CHAPTER-01: INTRODUCTION

Fish is the second most valuable agricultural crop of Bangladesh, and its production contributes to the millions of people's livelihood and employment. People of Bangladesh are referred to as "Macche-Bhate Bangali" or "a Bengali made of rice and fish" because of fish's popularity as food products. The culture and consumption of fish contribute to national income and food security of Bangladesh (Ghose, 2014). There are 289 freshwater fish species, 475 marine fish species, 24 prawn species, 36 shrimp species, and 12 exotic fish species available in the diversified aquatic ecosystem of Bangladesh (Khan et al., 2013). Bangladesh is regarded as the world largest inundated wetland and the third largest aquatic biodiversity in Asia. Thus, this country is assumed as one of the world's best-suited fisheries regions (Shamsuzzaman et al., 2017).

Bangladesh exists in the major fish producing countries of Asia (FAO, 2020). The total fisheries production was 4. 27 million MT with a 3.57% contribution to national GDP, 25.30% to agricultural GDP, and 11% of the population fully or partly engaged in the fisheries sector. Inland culture fisheries contribute 56.24% of total fish production, and the rest comes from inland and marine capture (DoF, 2018). According to FAO (2018), Bangladesh ranked third in open water inland capture production, fifth in aquaculture production, third in the tilapia culture development in Asia.

Aquaculture is the farming of fish and other commercially important aquatic organisms. Freshwater aquaculture contributes to ensure food security, poverty alleviation and employment generations for millions of people in worldwide. World aquaculture production exceeded 114.5 million tons in 2018, with a total value of USD 263.6 billion at farm level and 59.5 million people directly or indirectly engaged in aquaculture for their livelihoods (FAO, 2020).

Community-based Fisheries Management (CBFM) is a management tool aimed at facilitating the sustainable use and fair sharing of the benefits of inland fisheries by allowing communities to control their resources. Community-based fisheries management implementation has significant potential to be better than the current management system of aquatic resources in Bangladesh (Halls, 2017); especially in hilly regions where there is a lack of individual capability to manage resource due to financial and social constraints.

Community-based aquaculture (CBA) is a proven approach in rural areas to satisfy community needs, ensure safe protein sources, and provide sustainable use of waterbodies (Ananth et al., 2014). There are significant roles of CBA in coastal communities that helps community people determining how to handle these resources (Graham et al., 2006). CBA is a highly proposed design for generating alternative income sources to improve the livelihood and food security of impoverished coastal communities (Beveridge et al., 2013). It ensure participation of all stakeholders and develops a feeling of ownership in the decision–making process.

Community-based resource management increase fisheries production, improve biodiversity and helps in reducing climate change threats in the coastal communities (Mustafa et al., 2017). Community-based organizations (CBOs) motivates people in sharing and disseminating knowledge and experiences (Halls et al., 2017), and ensure women participation in farming process whereas FAO (2020) reported only 14% women among the 59.5 million people engaged in aquaculture.

Bangladesh has a mostly flat topography, but it contains 12% of the total landmass of the hill, mostly located in the southeastern part of the country including Khagrachari, Rangamati, Bandarban, Chattogram, Cox's Bazar, Mymensingh, Netrokona, Sylhet, Moulavibazar, and Habiganj districts (Ahmed et al., 2013) with indigenous people apart from standard income and livelihood. Indigenous people are the victims of the trap of poverty and the sufferers of high degrees of unemployment, they are vulnerable, marginalized, and disadvantaged groups in the world (Roy, 2012); they face problems such as land dispossession, limited education access in the social services, and discrimination (Dhamai, 2006); dependent mainly on the primitive techniques and technologies (Hossain, 2013).

Aquaculture is less common in hilly regions than the capturing fish from natural water-bodies. There is 1096.85 ha of water bodies in Bandarban with immense potential for aquaculture, but aquaculture covers just 319.9 ha (Mustafa, 2018). One thousand two hundred (1200) creeks surround the Kaptai Lake, but aquaculture's desired product is not achieved yet. Kaptai Lake itself, being a water-body of 68800 ha has total fish production of only 10152.32 MT (DoF, 2018).

Tribal peoples and residents of Bangladesh's hill tracts have a lack of ability, knowledge, and financial support to develop the individual enterprise to improve and sustain their livelihood. Community-based approaches for developing aquaculture in these hilly regions are necessary to improve these marginalized people's livelihoods and income. This research aims to generate a sustainable community-based aquaculture model for the peoples of the study area based on the analysis of their existing aquaculture problems, available resources, and opportunities.

1.1 Objectives

1. To identify existing problems and prospects of aquaculture in the hilly area and finding applicable solutions.
2. To generate a sustainable community-based aquaculture model for the study area.

1.2 Scopes of the study

This research work will add a new dimension to improve the aquaculture sector in the hilly area of Bangladesh by generating a sustainable community-based aquaculture model. This CBA model will be environment-friendly, technically appropriate, economically feasible, and socially acceptable to aid the living standards of the people of the study area. The model will also encourages the involvement of women and youths in the aquaculture sector directly or indirectly.

CHAPTER-02: REVIEW OF LITERATURE

It is essential to look at previous research activities related to science or experiments before performing a study or experimental procedure. Community-based aquaculture is a worldwide recognized method for the management of fisheries resources. It is an efficient resource management strategy that requires the active participation of different people in the management processes. The following provides a close review of different published literature relevant to this research:

2.1 Fisheries and Aquaculture in Bangladesh

According to FAO (1988), aquaculture is the cultivation of fish and other commercially important aquatic organisms in coastal and inland water bodies and farming required some intervention to increase production, such as regular stocking, predator protection, and some of the stock's private rights intervention. Aquaculture is also considered as having the potential for food security in Bangladesh (E-Jahan et al., 2010). According to Mazid (1999), 73% of rural households are directly engaged in freshwater aquaculture systems especially in floodplain area of the country. Inland aquaculture has great potential in Bangladesh because it generally experienced with faster growth, establishment, and adoption of new technologies, species, and intensification and improvement of farming systems, particularly in pond aquaculture (DoF, 2018).

Dey et al. (2008) stated that availability for fish for human consumption is increased, but the aquaculture sector of Bangladesh is not fully utilized yet. The form of aquaculture is dependent on the existing policies, institutional, and socio-economic conditions. Proper planning is required in every manufacturing sector according to the up-dated knowledge, opportunities, current conditions, and challenges. For the lack of adequate information and socio-economic details, the developmental program's implementation is often ineffective in aquaculture and fisheries (Hassan et al., 2012).

There is a limited semi-intensive practice recorded in fish farming in Bangladesh but rapid commercialization, and enormous increase in the production of farmed have taken place over the last decade due to adoption of new technologies in the aquaculture sector (Belton and Azad, 2012).

2.2 Existing Aquaculture system and model in Bangladesh

According to Edward (1993), aquaculture system can be classified into i) extensive system relying on natural food produced in the water body without additional inputs, ii) semi-intensive systems relying mostly on the natural feed but supplemented with feed and fertilizer and iii) intensive systems relying on nutritionally complete concentrate feed and fertilizers. Thompson et al. (2002) reported that most of the freshwater pond in Bangladesh are practicing either extensive or semi-intensive and intensive in very few cases. Jahan et al. (2016) reported 14 different commercial and subsistence aquaculture systems were practiced across the country. Bangladesh utilizing a variety of aquaculture techniques such as pangas, tilapia, koi and carp monoculture, polyculture of different fish species, polyculture with SIS, rice-fish integrated culture, shrimp and prawn monoculture, shrimp and prawn-rice integrated culture.

Sakib and Afrad (2014) reported adopting acceptable modern aquaculture technologies, suitable domesticated species, capitalization, efficient methods, and adequate marketing facilities are required for optimum production and commercial success in aquaculture. According to DoF (2017), with the expansion of different developed technologies, the pen and cage culture is becoming popular day by day in Bangladesh. Dey et al. (2008) categorized freshwater fish-culture systems in Bangladesh into four groups: polyculture of carp, mixed culture, monoculture, and integrated fish culture. Polyculture of Indian major carps and a few other exotic species is most practiced culture system in Bangladesh. Farming of exotic carp species, tilapia, pangas is massively expanded in Bangladesh (Belton et al., 2014).

2.3 Aquaculture in the hill

Hilly region of Bangladesh is blessed by a variety of aquatic ecosystems such as rivers, streams, creeks, and a large reservoir known as the Kaptai Lake (Hossain and Wahab, 2010). Government established the creek aquaculture system under the project "Improving and extending fish farming by developing creeks in the Hills of Chittagong 2000–2010” to expand aquaculture in the hill (DoF, 2012). About 4227 creeks with 4375.90 ha areas were constructed in the Chittagong hill tracts might be used for fish culture under this project. A total of 1200 creeks were constructed surrounding Kaptai Lake and these created huge potentiality of aquaculture in the hill (Alamgir and Ahmed, 2008). A creek is a hillside depression filled with hilly streams over the monsoon

(Rahman et al., 2017). Creek aquaculture techniques might increase fish production in the hill because the creek's production capacity in the hill is 2100 kg/ha, which is 8 to 9 times more than the Kaptai Lake (Alamgir and Ahmed, 2005).

2.4 Scope and challenges of aquaculture in the hilly area

Aziz and Hossain (2002) stated that hilly area of Bangladesh contain some rivers and streams, creeks, and a large reservoir called Kaptai Lake. Aquaculture in creeks might be useful for the increasing fish production of the hilly regions. There is 1096.85 ha of waterbody in Bandarban district having tremendous aquaculture potentiality, but aquaculture expanded in 319.9 ha area (Mustafa et al., 2018). Das (2018) reported the excellent potential for indigenous fish species for aquaculture in the mid-hill region of Northeast India. In the hill area, the aquaculture sector's growth has many constraints, such as unavailability of quality fish seed and poor communication system. Khan et al. (2016) reported that proper fishing right of the fishermen in the hill area not fully established. Most of the hill stream fish in Bangladesh are either extinct or on the verge of extinction (Hossain, 2014).

2.5 Feasibility of integrated aquaculture and polyculture in the hill

Rahman et al. (2017) found higher growth rates of catla, rohu, and mrigal in the creeks. Islam et al. (2014) also found satisfactory survival rate, growth, and economic viability of carps and fingerlings in the creeks of the Chittagong hill tracts. Nesar et al. (2011) reported that integrated farming reduces the requirements for feed, helps in integrated pest management (IPM), and provides a technological, cost-effective, and sustainable alternative way of aquafarming. It also ensure economic and environmental suitability. Nagoli et al. (2009) reported increased farm productivity, increased household incomes, improved adaptation and resilience to erratic climatic conditions, improved food and nutritional security through increased production and consumption of fresh fish and food crops grown in integrated farming. Polyculture is the best culture method for the complete use of the pond food web and ecosystem (Halver, 1984).

2.6 Community-based Fisheries Management (CBFM) and Community Based Aquaculture (CBA)

According to Blythe et al. (2017), Community based Fisheries Management (CBFM) is regarded as the most promising path to securing viable small-scale fisheries. Carlsson and Berkes (2005) stated that CBFM is highlighted by the transition of management power of the resources to local communities, allowing them to manage these resources and creating community collaborations with relevant stakeholders such as government organization and non-government organization. It was being introduced in Africa, in particular to manage inland fisheries resources (Wilson, 2002). It aimed to ensure the long-term protection of the fisheries resources (Hossain et al., 1998).

According to De and Saha (2007), Community-based aquaculture (CBA) is a useful tool for implementing scientific aquaculture programs based on participation principles and the basis of common interest groups working together regardless of sex and age. Haque and Dey (2017) stated community-based fish culture (CBFC) technology required suitable topography and institutional arrangements. It also ensure participation of all the stakeholders of aquaculture such as landlords, renting agents and farmers. From 2005-2010, the CBFC tested in Bangladesh, Cambodia, China, Vietnam, and Mali in different socio-cultural and institutional settings. CBFC launched in Bangladesh, by WorldFish and its research partners through a project entitled "Community-based Fish Culture in Seasonal Floodplains and Irrigation Systems" (Dey et al. 2005). Department of Fisheries widely applied community-based innovations to the fish farming in floodplains region of Bangladesh. The CBFC system has significant potential benefits to expansion of aquaculture in rural area (Haque and Dey, 2017).

2.7 Prospects and Constraints of CBFM and CBA

According to Thompson et al. (2003), CBFM ensure participation of different formal and informal institutions in the decision-making process, including state-run bodies and other administrative units of the local government, which helps to mitigate social conflict for the resource ownership and management rights. Sultana and Thompson (1999) outlined the considerable prospects of CBFM approach in the case of inland fisheries resource management. According to Blake et al. (2004), women could be vital part of CBFM and may contribute in the increasing household income. Community based organizations (CBOs) might be used to communicate and disseminate farming information and experiences through meetings, visits, and newsletters (Halls, 2005).

CBFM aimed to developed new standards and institutions to build knowledge and skill of fish farmer for the management of their resources and livelihoods (Sultana and Thompson, 2010). According to Hossain et al. (2013) reported critical internal constraints of stakeholders such as the lack of expertise, education, technical awareness, and conflicts. Lack of government department cooperation, insufficient marketing facilities, infrastructure, financial services, and environmental externalities have been described as significant external constraints to the effective implementation of CBFM. The constraints also include lack of clear policy guidance and strategy, the inadequacy of the current regulatory system, non-enforcement of legislation and jurisdictional disputes, the absence of frequent law review and updating mechanism (Rahman et al., 2018a).

