena have also been reported by Chattopadhyay et al. (2013), Sharma and Chakrabarti (2003).

11.9.1.2 Economics of the fish culture

During study period (150 days) total cost, return, net benefit and CBR significantly ($p < 0.05$) varied from 2288.26 ± 6.23 (T₃) to 3578.82 ± 15.14 (T₁) USD ha⁻¹, 3928.82 ± 110.54 (T₁) to 5076.61 ± 8.28 (T₃) USD ha⁻¹, 350 ± 123.49 (T₁) to 2788.35 ± 10.26 (T₃) USD ha⁻¹ and 0.1 ± 0.04 (T₁) to 1.22 ± 0.01 (T₃), respectively (Table 48). Total cost was found lowest in treatment T₃, but net benefit and CBR were found highest in treatment T₃ (Table 48). This study revealed that the total cost was enhanced with the increasing stocking density. This may occur due to a higher operating charge (mostly for fingerlings and feed prices). On the other hand, the higher yield was recorded from lower stocking density which may be attributed to a higher survival rate at lower stocking density. Therefore, net return was significantly higher at T₃ than T₁ and T₂. Contrastingly, the net benefit was reported higher at over stocking density of *Pangasius bocourti* (Jiwyam, 2011) and *Clarias gariepinus* (Hengsawat et al., 1997) which is attributed by tolerance of much crowding stress with poor water quality compared to carps, these can grow in overstocking density.

11.9.1.3 Water quality parameters

Water quality parameters varied slightly across the treatments (Table 49). The mean values of water pH, salinity, DO, transparency, and temperature ranged from 8.02 ± 0.15 to 8.09 ± 0.13 , 0.14 ± 0.02 psu to 0.15 ± 0.04 psu, 5.08 ± 0.26 mg/L to 5.2 ± 0.25 mg/L, 35.74 ± 1.36 cm to 36.54 ± 1.76 cm, and 26.35 ± 0.63 °C to 26.67 ± 0.49 °C, respectively among the treatments. During the 5-month culture period, the pH of water varied within a range of 7.50–8.28 with higher values (> 8.00) recorded from the middle of November to December (4th to 5th month of culture). Water temperature along with dissolved oxygen in each pond varied monthly. The concentration of nitrate varied from 5.51 ± 3.56 mg/L to 5.93 ± 3.54 mg/L among the treatments whereas phosphate and sulphate differ from 0.3 ± 0.03 to 0.35 ± 0.07 and 0.14 ± 0.02 to 0.27 ± 0.41 , respectively (Table 49). Water quality parameters among treatments denoted no improvement or decline in water quality due to different stocking in diverse treatments. The water quality parameters in each pond and month may vary due to the temporal variation (Das et al., 2018; Yengkokpam et al., 2017). The water temperature was recorded highest in October and lowest in December which supported the findings of Yengkokpam et al. (2020). However, the observed water quality parameters were found to be

non-toxic and acceptable for tropical fish culture (Alabaster and Lloyd, 1982; Boyd and Tucker, 1998; Dulic *et al.*, 2010).

11.9.2 Carp-based polyculture for homestead pond stocked with wild and hatchery seed

11.9.2.1 Fish growth assessment

Significant variations ($p < 0.05$) were found among the three treatments in terms of weight gain, final weight, and SGR during carp polyculture (Table 50). Weight variation of the harvested fishes influence due to availability of food, species type according to choose and frequency of feeding and the collaborations among species (Habib *et al.*, 2003). The survival rates of *L. rohita* (85.42%), *C. mrigala* (81%) and *C. catla* (80%) as described by Mamun and Mahmud (2014) was more or less similar to the present study. The yield and FCR of four IMCs fish species from different sources have summarized in Table 51. Halda river seeds had a lower FCR (1.65 ± 0.10) than the hatchery seed sources, T_2 (1.83 ± 0.20) and T_1 (1.92 ± 0.22). The yield of total fish also varied significantly ($p < 0.05$) from 1686.36 ± 129.92 (T_3) to 1376.78 ± 112.64 (T_1) kg/ha/6month during present study. The higher yield of wild seed supplies also means that this species is more capable of resisting stressors (e.g. low dissolved oxygen or disease) than seeds from hatchery sources. In addition, growth and yield have medium to high heritability for some native Indian major carp species, indicating that a large-scale selection program for these species could achieve improvements in culture efficiency.

11.9.2.2 Economics of the fish culture

The mean total cost varied from 177906.50 ± 17045.98 (T_1) to 196396.2 ± 3875.56 (T_3) BDT ha^{-1} 6-month $^{-1}$. The net half yearly total return (BDT ha^{-1}) and net benefit significantly ($p < 0.05$) varied from 351312 ± 24592.93 (T_1) to 410427.2 ± 26042.5 (T_2) and 173405.20 ± 9170.60 (T_1) to 228307.30 ± 22651.30 (T_2), respectively (Table 52). The CBR among the treatments was varied from 0.97 ± 0.08 (T_1) to 1.25 ± 0.10 (T_2) respectively. Total cost was found higher in treatment T_3 than other treatments, and CBR were found highest in treatment T_2 . The results clearly showed that, in terms of fish growth, and fish production, carp polyculture of wild seeds performed better than hatchery seed production. Current findings were supported the results of Shah (2010) who found relatively low rate of growth of hatchery-seed than wild sources and also with Biswas *et al.* (2008) who observed best performances in polyculture research of wild sourced carp seeds (Halda River seeds) over carp seeds produced by hatchery. Due to the higher price of wild seed and transportation cost, the CBR was recorded lower in case of wild seed, therefore, the farming of Indian major carp species from hatchery seeds is more viable and profitable in the coastal homestead ponds, Bangladesh.

11.9.2.3 Water quality parameters

The mean values of water pH, salinity, DO, transparency, temperature, TDS, and conductivity ranged from 7.72 ± 0.29 to 7.87 ± 0.20 , 0.15 ± 0.02 psu to 0.16 ± 0.05 psu, 5.11 ± 0.20 mg/L to 5.2 ± 0.18 mg/L, 30.16 ± 2.29 cm to 32.96 ± 2.06 cm, and 23.68 ± 2.52 °C to 23.86 ± 2.87 °C, 285.15 ± 21.74 mg/L to 306.53 ± 36.02 mg/L, and 570.38 ± 43.42 mg/L to 613.17 ± 72.06 mg/L respectively among the treatments (Table 53). The mean water quality parameters in present study were more or less closer to other studies (Alam *et al.*, 2002; Hossain *et al.*, 2008; Ahmad *et al.*, 2013) and also acceptable range for fish farming (Alikunhi, 1957; Boyd, 1998).

Table 48. Economics of carp polyculture at different stocking density

Parameters	Treatment			<i>F</i>	<i>p</i> value
	T ₁	T ₂	T ₃		
Cost items					
Lime	71.43 ^a	71.43 ^a	71.43 ^a	–	–
Fertilizer	47.62 ^a	47.62 ^a	47.62 ^a	–	–
Fish seed	1505.41 ± 2.79 ^a	1411.11 ± 4.9 ^b	977.15 ± 2.43 ^c	18500	<0.001
Feed	1954.37±12.4 ^a	1597.22 ± 9.09 ^b	1192.07±3.83 ^c	5221	<0.001
Total cost	3578.82±15.14 ^a	3127.38±13.92 ^b	2288.26±6.23 ^c	8357	<0.001
Return					
Total return	3928.82±110.54 ^a	4575.2±156.41 ^b	5076.61±8.28 ^c	81.08	<0.001
Net benefit	350±123.49 ^a	1447.82±145.5 ^b	2788.35±10.26 ^c	364.5	<0.001
Cost-benefit ratio	0.10±0.04 ^a	0.46±0.05 ^b	1.22±0.01 ^c	808.7	<0.001

Figures bearing common letter (a, b, c) in a row as superscript do not differ significantly ($p < 0.05$)

Table 49. Water quality parameters in different stocking density

Parameter	Unit	Treatments			F	p value
		T ₁	T ₂	T ₃		
pH	-	8.05 ± 0.09 ^a (7.87–8.17)	8.09 ± 0.13 ^a (7.75–8.28)	8.02 ± 0.15 ^a (7.5–8.21)	2.486	0.089
Salinity	psu	0.14 ± 0.03 ^a (0.09–0.2)	0.15 ± 0.04 ^a (0.07–0.21)	0.14 ± 0.02 ^a (0.10–0.18)	2.54	0.08
DO	mg/L	5.08 ± 0.26 ^a (4.65–5.61)	5.1 ± 0.23 ^a (4.7–5.56)	5.2 ± 0.25 ^a (4.68–5.59)	2.031	0.1386
Transparency	cm	36.2 ± 1.51 ^a (32–38.5)	35.74 ± 1.36 ^a (32–37.8)	36.54 ± 1.76 ^a (32–38.5)	2.194	0.117
Water temperature	°C	26.35 ± 0.63 ^a (25.3–27.3)	26.67 ± 0.49 ^a (25.58–27.23)	26.53 ± 0.67 ^a (25.38–27.5)	2.334	0.1023
Nitrate	mg/L	5.75 ± 3.39 ^a (1.23–8.90)	5.93 ± 3.54 ^a (1.25–8.8)	5.51 ± 3.56 ^a (0.71–7.95)	0.03	0.97
Phosphate	mg/L	0.3 ± 0.03 ^a (0.27–0.36)	0.35 ± 0.07 ^a (0.29–0.45)	0.33 ± 0.03 ^a (0.29–0.35)	2.16	0.14
Sulphate	mg/L	0.14 ± 0.02 ^a (0.12–0.16)	0.27 ± 0.41 ^a (0.12–1.35)	0.19 ± 0.1 ^a (0.13–0.42)	0.72	0.5

Figures bearing common letter (a, b, c) in a row as superscript do not differ significantly ($p < 0.05$)

Table 50. Growth and production of fishes under different sources of fish seeds

Species	Treatment	Number of sp./ Ha	Average initial weight (g)	Average final weight (g)	SGR (%/day)	Weight gain (g)	Survival rate (%)
Catla	T1	878	130.49±7.31 ^a	889.23±62.39 ^a	1.06±0.011 ^a	758.74±55.56 ^a	77.78±6.93 ^a
	T2	870	136.88±5.55 ^a	10096.14±27.9 ^b	1.11±0.01 ^b	872.26±23.14 ^b	82.78±2.54 ^a
	T3	823	137.40±0.76 ^a	1117.92±41.16 ^c	1.16±0.012 ^c	980.51±40.42 ^c	90.11±4.83 ^a
	F	-	1.57	18.5	45.21	21.05	4.44
Rui	P	-	0.28	0.002	<0.001	0.001	0.06
	T1	988	110.79±1.30 ^a	804.21±7.58 ^a	1.1±0.01 ^a	693.42±7.67 ^a	75.11±8.33 ^a
	T2	823	120.83±1.93 ^b	956.49±12.42 ^b	1.15±0.01 ^b	835.66±13.40 ^a	74.11±12.27 ^{ab}
	T3	823	115.93±1.01 ^c	1039.94±17.09 ^c	1.19±0.035 ^{bc}	924.01±18.08 ^a	91.44±4.07 ^b
	F	-	34.88	255	14.67	215.4	3.60
	P	-	<0.001	<0.001	0.005	<0.001	0.09
Mrigal	T1	660	120.46±3.04 ^a	665.10±13.16 ^a	0.95±0.04 ^a	544.63±11.16 ^a	74.50±5.77 ^a
	T2	658	117.95±1.98 ^a	643.19±6.16 ^a	0.96±0.02 ^{ab}	525.24±8.06 ^a	72.91±8.99 ^{ab}
	T3	659	118.85±1.04 ^a	766.04±14.34 ^a	1.06±0.03 ^c	647.19±13.33 ^{bc}	92.85±6.90 ^c
	F	-	1.02	92.64	12.62	105.2	6.82
	P	-	0.41	<0.001	0.007	<0.001	0.03
Kalibaus	T1	658	116.39±3.35 ^a	701.87±15.20	1.07±0.01 ^a	585.48±12.38 ^a	77.78±2.67 ^a
	T2	660	118.55±2.31 ^a	758.61±14.43	1.03±0.02 ^b	640.06±13.48 ^b	86.81±7.87 ^{ab}
	T3	658	119.56±0.65 ^a	806.72±6.95	1.00±0.015 ^{bc}	687.15±7.60 ^c	94.77±2.34 ^b
	F	-	1.38	50.8	17.65	59.27	8.71
	P	-	0.31	<0.001	0.003	<0.001	0.01

Figures bearing common letter (a, b, c) in a column as superscript do not differ significantly ($p < 0.05$)

Table 51. Fish yield (kg/ha/6month) and FCR in different sources of fish seeds.

Species	Fish yield (kg/ha/6month)			F	p value
	T ₁	T ₂	T ₃		
<i>Gibelion catla</i>	352.35±151.90 ^a	598.77±67.84 ^a	559.65±86.28 ^a	4.49	0.06
<i>Labeo rohita</i>	468.20±67.24 ^a	478.65±94.24 ^{ab}	589.77±12.07 ^{bc}	3.01	0.12
<i>Cirrhinus mrigala</i>	149.41±91.26 ^a	169.12±57.21 ^a	217.03±78.37 ^a	0.61	0.57
<i>Labeo calbasu</i>	205.60±61.81 ^a	338.29±69.66 ^{ab}	319.90±3.86 ^{bc}	5.35	0.05
All species	1376.78±112.64 ^a	1584.85±126.53 ^{ab}	1686.36±129.92 ^{bc}	4.91	0.05
FCR	1.92±0.22 ^a	1.83±0.20 ^a	1.65±0.10 ^{bc}	5.35	0.04

Figures bearing common letter(s) in a row as superscript do not differ significantly ($p < 0.05$)

Table 52. Economics of carp polyculture stocked from different sources

Parameters	Treatment			F	p value
	T ₁	T ₂	T ₃		
Cost					
Lime	6000 ^a	6000 ^a	6000 ^a	–	–
Fertilizer	4000 ^a	4000 ^a	4000 ^a	–	–
Fish seed	98977.87 ± 6416.57 ^a	96461.59 ± 3773.91 ^a	99899.43 ± 1189.90 ^a	0.50	0.62
Feed	68928.62 ± 10665.44 ^a	75658.30 ± 6357.54 ^a	86496.78 ± 3358.66 ^a	4.27	0.07
Total cost	177906.50±17045.98 ^{ac}	182119.9±3400.69 ^c	196396.2±3875.56 ^a	2.26	0.15
Return					
Total return	351312±24592.93 ^a	410427.2±26042.5 ^b	392028.3±27161.81 ^{ab}	4.07	0.07
Net benefit	173405.20±9170.60 ^a	228307.30±22651.30 ^{bc}	195332.10±28544.78 ^{ab}	4.87	0.05
Cost-benefit ratio	0.97 ± 0.08 ^a	1.25 ± 0.10 ^b	1.00 ± 0.15 ^{ab}	5.40	0.04

Figures bearing common letter(s) in a row as superscript do not differ significantly ($p < 0.05$)

Table 53. Water quality parameters in different sources of fish seeds

Parameter	Unit	Treatments			F	p value
		T ₁	T ₂	T ₃		
pH	-	7.98±0.26 ^a (7.3-8.35)	7.72±0.29 ^b (7.2-8.3)	7.87±0.20 ^c (7.3-8.21)	9.68	0.00013
Salinity	psu	0.15±0.04 ^a (0.08-0.24)	0.16±0.05 ^a (0.07-0.29)	0.15±0.02 ^a	0.929	0.397
DO	mg/L	5.12±0.24 ^{ab} (4.69-5.61)	5.11±0.20 ^a (4.7-5.56)	5.20±0.18 ^b (4.90-5.59)	2.093	0.13
Transparency	cm	30.16±2.29 ^a (25.5-33.2)	32.96±2.06 ^a (28.5-35.5)	30.76±2.04 ^a (25.9-33.8)	18.53	<0.001
Water temperature	°C	23.68±2.52 ^a (18.2-26.1)	23.86±2.87 ^a (18.4-26.55)	23.68±2.80 ^a (18.5-26.7)	0.05	0.94
TDS	mg/L	285.15±21.74 ^a (244-333)	299.10±28.30 ^b (256-353)	306.53±36.02 ^{bc} (260-400)	5.36	0.005
Conductivity	µS/cm	570.38±43.42 ^a (488-666)	598.30±56.60 ^b (512-706)	613.17±72.06 ^{bc} (520-800)	5.37	0.005

Figures bearing common letter (a, b, c) in a row as superscript do not differ significantly ($p < 0.05$)

12. Research highlight

Research highlight : 01

Title: *Development of nutrient information rich BCC tools and to generate information on micronutrients, type and level of contaminants in commonly used rice varieties*

Background

Addressing of malnutrition and food safety issues are bonding by many interrelated factors those determine the effectiveness of the approach and the ultimate results that enjoyed by the beneficiaries. In case of our country, the major causative factor of malnutrition is not only the shortage of food but other factors like food distribution and intake habit, food safety, knowledge about food nutrition and age and health condition-based nutrition requirement for human and food processing methods, as well. In other cases, type and degree of presence of contaminants and micronutrients in foods, particularly in staple foods also plays an important role in establishing food security and food safety measures. Therefore, adequate and continuous research on nutrients of food items, their consumption categorization as per growing stages and in other vital stages of development and safe processing method and information on micronutrients, heavy metals and other contaminants is important.