2.8 Methods of CBA model formulation

De and Saha (2007) developed CBA model in the Puri district of Orissa and the Purulia of West Bengal district in India. Data collection tools such as semi-structured interviews and focus group discussion schedules, were employed in the study area through consultation with related field experts. Community participation index, participation of women, quality determination factors, and CBA constraints were determined to form the CBA model. By using a structured questionnaire, individual respondents were interviewed.

Paul et al. (2014) used focus group discussion, semi-structured interviews and other PRA tools to evaluate effects of CBFM in the Begumganj, Noakhali, Bangladesh. Water quality was also closely monitored in the research period. Hugues-Dit-Ciles (2000) designed closed-ended questions to collect necessary data from fishers and arranged several meetings among the target groups for developing a Sustainable Community-Based Aquaculture Plan for the Lagoon of Cuyutlàn.

CHAPTER-03: MATERIALS AND METHODS

3.1 Study Area

This study was conducted at Matiranga Upazila in the district of Khagrachari from February 2019 to March 2020. The research area is located in the hill tracts of Chattogram, the south-eastern part of Bangladesh (Figure-01).

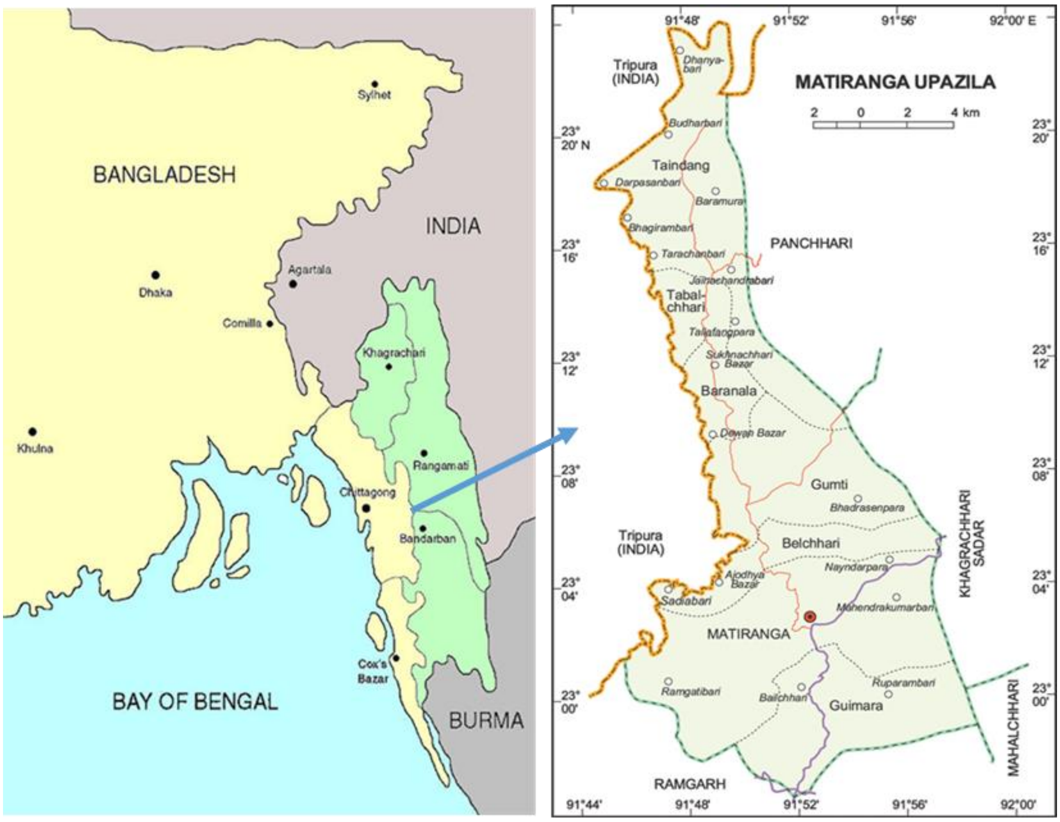

Figure-01: Study area

3.2 Selection of fish farms and farmers

Twenty (20) fish farms were selected among the 60 fish farms for both survey and laboratory analysis in the study area. For study purpose, 33.34% of the total farms were selected as sample in the study area. Geographical coordinates of the selected farms were recorded by using "GPS coordinates" software, and a map was constructed by using "Arc-GIS" (Version-10.3) software (Figure-02).

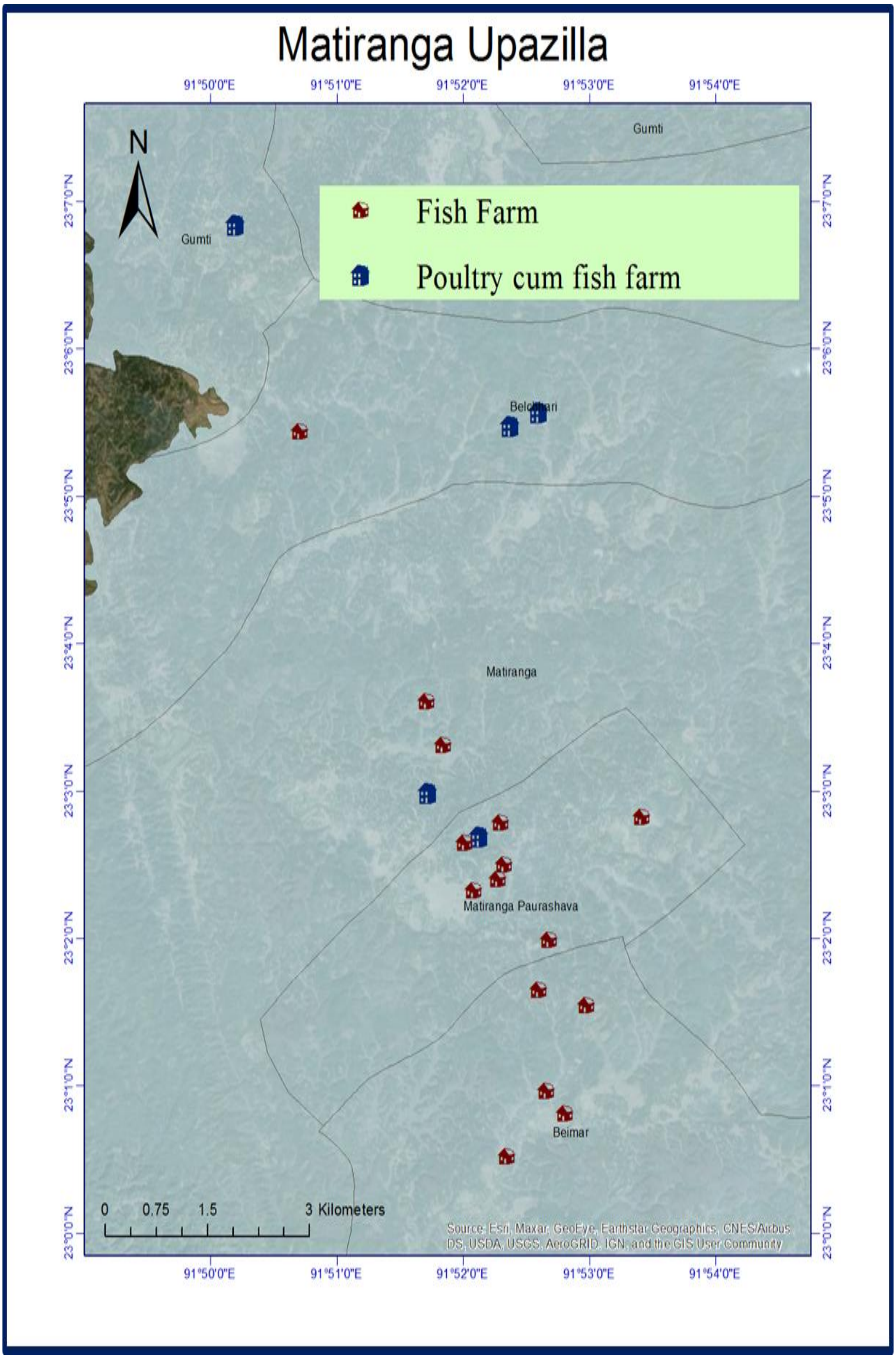

Figure-02: Map of selected farms

3.3 Analysis of the fish farming system

To explore fish farming systems, their potentialities and problems, and all other related issues in the study area, both field surveys and laboratory analyses were conducted in the study area.

3.3.1 Field survey

Adopted fish farming techniques, fisheries resources, relevant stakeholders, current problems, and prospects of aquaculture techniques were identified through various survey techniques.

3.3.1.1 Selection of survey techniques and preparation of the questionnaire

Five survey techniques were chosen, such as focus group discussion, field visit, farmer's interview, direct observation, and problem ranking. A questionnaire was prepared to obtain information on existing farms, management issues, feeding stuff, fish seeds, and potential prospects for fish farming of the study area (Appendix-A).

3.3.1.2 Farmers' interview and field visit

A pre-constructed questionnaire was used for the interviewing selected farmers. Local farmers took part in the interview and expressed their perspectives on all aspects of existing aquaculture techniques, problems, and prospects (Appendix-B).

3.3.1.3 Focus group discussion

Two focus group discussions were employed in different places in the study area to identify people's opinions and degree of involvement in the existing aquaculture practices. People spontaneously participated in the focus group discussions and expressed their opinion about fish farming and also shared information about available resources (Appendix-C).

3.3.1.4 Stakeholder's analysis

Relevant stakeholders like seed and feed suppliers, upazila fisheries officer (UFO), local governments, and traders were interviewed to visualize relationships, degree of involvement, and conflicts among stakeholders by questionnaire survey.

3.3.2 Laboratory analysis

Analysis of the farming component, including water quality, sediment characteristics, and presence of hazardous substances in farming components, were analyzed through field and laboratory test protocol.

3.3.2.1 Sample collection

Samples including water, sediment, whole fish, fish feed, poultry feed, and poultry feces were collected from the selected farms. Water samples and sediment samples were transported in plastic bottles and polyethylene bags. Fish samples were transported in an icebox by maintaining low-temperature condition for further laboratory analysis.

3.3.2.2 Determination of water and sediment quality parameters

Water and sediment quality parameters including temperature, pH, dissolved oxygen (DO), total suspended solids (TSS), total dissolved solids (TDS), iron, phytoplankton abundance, organic carbon, and organic matter were determined at the selected farms by using different instruments and laboratory manual, which are described below:-

3.3.2.2.1 Determination of water temperature

Water temperature was determined by using a Celsius thermometer.

3.3.2.2.2 Determination of water pH

Water pH was determined by using a pH meter **(**Instrument name: pH meter, model number: H198107 and company name: HANNA).

3.3.2.2.3 Determination of dissolved oxygen (DO)

Dissolved oxygen was determined by using a dissolved oxygen meter (Instrument name: DO Meter, model number: DO200A and company name: HANNA**).**

3.3.2.2.4 Determination of ammonia

Ammonia was determined by using ammonia hach-kit (Model number: NI-SA).

3.3.2.2.5 Determination of transparency

Transparency of water was determined by using a Secchi disk.

3.3.2.2.6 Determination of iron

Pond and underground water iron content was determined by using an Iron meter (Instrument name: Handheld Colorimeter Iron, model number: HR, 04050153101 and company name: HANNA).

3.3.2.2.7 Determination of total suspended solids (TSS)

TSS was determined according to the laboratory protocol, followed by Saha (2010).

Procedure:

Three filter paper dried at 105^{o} C at hot air oven for 2 hours, cooled at desiccator and weighted. Filter paper folded and placed in the filtration unit. 250 mL sample were taken and filtrated through by filtration unit. Filter paper dried at 105 ^{o}C at hot air oven for 2 hours, cooled at desiccator and weighted. Average weight taken for samples and calculation was done by the following formula.

Calculation: TSS (mg/L) =$(\mathrm{A} - \mathrm{B}) * \frac{1000}{\mathrm{SV}}$

Where,

A=Final weight of filter paper with sample (mg/g)

B= Initial weight of filter paper without a sample (mg/g)

SV= sample volume in mL

3.3.2.2.8 Determination of phytoplankton abundance

Ten liters of water were collected from each sampling area and passed through the plankton net. The mesh size of the plankton net was 25 µm. The collected sample was concentrated into 50 mL. One ml of concreted solution was taken in the Sedgwick-Rafter (S-R) cell. Ten squares of S-R cells were counted for the qualitative and quantitative study of the phytoplankton. Total number of plankton cell was calculated in the sample water by using of the formula of Rahman (1992).

Number of plankton (N) = $\frac{F \times C \times 1000}{F \times V \times L}$

Where,

V = Volume of the S-R cell field

F = number of field count

C = Volume of the final concentration of the sample

A = Total no. of plankton counted

L = Volume of the original water

N = number of plankton cells per liter

3.3.2.2.9 Determination of sediment organic carbon and organic matter

Organic carbon and organic matter of collected samples were determined in the ecology laboratory of Chattogram Veterinary and Animal Sciences University (CVASU) according to the laboratory protocol followed by Saha (2010).

Procedure:

Two gram of dried sediment sample were taken in a conical flask. Ten mL (1 *N*) of $K_2Cr_2O_7$ and 20 mL of concentrated H_2SO_4 and a pinch of silver nitrate taken and placed for 30 minutes in the dark condition. Then the solution was diluted with 200 mL distilled water, and 5 mL of phosphoric acid added to the diluted solution. Finally, the solution was titrated against standard $FeSO_4$ solution with 1 mL diphenylamine as an indicator. A blank sample (without sediment) also ran in the same way.

Calculation:

- Organic carbon (%) = $\frac{(B-U)*D*N*A*100}{B*W}$
- Organic matter (%) = $\text{Organic carbon} \times 1.724$

Where,

B= Volume of $FeSO_4$ required for the blank

U= Volume of $FeSO_4$ required for the sample

D= ml of $K_2Cr_2O_7$ used

N= Normality of the $K_2Cr_2O_7$ (1 *N*)

A= mEq of carbon (0.003)

W= Weight of the sample used

3.3.2.2.10 Determination of sediment iron content

Sediment samples were sent to Bangladesh Council of Scientific and Industrial Research (BCSIR), Chattogram to determine sediment iron content of the selected farms in the study area (Appendix-D).

3.3.2.3 Identification of hazardous substances

Poultry feces, fish feed, and fish samples were sent to identify the presence of heavy metal, antibiotic residues, and pathogenic bacteria in the Quality Control Laboratory, Fish Inspection and Quality Control (FIQC), Chattogram (Appendix-E).

3.4 Analysis and visualization of collected data

Collected data were summarized, categorized, and analyzed in Microsoft Excel (Version-2016), SPSS (Version- 22.0), and Programming Language R (Version- 3.6.3).

3.5 Determination of the problems and prospects of the aquaculture

Problems and prospects were ranked in the study area Based on survey data using Microsoft Excel (Version-2016).

3.6 Formulation of community based aquaculture model

Community based aquaculture model was suggested based on the analysis. The formulated model was further discussed with the fish farmers through focus group discussion to identify the precision, acceptance, integrity, and validity**.**

PHOTO GALLERY

Plate-01: Farmers interview

Plate-02: Farm visit

Plate-03: Creek and pond

Plate-04: Poultry cum fish farm

Plate-05: Vegetable culture on the pond dyke

Plate-06: Fish seed collection from nursery pond

Plate-07: Focus group discussion

Plate-08: Fish market visit

Plate-09: Meeting with upazila fisheries officer of Matiranga

Plate-10: Water quality testing in the field

Plate-11: Sample collection

Plate-12: TSS determination

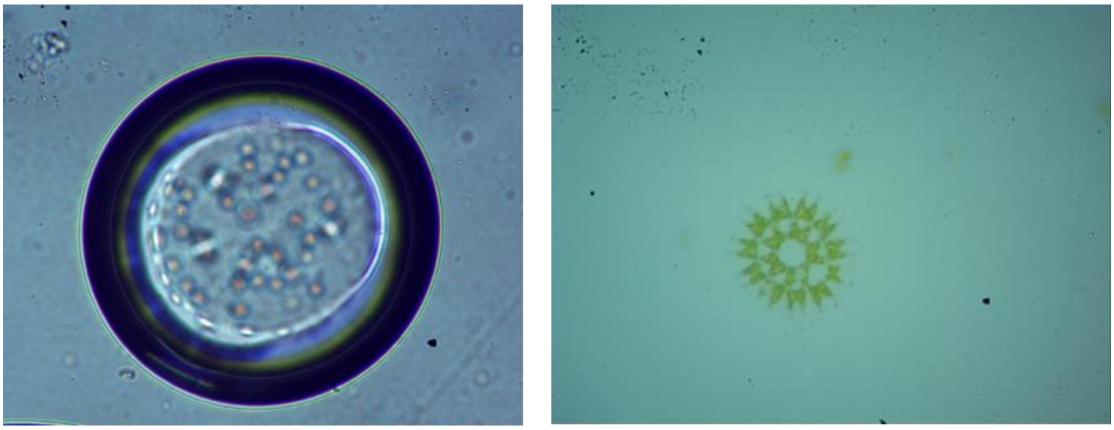

Plate-13: Phytoplankton cell count and identification

Plate-14: Sediment organic carbon determination

CHAPTER-04: RESULTS

4.1 Diversity of occupation

Among selected fish farmers, 20% were reliant solely on fish farming and its related activities including the fish selling (15%) and fish merchanting (5%). The remaining fish farmers (80%) were engaged in other occupation such as business (30%), driving (20%), teaching (10%), politics (5%), agro-farming (5%) and day laborer (10%), and they considered fish farming as an additional income-generating strategy (Figure-03).

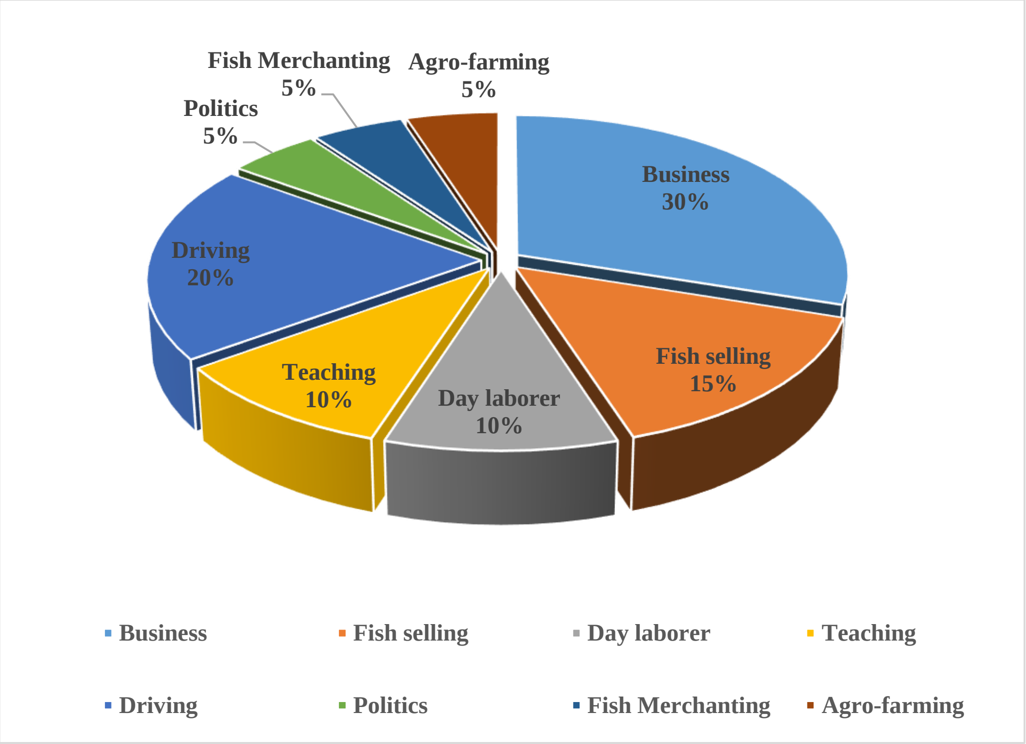

Figure-3: Diversity of occupation

4.2 Ownership, types of waterbody, area and farming type

There were two types of waterbody, creeks and ponds, where 10% was earthen pond, and 90% was creek. Among the selected farms, 45% of farms were under leasing and 55% farms were self-owned. A total of 4030 decimal (16.31 ha) area was allocated for fish culture, and the maximum farming area was 640 decimal (2.59 ha), and the minimum was 35 decimal (0.14 ha) among the selected farms. Two categories of farms were observed, poultry cum fish culture denoted as poultry-fish farms (25%) and fish farms denoted as non-poultry farms (75%) in the study area (Figure-04 and Appendix-H).

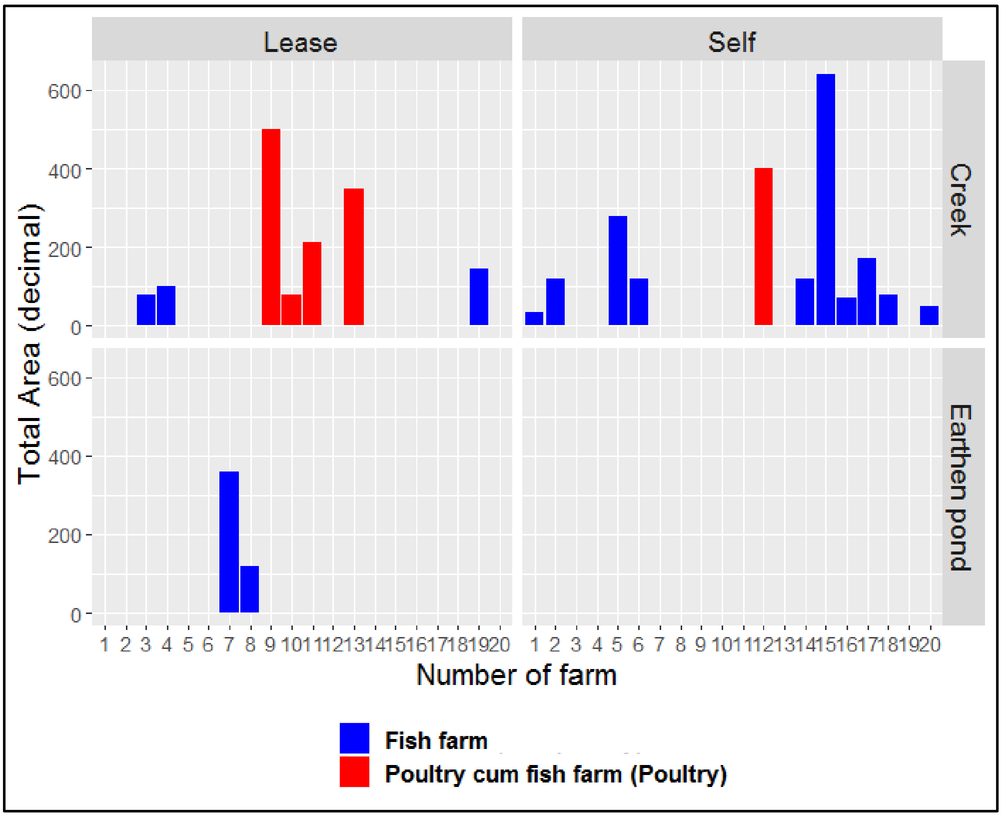

Figure-04: Ownership, types of waterbody, area and farming type

4.3 Important aspects of fish farming

Important aspects of fish farming in the study area were identified through the survey process. Among the selected farmers, 56% applied lime and fertilizer in their ponds during culture period. Twenty (20%) of the selected farmer claimed that they found government support such as consultancy and training, and sixteen (16%) farm owner involved women in the fish farming. Only 4% farmers claimed that they monitor water quality and 4% found engaged in vegetable and fish integration (Figure-05).

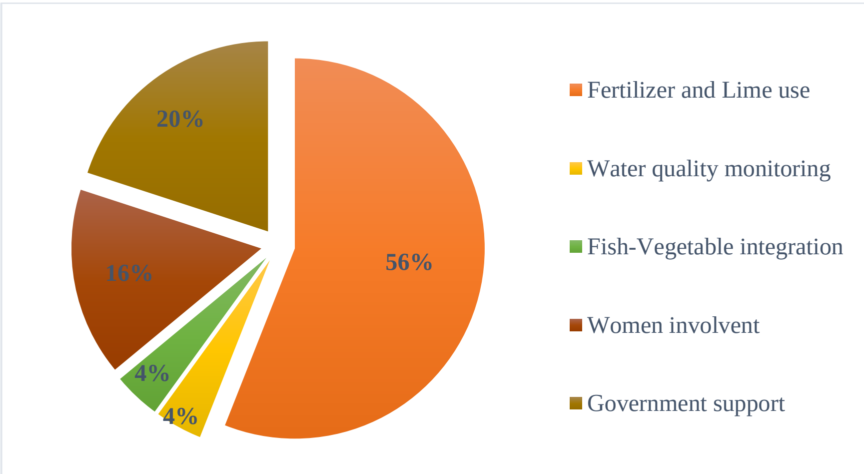

Figure- 05: Important aspects of fish farming

4.4 Fish culture methods

Among the fish farming method practiced in the study area, 60% were polyculture, 10% were nursing and 30% were mixed farming (where mixed farming represents the combination of polyculture and nursing). Among the practiced methods, polyculture was seemed to be popular in the study area (Figure-06 and appendix-H).

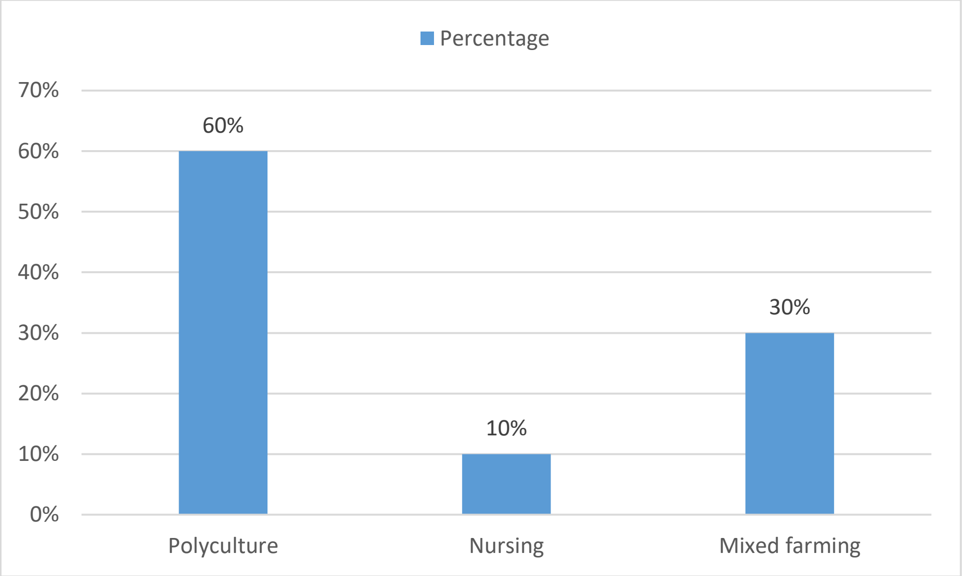

Figure-06: Identified culture methods

4.5 Culture species

Eleven (11) fish species were identified as culture species among the selected fish farms in the study area. Tilapia (*Oreochromis mossambicus*) was observed in maximum (90%) of the farms and magur (*Clarias batrachus*) in only (5%) of the farms (Figure-07 and appendix-F). Tilapia found most popular culture species in the study area due to its high growth rate.