Objectives

- Development of a nutrition information rich tool (*Behaviour Change Communication: the BCC tool*) to focus the nutritional requirement and sources for selected categories of people (Child, adolescent girls, lactating mother and pregnant women) and safe method of food processing, that will ultimately increase the knowledge and awareness of the beneficiaries.
- Generation of information on micronutrients and type and level of contaminants (heavy metals) in commonly used rice varieties.

Methodology

BCC tool development

Generation and gathering of information done through survey research by using a structured questionnaire and review of literatures for development of nutrition information rich BCC/SBCC tools for disseminating information to the children's, adolescent girls, lactating mothers and pregnant women for up-scaling malnutrition.

Micronutrient study of rice varieties

Micro-nutrients compositions of 11 normal and fermented rice varieties like BRRI dhan 28, Najir, Pari, Miniket, Biroi, Aush, Tepi Boro, Guti, Sorna, Aman and Red Balam were analysed for Calcium (Ca), Iron (Fe), Potassium (K) and Sodium (Na) and to understand the level of contents under the changing fermentation process. All the analysis were done in triplicate in the accredited lab of SGS Bangladesh. Test method followed as per AOAC (20th Edt.2016) by ICP-OES/MS considering an amount sample quantity of 300gm in each case.

Heavy metal analysis of rice varieties

Locally available thirteen varieties of rice samples were collected from different retail and wholesale markets of Dhaka city for detection and quantification of selected heavy metals

such as As, Cd, Cr and Pb. Sample preparation and analysis were conducted in the laboratory of SGS Bangladesh following the standard methods.

Key findings

- The BCC tool (plate) developed covered various categories of food items from energy provider to growth and development accelerator to disease resistance/immunity developer food items for all categories of age group people.
- Increase in Ca content was observed higher in fermented BRRI dhan 28, Pari, Miniket and in Balam Red samples. Highest amount of increase in Ca concentration (352%) recorded in Miniket. While for all other samples of rice, fermented samples exhibit decreasing values (from 4.25 -63.74%). In case of Fe, increased amount was recorded for BRRI dhan 28, Pari, Miniket and Guti fermented rice samples (4.35-55.83%). While the other fermented rice samples showed decrease in Fe content that varied from 5.67 – 64.49%. Potassium (K) content in all the fermented rice samples showed decreasing concentration than in normal rice samples. The value for fermented samples were varied between 34.40 -89.58%. Except for BRRI dhan 28, Miniket and Aush rice all other fermented rice samples exhibits decreasing tendency for Na content in fermented form and the values varied between 5.91 – 295.43%.
- Presence of heavy metals (As, Cd and Cr) concentration of in all the sampled varieties are below the recommended level of FAO/WHO/EU. In case of Pb, only one sample of rice (Kohinoor Bashmati Rice) showed higher concentration (0.48 ppm) than the recommended level (0.20ppm).

Key words : BCC tool, Nutrition, Rice, Fermented, Micronutrients, Heavy metals

Research highlight: 02

Title: *To improve household food security, income generation and nutrition of the rural poor through improve household agro-processing, preservation, value addition and marketing.*

Background

Malnutrition is truly the “hidden disaster” which continues to hold back economic development in Bangladesh. In Bangladesh about 31.5% of the population is living below the poverty line and a big portion of them is also below the “hardcore” poverty line that is called ultra poor and the rate of it is 7.7%. More than 60% of all children are either undernourished or malnourished, and the average height of the population in Bangladesh is decreasing. Thus nutritional intake is even more important. The big task ahead is to make food available in sufficient quantities and with sufficient nutritional value. The concern is whether the food available is nutritious or not. Cereals provide calories needed for energy, and some protein, but they fail to provide the balanced diet needed to eliminate malnutrition. Availability of other foods such as fruits and vegetables, fish, pulses, oilseeds, poultry and livestock needs to increase and to provide balance to Bangladesh diets.

Therefore, a food-based initiative to improving nutrition for household food security in Bangladesh should be undertaken with a long-term goal for sustainable improvement of food and nutrition of the rural poor. Considering the above issues, the sub-project is designed to implement in Khagrachari and Noakhali district. The eastern hill district Khagrachari and the

southern coastal *charlands* of Noakhali district are comparatively less developed area due to natural position and agro-ecosystem, low level of management in agriculture, migratory nature of people and distance form headquarters of development agents. Modern agricultural technological intervention with adequate input and effective management through crop diversification and intensification would create opportunities for higher productions and income. Similarly, diversification and integration of livestock and fisheries enterprises would give higher production and income with modern breeds/species, inputs and management practices.

Objectives

- i) To improve household food security, income generation and nutrition for the rural poor.
- ii) To improve household ago-processing, preservation, value addition and marketing optimizing income.
- iii) To ensure awareness building on nutrition, environment conservation and gender issues among the poor.
- iv) To ensure improved capability in developing technology and research/extension on balanced dietary intake, eradication of nutritional deficiency diseases and generation of nutritional database.

Objective wise highlights

Objective 1. To improve household food security, income generation and nutrition for the rural poor.

Methodology

The sub-project activities of BLRI component was implemented in different topographic locations one is Kalapani and Kaminipara (both sites called as panchmile) under 4 no. Perachara union and another is Munigram, Robijoy Para, Chittaranjan Para and Porchim Muslim Para under 5 no. Vaibonchara union of Khagrachari Sadar Upazila of Khagrachari district. In Khagrachari, on the basis of the PRA result total number of 60 households was selected purposively from two locations of which 30 households from each. A short PRA and baseline survey of the household was conducted. To achieve the goal and objectives of the sub-project whole activities of the BLRI Component was divided into two parts: one was Component Research Programme and another was Component Development Programme. The Component Research Programme was focused on two issues (a) household food security and (b) dietary intake status of selected households. The Component Development Programme was emphasis on technology dissemination through technological intervention on the basis of the resource's allocation of selected households' technological intervention was developed. So, to achieve this objective, the sub-project had ensured the year-round food availability through production and purchase of different inputs (crop, vegetables, livestock & fisheries as per capacity). Then it was calculated the age and sex wise energy status improvement along with the improvement of nutrient deficiency and income from divercified sources of the households.

Key findings

- i. Average gross margin farm⁻¹ year⁻¹ of marginal, small and medium farms were increased 341%, 96% and 261% for monigram site and 248%, 118% and 58% for panchmile site, respectively over inception year.
- ii. Changed the cropping pattern, cropping system, diversified food consumption (65%)
- iii. Overall findings indicated that efficiency of productivity increase was the highest in medium farm.
- iv. BCR increased after intervention because of intensification of enterprises which indicated the household security increased over initial year.
- v. The additional income was spent for purchases food, health care, education, repayment of loan, land rent in, inputs for farming activities etc.
- vi. The level of food security of was secured on the basis of consumption of cereals and the percentages were 171.34 and 162.52, respectively in both before and after intervention.
- vii. The level of food security of cereal was decrease 20.35 percentage after intervention due to increase the consumption of other food items specially vegetables.
- viii. It was also found that 78 percent farmers produced rice of which 45 percent farmers were secured in terms of production. It indicated that the level of food security of the majority farmers (55 percent) was not secured on the basis of production.
- ix. The study also revealed that findings of the level of food security of vegetables, fish, potato and spices was secured and their percentage were 218.38, 103.45, 122.75 and 168.35, respectively while the level of food security the other food items such as pulses, milk, meat, egg, oil and sugar/gur were not secured though after intervention it was increased.

Key words: Ethnic people, Household food security, Nutrition, Consumption.

Objectives 2. To improve household ago-processing, preservation, value addition and marketing optimizing income.

Methodology

From a short PRA and baseline survey few households were selected. Some indigenous fruits (Papaya, Lemon, Malta, Bael, Wood apple, Safeda etc.) were cultivated by them. Training on pickle making, vegetable and seed production techniques, storage and preservation was given to the selected household. Farmers were recommended to sell their raw products mostly in front of the farmer's households and to communicate by the local Karber (local agent) for easy marketing.

Key findings

- The raw products harvested by the farmers were sold mostly in front of the farmer's households.
- The local Karber (local agent) are now communicating with the farmers which created easy marketing.
- As some fruits are long term fruits, so it was not possible to value add their production so far.

Key words: Preservation, Value addition, Marketing

Objectives 03. To ensure awareness building on nutrition, environment conservation and gender issues among the poor

Methodology

Nutrition based knowledge and nutritional awareness related meeting and trainings were arranged with the selected households. To avoid the use of organic manure, excessive use of fertilizers, little or no use of pesticides, farmers were trained to make compost by household wastage with livestock manure. Profitable price of raw and value-added products for sale was ensured through effective linkage development between the market operators and producers, karbari (local name), etc.

Key findings

- Some modern agricultural technologies (Drip Irrigation, Using Pheromone, Mulching etc) were started to use by the farmers
- Almost all farmers started to make compost using household wastage and livestock manure
- Profitable price of raw and value-added products for sale was ensured

Key words: Nutrition, Environment conservation, Agricultural technologies, Household wastage, Livestock manure

Objectives 4. To ensure improved capability in developing technology and research/extension on balanced dietary intake, eradication of nutritional deficiency diseases and generation of nutritional database.

Methodology

Some year-round vegetables, rare and new technologies were introduced to the farmers to increase their income and dietary intake. Awareness building campaign on nutrition, nutritional deficiency diseases were arranged throughout the year.

Key findings

- Red Lady papaya and yard long bean production were an outstanding performance in project site.
- Some of the farmers show their interest to establish the papaya orchard.
- It empowers the women and creating employment opportunity.

Key words: Balanced diet, Nutritional deficiency, Red lady papaya, Yard long bean.

Research highlight: 03

Title: Assess current nutritional status of coastal household's families

Background

Malnutrition remains to be the foremost public health problems in Bangladesh. Infectious diseases like acute respiratory diseases and diarrheal diseases are responsible for most

nutrition-related health problems in this country. Due to malnutrition, anemia probably is another major public health issue in all developing countries. As per Bangladesh Demographic and Health Survey (Biswas et al., 2008) report, 29.1%, males were underweight, overweight and 3% obese. Recently in Bangladesh, to meet the nutritional demand of Sustainable Development Goals (SDG) there has been making an attempt in reducing malnutrition problems.

Objective

To assess current nutritional status of coastal household's families and facilitate them to better nutrition standard in family-based diet.

Methodology

A draft questionnaire was developed and pre-tested with a few pond fish farmers before collecting primary data. The questionnaire included anthropometric characteristics (Height, weight, MUAC), anaemia prevalence (Hb level) and socio-demographic (Sex, age, religion, education, annual income) characteristics of the pond fish farmers. Height and weight was measured using ideal height and weight measuring scale. Nutritional health condition was calculated by Body Mass Index (BMI), Mid-Upper Arm Circumference (MUAC). Anaemia prevalence was assessed by determining the haemoglobin level (gdl-1) according to (WHO, 1992; WHO, 2001) using Hemoglobin analyzer (HemoCue Hb 201+).

Key findings

Body mass index (BMI) increased in normal health condition from 42% to 58% among men, 36% to 68% among women and 48% to 55.5% among children. The mid-upper arm circumference (MUAC) indicates the successive improvement of health status. The prevalence of mild anaemia decreased from 79% to 47% among men and 93% to 79% among women of beneficiary families. It proved that fish culture greatly impacted the nutritional and health status of homestead pond farmers of Noakhali by reducing malnutrition.

Key words: Nutritional status, Body mass index, Anaemia, Fish culture.

Research highlight: 04

Title: Enhance income generation capacity of housewives through family approach

Background

Most of the households in rural Bangladesh own a small pond adjacent to their homestead. Approximately 20% of rural households which implies 4.27 million households hold a pond, occupying an area of 266,259 ha, is prevalent for aquaculture throughout Bangladesh. Importantly, ponds adjacent to the homestead offer an ideal opportunity for women to engage and participate in fish culture. These ponds play a very crucial role in providing both household income generation through fish production and fish for family consumption and nutrition supply, which performs 3 to 15% of total household income and 25%–50% of total fish consumption.

Objective

To enhance income generation capacity of housewives through whole family approach by opportunistic employment.

Methodology

Farmers of low-income and landless households, each own a homestead ponds in their households, which can be utilized for income generating capacity of housewives were selected by union chiefs. The selected housewife farmers were provided with aquaculture supplies (fish seed, fish feed, fertilizer, lime), technical supports, and management assistance for homestead pond fish culture as a source of household income.

Key findings

Consumption of fish as a major source of animal protein is mainly depends upon financial ability of the family (income generation) as well as production, access and distribution. The households with homestead pond consumed 1.2 times more fish (121.13 g/person/day) than the households with no ponds (99.82 g/person/day). Fish consumption was almost doubled after completion of three culture cycles with a gradual increase from 59.57 g/person/day to 120.10 g/person/day.

Key words: Fish consumption, Income generation, Homestead ponds, Culture cycle.