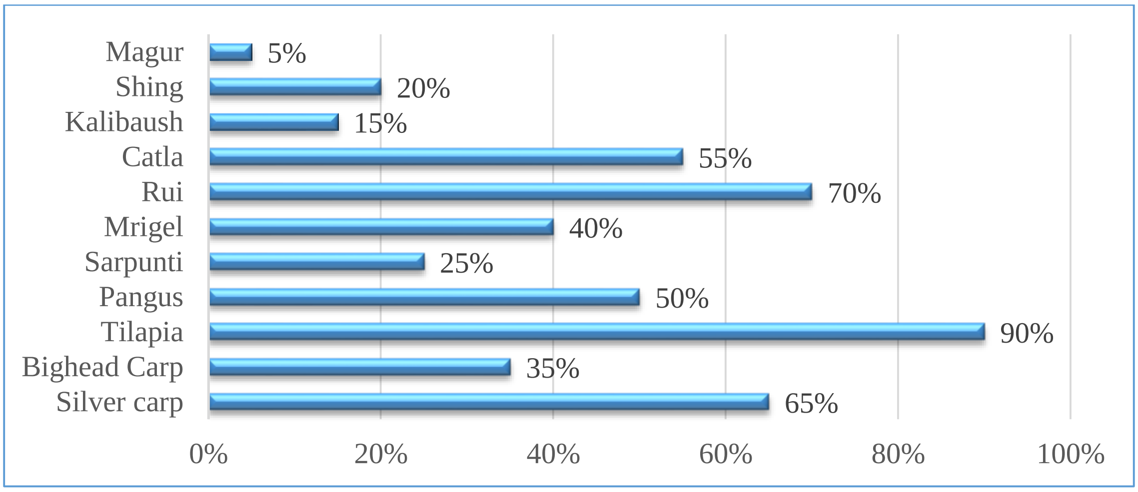

Figure-07: Identified culture species

4.6 Types and sources of seed

Both fish fry (1-2 cm) and fingerling (10-15 cm) was used as fish seed for aquaculture. Sources of fish seed were studied in the study area and found that 45% farms brought fish fry from remote districts, including Cumilla (35%), Lakshmipur (5%), Chattogram (5%) while the remaining eleven (55%) farms were found dependent on fingerlings from local nursers. Thirty (30%) of the selected farms that brought fries from remote areas, they also purchased fingerlings from local nursers (Figure-09).

4.7 Costing of seed at source and transportation

In the total seed cost per year of the selected fish farms, 89% (BDT 13,63,150) cost found for seed purchasing, and 11% (BDT 1,64,800) cost found for seed transportation. Among the selected farms, highest transportation cost was recorded 32% of the total seed cost that brought fries from remote districts, and lowest 3% of the total seed cost that brought fingerlings from local nursers. The costs related to seed transportation was seemed to be high in the study area (Figure-08).

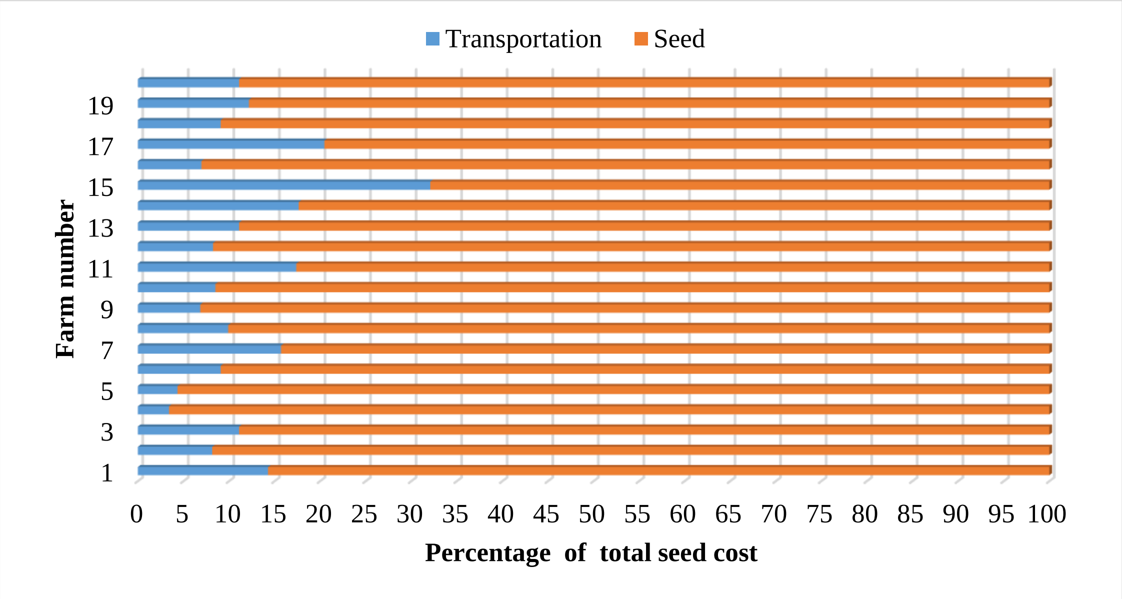

Figure-08: Costing of seed at source and transportation

4.8 Average transportation cost and mortalities for fish seed

The average distance for fry transportation from remote districts was found 153.7 km and for fingerlings from local source was 5.05 km. In the total cost of transportation per year, 76.45% was found for fry transportation and 23.55% for fingerlings transportation. The average mortalities were found 7.2% for fry and 2.8% for fingerlings, in the total mortality for each category (Figure-09).

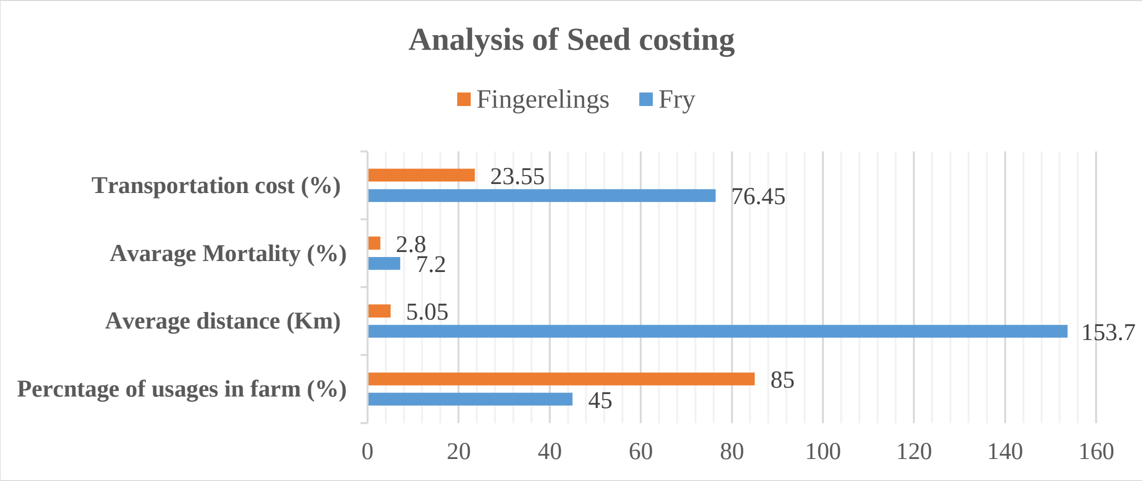

Figure- 09: Average transportation cost and mortalities for fish seed

4.9 Costs associated with feeding

Feed categories used in the study area were analyzed and found 90% of selected farms used commercial pellet feed, and 10% use on farm made feed (Figure-10). Among the farms that use commercial pellet feed, 35.50% farms were recorded to use floating feed, and 64.50% farms were recorded to use sinking feed (Figure-11). The total feed purchase cost for the selected farms were found BDT 32,84,000 per year in which commercial pellet feed cost was BDT 2,551,000 (78%), and on farm made feed cost was BDT 7,33,000 (22%) (Figure-10).

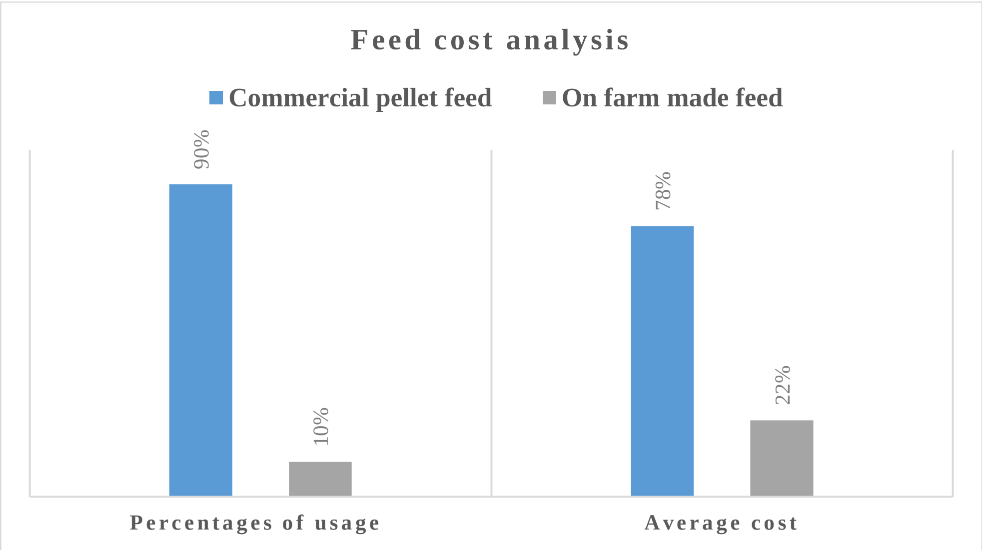

Figure-10: Feed cost analysis

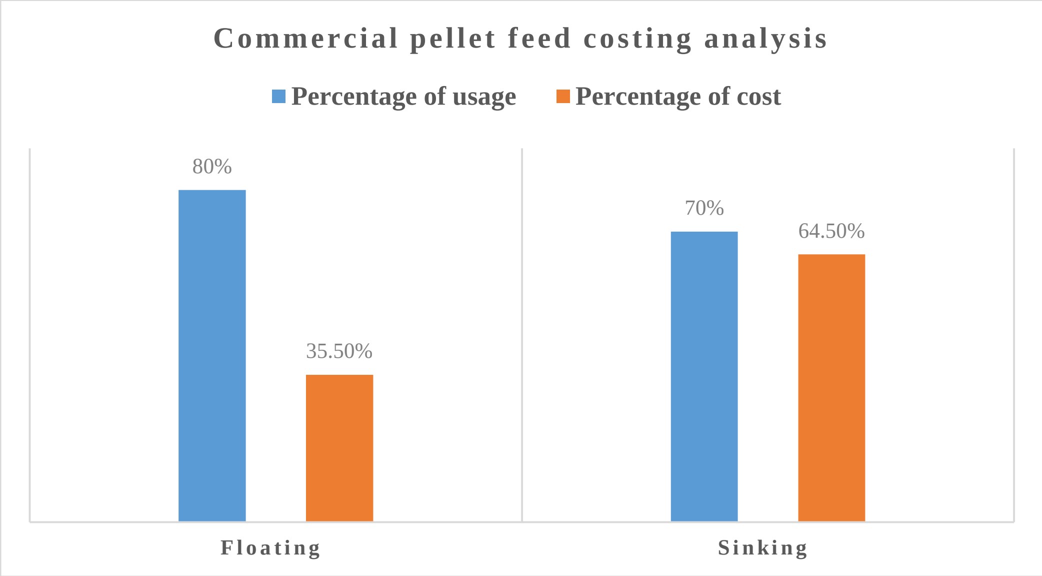

Figure-11: Comparison of floating and sinking feed

4.10 Total cost analysis

Among the selected farms, total cost of the fish farming was found BDT 58,07,500 per year in which the seed cost was BDT 15,27,950 (26.3%), feed cost was BDT 33,93,850 (58.4%), and other costs associated with leasing, lime and fertilizer, medicine, harvesting, electricity, and labor was BDT 8,85,700 (15.3%). Seed and feed cost (84.7% of the total cost) were found major cost of the fish farming among the selected fish farms (Figure-12).

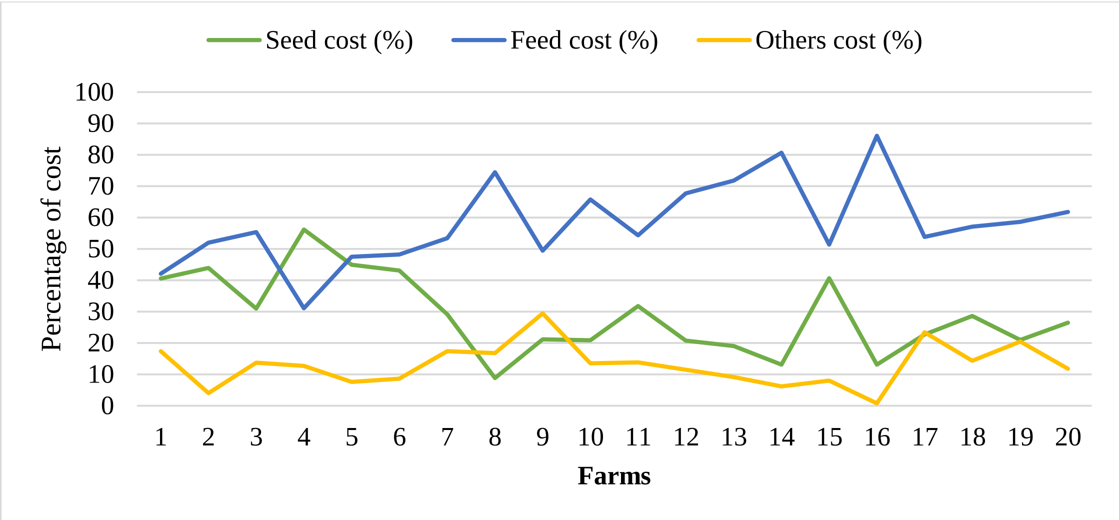

Figure-12: Comparison of the different types of costing among the farms

4.11 Cost, production and revenue analysis

Average production per year from the selected farms were recorded 14 kg/decimal while 38 kg/decimal and 4 kg/decimal recorded as maximum and minimum production respectively (Figure-14). The maximum cost per year was recorded BDT 3,528/ decimal, and the minimum cost BDT 311/decimal (Figure-13). The average income per year was found BDT 786/decimal, while the maximum was BDT 2 097/decimal and minimum BDT 162 /decimal from the selected farms (Figure-15).

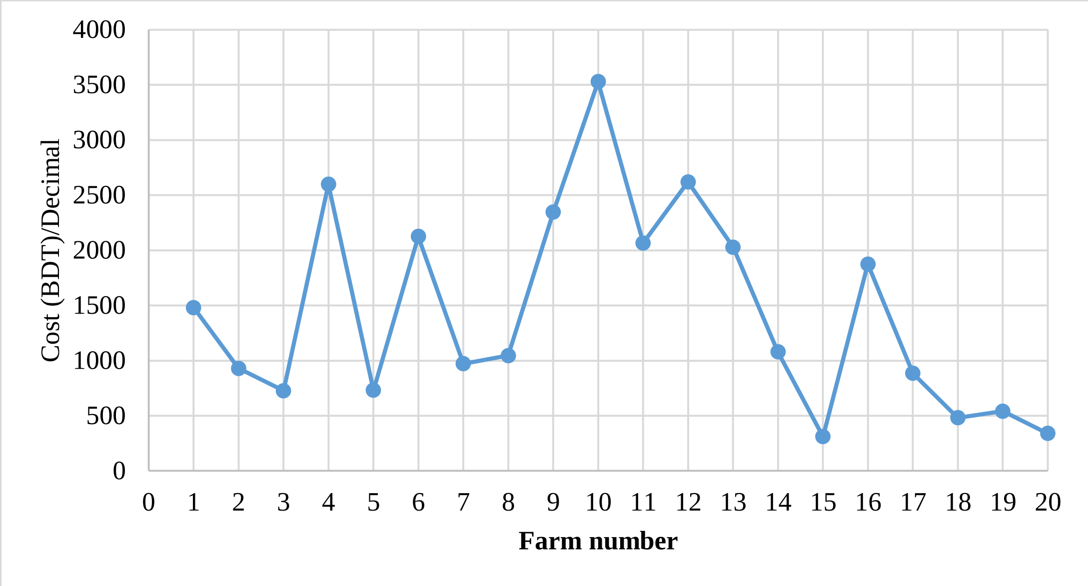

Figure-13: Costing of the farms per unit area

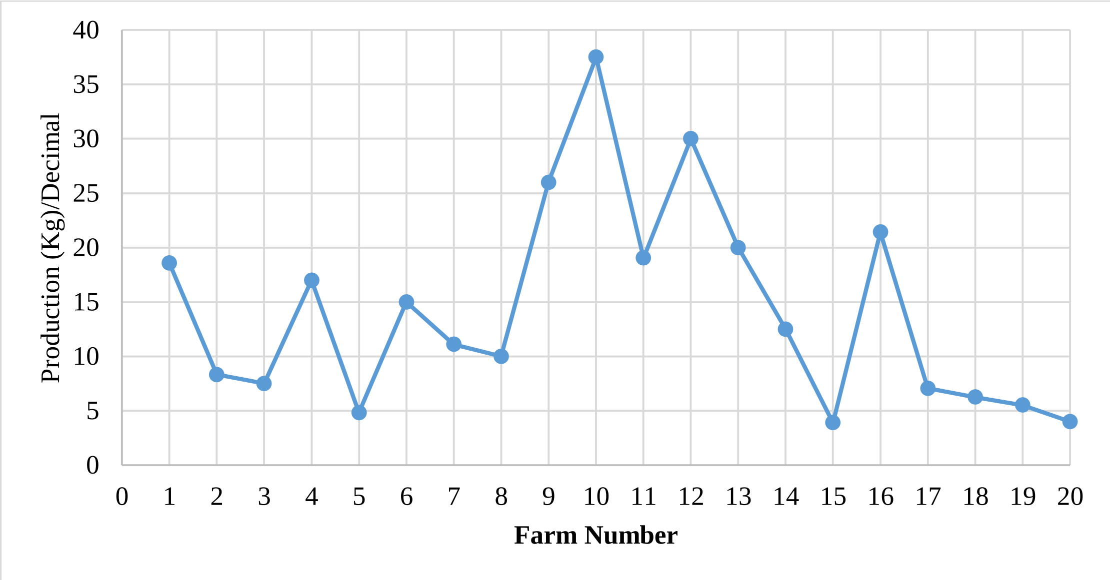

Figure-14: Production per unit area among the selected farms

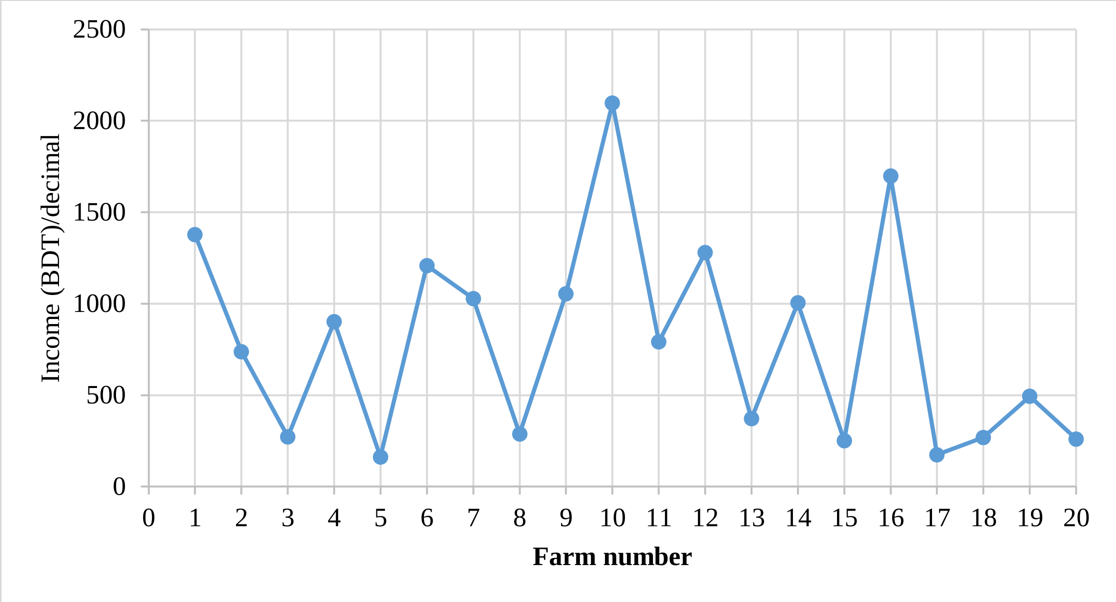

Figure-15: Revenue per unit area among the selected farms

4.12 Profit scenario based on farming types

Among the selected farms, profit was found higher in poultry farms than the non-poultry farms as production was higher in poultry farms than the non-poultry farms (Figure-16).

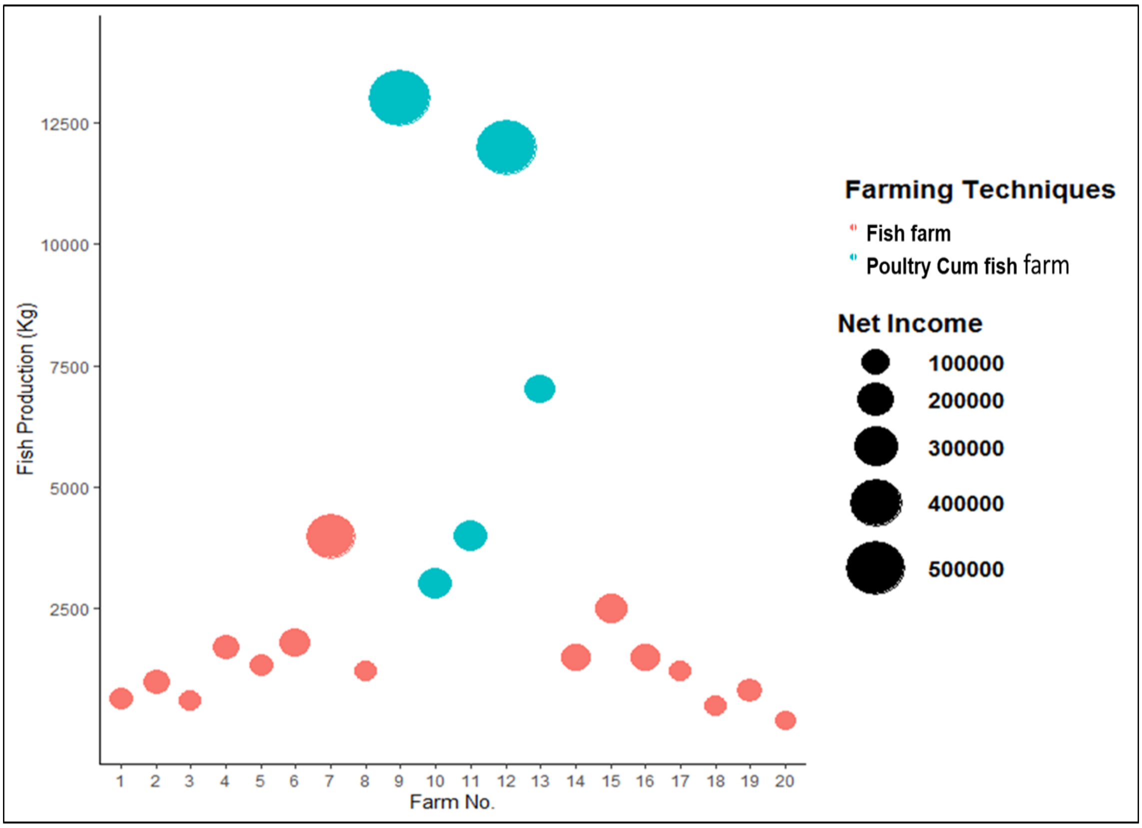

Figure-16: Profit scenario based on farming types

4.13 Water and sediment quality parameters

Different water and sediment quality parameters of the selected farms were measured, and mean values were obtained (Appendix-J). The mean value of dissolved oxygen (mg/L), pH, NH_3 (ppm), water iron (ppm), temperature (^{0}C), total suspended solids (mg/L), total dissolved solids (mg/L), transparency (cm), phytoplankton cell count (cells/L), sediment organic carbon (%) and sediment organic matter (%) of the non-poultry and poultry farms shown in Table-1 and Table-2.

Table-1: Water and sediment quality parameters of non-poultry fish farms

Parameter name	Unit	Minimum	Maximum	Mean	Standard Deviation
Temperature	ºC	28.30	31.60	30.06	1.01
Dissolved oxygen	mg/L	6.68	9.97	8.18	1.01
pH	-	7.00	9.20	8.23	0.60
Ammonia (ppm)	ppm	0.27	0.94	0.50	0.22
Total Suspended solids (TSS)	mg/L	14.82	30.33	23.21	5.38
Total Dissolved solids (TDS)	mg/L	47.40	81.45	61.92	10.24
Transparency (cm)	cm	29.10	45.80	36.46	4.45
Water Iron (ppm)	ppm	0.14	1.34	0.90	0.35
Sediment Organic Carbon	(%)	0.40	0.71	0.51	0.10
Sediment Organic Matter	(%)	0.69	1.23	0.89	0.20
Phytoplankton Cell Count	Cells/L	1.05×10^4	2.20×10^4	1.81×10^4	0.34×10^4

Table-2: Water and sediment quality parameters of poultry fish farms

Parameter name	Unit	Minimum	Maximum	Mean	Standard Deviation
Temperature	ºC	29.60	31.30	30.32	0.68
Dissolved oxygen	mg/L	6.50	9.20	7.89	0.96
pH	-	7.90	9.50	8.70	0.69
Ammonia (ppm)	ppm	0.37	1.31	0.88	0.34
Total Suspended solids (TSS)	mg/L	45.87	58.03	51.59	5.36
Total Dissolved solids (TDS)	mg/L	118.70	152.12	131.35	12.68
Transparency (cm)	cm	23.10	32.50	26.28	3.84
Water Iron (ppm)	ppm	1.32	2.14	1.76	0.33
Sediment Organic Carbon	(%)	0.72	1.55	1.10	0.39
Sediment Organic Matter	(%)	1.23	2.67	1.90	0.67
Phytoplankton Cell Count	Cells/L	3.30×10^4	4.35×10^4	3.88×10^4	0.41×10^4

4.14 Comparison of water quality and sediment parameters

Comparison among the mean values of water and sediment quality parameters shown in Table-03.