Research highlight: 05

Title: To convert under-utilized water bodies to productive aquaculture system as a potential source of family nutrition

Background

The aquaculture sector plays an important role in the socio-economic development (Chowdhury et al. 2007), nutrition supply, employment generation, poverty alleviation and foreign exchange earnings of the Bangladesh. The major parts of coastal districts of Bangladesh are characterized by the presence of underutilized and low productive aquaculture ponds and seasonal water bodies. In central coastal region of Bangladesh, there are thousands of homestead ponds covering an area of 1,068 ha with fish production of 1,438 MT (DoF 2005) that implies lower fish production as extensive fish culture is mainly practiced depending on natural food (Akter et al. 2018).

Objective

To convert under-utilized water bodies to productive aquaculture system and enhance community based fish farming in coastal floodplain as a source of nutrition.

Methodology

All of the aquatic weeds were removed manually before the research starting as well as undesirable fish species and other species were removed from the pond by repeated netting. In addition, liming and fertilization was done to sustain good water quality for productive

ecosystem. To enhance community-based fish farming, a carp-based polyculture technology suitable for homestead ponds was developed through stocking of Indian major carps (IMCs) with various densities and from different sources (hatchery and wild).

Key findings

The specific growth rate was revealed highest at low stocking density (370 kg/ha). An inverse relationship was detected between fish growth, survival and stocking density where lower fish growth and survival rate were documented at higher stocking density in the case of all species. Besides, the highest net benefit (2788.35±10.26 USD) and cost-benefit ratio (1.22±0.01) also proved that carp polyculture at 370 kg/ha stocking density is more viable for coastal homestead ponds. Though the wild sourced seeds had lower FCR (1.65±0.10) and higher production (2687.07±140.68 kg/ha/6 month) than the hatchery seeds, but due to the higher price of wild seed and transportation cost, the CBR was recorded lower in case of wild seed.

Key words: Growth rate, Stocking density, Net benefit, Cost-benefit ratio.

B. Implementation Status

1. Procurement (component wise)

Coordination component: Not applicable

Component 1 (BLRI)

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (No.)	Financial (Tk.)	Physical (No.)	Financial (Tk.)	
(a) Office equipment					
a) Executive Table	2	40000	2	40000	
b) Executive Chair	2	20000	2	22000	
c) Visitor/front chair	8	32000	8	32000	
d) Steel almira	1	24000	1	25000	
e) Computer table	1	5000	1	8200	
f) Computer chair	1	3500	1	3500	
g) Book self	2	44000	2	36800	
	SubTotal	168500		167500	
(b) Lab & field equipment					
a) Digital camera	1	25000	1	50000	
b) Computer	2	120000	1	105000	
c) UPS	1	8000	1	6000	
d) Scanner	1	7000	1	6000	
e) Printer	1	20000	1	15000	
f) IPS	1	50000	1	65000	
g) Multimedia	1	70000	1	50000	
	SubTotal	300000		297000	
(c) Other capital items					
Motorcycle	1	200000	1	197900	
	SubTotal	200000		197900	
		608500		662400	

Component 2 (NSTU)

Description of equipment and capital items	PP Target		Achievement		Remarks
	Physical (No.)	Financial (tk)	Physical (No.)	Financial (tk)	
(a) Office equipment					
Executive table	1	20000	1	20000	
Executive chair	1	10000	1	10000	
Visitor/front chair	5	20000	5	20000	
Steel Almira	1	24000	1	24000	
Computer table	1	5000	1	5000	
Computer chair	1	3500	1	3500	
			Sub-total	82500	
(b) Lab & field equipment					
Multi-parameter portable water test kit (FF-2)	1	150000	1	134760	
Stero Microscope with camera	1	500000	1	447500	
Digital camera	1	25000	1	25000	
Laptop/computer	2	120000	2	120000	
Printer	2	40000	2	40000	
Portable projector	1	55000	1	53500	
Sediment grain analyzer	1	400000	1	400000	
Digital Microscope	1	30000	1	30000	
			Sub-total	1250760	
(c) Other capital items					
Motor cycle	1	170000	1	165000	
Bicycle	2	30000	2	30000	
Sub-total				195000	
Grand Total				1528260	

2. Establishment/renovation facilities**Coordination component**

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
1. Work Partition (2 inch. Aluminum profile with Fabric and glass) 2. Table top 3. Set up mobile drawer 4. Keyboard Tray	298800.00	298800.00	N/A	N/A	100% achievement

Component 1 (BLRI): Not applicable

Component 2 (NSTU)

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Phytoplankton identification	01	01	N/A	N/A	
Benthos & Zooplankton identification	01	01	N/A	N/A	
Anaemia (Hb) determination	01	01	N/A	N/A	

3. Training/study tour/ seminar/workshop/conference organized by the sub-project

Description	Number of participants	Duration (Days)			Remarks
		Male	Female	Total	
Coordination component					
Inception Workshop (1)	56	7	63	1 day	All workshops held at the Conference room of BARC as per schedule of activity of the Coordination component
Half yearly Research Prog. Review Workshop (2 no.)	65+62	9+8	144	1+1 = 2 days	
Annual Research Prog. Review Workshop (2 no.)	60+63	7+8	138	1+2 = 3 days	
Project Completion Report Review Workshop (1 no)	45	6	52	01 day	
Component-1: PSTU					
Others Awareness meeting – 04 No.	68	12	80	01 day	
Component-2: HSTU					
Not applicable					
Component 1 (BLRI)					
(a) Training					
1. Training on 'Production and Management Practices of Winter Vegetables' (04 nos.)	34	74	108	01 day	
2. Training on 'Improve Management Practice of Goat and Sheep Rearing' (02 nos.)	14	32	46	01 day	
3. Training on 'Poultry Management' (chicken, turkey, duck) (02 nos.)				01 day	
4. Training on 'Production and Management Practices of Watermelon' (01 no.)	3	5	8	01 day	
5. Training on 'Management Practices of Fruits Orchard' (02 no.)	16	25	41	01 day	

Description	Number of participants	Duration (Days)			Remarks
		Male	Female	Total	
6. Training on ‘Production and Management Practices of Onion’ (01 no.)	5	7	12	01 day	
7. Training on ‘Rearing and Management Practices of Honeybee’ (01no.)	1	3	4	01 day	
8. Training on ‘Seed Production and Seed Storage in Farmers Household’ (04 nos.)	28	84	112	01 day	
9. Training on ‘Household Nutrition and Food Security’ (01 no.)	06	36	42	01 day	
10. Training on ‘Production and Management Practice of Papaya’ (02 nos)	04	28	32	01 day	
11. Training on ‘Production and Management Practice of Potato’ (02 nos)	12	16	28	01 day	
12. Training on ‘Modern Techniques of Rice Production’ (01 no)	03	07	10	01 day	
(b) Workshop					
(c) Seminar on Nutrition & Health issues for Human (01 no)	36	68	104	01	Upazilla Porishod
(d) Monthly Awareness meeting on nutrition, balance diet, health and sanitation					Farmers homestead
Component 2 (NSTU)					
Training: Mapping research data using ARC GIS	5	15	20	02 days	Training for project staffs
Seminar					
মৎস্য চাষ, পুষ্টি ও স্বাস্থ্য বিষয়ক কর্মশালা	10	30	40	1 days	Sub-project beneficiaries
করোনা সংকটে পুষ্টি ও খাদ্যের চাহিদা পূরণে মৎস্য চাষের ভূমিকা	10	30	40	1 days	
মৎস্য চাষের অভিজ্ঞতা বিনিময় কর্মশালা	10	30	40	1 days	

C. Financial and Physical Progress

Combined 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	7323636	7135636	7009952	125684	95.72	
b. Field research/lab expenses and supplies	18126083	17522126	17521524	602	96.66	
c. Operating expenses	1684067	1510099	1451245	58854	86.18	
d. Vehicle hire and fuel, oil & maintenance	1796342	1713376	1587663	125713	88.38	
e. Training/workshop/ seminar etc.	621600	455400	455400	0	73.26	
f. Publications and printing	859100	844000	844000	0	98.24	
g. Miscellaneous	215721	212054	205525	6529	95.27	
h. Capital expenses	2489460	2495560	2489460	6100	100.00	
Total	33116009	31888251	31564769	323482	95.32	

Coordination component

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	2503650	2503650	2503650	0	100.00	Unspent money refunded to PIU, BARC
b. Field research/lab expenses and supplies	293942	293942	293942	0	100.00	
c. Operating expenses	139801	138556	138556	0	99.11	
d. Vehicle hire and fuel, oil & maintenance	404293	403496	403496	0	99.80	
e. Training/workshop/ seminar etc.	96600	96600	96600	0	100.00	
f. Publications and printing	474700	460100	460100	0	96.92	
g. Miscellaneous	68214	68180	68180	0	99.95	
h. Capital expenses	298800	298800	298800	0	100.00	
Total	4280000	4263324	4263324	0	99.61	

Component 1 (BLRI)

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	2937017	2753727	2628043	125684	89.48	Unspent money refunded to PIU, BARC
b. Field research/lab expenses and supplies	14677141	14073743	14073141	602	95.88	
c. Operating expenses	934266	893120	834266	58854	89.30	
d. Vehicle hire and fuel, oil & maintenance	892049	852762	727049	125713	81.50	
e. Training/ workshop/ seminar etc.	0	0	0	0	0	
f. Publications and printing	248400	248400	248400	0	100.00	

g. Miscellaneous	77507	74094	67565	6529	87.17	
h. Capital expenses	662400	668500	662400	6100	100.00	
Total	20428780	19564346	19240864	323482.00	94.19	

Component 2 (NSTU)

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	1882969	1878259	1878259	0	99.75	
b. Field research/lab expenses and supplies	3155000	3154441	3154441	0	99.98	
c. Operating expenses	610000	478423	478423	0	78.43	
d. Vehicle hire and fuel, oil & maintenance	500000	457118	457118	0	91.42	
e. Training/workshop/ seminar etc.	525000	358800	358800	0	68.34	Due to COVID-19 seminar couldn't be arranged
f. Publications & printing	136000	135500	135500	0	99.63	Unspent money refunded to PIU, BARC
g. Miscellaneous	70000	69780	69780	0	99.69	
h. Capital expenses	1528260	1528260	1528260	0	100.00	
Total	8407229	8060581	8060581	0	95.88	

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

General/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)
Component 1 (BLRI)			
To improve household food security, income generation and nutrition for the rural poor	<ul style="list-style-type: none"> • Creating homestead on farm rearing practice • Perform feeding trials • Monitoring health problems of animal • Evaluate animal production performances 	Farmers adopted this technology	Change the living status
To improve household agro-processing, preservation, value addition and marketing optimizing income	<ul style="list-style-type: none"> • Compare on-farm data to respective on-station data • Evaluate the benefit cost ratio through rearing hilly chicken & native sheep 	Year round income increased	Research outcomes may help to increase commercial hilly chicken and sheep farming under intensive or stall feeding system
To ensure awareness building on nutrition, environment	Awareness building campaign through training & others program	Farmers were motivated	Created additional income source

General/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)
conservation and gender issues among the poor			
To ensure improved capability in developing technology and research/extension on balanced dietary intake, eradication of nutritional deficiency diseases and generation of nutritional database	Evaluate the income & dietary status	Increase calorie intake	Proceeding publication
Component 2 (NSTU)			
Uncover the present status of carp polyculture and biological productivity of homestead pond as a potential source for family nutrition	<p>Present status</p> <ul style="list-style-type: none"> ➤ Participatory Research Approach (PRA) tools– <ul style="list-style-type: none"> • Focus Group Discussion (FGD) • Crosscheck Interviews (CI) <p>Biological productivity</p> <ul style="list-style-type: none"> • Sample collection by plankton net, mud-core • Steromicroscopic identification • Enumeration by Sedgwick- Rafter cell 	<p>Present status</p> <ul style="list-style-type: none"> ➤ Stocking density of carp was 11122 fingerlings/ha ➤ Fish production of homestead pond was 2350 kg/ha/yr ➤ Annual income from homestead pond was 472–650 USD <p>Biological productivity</p> <ul style="list-style-type: none"> ➤ 34 phytoplankton taxa was found with a mean of $165.27 \pm 29.51 \times 10^4$ cells/L ➤ 21 zooplankton taxa was observed with a mean of 50.99 ± 6.91 ind./L ➤ 15 benthos taxa recorded with a mean of 3630 ± 2883 ind./m² 	<ul style="list-style-type: none"> ➤ Awareness on fish farming among the homestead pond owner had been raised.
Assessment of the nutritional and health status of coastal rural people	<ul style="list-style-type: none"> • Fish consumption was measured by questionnaire survey • BMI was measured by weight and height • Anaemia was determined through haemoglobin level using a HemoCue (Hb 201) machine 	<ul style="list-style-type: none"> ➤ Fish consumption (person/day) was lower (59.57 g) before the culture cycle and increased (121.13 g) after the completion of culture cycle ➤ BMI status revealed increase in normal health 	<ul style="list-style-type: none"> ➤ Malnutrition slightly minimized ➤ Anaemic status slightly decreased ➤ Increased knowledge on nutritious diet

		<p>condition</p> <ul style="list-style-type: none"> ➤ Haemoglobin level stated decrease in Anaemic condition 	
<p>Know the fish diversity and determine the nutritional value of fishes available in the homestead ponds for estimating the contribution of fish in family nutrition as a potential source to minimize malnutrition</p>	<p>Fish diversity study</p> <ul style="list-style-type: none"> • Fish sample was collected using net or during harvesting • Fish were identified by morphometric and meristic counts <p>Nutrients</p> <ul style="list-style-type: none"> • Proximate analysis of 47 species was performed by Association of Official Analytical Chemists method • Minerals of 12 species was determined by Atomic absorption Spectrophotometry method • Fatty acids of 12 species was measured by Fatty Acid Methyl Ester method 	<ul style="list-style-type: none"> ➤ 52 fish species were recorded from the homestead ponds <p>Nutrients</p> <ul style="list-style-type: none"> ➤ Proximate– moisture: $75.65 \pm 2.69 \%$, protein: $14.70 \pm 1.38 \%$, lipid: $2.39 \pm 0.78 \%$, fibre: $0.91 \pm 0.56 \%$, ash: $3.71 \pm 1.22 \%$ and carbohydrate: $2.73 \pm 1.41 \%$. ➤ Minerals (mg/100 g)– Ca: 1663.39 to 3550.79, P: 1187.03 to 3713.38, Mg: 242.16 to 487.82, Fe: 13.57 to 38.12, Zn: 3.24 to 9.40 and K: 438.75 to 1399.58. ➤ Fatty acid: Palmitic acid, Oleic acid, Linoleic acid, Myristic acid, Stearic acid, Palmitoleic acid and Linolenic acid. 	<ul style="list-style-type: none"> ➤ Nutritional value of fishes will be helpful in policy making to minimize malnutrition and improve health status
<p>Development of a modified carp-based polyculture system suitable for homestead ponds for introducing and or substituting fish as the major sources of dietary protein to the coastal community through eco-friendly fish culture</p>	<p>Development of a modified carp-based polyculture system</p> <ul style="list-style-type: none"> ➤ Field experiments were conducted by– • Stocking at different density • Stocking of advanced carp fingerlings • Stocking from different sources (wild and hatchery) 	<p>Different stocking density</p> <ul style="list-style-type: none"> ➤ Growth and survival were higher at 370 kg/ha (low stocking density) ➤ Net benefit was maximum (2788.35 ± 10.26 USD) at low stocking density (370 kg/ha) ➤ Cost-benefit ratio was higher (1.22 ± 0.01) at the stocking density of 370 kg/ha ➤ Carp seeds of 	<ul style="list-style-type: none"> ➤ Increased in fish production ➤ Economic benefit ➤ Fish attain plate size within 6 month ➤ Women's participation in family income