Table-3: Comparison of water quality and sediment parameters

Parameters name	Unit	Non-poultry fish farm	Poultry fish farm
Temperature	oC	30.07	30.32
Dissolved oxygen	mg/L	8.18	7.89
pH	-	8.23	8.70
Ammonia (ppm)	ppm	0.5	0.88
Total Suspended solids (TSS)	mg/L	23.22	51.59
Total Dissolved solids (TDS)	mg/L	61.93	131.35
Transparency (cm)	cm	36.47	26.28
Water Iron (ppm)	ppm	0.91	1.76
Sediment Organic Carbon	(%)	0.51	1.10
Sediment Organic Matter	(%)	0.90	1.90
Phytoplankton Cell Count	Cells/L	1.81×10^4	3.88×10^4

4.15 Sediment iron content

According to the report of the Bangladesh Council of Scientific and Industrial Research (BCSIR), Chattogram, sediment iron content of poultry fish farm and non-poultry fish farm was recorded 1.69 mg/kg and 7.99 mg/kg respectively. Poultry fish farm showed greater deposition of iron in the sediment (Appendix-D).

4.16 Presence hazardous substances

According to the report of the quality control laboratory of Fish Inspection and Quality Control (FIQC), Chatttogram, hazardous substances like chloramphenicol, nitrofuran metabolites, and heavy metal was not detected in fish and fish feed sample of non-poultry farms. Chloramphenicol was detected in the poultry feces sample of the selected poultry farms (Appendix-E).

4.17 Prospects and problems of aquaculture

Significant problems and prospects were identified through the questionnaire and ranked later according to farmer opinions in the focus group discussion (Figure-17 and 18).

Prospects identified:

According to analyzed data, significant aquaculture prospects were unutilized creeks for aquaculture, women and youths can be engaged, integrated aquaculture system may be potential culture techniques, people have desire to involve in aquaculture, enough human resources.

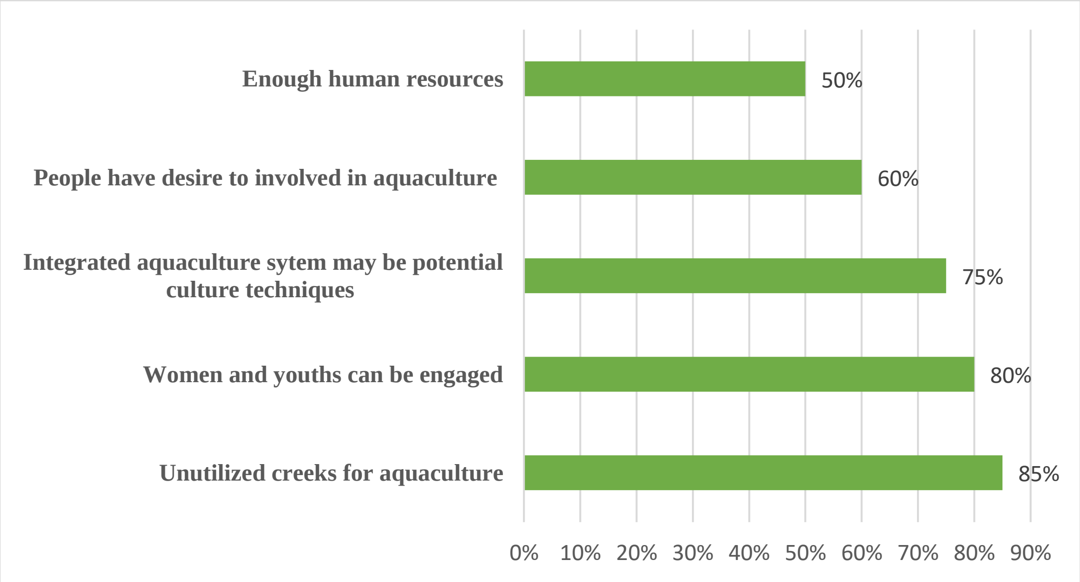

Figure-17: Prospects ranking

Problems identified:

According to analyzed data, significant aquaculture problems were lack of hatchery in the study area, excessive cost for feed purchasing, lack of strong stakeholder linkage, lake of proper knowledge, guideline and consultancy and assuming hill soil has low production rate.

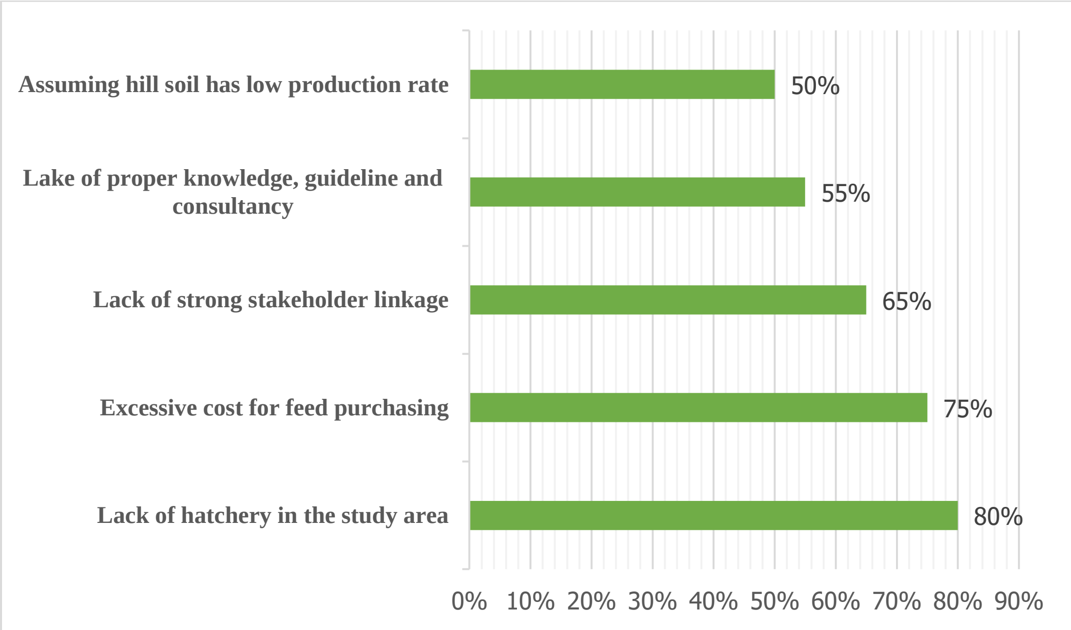

Figure-18: Problem ranking

4.18 SWOT analysis for the aquaculture expansion

Table-04 presented, the analysis of the strength, weakness, opportunity and threats for aquaculture expansion in the study area is given below:

Table-04: SWOT analysis for the aquaculture expansion

Strength	**Weakness**
• Available manpower • Interest of local people in aquaculture • Local nurserers and aquaculture entrepreneurs • Traditional knowledge in aquaculture	• Lack of availability of aquaculture inputs • Lack of stakeholder linkage • Lower fertility of bottom soil • Lack of skilled and technical person • Negative approaches in technology adoption • Marketing chain is not well developed
Opportunity	**Threats**
• Utilizable creeks for aquaculture • Suitability of creeks for aquaculture • Greater demand for fish at local level and countrywide • Potentiality of safe and hazard free integrated aquaculture • Women engagement in fish farming • Employment of local people	• High prices of feed and seeds • Extortion and influence of middleman • Institutional supports and funding were insufficient • Higher transportation cost • High concentration of soil iron • Water scarcity in winter season

4.19 Community-based aquaculture model for the target area

After analyzing collected data, a community-based aquaculture model was formulated based on the problems and prospects of the present fish farming methods in the study area. The formulated model was further discussed with the fish farmers through focus group discussion. The model consists of the following steps (Figure-19).

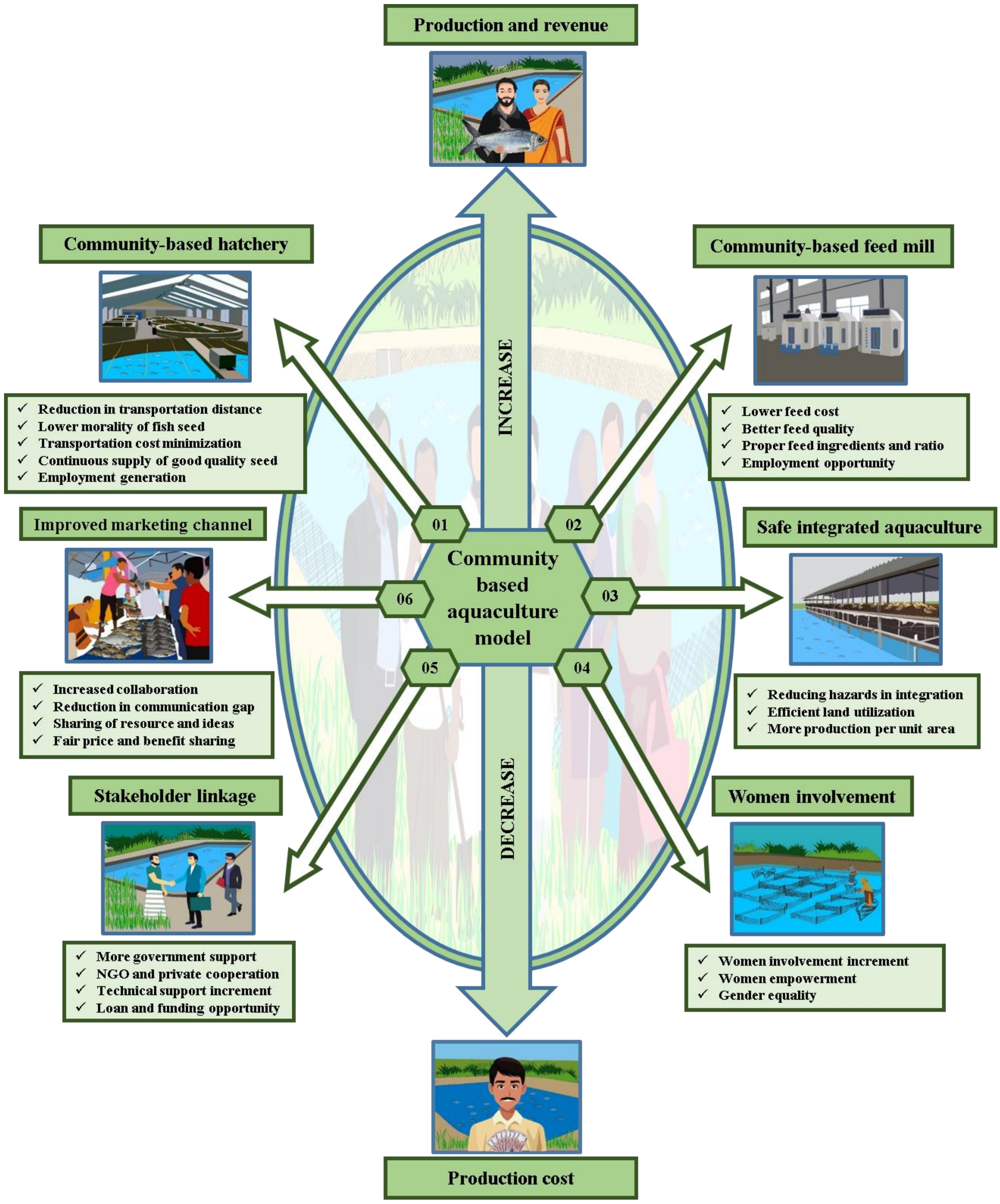

Figure-19: Community-based Aquaculture model

CHAPTER-05: DISSCUSSION

5.1 Diversity of occupation

The present study revealed that most of the farmers were employed in fish farming as their additional income-generating activities for maintaining livelihoods. Among the farmers 20% solely reliant on fish farming and its related activities and 80% related with others occupations (Figure-03). Adhikary et al. (2018) found that 24% of fish farmers were directly involved in fish farming as their main occupation, while 10% were in the industry, 50% in agriculture, and 16% in other occupations in Noakhali sadar upazila, which doesn't agree with our findings but similarly shows the diversity of occupation.

5.2 Ownership, types of waterbody, area and farming type

Present study identified creek (90%) as the primary type of waterbody, with 16.31 ha allocated for fish farming. As the study area comprises hills mostly, that's why creek culture appeared as the popular culture technique (Figure-04). According to DoF (2012), 727 numbers of creeks with an area of 4375.90 ha have the potentiality of fish culture in Chattogram hill tracts, making our findings evident. Two categories of the farms were observed in the study area, which were poultry cum fish culture denoted as poultry and fish farm without poultry denoted as non-poultry farms (Figure-04), and most of the poultry farms were found established on the dikes for integration with fish culture, and this finding agrees with Al-Mamun et al. (2011). According to the present study, 45% of farms were under leasing, while the remaining 55% were self-owned (Figure-04). Rahman et al. (2018b) found that 64% of farmers had their land, 24% possessed farms of joint ownership, and 12% of farmers operated farming activities in leased lands in their study area, which resembles the greater percentage of self-owned farms in the present study.

5.3 Important aspects related to fish farming

Present study found 56% farmers were use lime and fertilizer during culture period (Figure-05). Chowdhury et al. (2012) reported the use of lime and fertilizer during fish culture for fish health management in their study. Rahman et al. (2018b) observed that 96% farmers applied different organic and inorganic fertilizers in the integrated farming systems. Present study indicated that 20% farmers get government support, including consultancy and training (Figure-05). According to Aziz and Hossain (2002), the government of Bangladesh launched a project named "Fish Culture Development (in hills) and Extension" emphasizing farmers' training to encourage aquaculture in creeks, ponds, and lakes of the hill districts, and this information shows the incentives of government support in the hilly area. Among the selected farms 16% farms owner involved women in farming activities such as feeding, fertilization and liming (Figure-05). Shirajee et al. (2010) stated in his study that women could be engaged in various farming activities such as seed stocking, fish feeding, fertilization, liming, fish processing, and marketing which agrees with the findings of present study.