		<p>150–250 g (advanced fingerling) attain plate size within 6 month</p> <p>Different sources</p> <ul style="list-style-type: none"> ➤ Halda seeds yield high (1686.36 ± 129.92 kg/ha/ 6months) in the homestead pond ➤ Maximum net benefit (228307.30 ± 22651.30 BDT) was found in the hatchery seeds ➤ Hatchery seeds (wild) was more suitable for homestead pond aquaculture 	
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E. Information/Knowledge generated/Policy generated

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
Coordination component			
To develop /produce BCC/SBCC	Collection of nutrition status data of different segment of people and survey to know the nutrition status and to develop nutrient information rich awareness building BCC/SBCC tools	Developed BCC/SBCC tools to disseminate it to the children's, adolescent girls, lactating mothers and pregnant women for up-scaling malnutrition	Up-scaling malnutrition of children's, adolescent girls, lactating mothers and pregnant women
To analyze the micro-nutrient (Fe, Ca, K & Na) content of different variety of rice and fermented rice	Analysis of micro-nutrients compositions of normal and fermented rice varieties like BRRI dhan 28, Najir, Pari, Miniket, Biroi, Aush, Tepi Boro, Guti, Swarna, Aman and Red Balam for Calcium (Ca), Iron (Fe), Potassium (K) and Sodium (Na) and to understand the level of contents under the changing fermentation process.	<ul style="list-style-type: none"> • Increase in Ca content was observed higher in fermented BRRI dhan 28 dhan, Pari, Miniket and in Balam Red samples. • Highest amount of increase in Ca concentration (352%) recorded in Miniket. While for all other samples of rice, fermented samples exhibit decreasing values . • In case of Fe, increased amount was recorded for BRRI dhan 28, Pari, Miniket and Guti fermented rice samples. 	Generated Information will help to improve the knowledge about qualitative aspects of various rice varieties

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
		<p>While the other fermented rice samples showed decrease in Fe content that varied from 5.67 – 64.49%.</p> <ul style="list-style-type: none"> • Potassium (K) content in all the fermented rice samples showed decreasing concentration than in normal rice samples. • The value for fermented samples were varied between 34.40 -89.58%. Except for BRR I dhan 28, Miniket and Aush rice all other fermented rice samples exhibits decreasing tendency for Na content in fermented form. 	
To analyse the heavy metals content of selective rice	Collection of locally available varieties of rice samples from different retail and wholesale markets of Dhaka city and detection and quantification of selected heavy metals such as As, Cd, Cr and Pb.	<ul style="list-style-type: none"> • Presence of heavy metals (As, Cd and Cr) concentration of in all the sampled varieties are below the recommended level of FAO/WHO/EU. • In case of Pb, only one sample of rice (Kohinoor Bashmati Rice) showed higher concentration (0.48 ppm) than the recommended level (0.20ppm) of WHO. 	Information on type and level of heavy metals in rice varieties will help consumers to understand the food safety aspect
Component 1(BLRI)			
Improvement of household food security, income generation and nutrition for the rural poor	<ul style="list-style-type: none"> • Assessing nutrition and health status of people • Calculating the calorie intake of all household with their family member to know the malnutrition status • Determining productivity of all inputs • Calculating the cost-benefit analysis of cultivated products • Training workshop for demonstrating the method and nutritional status 	<ul style="list-style-type: none"> • Year round food availability ensured by production and purchase • Age and sex wise energy improvement • Reduction of micro nutrient deficiency • Increased income from diversified source 	<ul style="list-style-type: none"> • Improvement of family health, reduced malnutrition, increase income and women empowerment
To improve household agro-processing, preservation, value addition and marketing optimizing income	<ul style="list-style-type: none"> • Awareness building through training among target households and community about agro-processing, preservation 	<ul style="list-style-type: none"> • More than 60% farmers have cultivated some indigenous fruits • Ensuring profitable price of raw and value added 	<ul style="list-style-type: none"> • Utilization of homestead unused land with modified items • Return on

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
	<p>and value addition through various media and campaign for product marketing.</p> <ul style="list-style-type: none"> Linkage development among market operators and groups for marketing of primary and processed/preserved secondary and value added products for mutual benefit 	<p>products for sale through effective linkage development between the market operators/ karbari (local name) and producers</p>	<p>investment</p>
<p>To ensure awareness building on nutrition, environment conservation and gender issues among the poor</p>	<ul style="list-style-type: none"> Awareness building among target households and community (men and women), on nutrition value of various foods, balance diet with available diverse food items, nutritional deficiency diseases and importance of nutrition. Recommended to avoid the use of organic manure, excessive use of fertilizers, little or no use of pesticides, farmers were trained to make compost by household wastage with livestock manure 	<ul style="list-style-type: none"> 100% target farmer along with different people of society were awarded on nutrition value of various foods, balance diet with available diverse food items, nutritional deficiency diseases and importance of nutrition. 100% target farmer were started to use their household effluents and wastage along with livestock manure to make compost 	<ul style="list-style-type: none"> Understanding nutritional deficiency or requirements. Reduced using fertilizer Reduced production cost Reduced environment pollution
<p>To ensure improved capability in developing technology and research/extension on balanced dietary intake, eradication of nutritional deficiency diseases and generation of nutritional database.</p>	<ul style="list-style-type: none"> Calculating the cost-benefit analysis of daily intake compared to productivity Training/ program for demonstrating the methods and technologies 	<ul style="list-style-type: none"> Low cost balanced diet with available feed stuffs have developed at the end of project Malnutrition minimized (not yet up to the mark) 	<ul style="list-style-type: none"> Leading healthy life with increased buying capacity, educated family
Component 2 (NSTU)			
<p>Assessment of current nutritional status of coastal household's families and facilitate them to better nutrition standard in family based diet</p>	<ul style="list-style-type: none"> Fish consumption was measured by questionnaire survey BMI was measured by weight and height Anaemia was determined through haemoglobin level using a HemoCue (Hb 201) machine 	<ul style="list-style-type: none"> Fish consumption (person/day) was almost double (59.57 g to 120.10 g) from baseline to end line. BMI stated increase in normal health condition from 42 to 58% among husbands, 36 to 68% among wives and 48 to 55.5% among children The prevalence of mild anaemia decreased from 79 to 47% among 	<ul style="list-style-type: none"> Increased fish production Improved nutritional and health status Decreased anaemic condition

General/specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output	Outcome (short term effect of the research)
		husbands and 93 to 79% among wives of beneficiary farmers.	
Enhancement of income generating capacity of housewife through whole family approach by opportunistic employment	<ul style="list-style-type: none"> Field study through questionnaire survey 	<ul style="list-style-type: none"> Women help men mainly in feeding and fertilization of homestead ponds. Annual income from homestead pond was 472–650 USD 	<ul style="list-style-type: none"> Women's participation in family income

F. 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	
Coordination component			
Technology bulletin/ booklet/leaflet/ Book /flyer etc.		02	<ul style="list-style-type: none"> পাস্তা ভাতের পুষ্টিমান ও স্বাস্থ্য উপকারিতা ড. মোঃ মনিরবল ইসলাম. বাংলাদেশ কৃষি গবেষণা কাউন্সিল, ফার্মগেট, ঢাকা-১২১৫ চাউলে ভারী ধাতুর উপস্থিতি ড. মোঃ মনিরবল ইসলাম. বাংলাদেশ কৃষি গবেষণা কাউন্সিল, ফার্মগেট, ঢাকা-১২১৫
Video clip/TV program/ Media coverage		06	<p>**https://fb.watch/6PmOrVVBZK/ Fermented Food:Channel 24; Daily Star, Amader samoy, Kaler kontho, Prothom Alo</p> <p>**https://www.facebook.com/100000502516980/videos/4407989975894376/ Khagrachari field research report Channel 24</p>
Component 1(BLRI)			
Technology bulletin/ booklet/leaflet/ Book /flyer etc.	02	01	<ol style="list-style-type: none"> দারিদ্র বিমোচনে পাহাড়ি এলাকায় দেশীয় ভেড়া পালন মডেল পাহাড়ি এলাকায় দেশীয় জাতের মুরগি পালন মডেল পাহাড়ি জনগোষ্ঠীর পুষ্টি চাহিদা পূরণে সমন্বিত চাষ পদ্ধতির সফলতা
Journal publication	01	02	<ol style="list-style-type: none"> <i>Jalil et al.</i>(2021)Diversity of non-conventional vegetables in two ethnic communities of Khagrachari Sadar, Khagrachari, Bangladesh, International Journal of Forestry, Ecology and Environment, Vol.02, Issue 01: 48-59. <i>Jalil et al</i> (2021) Diversity of minor fruit species in two tribal communities of Sadar upazila, Khagrachari, Bangladesh, International Journal of Forestry, Ecology and Environment, Vol.01, Issue 02: 28-34 <i>Jalil et al</i> (2021)Study on farming system with prospects and possibilities in two tribal villages of Khagrachari Sadar, Khagrachari, International Journal of Business, Management and Social Research

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
			(Accepted)
Video clip/TV program/ Media coverage	-	02	<ul style="list-style-type: none"> ➤ Channel I, Field Report (27.02.21) ➤ Channel 24, Field Report (27.02.21)
Newspaper/Other publications		04	<ul style="list-style-type: none"> ➤ The daily 'Kaler Kontho' (28.02.21) ➤ The daily 'Shomokal' (28.02.21) ➤ Local on line newspaper (27.02.21) ➤ News on feedback of beneficiaries by adopting the agricultural technologies
Component 2 (NSTU)			
Technology bulletin/ booklet/leaflet/ flyer		02	<ol style="list-style-type: none"> ১. বসত-বাড়ির পুকুরে কার্প জাতীয় মাছের মিশ্রচাষ ব্যবস্থাপনা ও পুষ্টিকথন ২. বসত-বাড়ির পুকুরে মাছের প্রাকৃতিক খাদ্য
Journal publication	04	04	<p>Published</p> <ol style="list-style-type: none"> 1. Pingki et al. 2020. Prevalence of malnutrition and associated factors of pond fish farmers from Noakhali Coast, Bangladesh. <i>Journal of Environmental Biology</i>, 41(5), 1171-1178. IF: 0.719 2. Sarker et al. 2021. Unravelling the diversity and assemblage of phytoplankton in homestead ponds of central coastal belt, Bangladesh. <i>J. Aquaculture Research</i>, 52(1), 167-184. IF: 2.082 3. Islam et al. 2020. Nutrient Composition of Small Indigenous Fish (SIS) species from Homestead Ponds of Noakhali Coast, Bangladesh. <i>Egyptian Journal of Aquatic Biology & Fisheries</i>. 24(7-Special issue), 943-954. IF: 0.737 4. Hossain, I and Hossain, M. B. 2021. Community structure of macrobenthos in homestead ponds of Noakhali coast, Bangladesh. <i>Acta Ecologica Sinica</i>, 41(6), 611-619. IF: 0.93 <p>Completed and submitted to the journals (By Hossain et al.)</p> <ol style="list-style-type: none"> 1. Hossain and Sarker (2022). Optimizing carp stocking density in coastal homestead ponds for higher production and family income generation 2. Hossain and Nur (2022). Growth, yield and profitability of Indian major Carp culture in homestead ponds stocked with wild and hatchery seed in Noakhali coastal area, Bangladesh 3. Hossain and Pingki (2022). Homestead pond fish culture minimizes malnutrition and improves health status in the coastal rural area, Bangladesh 4. Community structure of macrobenthos in homestead ponds of Noakhali coast, Bangladesh <p>Under preparation</p> <ol style="list-style-type: none"> 1. Role of homestead ponds in food security of the central coastal rural people, Bangladesh. 2. Diversity and assemblage of harmful algal blooms in homestead ponds of central coastal area, Noakhali, Bangladesh 3. Nutrient dynamics of homestead ponds sediment in central coastal area, Noakhali, Bangladesh
Book	01	07	<p>Books and book chapters published by Lambert Academic Publishing (LAP) and the department of Fisheries & Marine science, NSTU. Written by: Dr. Md. Belal Hossain</p>

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
			<ol style="list-style-type: none"> 1. Sarker et al (2020). Phytoplankton of homestead pond, Noakhali, Publisher: Lambert Academic Publishing (LAP) 2. Hossain et al. (2020). Community structure of macrobenthos in homestead ponds, Bangladesh, Publisher: Lambert Academic Publishing (LAP) 3. Karmakar et al. (2020). Community structure of zooplankton in homestead ponds, Bangladesh; Publisher: Lambert Academic Publishing (LAP) 4. Nutritional health status of homestead pond fish farmers, Bangladesh, Publisher: Lambert Academic Publishing (LAP) 5. Haque et al. (2020). Fish diversity in the homestead ponds of Noakhali, Bangladesh 6. Islam et al. (2020). Proximate composition of some SIS from homestead ponds of Bangladesh 7. Hasan et al. (2020). Status of homestead pond polyculture in the central coast, Bangladesh. 8. Hossain, M. B. (2021). Pond Fishes of Greater Noakhali
Video clip/TV program		01	Food-based Initiative (ID: 011)
Newspaper/Media coverage		03	<ol style="list-style-type: none"> 1. নোয়াখালীতে মৎস্য চাষ ও স্বাস্থ্য বিষয়ক কর্মশালা 2. (The Campus Today-06/02/2020) করোনা সংকটে নোয়াখালীতে মৎস্য চাষ বিষয়ক কর্মশালা (The Campus Today-20/07/2020) 3. নোবিপ্রবির উদ্যোগে 'অভিজ্ঞতা বিনিময় কর্মশালা' অনুষ্ঠিত (আমার সংবাদ- 25/02/21)

G. Description of generated technology/Knowledge/Policy

i. Technology Factsheet

Component I (BLRI)

1. Title of the technology: *Native sheep rearing in hill environment*

Introduction

The main food of all ruminant is green grass. There is no difference in the case of sheep. When there is not enough grass, they look for alternative feed to survive and become accustomed to it. Alternative feeds are crop residues, leaves, shrubs, etc. Sheep usually graze in the field in groups and eat green grass. They climb in groups in courtyards, fallow lands, pastures, ponds, hill slopes, high and low hills. The climate in the hilly areas is very conducive to sheep rearing. In the hilly areas it is possible to raise native sheep without any conditions. Indigenous sheep rearing is easy, so women and children in hilly areas can also be involved. Since native sheep are accustomed to grazing on grazing lands and there is a lot of fallow land in hilly areas, where there is ample grass, forest herbs, there is huge potential for raising sheep in hilly areas..