5.4 Fish culture methods

Present study identified polyculture (60%) as the popular culture methods practiced in the study area (Figure-06). Das and Khan (2016) found polyculture (93.16%) as the popular culture method in their study, which agree with the present study findings. Polyculture is the best culture system for maximum utilization of pond food web and ecosystem; can give higher production with fishes of different feeding habits (Halver, 1984); increase fish yield per unit area (Hossain and Islam, 2006).

5.5 Culture species

Eleven (11) fish species were identified as culture species in the present study, including Rui (*Labeo rohita*), Catla (*Gibelion catla*), Mrigel (*Cirrhinus cirrhosus*), Kalibaush (*Labeo calbasu*), Sarpunti (*Puntias sarana*), Pangus (*Pangasius hypophthalmus*), Tilapia (*Oreochromis mossambicus*), Bighead carp (*Hypophthalmichthys nobilis*), Silver carp (*Hypophthalmichthys molitrix*), Shing (*Heteropneustes fossilis*) and Magur (*Clarias batrachus*) (Figure-07). Findings of the present study agree with the conclusion of Aziz and Hossain (2002) regarding suitable aquaculture species of the hilly area. Ullah et al. (2020) and Rahman et al. (2018b) also found polyculture of the similar fish species in an integrated way.

5.6 Types and sources of seed

Present study found that 45% farms brought fish fry from remote districts such as Cumilla, Lakshmipur, and Chattogram while the remaining (55%) farms were dependent on fingerlings from local nurserers. Dependency on remote districts for fish seed was evident in the study area (Figure-09). Islam et al. (2005) stated that scarcity of fish seeds of major carps is one of the main problems to the development of aquaculture in Bangladesh. The study also mentioned that fry traders bring fish seeds from various hatcheries and make them available to fish farmers. Das et al. (2018)

mentioned the unavailability of quality fish seeds in sufficient quantity as one of the major problems faced by fish farmers in Bangladesh. Similar findings were reported by Marina (2009) and Robbani (2002) as well.

5.7 Seed transportation and mortalities

According to present study, seed purchase cost was found 89% and seed transportation cost was 11% in the total seed cost (Figure-10). The costs related to fry transportation was high as these were brought from remote sources. So, the study clarifies the necessity of local hatcheries for supplying enough fish seeds for mitigating demand. According to a study by Rahman et al. (2018b), farmers were mainly dependent on private hatcheries to collect carp fingerlings, which represents the need for government hatcheries increment as like our finding. Hasan (2009) also emphasized the necessity of hatcheries to reduce transport constraints. The study found average mortalities 7.2% for fry (1-2 cm) and 2.8 % for fingerlings (10-15 cm) in the total mortality of the selected farms that reflects the necessity of development of a fish hatchery in the study area (Figure-09). According to Das et al. (2005), heavy mortality occurs during fish seed transportation because of several internal and external factors which justify findings of the study.

5.8 Total cost analysis

In the total cost of fish farming of the selected farms, 26.3% cost required for seed, 58.4% cost for feed, and the remaining 15.3% cost for others farming activities such as leasing, liming and fertilization, medicine, harvesting, electricity, and labor (Figure-12). The maximum cost was found BDT 3,528/decimal/year, and the minimum cost was BDT 311/decimal/year (Figure-13). Mohsin et al. (2012) found feed cost as the major cost of fish farming in their study which is similar to present study findings. Ahmed (2007) also accounted feed cost as the highest operational cost in intensive, semi-intensive and traditional practices of the fish farming in his study.

5.9 Production and Income

Present study found average production 14 kg/decimal/year while 38 kg/decimal/year and 4 kg/decimal/year were maximum and minimum production respectively (Figure-14). The average income was recorded BDT 786/decimal/year from the selected farms (Figure-15). Hossain et al. (1997) found 16.5 kg/decimal/year as maximum production 12.7 kg/decimal/year as minimum production from the traditional polyculture which is close to present study findings.

5.10 Water and sediment quality parameters

Different water and sediment quality parameters were measured for both poultry and non-poultry fish farm (table-1 and 2). Range of temperature, dissolved oxygen, pH, ammonia, total suspended solids, total dissolved solids, transparency, water iron, sediment organic carbon, sediment organic matter, and phytoplankton cell of non-poultry farms were found 28.30 to 31.60 C, 6.68 to 9.97 ppm, 7.00 to 9.20, 0.27 to 0.94 ppm, 14.82 to 30.33 mg/L, 47.40 to 81.45 mg/L, 29.10 to 45.80 cm, 0.14 to 1.31 ppm, 0.40 to 0.71 % , 0.69 to 1.23 %, and 1.05 x 10^4 to 2.20 x 10^4 cells/L respectively. Range of temperature, dissolved oxygen, pH, ammonia, total suspended solids, total dissolved solids, transparency, water iron, sediment organic carbon, sediment organic matter, and phytoplankton cell of poultry farms were found 29.60 to 31.30 ^{o}C, 6.50 to 9.20 ppm, 7.90 to 9.50, 0.37 to 1.31 ppm, 47.87 to 58.03 mg/L, 118.70 to 152.12 mg/L, 23.10 to 32.50 cm, 1.32 to 2.14 ppm, 0.72 to 1.55 %, 1.23 to 2.67 % , and 3.30 x 10^4 to 4.35 x 10^4 cells/L respectively. Sediment iron content of poultry fish farm and non-poultry fish farm was recorded 1.69 mg/kg and 7.99 mg/kg respectively.

Dewan et al. (1991) recorded temperature range of 25.9 to 34.5 ^{o}C in a fish polyculture pond. Hassan et al. (2017) found mean value of iron 42.02 mg/kg in sediment of Chattogram hill tracts which is relatively higher than our findings. Akter et al. (2015) reported a temperature range from 25 to 30°C, transparency 25 to 35 cm, pH 6.90 to 8.90, dissolved oxygen (DO) 3.70 to 5.00 mg/L in the studied ponds, and these findings are almost agree with the present study. The mean value of TDS value was higher poultry fish farm than the non-poultry fish farm because of the use of poultry feces in the poultry-fish farms in the study area. Abedin et al. (2017) found a concentration of organic carbon from 0.86 to 2.52% and the concentration of organic matter varied from 1.48 to 3.75%. Soils of hills generally have greater organic matter than that of agricultural soils (Osman, 2012) and this statement shows compliance with our observation in the case of sediment organic matter and sediment organic carbon. Akter et al. (2015) reported that the abundance of phytoplankton in culture ponds varied from 36×10^5 cells/L to 94.92×10^5 cells/L and this range is relatively higher than range of present study.

5.11 Presence of microbes and hazardous chemical component in the farming component

The presence of hazardous substances like chloramphenicol, nitrofuran metabolites, and heavy metals were tested and none of these were found in the non-poultry fish farms. In poultry-fish farms, chloramphenicol was observed in the poultry feces sample (Appendix-E). Petersen et al. (2002) reported that antimicrobials substances is used in poultry farm for promoting growth or curing disease. According to Ampofo and Clerk (2010), used poultry litter in fish pond which considered as a contributing factor to salmonella contamination and also major causes of introduction of hazardous substances.

5.12 Prospects identified

Prospects were identified and ranked according to the view of the respondents (Figure-17). Majhi (2005) reported the feasibility of integrated farming in hilly regions to produce multiple crops at same time. According to Little and Edward (2003), integrated aquaculture system initiation was to meet basic requirements including food security, effective utilization of valuable resources, and pollution control. Integrated fish farming is ecologically sound and improves soil fertility by making nitrogen and phosphorous available (Dugan et al., 2006). Rural women might be contributed to fisheries-related activities besides their household works (Shelly and Costa, 2002). According to Allison (2011), aquaculture and fisheries has potential to contribute in the employment generation for youths.

5.13 Problems identified

Several problems are identified in this study and ranked according to the opinions of respondents (Figure-18). Rahman et al. (2018b) stated that the unavailability of quality fish seeds in sufficient quantity is one of the major problems for integrated aquaculture. The high price of inputs, low price of products, lack of capital, inadequate scientific and technical knowledge, insufficient extension services, high lease value, poor loan facility, etc. were reported as other constraints as well. Rahman et al. (2015) reported about lack of proper initiatives to conduct training for fish farmers in the aquaculture sector of Bangladesh. Das et al. (2018) reported inadequate supply and low-quality seed, insufficient loan facilities, lack of technical knowledge and training and multiple ownership as the significant constraints for fish farming.

5.14 Community based aquaculture model

After analyzing the collected data, a community-based aquaculture model was formulated based on the problems, prospects and SWOT analysis of the present fish farming in the study area (Figure-19).

- **Establishment of a community based hatchery**

As there was no hatchery in the study area, farmers usually depend on remote sources for collecting seed. Transportation of seeds from remote areas reduced the quality of seeds and also increasing cost. In the total cost of transportation, 76.45% cost required for fry transportation from remote sources (average distance: 153.7 km) and 24.55% required for fingerlings transportation from adjacent (average distance: 5.05) sources. Average mortality was 7.2% for fry and 2.8% for fingerling among the selected farms (Figure-09). So, the establishment of hatcheries in the study area found to be very important to overcome the seed supply constraint for fish farming. Moreover, the local peoples were not seemed to financially capable to establish hatcheries in private ownership. Therefore, community-based initiative is required to establish a hatchery in the study area. A well-established hatchery can ensure reduction of seed costs by reducing average travel distance of about 148 km in case of fry (Figure-09). Besides local source of good quality seed, local people employment will be ensured.

- **Establishment of a community based feed mill**

In the study area, 75% farmers said that feed cost was the 2nd most important problem in aquaculture because they had lack of capital for feed purchasing (Figure-18). Moreover, there was no local feed mill and feed manufacturer in the study area. Feed cost was estimated 58.4% of the total cost for aquaculture in the study area (Figure-12). A community based feed mill establishment might be an appropriate solution of this problem. A community based feed mill may ensure the availability of fish feed, reduce the transportation cost, and may reduce total production cost of fish farming. It will also ensure proper and specific ratio of feed ingredients for particular fish species and will create employment opportunities for local people.

- **Safe integrated aquaculture system**

In the study area, majority of fish farmers had no interest in integrated aquaculture. Poultry cum fish culture denoted as poultry fish farm was found 25% of the total selected farm (Figure-04). Vegetable-fish integration was found in the 4% of the selected farms (Figure-04). Practiced poultry fish farming in the study was found not safe as they directly deposit poultry liter in the fish pond to minimize feed cost. Hazardous substances (Chloramphenicol) was detected in the poultry feces sample (Appendix-E). According to FAO (2003), livestock-fish farming is need to be more precisely design or manage to avoid health risks for human. Buras (1993) raised health concerns about poultry cum fish farm as there is a possibility of transferring pathogens to humans. Nnaji et al. (2011) reported that rearing of fish with poultry liter for long time has risks of being contaminated with heavy metal and which may transfer to the human through food chain. According to Code of Conduct For Segments of the Aquaculture-Based Shrimp Industry in Bangladesh (2015), poultry liter should not used as fertilizer or feed in the pond because it could create microbial contamination. Integrated aquaculture may reduce overall production costs and generate higher profits but it must be practiced in a safe way. So, introduction of safe integrated aquaculture system in the study area is necessary to increase fish production, profit, and improving the natural productivity of the soil and water.

- **Involvements of women**

In the study area, 16% farm owner involved women in the aquaculture (Figure-04). Das and Khan (2016) showed that women could be engaged in liming, feeding, regular supervision, medication, pond drying, harvesting, marketing, seed supply, and trading processes of aquaculture. The involvement of women in the production line will reduce production costs as well as secure women's rights and gender equality in the study area.

- **Establishment of stakeholder linkage**

Linkage among stakeholders is very important for the aquaculture and fisheries sector. In the research area, lack of adequate linkage among the stakeholders was observed. Among the selected farmers 20% claimed that they found support for aquaculture from the government agency (Figure-04). Government agency has lack of manpower that’s why they could not able provide sufficient support to the fish farmers in the study area. Efficient linkage among stakeholders is necessary to achieved sustainable fish production. Collaborative effort and strong linkage will ensure sharing knowledge, experience and resources among the stakeholders. It will ensure loan and capital generation for fish farming from government, NGO and private organizations in the study area.

- **Establishment of a marketing channel**

Communication among producers, processors, traders and other interested parties is very important for successful fish farming. If two ways of communication can be established, it will greatly increase the facilities for the fish farmers and traders of the study area. A comprehensive market chain development through community-based incentives will ensure greater profit, fair distribution of profits and most importantly reduce the extortions by middlemen in the market chain. Consequently, the involvement of people in fish farming will be increased, and sustainable livelihoods will be ensured.

CHAPTER-06: CONCLUSION

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Community based aquaculture (CBA) is a globally accepted methods which ensure active participations of farmers and relevant stakeholders in farm management process and enables them to make appropriate decisions. Present study was conducted in the hilly area of Bangladesh to formulate an effective CBA model to minimize the problems of aquaculture, boosting production and increasing livelihood opportunities of the farmers. It will lower the production cost through minimizing feed and seed constraints and will ensure greater revenue from fish farming. The CBA model will ensure participation of the local farmers in production process as well as fair sharing of benefits among the farmers. Collaborated efforts of community fish farmers by this model may contribute to overall aquaculture development in the study area. This model may become an effective management strategy in sustaining fish production in the hilly area of Bangladesh.