Description

Adequate raw grass / silage / urea molasses straw (UMS) and concentrate feed should be provided to the ewe during pregnancy and lactation to produce commercial lamb from native sheep. Studies have shown that at this time, a domestic ewe eats about 3.0-3.50 kg of raw grass or the same amount of silage or 650-1000 gm of UMS daily. Our research has shown that the 17% protein and 12 MJ of ME/kg of DM in the supplied concentrate feed mixture increases the production efficiency of sheep and lambs. The concentrate should be given at the rate of 1.5% of the body weight of the pregnant ewe in two equal portions in the morning and afternoon. Healthy sheep is a prerequisite for running a profitable farm. The farm can be damaged in various ways due to the disease. Diseased sheep have less physical growth, lambing and milk production. For this the health management of the sheep farm is an important issue. Before diagnosing sheep disease, it is important to know the symptoms of a healthy sheep. Sheep are constantly attacked by various harmful germs from the surrounding environment. Most of the time sheep are protected from these germs through the body's normal immune system. Sheep become infected if the body's immune system fails to resist harmful germs. Therefore, in order to keep the sheep healthy, it is necessary to maintain a healthy environment on the farm. If sheep have been reared for more than 2 years, they should be vaccinated with PPR at the age of 2.5 years and Ship-Pox vaccination one month later. Since it is less likely to get many sheep of the same age in one day and all these vaccines are not available as a single dose, the age of the sheep (excluding ecthyma) can be postponed up to 1 month for vaccination under the program described. Vaccination program of Sheep Worms weaken the sheep by absorbing nutrients in the body. External parasites damage the skin and fur of the body and absorb blood. For this, high power deworming should be given to the farm twice regularly before monsoon and winter. Sheep and calves (from three months of age) should be dewormed every three / four consecutive months. At different times of the year, sheep attacks by external parasites like lice, atali, myasis, meningitis etc. To keep sheep free from all these external parasites, dipping should be done at least once a month in 0.5% malathion solution (0.5 liters of malathion in 100 liters of water). If there is any sheep in the farm with skin disease, it should be injected with 0.5 cc of Ivermectin separately under the skin and malathion dipping (bath) should be done after 2-3 days till the disease is cured. Ivermectin, a national drug applied to sheep every six months, has good results in controlling internal and external parasites. Lamb (from 3 months of age) and wolves should be bathed in 0.05-0.1% melatonin solution once a month to prevent lice, measles, mumps, etc. This health management will make it possible to keep most of the farms disease free.

A sheep rearing house can be built as follows for keeping 10 sheep

- ❖ The floor of the house will be 0.7 1.0 m above the ground.
- ❖ Sheep house = 2.6 m long x 2.6 m wide x 2.6 m high
- ❖ Number of poles = 8 (4 nos. in front with 4.0 m long and 4 nos. in back with 4.2 m long tin)
- ❖ 4 nos. 2.6 m long tins should be used for roof.
- ❖ 2 tins of 2.0 m length should be used in the width of the house i.e. east-west side.

In order to make the sheep farm profitable, the farm has to be kept disease free. Cleanliness is the main way to keep it disease free. The following points should be kept in mind to keep the sheep farm disease free.

- The farm should be fenced / fenced.
- Rats, cats and other insects should be prevented from entering the farm.

- Keep the house clean, dry and light and airy every day.
- Give clean water and balanced feed every day as a rule.
- Rotten, stale and smelly feed should be avoided.
- One day a week the sheep house, feed and water containers should be cleaned with disinfectant.
- Must be vaccinated regularly.
- Sick sheep should be kept separate from healthy sheep.
- When new sheep comes from the market or other farm, it cannot be kept with other sheep of your own farm. It can be kept aside for at least 14-21 days and then tested and kept on the farm.
- The dead animal should be burnt or put in a deep hole and dry lime should be sprinkled around the hole.
- Young and old sheep should be kept separately according to age and sex.
- Separate houses should be built to keep sick and diseased sheep some distance from the farm.
- Sick sheep should be treated by a doctor.

Suitable location/ecosystem : Chattagram, Rangamati, Khagrachari and Bandarban districts

Benefits

As no religious restrictions, native sheep are acceptable to people of all faiths and suitable for sale within one year. With income from native sheep throughout the year, it is possible to change the quality of life in hilly areas, empower women, socio-economic development of poor people and create employment locally. With proper management, 11-12 kg of meat can be obtained from a 1-year-old domestic sheep, the choice of domestic sheep feed is very low, an adult sheep can give birth to its first lamb at the age of 12-14 months, the ewes can be bred after 25-30 days of lambing and the duration of heat is between 16-24 hours, the birth weight of the lamb is 1-1.5 kg, the immunity of the native sheep is strong and their mortality rate is below 5.0%. The care of the unborn lamb actually depends on the care of the pregnant ewe

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Plate 46. Native sheep rearing in hills.

2. Title of the technology: *Native chicken rearing in hill environment*

Introduction

Livestock is a significant sector of agricultural economy in Bangladesh which is increasing with importance day by day. Poultry, one of its sub-sector, is playing a vital role in meeting the nutritional needs of the country, including animal meat and other nutrients, and in building a country free from hunger and poverty. According to various sources, the poultry industry has created direct and indirect employment opportunities for more than 6 million people. In addition, the country's large female population is making a significant contribution to the national economy as well as improving their own fortunes through poultry rearing. Although the development of commercial poultry industry started in the nineties, a large number of people in rural Bengal have been rearing domestic breeds of poultry in their homes for eggs without any special care and with the leftover food of the household. According to the study, 80 % of the existing breeds of chickens are scavenging and a significant portion of the meat and eggs of domestic breeds and total chickens are produced from them. Despite the unexpected proliferation of commercial poultry in response to growing demand, this has not happened in the case of domestic poultry, and no steps have been taken to improve it. The Bangladesh Livestock Research Institute (BLRI) at Savar has been making an efforts for the development of livestock and poultry since its inception

Description

The number of domestic chickens reared on family basis is over 200 million. At present, there are three types of chickens in the country, namely, Common deshi, Hilli and Gola chilla. In the hilly areas of Bangladesh (Chattogram, Rangamati, Khagrachhari and Bandarban) the practice of raising indigenous breeds of chickens for the purpose of improving the quality of life of relatively low income people and making them happy, prosperous and subsistence has started and it has become quite profitable. Black-spotted hilli chickens are the most common, but white, gray and red chickens are also the most common. These chickens are usually relatively larger than native chickens. Featherless legs and yellow skin are some of their features. Single comb with red color are found mostly but brown and gray comb are also available. Ear lobes are white but red and white mixed lobes are also seen. The toes are white but yellow and black are also found. The color of the egg is light brown. At the end of laying the eggs, starts incubation, but this feature has been greatly reduced due to long-term practices in confinement or cages, why the diseases are found less. The animal protein obtained from chicken meat and eggs is about half of the total animal meat intake.

Also, chicken is low in fat and high in protein. Indigenous breeds of chickens adapt to the climate of our country in all seasons. They have higher immunity, so the death rate is much lower. Medication costs are also much lower, only with regular vaccinations. Raising can be done both by scavenging and by confinement or in cages. The cost of production is much lower in cage of scavenging method. Indigenous breeding of chickens is a special source of income for the rural people, as well as an important and readily available source of family nutrition which is making a significant contribution to the agricultural sector of the country.

Rearing Procedure

Among the hill farms, domestic chickens, like other commercial chickens, are being reared successfully in caged and non-caged areas. Day old chicks (DOC) with healthy, strong and problem free quality are brooded for 3-4 weeks. From brooding to 6 weeks of age, hens are reared together on the floor in separate pans depending on the breed. Then, healthy chickens are selected on the basis their external characteristics, genetic value and selection index values and kept in separate cages. During the rearing of chickens, a balanced supply of nutritious food and pure, fresh water must be ensured.

Suitable location/ecosystem : Chattogram, Rangamati, Khagrachhari and Bandarban districts

Benefits

As there is enough space in almost all the homestead in the hilly areas, it is possible to keep the native chickens easily. As it is suitable for sale in about eight weeks, so selling domestic chickens and eggs all year round helps in filling the meat deficit by eating meat with financial gain, which can change the quality of life in hilly areas, empower women, socio-economic development of poor people and create employment locally.

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Plate 47. Hilly chicken rearing in hills.

Component 2 (NSTU)

Title of the Technology: *Development of modified carp based polyculture system suitable for homestead pond for minimizing malnutrition and family income generation*

Introduction

Fish plays a significant role as healthier source of protein compared to livestock s but a little is known about the combined culture technique of fish species from diverse trophic level. Therefore, this investigation aimed to develop a modified carp-based polyculture system suitable for homestead ponds to boost the fish productivity and thus minimizing malnutrition by culturing Indian major carps (IMC) in the coastal region of Bangladesh.

Description

Two separate experiments were carried out, each having three replicates. Four advanced fingerlings of carps viz. catla (*Gibelion catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus cirrhosus*), and kalbasu (*Labeo calbasu*) with mean stocking weight of 243 ± 1.87 g, 223.56 ± 2.35 g, 155.89 ± 1.69 g, 158.72 ± 1.35 g, respectively were stocked at 825 kg (T₁), 560 kg (T₂) and 370 kg (T₃) fish seed per hectare. Based on the findings of previous experiment, seed from two hatcheries and wild sources were cultured to elucidate the growth performance, yield and economics of carp polyculture. Wild seed were collected from Halda River, natural breeding ground of Indian Major Carp in Chittagong, Bangladesh.

Suitable location/ ecosystem : The coastal homestead ponds of Bangladesh are typically seasonal that hold water for 5–6 months and is prevalent for aquaculture where Tilapia, Indian major carps, Chinese carps species are mainly cultured. Therefore, Noakhali district was selected as the suitable location for this experiment.

Benefits

The findings of present study suggested 370 kg/ha (low stocking density) of advanced carp fingerling (150-250 g) as the optimum stocking density and the farming of major carp species from wild sources yielded a higher growth. But due to the higher price of wild seed and transportation cost, the net profit was recorded lower than hatchery seed. Hence, polyculture with hatchery seed was suggested to be more viable and profitable in the coastal homestead ponds, Bangladesh.

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ii. Effectiveness in policy support (if applicable)

- The output of this sub-project activities will help to change the present socio-economic situations and livelihood pattern of the ethnic people with a view to increase food security and adequate dietary intake in terms of energy, protein, fat, vitamin and other micronutrients. It would also assist the policy makers of the livestock sector for setting their future research directions.
- The success of the present research through complete utilization of homestead underutilized small water holding ponds involving the family women for fish production through applying improved methods that has resulted significant increase in production, family consumption of fish, income through fish sale and nutrition intake level of family members. In the present fish policy, the use of underutilized homestead water bodies and action plan need to be guided with emphasize. The present research finding can be a good example that can be referred in amending respective regulation/act in the policy paper.

H. Technology/Knowledge generation/Policy support

i. Immediate impact on generated technology (commodity & non-commodity)

- a) Increased the agricultural production with diversified and newly introduced items in the homestead area.
- b) Increased in fish production at lower stocking density with advanced carp fingerlings from wild source of seeds in the homestead ponds.

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

- a) Through adopting new technology some farmers might be entrepreneur which may help to validate new technology in future.
- b) Developed a modified advance carp-based polyculture system suitable for the homestead ponds of Noakhali.

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

Under the sub-project activities, the following technologies has been developed and transferred to the farmers of hills of Khagrachari and coastal rural rural peoples of Noakhali those helped singicantly to increase food production and income generation, as well.

- a) Generated and transferred technology on Honeybee and Sheep Rearing in Hills environment.
- b) Technology on stocking of advanced carp fingerlings at low density from wild source increased the fish productivity and thus farmer's income of the Noakhali coastal areas.

iv. Policy support

- a) Increased policy support for advance hill agriculture development on the basis of hill demography and topograpgy. Small, landless, and marginal farmers involvement with input support for agrarian activity need to be encouraged with provision of incentives particularly for birds, fruits, bees, sheep/goat rearing activities.
- b) Considering the present success of homestead pond culture, policy should be reframed to make it a compulsory for utilizing those water bodies. Role of extension agents should be defined for this area including routine training and supervising of field activities and facilitating credit support for poor households.

I. Information regarding desk and field monitoring

h) Desk monitoring

Date of the programs	Program descriptions	Implementation Unit	Remarks/output
24 December, 2017	Signing of the Letter of Agreement (LoA)	PIU-BARC, NATP-2	Duly signed as per the terms and condition of LoA
06 November, 2018	Inception workshop	Nutrition Unit, BARC	The meeting was to inform the PIs of the sub-project how follow the PPR 2008 for the recruitment of manpower and procurement of equipment's, chemicals and reagents as per budget.
21 June, 2019	Monitoring workshop	Nutrition Unit, BARC	Progress of procurements of equipment's, chemicals and reagents and research activities
23 July, 2019	Financial management workshop	PIU-BARC, NATP-2	Procurement of equipment's , chemicals and reagents as per the rule of PPR 2008 and the audit rules
14 October, 2019	Coordination meeting	BARC	Discussion among the coordinator, director, PIs and Co-PIs about the guidelines how to achieve the goal collaborately
20 November, 2019	Annual progress review workshop	PIU-BARC, NATP-2	Presentation on annual research progress through multimedia presentation, .Received review comments on progress and future works
25 January, 2020	Half yearly progress review workshop	Nutrition Unit, BARC	Presentation on half yearly research progress through multimedia presentation and all the suggestions were complied
27 June, 2020	Half yearly review workshop	Nutrition Unit, BARC	Presentation of research progress through multimedia presentation. Received review comments.
7 September, 2020	Virtual Meeting on Progress Monitoring	PIU-BARC, NATP-2	Presentation of research progress through multimedia presentation. Received review comments.
23 September, 2020	Annual progress review workshop	PIU-BARC, NATP-2	Presentation on annual research progress through multimedia presentation and the suggestions from the workshop were complied.
24 October, 2020	Annual progress review workshop	PIU-BARC, NATP-2	Presentation on annual research progress through multimedia presentation and the suggestions from the workshop were complied.
22 November, 2020	Inaugural Session of Annual Review Workshop on PBRG Sub-projects	PIU-BARC, NATP-2	Honourable Minister, MoA inaugurated and the progress of research sub-project was through virtual multimedia presentation

Date of the programs	Program descriptions	Implementation Unit	Remarks/output
			and the suggestions from the workshop were complied.
26 December, 2020	Preparation process of Project Completion Report (PCR) of PBRG sub-project of Fisheries	Nutrition Unit, BARC	Detail discussion was on the guidelines how to write and submit the draft of PCR of the sub-project in time. Discussion was very effective
16 June, 2021	Virtual Meeting on Progress Monitoring of PBRG Sub-projects	PIU, NATP-2, BARC	Further discussion on submission of technology fact sheet and submission of PCR in time

ii) Field Monitoring

SL	Monitoring team	Date(s) of visit	Total visit (No.)	Output
Component 1 (BLRI)				
01	27.10.2019, 15.03.2020, 18.07.2020	Technical Division/ Unit, BARC	03	Improved the methodology & designing of the study relating to nutritional and health status.
02	2019-02 no. 2020-04 no.	PIU-BARC, NATP-2	06	Improved the knowledge of sub-project implement techniques
03	2019-09 no. 2020-06 no. 2021-04 no.	Internal Monitoring (BLRI)	19	Speed up the sub-project activities
04	2019-01no. 2020-02 no.	Others Visitors (KGF& PKSF)	03	Shared the diversified sub-project activities and knowledge
Component 2 (NSTU)				
01	08/03/2019	Team Leader: Dr. Md. Monirul Islam, Director (Nutrition) BARC, Farmgate, Dhaka. Member: Md. Al Mobasher Hussen, Senior Training Officer, BARC Md. Jashim Uddin Chowdhury, DD (Budget), BARC Md. Hasan Mahmud, CDA, PIU-BARC, NATP-2	03	➤ Improved the methodology & designing of the study relating to nutritional and health status.
02	27/10/2019 06/07/2020	Team Leader: Dr. M. N. Ali Sardar Monitoring Specialist, PIU-BARC, Framgate, Dhaka Member: Krishibid Md. Abdur Rahman Monitoring Associate, PIU- BARC, Framgate, Dhaka.	02	➤ Completing the baseline study & comparing the end result with baseline study. ➤ Setting control site nutritional and health status

SL	Monitoring team	Date(s) of visit	Total visit (No.)	Output
		Krishibid Dipok Kumar Monitoring Associate, BARC, Framgate, Dhaka. Md. Hasan Mahmud Monitoring Associate, BARC, Framgate, Dhaka	PIU- PIU-	
03	15/01/2020 20/02/2021	Dr. Saleh Uddin Ahammed Consultant;PBRG, BARC, Framgate, Dhaka 1215	02	➤ Discussed technique for increasing carp production



Plate 48. Field Monitoring of the sub-project activities at Khagrachari by the sub-project Coordinator and different monitoring team members.

iii) Weather data, flood/salinity/drought level (if applicable) and natural calamities

Three years average weather data of Khgrachari region

Parameters	Seasons						Remarks
	Pre-Monson (January – April)		Monson (May – August)		Post Monson (Sept – December)		
	Max	Min	Max	Min	Max	Min	
Av. Rainfall (mm)	52.5	0	236.2	132	105.8	0	
Av. Temperature (°C)	29.5	16.5	32.25	24.5	28.66	17.3	
Av. Humidity (%)	83	61	86	77	82	71	
Flood (year & category)	No flood seen yet in the area						
Av. Salinity (ppt)	-	-	-	-	-	-	
Natural calamity (Frequency & category)	No reportable natural calamity						

Three years average weather data of Noakhali region

Parameters	Seasons						Remarks
	Pre-Monson (January – April)		Monson (May – August)		Post Monson (Sept – December)		
	Max	Min	Max	Min	Max	Min	
Av. Rainfall (mm)	51	0	117	0	115	0	
Av. Temperature (°C)	36.4	11.3	36.7	21	34	12.5	
Av. Humidity (%)	100	22	100	46	100	31	
Flood (year & category)	No flood	No flood	1, category 5		1, category 2		
Av. Salinity (ppt)	0.5 – 1.5 range						
Natural calamity (Frequency & category)	No reportable calamity						

J. Sub-project Auditing

Coordination component

Types of audits	Major observation/ issues/ objections raised; if any	Amount of Audit (Tk.)	Status at the sub- project end	Remarks
Financial & Performance Audit by FAPAD on 29.10.19 for the year 2018-2019	No objection raised, Found all relevant documents updated as per guideline	71944.00	Financial management of the component found running smoothly till the end of the sub- project. No query or objection raised at any stage of operation by the	Financial management & sub-project performance found satisfactory
Financial & Performance Audit by FAPAD on 09.12.20 for the year 2019-2020.	No objection raised, Found all relevant documents updated as per guideline	1083411.00		Financial management & sub-project performance found satisfactory

Financial & Performance Audit by FAPAD on 11.10.21 for the year 2020-2021	No objection raised, Found all relevant documents updated as per guideline	1962961.00	audit teams.	Financial management & sub-project performance found satisfactory
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Component 1 (BLRI)

Types of audits	Major observation/ issues/objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
Financial & Performance Audit by FAPAD on 31.10.19 for the year 2018-2019	No objection raised, found all relevant documents updated as per guideline	6870695.00	Financial management of the component found running smoothly till the end of the sub-project. No query or objection raised at any stage of operation by the audit teams.	Financial management & sub-project performance found satisfactory
Financial & Performance Audit by FAPAD on 19.11.20 for the year 2019-2020.	No objection raised, found all relevant documents updated as per guideline	7330729.00		Financial management & sub-project performance found satisfactory
Financial & Performance Audit by FAPAD on 11.10.21 for the year 2020-2021.	No objection raised, found all relevant documents updated as per guideline	4984132.00	Report not yet	Financial management & sub-project performance found satisfactory

Component 2 (NSTU)

Types of audits	Major observation/ issues/objections raised; if any	Amount of Audit (Tk.)	Status at the sub-project end	Remarks
Financial & Performance Audit by FAPAD on 31.10.19 for the year 2018-2019	No objection raised, found all relevant documents updated as per guideline	2163598.00	Financial management of the component found running smoothly till the end of the sub-project. No query or objection raised at any stage of operation by the audit teams.	Financial management & sub-project performance found satisfactory
Financial & Performance Audit by FAPAD on 09.12.20 for the year 2019-2020	No objection raised, found all relevant documents updated as per guideline	2993354.00		Financial management & sub-project performance found satisfactory
Financial & Performance Audit by FAPAD on 12.10.21 for the year 2020-2021	No objection raised, found all relevant documents updated as per guideline	2318686.00		Financial management & sub-project performance found satisfactory

K. Lessons learned

- i. Social change was resulted on the basis of improvement of livelihood in terms of nutrition, housing, education, communication and diversification of occupation.
- ii. Early maturity and yield of BRR1 dhan 71 is advantageous for short duration mustard and winter vegetable cultivation.
- iii. Women were more interested in goat and sheep rearing. Goat & sheep rearing with some supplementary feed may be an additional income generating activity among rural women as they were good scavenger.
- iv. Red lady Papaya, Yard Long Bean, BARI Alu-36, 49 & 53 found tremendous contribution amongst the farmers as newly introduced crop.
- v. Homestead ponds of the Noakhali are suitable for carp polyculture based on natural food and production may be increased by supplementary and/or complete diet.
- vi. Nutritional and health status of the homestead pond farmers might be improved through carp polyculture by planned utilization of their homestead ponds
- vii. Stocking of advanced IMCs fingerlings at low density from natural source enhanced the production of fish in the homestead pond of Noakhali

L. Challenges

During the study period the major challenges were as follows:

- a. Language communication is the first challenges for implementation of any research activities in the hill aresa
- b. Heavy rainfall occurred not to prepare the seedbed in time
- c. Farmers are not interested to follow the advice and instruction on new management practices
- d. Water scarcity for irrigation in the summer and winter season for crop production.
- e. Wild dog attacking was the vital factor for making disinterest of sheep and poultry rearing.
- f. Low productivity for local and low-quality seeds.
- g. Social clash of different groups of the etheric community.
- h. Transportation of fish seeds both from natural source (Halda) and hatchery is one of the major challenges.
- i. Lack of technical knowledge and credit for fish culture is another challenge.
- j. Poaching also occurs during homestead pond fish farming that reduce production

M. Suggestions for future planning

A lot of difficulties were faced during the implementation period of the sub-project of which some are manageable. But to increase the productivity as well as improvement of the livelihood of the ethnic community and the nutrition intake and income generation of the rural people the following suggestions may be considered in future planning:

- a) Development of low-cost hill irrigation facilities.
- b) Ensure quality and improved varieties of seeds in time.
- c) Organize appropriate and problem oriented training.
- d) Study of component 2 (NSTU) suggested the stocking of advanced IMCs fingerlings at low density from natural source enhanced the production and therefore the availability and affordability (credit) of advanced IMCs fingerlings from natural source and/or hatchery should need to be developed for improving household food security, income generation and minimize malnutrition.

N. References

- Abdullah, M. R., Haque, M. E., Rahman, M. M., Hossain, A. K. M. Z. and Fakir, M. S. A. 2017. Diversity of underutilized fruits in 'Kaptai' reserve forest, 'Rangamati', Bangladesh. 4th International Symposium on Minor Fruits, Medicinal & Aromatic Plants, College of Horticulture and Forestry, Pasighat, Arunachal Pradesh, India December 2017.
- Affan, A., Jewel, A. S., Haque, M., Khan, S. and Lee, J. B. 2005. Seasonal cycle of phytoplankton in aquaculture ponds in Bangladesh. *Algae*, 20(1), 43-52.
- Ahmad, M., Abbas, S., Javid, A., Ashraf, M., Iqbal, K. J., Azmat, H., Khan, T., Mahmood, S. and Haider, R. 2013. Effect of varying stocking density of bottom feeder fish *Cirrhinus mrigala* and *Cyprinus carpio* on growth performance and fish yield in polyculture system. *International Journal of Fisheries and Aquaculture*, 5(11), 278-285.
- Ahmed, F. 2003. *Comparative study on carp polyculture practices of three different NGOs in Mymensingh district*. Ms Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, 56pp.
- Akter, S., Bhoyain, A. M., Azad, S. and Nasrin, D. 2016. Influence of Physico-Chemical Factors on the Zooplankton Population of Bostami Pond of Chittagong. *Bangladesh Journal of Zoology*, 44(1), 73-87.
- Akter, S., Ferdousi, S. S., Haque, M. A. and Sarker, M. A. A. 2018. Present status of traditional aquaculture and socio-economic condition of fish farmers at Paba upazila in Rajshahi District, Bangladesh. *Research in Agriculture Livestock and Fisheries*, 5(2), 269-277.
- Akther, S. and Hossain, M. J. 2015. Abundance of Zooplankton in Ramsagar-Dighi, Dinajpur, Bangladesh. *Bangladesh Journal of Zoology*, 43(2), 303-312.
- Al, M. A., Akhtar, A., Hassan, M. L., Rahman, M. F. and Warren, A. 2019. An approach to analyzing environmental drivers of phytoplankton community patterns in coastal waters in the northern Bay of Bengal, Bangladesh. *Regional Studies in Marine Science*, 29, 100642.
- Alabaster, J.S. and Lloyd, R., 1982. Water quality criteria for freshwater fish, 2nd edn. Butterworth's, London.
- Alam, G. 2006. Status of fish farming and livelihoods of fish farmers in some selected areas of Mithapuqur upazila in Rangpur district. MS Thesis, Department of Fisheries Management, Bangladesh Agriculture University, Mymensingh.
- Alam, M. J., Kohinoor, A. H. M., Islam, M. S. and Mazid, M. A. 2002. Polyculture of carps using over-wintered fingerlings under different stocking densities. *Bangladesh Journal of Fisheries Research*, 6(2), 117-124.
- Ali, H., Azad, M. A. K., Anisuzzaman, M., Chowdhury, M. M. R., Hoque, M. and Sharful, M. I. 2009. Livelihood status of the fish farmers in some selected areas of Tarakanda upazila of Mymensingh district. *Journal of the Agroforestry and Environment*, 3(2), 85-89.
- Ali, M. and Kausar, F. I. 2013. Present status of fisheries and livelihood of the fishermen in Atrai river, Dinajpur. *International Journal of Fisheries and Aquatic Studies*, 2(6), 402-408.

- Ali, M. H., Hossain, M. D., Hasan, A. N. G. M. and Bashar, M. A. 2008. Assessment of the livelihood status of the fish farmers in some selected areas of Bagmara upazilla under Rajshahi district. *Journal of the Bangladesh Agricultural University*, 6(2), 367-374.
- Ali, S. and Chakrabarty, T. 1992. *Bangladesher Mitha Panir Amerudandi Prani (A Book of Freshwater Invertebrates of Bangladesh)*. Bangla Academy, Dhaka Bangladesh, 207.
- Alikhuni, K. H. 1957. Fish culture in India. *Farm Bulletin of Indian Countries Agriculture Research*, 20, 1-144.
- American Public Health Association (APHA). 1992. *Standard methods for examination. of water and wastewater (18th edn)*. New York, Washington: AWWA, WPCF.
- AOAC (Association of Official Analytical Chemists). 1995. *Official methods of analysis. AOAC international*. 12th Ed. Washington, DC.
- AOAC (Association of Official Analytical Chemists). 2016. *Official methods of analysis. International*. 16th Ed. Arlington (VA)
- Basak, S. S., Bashar, M. A., Uddin, K. B., Islam, A. S. and Mahmud, Y. 2015. Seasonal Variation of Zooplankton Population with Reference to Water Quality of Kaptai Lake, Bangladesh. *Bangladesh Research Publications Journal*, 11, 127-133.
- Battish, S. K. 1992. *Freshwater Zooplankton of India*. Oxford & IBH Publishing Company.
- BBS (Bangladesh Bureau of Statistics). 2009. *Statistical Tearbook of Bangladesh Statistics Division*, Ministry of Planning, Government of the People's Republic of Bangladesh.
- BBS. 1984. *The survey of ponds-1982*. Bangladesh Bureau of Statistics, Statistics Division, Government of Bangladesh, Dhaka, 113pp.
- BBS. 2016. *Statistical Year Book Bangladesh 2015*. Statistics and Informatics division (SID), Ministry of Planning, Government of the People's Republic of Bangladesh, 35, 560p.
- BBS. 2019. *Statistical Yearbook of Bangladesh*, Bangladesh Bureau of Statistics, Statistical Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.
- BBS. 2020. *Household income & expenditure survey (HIES)*. Dhaka: BBS; 2017b. Retrieved June 15, 2020.
- BBS. 2020. *Year book of agricultural statistics*. Dhaka: Statistics division: BBS; 2017a. Retrieved June 14, 2020.
- Begum, M., Hossain, M. Y., Wahab, M. A., Ahmed, Z. F., Alam, M. J., Shah, M. M. R. and Jasmine, S. 2007. Effects of iso-nutrient fertilization on plankton production in earthen ponds of Bangladesh. *Pakistan Journal of Biological Sciences*, 10(8), 1221-1228.
- Beier, S. and Traunspurger, W. 2001. The meiofauna community of two small German streams as indicator of pollution. *Journal of Aquatic Ecosystem Stress and Recovery*, 8(3-4), 387-405.
- Belcher, H. and Swale, E. 1976. *A beginner's guide to freshwater algae*. London: Her Majesty's Stationary Office.
- Bert, W., Messiaen, M., Hendrickx, F., Manhout, J., De Bie, T. and Borgonie, G. 2007. Nematode communities of small farmland ponds. *Hydrobiologia*, 583(1), 91-105.
- Biswas, B. K., Shah, S., Takii, K. and Kumai, H. 2008. A comparison of growth performance of Indian major carps, *Catla catla* (Hamilton) and *Cirrhinus cirrhosus* (Bloch) from natural and hatchery sources in Bangladesh. *Aquaculture Science*, 56(2), 245-251.
- Boyd, C. E. 1998. *Water quality for fish pond*. Aquaculture Research and Development Series No. 43. Auburn University, Alabama, USA, p. 37.

- Boyd, C. E. and Tucker, C. S. 1998. Water quality and pond soil analyses for aquaculture. Alabama Agricultural Experiment Station, Alabama.
- Chattopadhyay, D. N., Mohapatra, B. C., Adhikari, S., Pani, K. C., Jena, J. K. and Eknath, A. E. 2013. Effects of stocking density of *Labeo rohita* on survival, growth and production in cages. *Aquaculture International*, 21(1), 19-29.
- Chowdhury, M. 1999. Inaugural speech on workshop Food-based Nutrition in Bangladesh. Proce. Food-based Nutri. In Bangladesh. BARC, Dhaka, April 26-27. 1998. p. 17-18.
- Chowdhury, M. M. R., Mondol, M. R. K. and Sarker, C. 2007. Seasonal variation of plankton population of Borobila beel in Rangpur district. *University Journal of Zoology, Rajshahi University*, 26, 49-54.
- Das, M., D. J. Wiley, X. Chen, K. Shah and F. Verde. 2009. The conserved NDR kinase or b6 controls polarized cell growth by spatial regulation of the small GTPase Cdc42. *Current Biol.* 19:1314-1319.
- Das, P., Borah, S., Yadav, A. K., Bhattacharjya, B. K. and Das, B. K. 2018. Openwater fisheries of Assam and strategies for its development. *Fishing Chimes*, 38(1&2), 17-28.
- Dasgupta, N. and De, B. (2007). Antioxidant activity of some leafy vegetables of India: A comparative study. *Food Chemistry* 0308-8146, 101:471-474.
- Dhaliwal, G. S., A. K. Dhawan and R. Singh. 2007. Biodiversity and ecological agriculture: issues and perspectives. *Indian J. Ecol.* 34: 100-109.
- DoF. 2001. *Sharonika, Matsha Saptah-2001*. Department of Fisheries, Ministry of Fisheries and Livestock, Government of Peoples Republic of Bangladesh, 79 pp.
- DoF. 2005. Basic Training of Fish Culture, Department of Fisheries, Dhaka, Bangladesh. pp. 87.
- Dulic, Z., Subakov-Simic, G., Ciric, M., Relic, R., Lakic, N., Stankovic, M. and Markovic, Z. 2010. Water quality in semi-intensive carp production system using three different feeds. *Bulgarian Journal of Agricultural Science*, 16(3), 266-274.
- Ellis, T., North, B., Scott, A. P., Bromage, N. R., Porter, M. and Gadd, D. 2002. The relationships between stocking density and welfare in farmed rainbow trout. *Journal of fish biology*, 61(3), 493-531.
- FAO. 1997. The State of Food and Agriculture. Rome, Italy.
- FAO. 2021. National Aquaculture Sector Overview. Bangladesh. National Aquaculture Sector Overview Fact Sheets. Text by Gias, U.A. In: *FAO Fisheries and Aquaculture Division*. Rome.
- Gogoi, P., Sinha, A., Sarkar, S. D., Chanu, T. N., Yadav, A. K., Koushlesh, S. K., Borah, S., Das, S. K. and Das, B. K. 2019 Seasonal influence of physicochemical parameters on phytoplankton diversity and assemblage pattern in Kailash Khal, a tropical wetland, Sundarbans, India. *Applied Water Science*, 9(7), 156.
- Habib, M. A. B., Sarker, B., Hossain, M. S. and Sarder, M. R.I. 2003. Species interaction between carp species in polyculture system. *Bangladesh Journal of Fisheries Research*, 7(1): 27-32.
- Hajong, Q. P., Sikder, B., Mondal, S. And Islam, M. A. 2018. Adoption and profitability of summer tomato cultivation in Jashore district of Bangladesh, ISSN 0258-7122., 2408-8293 (Online) Bangladesh J. Agril. Res. 43(4): 575-585, December 2018.
- Hassan M. R and MAI Talukder, 2011. Comparative performance of different regional native sheep in Bangladesh. *The Bangladesh Veterinarian*, 28: 85-94.

- Hautea, D. M., Taylo, L. D., Masanga, A. P., Sison, M. L., Narciso, J. O. and Quilloy, R. B. 2016. Field performance of Bt eggplants in the Philippines: cry1Ac expression and control of the eggplant fruit and shoot borer. *PLoS ONE* 11:e0157498. doi: 10.1371/journal.pone.
- Hels, O., N.Hassan, I. Tetens, and S. H. Thilsted. 2003. Food consumption, energy and nutrient intake and nutritional status in rural Bangladesh: Changes from 1981-82 to 1995-96. *Eur. J. Clin.Nutr.* 57: 586-594.
- Hengsawat, K., Ward, F. J. and Jaruratjamorn, P. 1997. The effect of stocking density on yield, growth and mortality of African catfish (*Clarias gariepinus* Burchell 1822) cultured in cages. *Aquaculture*, 152(1-4), 67-76.
- Hossain, K. Z., Miah, M. J. U. and Ali, M. H. 2008. Effects of inorganic fertilizers on the growth and production performance of exotic carps in polyculture system. *Progressive Agriculture*, 19(2), 129-137.
- Hossain, M. I., Alam, M. M., Alam, M., Kamal, B. M. M. and Galib, S. M. 2013. Investigation of phytoplankton and physico-chemical parameters in nursery, Growout and Broodstock Ponds. *Journal of Scientific Research*, 5(3), 555-571.
- Hossain, M. S. 2013. *An illustrated guide to fishes of Noakhali*. Centre for Coast, Climate and Community (Tetra-C), Chittagong.
- Hossain, M. S., Dewan, S., Islam, M. S. and Hossain, S. M. A. 1992. Survey of pond fishery resources in a village of Mymensingh district. *Bangladesh Journal of Aquaculture*, 14(16), 33-37.
- Hossain, M. Y., Begum, M., Ahmed, Z. F., Hoque, M. A., Karim, M. A. and Wahab, M. A. 2006. A study on the effects of iso-phosphorus fertilizers on plankton production in fish ponds. *South Pacific Studies*, 26(2), 101-110.
- Hossain, M. Y., Jasmine, S., Ibrahim, A. H. M., Ahmed, Z. F., Ohtomi, J., Fulanda, B. and Wahab, M. A.(2007. A Preliminary Observation on Water Quality and Plankton of an Earthen Fish Pond in Bangladesh: Recommendations for Future Studies. *Pakistan Journal of Biological Sciences*, 10(6), 868-873.
- Hossain, S., Rahman, M. M., Akter, M. and Bhowmik, S. 2015. Species Composition and Abundance of Zooplankton Population in Freshwater Pond of Noakhali District, Bangladesh. *World Journal of Fish and Marine Sciences*, 7(5), 387-393.
- Hyder, S. Z., Chowdhury, S. A. and Chowdhury, A. R. 1998. Prevalence of anaemia and intestinal parasites in a rural community of Bangladesh. Research and Evaluation Division, BRAC.
- Ingels, J., Tchesunov, A. V., and Vanreusel, A. 2011. Meiofauna in the Gollum Channels and the Whittard Canyon, Celtic Margin—how local environmental conditions shape nematode structure and function. *PLoS One*, 6(5), e20094.
- Islam, M. R. Saha, C. K. Sarker, N. R., Jalil, M. A. and Hasanuzzaman, M. (2016). Effect of variety on proportion of botanical fractions and nutritive value of different Napier grass (*Pennisetum purpureum*) and relationship between botanical fractions and nutritive value. *Asian Australasian Journal of Animal Sciences*, 16:837-842.
- Islam, M. S. and Dewan, S. 1987. *An economic analysis of pond fish production in some areas of Bangladesh* (No. 11). Bureau of Socioeconomic Research and Training, Bangladesh Agricultural University.
- IUPAC. 1979. Standard methods for the analysis of oils, fats and derivatives. 51 (12), 2503–2526.

- James, W. P., Mascie-Taylor, G. C., Norgan, N. G., Bistran, B. R., Shetty, P. S. and Ferro-Luzzi, A. 1994. The value of arm circumference measurements in assessing chronic energy deficiency in Third World adults. *European Journal of Clinical Nutrition*, 48(12), 883-894.
- Jiwyam, W. 2011. The effect of stocking density on yield, growth, and survival of Asian river catfish (*Pangasius bocourti* Sauvage, 1880) cultured in cages. *Aquaculture International*, 19(5), 987-997.
- Kader M. A., Haq, M. E., Majumder, r. and Hore, T. K. 2020. Early Maturing Drought Tolerant Rice Variety BRRI dhan71 Suitable for Drought Prone Environment in Bangladesh, *International Journal of Plant & Soil Science* 32(12): 1-11; Article no.IJPSS.60127 ISSN: 2320-7035.
- Kanak AR, MJ Khan, MR Debi, MK Pikar and M Aktar, 2012. Nutritive value of three fodder species at different stages. Food-based Nutri. In Bangladesh. BARC, Dhaka, April 26-27. 2012. p. 67-76.
- Karim, K. M. R. and Tasnim, T. 2015. Nutritional status, dietary food and nutrient consumption patterns in Monga affected area of the northern part of Bangladesh. *Asian Journal of Clinical Nutrition*, 7, 55-63.
- Karim, M. R., Rahman, M. S. and Alam, M. S. 2009. Profitability of Summer BARI Hybrid Tomato Cultivation in Jashore District of Bangladesh *Agri. Rural Dev* 7(1&2), 73-79, June 2009.
- Khan, M. A. R. 2011. Study on fish biodiversity and livelihood status of fishing community of the Tista River in Rangpur district. MS Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh.
- Khan, M. S. 1986. Socioeconomic factors in the development of pond fisheries. *Bangladesh Journal of Agricultural Economics*, 9(2), 1-06.
- Khan, N. S. and Bari, J. B. A. 2019. The Effects of Physico-chemical Parameters on Plankton Distribution in Poultry Manure and Artificial Formulated Feed Treated Fish Ponds, Noakhali, Bangladesh. *International Journal of Fisheries and Aquatic Studies*, 7(5), 1-7.
- Khatun, M. J. M., Rahman, M. M., Rahim, M. A. and Mirdah, M. H. 2015. Ethnic fruit diversity of Khagrachari district, Bangladesh and their traditional uses. 3rd international symposium on minor fruits, medicinal and aromatic plants, Bangladesh Agricultural University, Mymensingh, Bangladesh, 20-21 May, 2015 p.52.
- Khatun, S., Adhikary, R. K., Rahman, M., Sikder, M. N. A. and Hossain, M. B. 2013. Socioeconomic status of pond fish farmers of Charbata, Noakhali, Bangladesh. *International Journal of Life Sciences, Biotechnology and Pharma Research*, 1, 356-365.
- Kohli, M. P. S., Ayyappan, S., Langer, R. K., Dubey, K., Prakash, C., Reddy, A. K. and Deshmukhe, G. 2002. Cage culture of carps, *Labeo rohita* and *Cyprinus carpio* at Powai lake, Mumbai, Maharashtra. *Applied Fisheries and Aquaculture*, 2, 1-4.
- Kuljeet, K. and Amarjeet, K (2017), Papaya performance under various growing conditions cv. Red Lady 786, *Agric. Sci. Digest.*, 37(4) 2017 : 290-293 Print ISSN:0253-150X / Online ISSN:0976-0547.
- Kumar and Sahu, D. 1997. Commercializing papaya cultivation as potential as agro industries, *Farmers and Parliament*, 37(10): 7-22.

- Llido, L. O., and Mirasol, R. 2011. Comparison of body mass index based nutritional status using WHO criteria versus “Asian” criteria: report from the Philippines. *PHILSPEN Online Journal of Parenteral and Enteral Nutrition*, 1-8.
- Mamun, A. A. and Mahmud, A. I. 2014. Study on growth performance and production of juvenile Indian major carp (*Catla catla*, *Labeo rohita* and *Cirrhinus cirrhosus*) and their hybrids. *Journal of Fisheries and Aquatic Science*, 9(3), 92-108.
- Mane, A. M., Dube, K., Varghese, T., Chavan, B. R., and Kamble, M. T. 2019. Effects of Stocking Density on Growth Performance, Survival and Production of *Catla catla* and *Labeo rohita* During Nursery Rearing in Cages. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, 89(1), 275-281.
- Marengoni, N. G. 2006. Production of the Nile tilapia *Oreochromis niloticus* (Chitralada strain) reared in cages with different stocking densities. *Archivos de Zootecnia*, 210, 127.
- Momotaz, S. 2009. Socio-economic condition of small indigenous species beneficiaries at three villages (Garakhola, Chatiani & Jamira) of Phultala, Khulna. (B. Sc. Thesis, Fisheries and Marine Resource Technology Discipline, Khulna University, Khulna).
- National Institute of Population Research and Training (NIPORT), and Investment Capital Fund (ICF). 2020. *Bangladesh Demographic and Health Survey 2017-18*. Dhaka, Bangladesh, and Rockville, Maryland, USA: NIPORT and ICF.
- Navasero, M. V., Candano, R. N., Hautea, D. M., Hautea, R. A., Shotkoski, F. A., and Shelton, A. M. 2016. Assessing potential impact of Bt eggplants on non-target arthropods in the Philippines. *PLoS ONE* 11:e0165190. doi: 10.1371/journal.
- Needham, J. G. and Needham, P. R. 1962. *A Guide to the Study of Freshwater Biology*. HoldenDay. Inc. San Francisco.
- Nimbkar C, PM Ghalsasi, SW Walkden-Brown and LP Kahn, 2002. Breeding program for the genetic improvement of Deccani sheep of Maharashtra, India. 7th World Congress of Genetics Applied to Livestock Production, Montpellier, France. August 19-23.
- Obidiebube, E.A., P.G. Eruotor, S.O. Akparobi, S.O. Emosaariue, U.A. Achebe and P.E. Kator. 2012. Response of four cultivars of pepper (*Capsicum frutescens* L.) to different levels of N. P. K. fertilizer in rainforest agroecological zone. *Int. J. Agric. Sci.*, 2: 1143-1150.
- Oplinger, E. S., E. A. Oelke, D. H. Putnam, K. A. Kelling, A. R. Kaminsid, T. M. Teynor, J. D. Doll and B. R. Durgan. 2016. *Mustard: Alternate Field Crops Manual*. Minnesota and Wisconsin Extension Services.
- Phan, D. D., Nguyen, V. K., Le, T. N. N., Dang, N. T. and Ho, T. H. 2015. *Identification Handbook of Freshwater Zooplankton of the Mekong River and its Tributaries*. Mekong River Commission, Vientiane, 207.
- Pitchaikani. S. and Lipton S. 2016. Nutrients and phytoplankton dynamics in the fishing grounds off Tiruchendur coastal waters, Gulf of Mannar, India *J. 5:1405* DOI 10.1186/s40064-016-3058-8
- Population Stat. 2020. Bangladesh Population., from Population Stat- World Statistical Data: <https://populationstat.com/bangladesh>.
- Pravakar, P., Sarker, B. S., Rahman, M. and Hossain, M. B. 2013. Present status of fish farming and livelihood of fish farmers in Shahrasti upazila of Chandpur district, Bangladesh. *American-Eurasian Journal of Agriculture and Environment Science*, 13(3), 391-397.

- Prejs, A. and Blaszczyk, M. 1977. Relationships between food and cellulase activity in freshwater fishes. *Journal of Fish Biology*, 11(5), 447-452.
- Prodhan, M. Z. H., Hasan, M. T., Chowdhury, M. M. I., Alam, M. S., Rahman, M. L. and Azad, A. K. 2018. Bt eggplant (*Solanum melongena* L.) in Bangladesh: fruit production and control of eggplant fruit and shoot borer (*Guenée*), effects on non-target arthropods and economic returns. *PLoS ONE* 13:e0205713. doi: 10.1371/journal.
- Quddus, M. A., Rahman, M. S. and Moniruzzaman, M. 2000. Socio-economic conditions of the pond owners of Demra, Dhaka. *Bangladesh Journal of Fisheries Research*, 4(2), 203-207.
- Rahim, M. A., Kabir, M. A., Anwar, H. R. M. M., Islam, F., Sarker, B. C., Bari, M. S., Naher, N. and Alam, M. S. 2009. Underutilized fruits and vegetables in Bangladesh: contribution to the national economy, poverty reduction, household food security and nutrition. *ActaHortic.* 806, 423-428. <https://doi.org/10.17660/ActaHortic.2009.806.52>
- Rahman, A. A. 1989. *Freshwater fishes of Bangladesh*. Zoological Society of Bangladesh.
- Rahman, M. A., Sofiquzzoha, M. Z., and Nurullah, M. 1998. Efficiency of pond fish production in Bangladesh. *Bangladesh Journal of Agricultural Sciences*, 25, 235-239.
- Rahman, M. M. 2003. *Socio-economic aspects of carp culture development in Gazipur, Bangladesh*. MS thesis submitted to the Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh.
- Rahman, M. M. 2006. *Livelihoods of the people involved in pangasiid catfish (*Pangasius hypophthalmus*) farming in Mymensingh*. Doctoral dissertation, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh.
- Rahman, M. M. 2007. *Studies on pond fish farming and livelihoods of rural fish farming in some selected areas of Kurigram district*. MS Thesis, Bangladesh Agricultural University.
- Rahman, S., and Hussain, M. A. 2008. A study on the Abundance of Zooplankton of a Culture and a Non-culture Pond of the Rajshahi University Campus. *University Journal of Zoology, Rajshahi University*, 27, 35-41.
- Ramteke, S., Sahu, B. L., Dahariya, N.S. and Patel, K. S. 2016. Heavy metal contamination of vegetables. *Journal of Environmental Protection*; 07(07):996-1004.
- Rashid, M. M. 1996. *Vegetables Crops Agribusiness- A Consultancy Report*. Bangladesh AVRDC vegetables research project BARI, 253p.
- Reddy, P and Gowda, V. 2014. Influence of greenhouse cultivation on fruit quality of 'Red Lady' papaya. DOI:10.17660/ACTAHORTIC.2014.1024.10; Corpus ID: 132116882.
- Roy, U. Z. Z. A. L., Shaha, B. K., Mazhabuddin, K. H., Haque, M. F. and Sarower, M. G. 2010. Study on the Diversity and Seasonal Variation of Zooplankton in a Brood Pond, Bangladesh. *Marine Research and Aquaculture*, 1(1), 30-37.
- Saha, S. K. 2004. *Socio-economic aspects of aquaculture in Tangail Sadar Upazila*. MS Thesis, Department of Aquaculture. Bangladesh Agricultural University, Mymensingh.
- Sahu, K. C, Baliarsingh, S. K., Srichandan, S., M Lotlikar, A. A. and Kumar. T. S. 2013. *Monograph on Marine Plankton of East Coast of India-A Cruise Report*. Indian National Centre for Ocean Information Services, Hyderabad, 146 pp.
- Sarker, B., and Ali, M. F. 2016. Fish farming status at Sreemangal upazila of Moulvibazar district, Bangladesh. *Research in Agriculture Livestock and Fisheries*, 3(2), 361-368.

- Shafi, M. and Quddus, M. M. A. 2004. *Bangladesher Mothsho Shampad (in Bangla)*. Bangla Academy, Dhaka, 444 pp.
- Shah, M. M. R., Hossain, M. Y., Begum, M., Ahmed, Z. F., Ohtomi, J., Rahman, M. M., Alam, M. J., Islam, M. A. and Fulanda, B. 2008. Seasonal variations of phytoplanktonic community structure and production in relation to environmental factors of the southwest coastal waters of Bangladesh. *Journal of Fisheries and Aquatic Science*, 3(2), 102-113.
- Shah, M. S. 2010. Genetics of aquaculture and fisheries management. Fisheries and marine resource technology discipline, Khulna University, Khulna, Bangladesh, p. 267.
- Sharma, J. and Chakrabarti, R. (2003). Role of stocking density on growth and survival of catla, *Catla catla*, and rohu, *Labeo rohita*, larvae and water quality in a recirculating system. *Journal of Applied Aquaculture*, 14(1-2), 171-178.
- Siddiqui, K. (Ed.). 2007. *Encyclopedia of flora and fauna of Bangladesh*. Asiatic Society of Bangladesh.
- Sultana, A. and Ghosh, U. 2020. Estimation of effective moisture diffusivity of Red amaranth leaves (*Amaranthus tricolor* L.) for thin-layer drying technology, *International Journal of Agricultural Technology* 2021 Vol. 17(2):737-752 Available online <http://www.ijat-aatsea.com> ISSN 2630-0192 (Online).
- Talukded, MAH., Rahman, M. S., Haque, Z., Barman, K. K. and Laily, U. K. 2021. Dissemination of BARI released potato varieties in Rangpur region of Bangladesh, *Progressive Agriculture* 32 (1): 17-21, 2021 ISSN: 1017 – 8139.
- Tang, A. M., Dong, K., Deitchler, M., Chung, M., Maalouf-Manasseh, Z., Tumilowicz, A. and Wanke, C. 2013. Use of cutoffs for mid-upper arm circumference (MUAC) as an indicator or predictor of nutritional and health-related outcomes in adolescents and adults: a systematic review. *South African Journal of Clinical Nutrition*, 0(0), 1-6.
- Tetens, I., Hels, O., Khan, NH., Thilsted, S. H and Hassan, N. 2003. Rice-based diets in rural Bangladesh: How do different age and sex groups adapt to seasonal changes in energy intake? *Am. J. Clin. Nutr.* 78: 406-413.
- Traunspurger, W. 2000. The biology and ecology of lotic nematodes. *Freshwater Biology*, 44(1), 29-45.
- Van Vuuren, S. J., Taylor, J., Gerber, A. and Van Ginkel, C. 2006. Easy identification of the most common freshwater algae: a guide for the identification of microscopic algae in South African freshwaters. Resource Quality Services (RQS).
- Welch, P.S. 1948. *Limnological methods*. McGraw Hill, New York, USA.
- WHO. 1992. World declaration and plan of action for nutrition. Food and Agriculture Organization of the United Nations.
- WHO. 2000. The Asia-Pacific Perspective, Redefining Obesity and Its Treatment. Obesity: preventing and managing the global epidemic. Geneva: WHO.
- WHO. 2001. Iron deficiency anaemia: assessment, prevention and control, a guide for programme managers. Geneva: World Health Organization.
- Yengkokpam, S., Bhattacharjya, B.K., Debnath, D., Das, P., Yadav, A.K., Sarma, K.K., Sharma, N., Borah, S., Kakati, A. and Singh, N.S. 2017. Effect of stocking practices and riverine connectivity on fish productivity of beels, Assam. *CIFRI NEWS*, 22(1), 8.
- Yengkokpam, S., Das, B. K., Debnath, D., Das, P., Yadav, A. K., Sharma, N., Borah, S., Kakati, A. and Bhattacharjya, B. K. 2020. Effect of stocking density on growth and yield of *Labeo bata* fingerlings reared in cages. *Aquaculture Reports*, 18, 100506.

- Zannath, M. 2011. *Current Status of Traditional Aquaculture at Trishal Upazila in Mymensingh District*. MS Thesis. Department of Aquaculture, Bangladesh Agricultural University, Mymensingh.
- Zohara BF, Azizunnesa, Islam, M.F., Alam, M.G.S and Bari, F.Y. 2014. Reproductive Performances of Indigenous Ewes in Bangladesh. *IOSR Journal of Agriculture and Veterinary Science*, 7: 64-72.
- Zullini, A. 1976. Nematodes as indicators of river pollution. *Nematologia Mediterranea*, 4(1).

<p>Signature of the Coordinator</p>  <p>(Dr. Md. Monirul Islam) Date: 25.11.2021 Member Director (Fisheries) Bangladesh Agricultural Research Council</p>	<p>Counter signature of the Head of the organization/authorized representative</p>  <p>(Dr. Shaikh Mohammad Bokhtiar) Date: 25.11.2021 Executive Chairman Bangladesh Agricultural Research Council</p>
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Appendices

1. Coordination component (BARC)

Appendix A. Recommendation of the Inception Workshop and status of action taken

Recommendations	Action Taken
Component 1 (BLRI)	
<ul style="list-style-type: none"> Name of the village under sl. 4 of methodology should be write properly as “Punch mile” by using English alphabet but not as “5-mile” that does not represent the true name of the place; 	Correction done
<ul style="list-style-type: none"> There should be a coordination mechanism of area wise works within the project activities; 	Developed & followed
<ul style="list-style-type: none"> De-worming of the animals prior to vaccination to be followed in each case; 	Followed in every case
<ul style="list-style-type: none"> Emphasize coordination with local DLS department and market linkage study; 	Maintain linkage with DLS officials
Component 2 (NSTU)	
<ul style="list-style-type: none"> Per day per family person fish intake and nutrition status are to be covered under baseline survey; 	Included
<ul style="list-style-type: none"> Criteria for selection of respondent from the vulnerable groups need to specify in the methodology 	Already exist

Annexure B. Recommendation of the Half-yearly Workshops

Workshop recommendations	Actions taken
Component -1 (BLRI)	
<ul style="list-style-type: none"> Sufficient baseline data collection and analysis emphasized particularly for dietary intake level study of the stakeholders; 	Compliesd
<ul style="list-style-type: none"> Research based information was lacking in the presentation; 	Upgraded from the next presentation
<ul style="list-style-type: none"> Research should be targeted for the development of sustainable technologies considering the socioeconomic, cultural and environmental aspects of the locality; 	Proper attention paid in every step of activities
<ul style="list-style-type: none"> Production and food diversity should be compared with the base line information considering the role and effect of local business modules; 	Properly followed
Component -2 (NSTU)	
<ul style="list-style-type: none"> Baseline information on aquaculture involvement of women showed only 2% while the objective of the project targeted to work and income generating capacity enhancement of women through aquaculture that create contradiction which should be cleared up with proper justification; 	Participation of women increased gradually
<ul style="list-style-type: none"> Selection process of 110 ponds for baseline study not clearly focused; 	Focused in the report
<ul style="list-style-type: none"> Outputs shown in the presentation are not proper and misleading; 	Necessary correction done

Appendix C. Recommendation of the Annual Workshop

Recommendations of the First Annual Workshop	Action taken
Component 1 ((BLRI))	
<ul style="list-style-type: none"> Attempts for awareness creating among the farmers as far objective 2 & 3 of the sub-project need to be focused; 	Due attention given
<ul style="list-style-type: none"> Initial wt., size and number of chicks and lambs distributed among the hill families should be mentioned; 	Data recorded and mentioned in all followup reports
<ul style="list-style-type: none"> Emphasize should be given on the quality of seed those are under process of distributing among the hill farming families; 	Proper care taken
<ul style="list-style-type: none"> Investment, income generation and profitability should be analyzed (BCR) critically for every component separately; 	BCR analysis done where necessary
<ul style="list-style-type: none"> Activities and responsibilities of housewives must be taken into consideration in economic analysis of the sub-project by converting their direct and indirect contribution in household management under a standard economic valuation process; 	Due consideration given in respective part
Component 2(NSTU)	
<ul style="list-style-type: none"> A relation should be established and shown between fish intake by the community people and their socio-economic condition along with state of nutrition; 	Finding of the analysis presented in te report
<ul style="list-style-type: none"> The term “eradication” should be replaced by the term “minimizing” in the report; 	Complied
<ul style="list-style-type: none"> Matters related with minimizing of malnutrition through increased fish production and intake of fish should be focused in the report; 	Done properly
<ul style="list-style-type: none"> Information on amount of intake of own farmed/cultured fish by each family at baseline is lacking; 	Shown where necessary
<ul style="list-style-type: none"> A list of different fish seed sources with initial wt./size and a list of zooplankton taxa should be shown in the report; 	Complied
Recommendations of the Second Annual Workshop	Action taken
Component 1 ((BLRI))	
<ul style="list-style-type: none"> The progress report was lacking discussion on few vital activities like agro processing, preservation, value addition and marketing system (related with objective no. 2); Details of each of the technology/method followed by the project should be focused in next reports; 	Done accordingly
<ul style="list-style-type: none"> All effecting factors and their degree of impact should be judges critically while claiming success of the sub-project in particular areas of activities like production and income increase, food intake and livelihood changed etc; 	Considered with emphasize
<ul style="list-style-type: none"> Nutritional intake change of the sub-project stakeholders need to be compared at every step with the national standards; 	Compared partially where necessary
<ul style="list-style-type: none"> Documentation (video clip preparation etc) of success stories and inspirable approaches suggested; 	Documentation in various forms done
Component 2(NSTU)	
<ul style="list-style-type: none"> Annual progress report was not presented in the workshop. PI, CO-PI or any other representative did not attended the workshop 	Information conveyed to the respective authority

Appendix D. Recommendation of the coordination meetings

Central Coordination meeting at BARC	
Recommendations	Action taken
<ul style="list-style-type: none"> • Suggested to accelerate sub-project works as per activity and timeframe of the projet proposal; 	Complied
<ul style="list-style-type: none"> • Suggested prompt analysis of recently collected fish samples with especial emphasize to study of major micro-nutrients by the NSTU component. 	Properly followed
Two Other virtual Coordination meetings	
<ul style="list-style-type: none"> • To maintain steady progress in sub-project achievement particularly in this period of epidemic in the areas' temporary involvement of few local alternate labors suggested in place of effected project staffs; 	Followed in some possible cases
<ul style="list-style-type: none"> • As per sub-project objective, more emphasize is to be given on agro processing, preservation and value addition related research and awareness building activities in the rest of the project period; 	Followed
<ul style="list-style-type: none"> • Experiments under fruit processing and preservation should be completed under the current part or work; 	Complied as mentioned
<ul style="list-style-type: none"> • Development of model farmer to be completed within the next quarter of the project; 	Successfully done
<ul style="list-style-type: none"> • Evaluation of the performance of the sub-project activities with particular focus on intake of balance diet, level of eradication of nutritional deficiency disease and generation of a complete data base should be done within the latter half of the project year; 	Complied
Component 2 (NSTU)	
<ul style="list-style-type: none"> • Analysis of proximate composition of rest of the fish species (other than the previously studied 40 species) and completion of trace elements study of the SIS species under the present section of activities suggested; 	Followed all most all
<ul style="list-style-type: none"> • Finalizing the design of presentation of results to express income generation and employment, fish intake and increase in nutrition of the stakeholders in the next step need to be confirmed with a clear picture of difference as acceptable sub-project achievement; 	Followed from the next workshop presentations



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