CHAPTER-06: RECOMMENDATIONS AND FUTURE PERSPECTIVES

According to the findings of the present study, following recommendations may be done in the study area:

1. Optimum utilization of creeks through aquaculture should have to be ensured
2. Modern aquaculture technologies should be adopted to increase fish production
3. Financial capabilities may be ensured by formulating community based organizations (CBOs)
4. Loan with low interest for the fish farmers form different organization should be ensured
5. Considering food safety and hygiene issues, safe integrated aquaculture practice should be developed
6. Skilled manpower could be developed by providing training on modern fish farming techniques

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APPENDICES

Appendix-A: Pre-constructed questionnaire for the survey

1. Please mention your name: ………………………………………
2. Occupation?
3. Gender: Male ☐ Female ☐
4. How many ponds do you have? ☐
5. Farm ownership: Self ☐ Lease ☐
6. If leased, then cost: ☐ BDT
7. Farming type:
   - ☐ Poultry
   - ☐ Non-poultry
8. Do you grow any vegetables on your farm? Yes ☐ No ☐
9. If Yes, then which types of vegetables:
10. Yearly income from vegetables: ☐ BDT
11. Do you prepare your pond before culture? Yes ☐ No ☐
12. If yes, then what kind of fertilizer you used during pond preparation?
    - ☐ Urea
    - ☐ Lime
    - ☐ Cow dung
    - ☐ Others:
13. How much cost need for pond preparation: ☐ BDT
14. What types of culture?
    - ☐ Monoculture
    - ☐ Polyculture
    - ☐ Mixed
15. What types of species do you culture?
    - ☐ Rui
    - ☐ Catla
    - ☐ Tilapia
    - ☐ Pangus
    - ☐ Silver carp
    - ☐ Bighead
    - ☐ Mrigel
    - ☐ Shing
    - ☐ Kalibaush
    - ☐ Others: ………………………..

16. Fish seed:

Number	1	2	3	4	5
Seed name					
Size					
Source					
Distance					
Time/trip					
Cost/kg					
Amount/trip					
Amount/Year (Kg)					
Trip/year					
Expense/trip					
Mortality/trip					

17. Stocking density: ☐ m^3 or ☐ / Pond

18. When? Morning ☐ Evening ☐ other: …………

19. Feed:

Type	Floating	Sinking	Others
Source			
Brand Name			
Distance			
Feed cost/Kg or Packet			
Amount/year			
Cost/year			
Amount/trip			
Amount/Year (Kg)			
Trip/year			
Expense/trip			

20. Did you check your pond water quality parameter? Yes ☐ No ☐

21. If "Yes," then which parameters:

……………………………………………………..

22. How do you harvest your fish:

………………………………………………………………

23. Harvest cost: [ ] BDT/ Harvest or [ ] BDT/ Year

24. Production:

- Production/Year (Kg): [ ]
- Income/year (BDT): [ ]
  - I. Fish: [ ]
  - II. Poultry: [ ]

25. Are women of your family-related to your farming process? How?

    ………………………..……………………………………………………………

26. Does the government serve you any kind of assistance in the farming process, and how?

    ....……………………………………………………………………………

    ……………………...

27. What are the main problems in fish farming in this region?

    28.1.

    28.2.

    28.3.

    28.4.

    28.5.

28. What are the potential prospects of fish farming in this region?

    29.1.

    29.2.

    29.3.

    29.4.

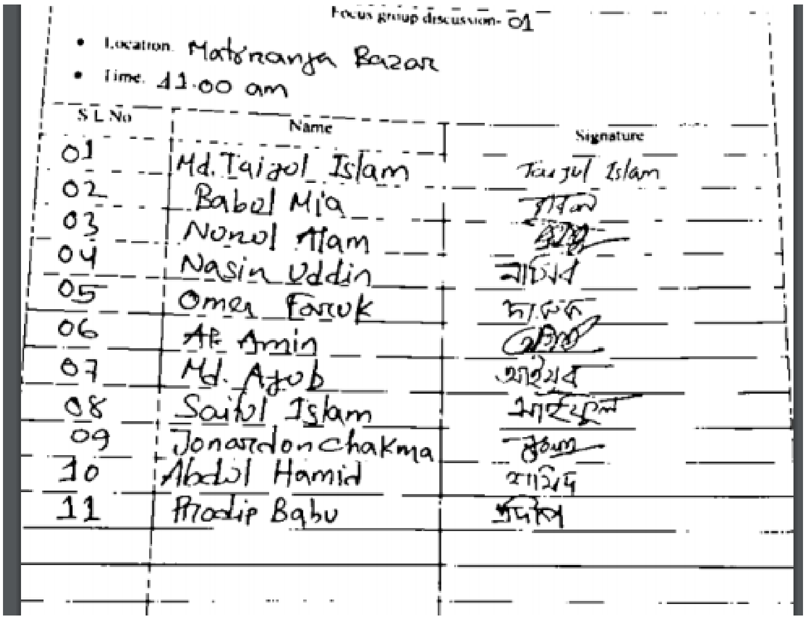
    29.5.

Appendix-B: Surveyed farmer list

Serial no.	Name	Contact number
1	Ohidul Islam	+8801909542618
2	Zohir Uddin	+8801552431828
3	Abdul Kuddus	+8801676720433
4	Md Salauddin	+8801857004220
5	Arifur Rahman	+8801618191706
6	Nurul Alam	+8801551025899
7	Md Hanif	+8801553125732
8	Md Mofiz	+8801553241707
9	Faruk Hasan	+8801533086202
10	Aminul Islam	+8801558397993
11	Sahadat Hossain	+8801866661400
12	Abdul Malik	+8801881638981
13	Abdul Hamid	+8801864986792
14	Moinal Hossain	+8801554287937
15	MD. Khokon	+8801557346630
16	Prodip Babu	+8801553792127
17	Jomardhon Chakma	+8801557430608
18	Nasir uddin	+8801553757893
19	Saiful Islam	+8801553280900
20	Nur Islam	+8801553090317

Appendix-C: Focus group discussion

Focus Group Discussion-1: It was conducted at Matiranga Bazar for 2 hours and 15 minutes and 11 persons were participated.

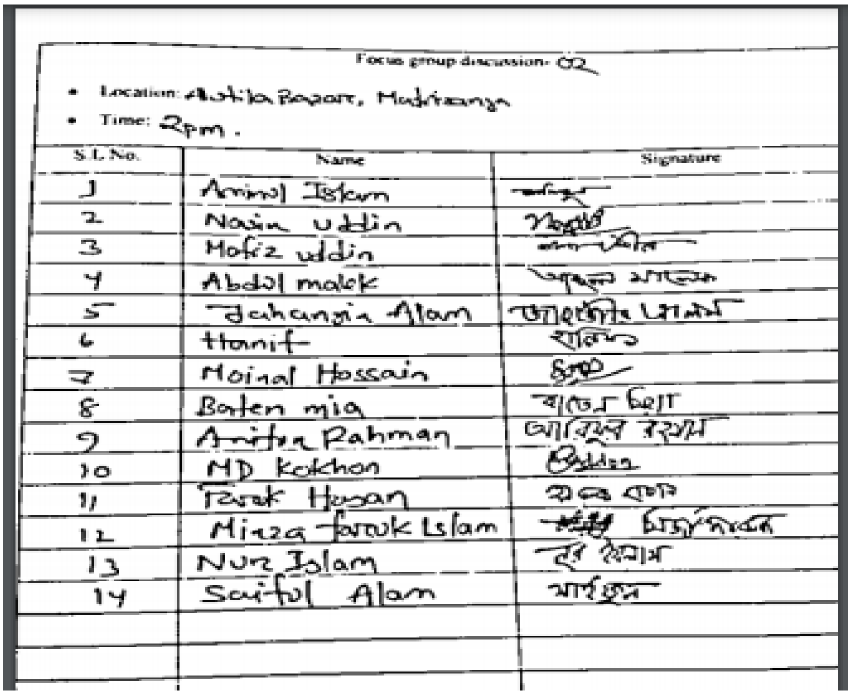


Focus group discussion- 01

- Location: Matiranga Bazar
- Time: 11.00 am

S.L No	Name	Signature
01	Md. Taijol Islam	Taijul Islam
02	Babol Mia	[illegible]
03	Norol Alam	[illegible]
04	Nasin Uddin	[illegible]
05	Omer Faruk	[illegible]
06	Al Amin	[illegible]
07	Md. Ayob	[illegible]
08	Saiful Islam	[illegible]
09	Jonardon Chakma	[illegible]
10	Abdul Hamid	[illegible]
11	Prodip Babu	[illegible]

Focus Group Discussion-2: It was conducted at Alutila Bazar, Matiranga Bazar for 1 hours and 40 minutes and 14 persons were participated.



Focus group discussion- 02

- Location: Alutila Bazar, Matiranga
- Time: 2pm.

S.L No.	Name	Signature
1	Aminul Islam	[illegible]
2	Nasin uddin	[illegible]
3	Hofiz uddin	[illegible]
4	Abdul malek	[illegible]
5	Jahangir Alam	[illegible]
6	Hanif	[illegible]
7	Moinal Hossain	[illegible]
8	Baten mia	[illegible]
9	Arifur Rahman	[illegible]
10	MD Kokhon	[illegible]
11	Faruk Hosan	[illegible]
12	Mirza faruk Islam	[illegible]
13	Nur Islam	[illegible]
14	Saiful Alam	[illegible]

Appendix-D: Iron content of sediment sample

Bangladesh Council of Scientific and Industrial Research (BCSIR)
P.O. Chattogram Cantonment, Chattogram-4220
Tel. : 031 683344, Fax+88 031 682505, email: bcsirlabsctg@yahoo.com

TEST REPORT

No. of Sample: 02 (Two)	BCSIR Ctg. Ref. No. : 39.02.1506.037.42.015.19.
Sample ID: Dec/04	
Date of Sample Receipt: 02/12/2019	Referred by: **Department of Fisheries Resource Management Faculty Of Fisheries.** CVASU, Zakir Hossain Road, Khulshi, Chattogram, Bangladesh.
Date of Test Commencement: 02/12/2019	
Date of Test Completion: 04/12/2019	
Date of Submission of Report: 05/12/2019	Vide their Ref. No.: ---, Date: 12/11/2019
Particulars of Samples: **Soil**	

Results:

Description of Sample	Batch No. & Expire Date	Test Parameter	Result	Standard Limit
Soil (Poultry Farm)	--	Total Iron	7.99 mg/kg	--
Soil (Non Poultry Farm)	--	Total Iron	1.69 mg/kg	--

Remarks:

05.12.2019
Signature of Scientist-in-Charge
Jahan Mohammad Morshed
Sr. Scientific Officer
BCSIR Laboratories, Chittagong.
Chittagong 4220, Bangladesh.

Countersigned by the Director
Dr. Mohammad Mostafa
Director (Add. Charge)
BCSIR Labs, Chattogram.

Note:
The result reported above pertains only to the sample supplied in this laboratory.
This report or any part of this should not be published without prior permission of the issuing authority.
Any overwriting / erasing in the test results should not be acceptable. Overwriting / erasing in the test results must have to be reported to the issuing authorities as early as possible.
Any complain about test report will not be acceptable after one month from the date of issuing of the said report.

Appendix-E: Chemical test report

Government of the People's Republic of Bangladesh
Department of Fisheries
Quality Control Laboratory
Chattogram, Bangladesh.
Telephone No. +880-31-2580973
Web: http://qamchattogram.fisheries.gov.bd

Lab Code : 1019E740

CHEMICAL TEST REPORT

SL. No: 0740

1. Reference No.& Date : Date: 29.10.2019
2. *Description of Sample* :
   - i. Sample Received From : Saifuddin Rana, MS Student, CVASU..
   - ii. Date of Sample Received : 29.10.2019
   - iii. Type of Products : Fish.
   - iv. Sample Code : 1(1.1,1.2,1.3)
   - v. Date of Test Commencement : 29.10.2019
   - vi. Date of Test Completion : 07.11.2019
   - vii. Date of Report Submission : 11.11.2019
3. Test Result :

Sl. No	Test Parameter	RPA/MRL/MRPL* (µg/kg)	Reporting Limit / CCβ (µg/kg)	Result	Method of Test
1.	Chloramphenicol	0.3	0.15	Negative	*ELISA* Screening (TMSOP/C 01)

*RPA: Reference Point of Action, MRL: Maximum Residue Limit, MRPL: Minimum Required Performance Limit

- **Comments (if any):**

11·11·19
Analyst
Md. Golam Mostofa
Technical Assistant
Quality Control Laboratory
Department of Fisheries
Chattogram

11.11.19
Technical Manager
Md. Mezanur Rahman
Bsc Fisheries (Hons) MS BCS(Fisheries)
Fish Inspection & Quality Control Officer
Quality Control Laboratory
Department of Fisheries
Chattogram

This report is issued under following conditions:
1. This report represents the results of the tested samples.
2. Test Method is in-house validated as per recommended international standard.
3. Samples are drawn by the FIQC Personnel.
4. Report will not be used for any publications without prior permission of laboratory authority.
5. Test report shall not be reproduced partially or full without written approval of the authority.
6. These results can only be used for certification of the products not allowed to any advertisement.
7. Additional remarks (if any)

Government of the People's Republic of Bangladesh
Department of Fisheries
Quality Control Laboratory
Chattogram, Bangladesh.
Telephone No. +880-31-2580973
Web: http://qamchattogram.fisheries.gov.bd

Lab Code : 1019E741

CHEMICAL TEST REPORT

SL. No: 0741

1. Reference No.& Date : Date: 29.10.2019
2. *Description of Sample* :
   - i. Sample Received From : Saifuddin Rana, MS Student, CVASU..
   - ii. Date of Sample Received : 29.10.2019
   - iii. Type of Products : Feed.
   - iv. Sample Code : 2(2.1,2.2,2.3)
   - v. Date of Test Commencement : 29.10.2019
   - vi. Date of Test Completion : 07.11.2019
   - vii. Date of Report Submission : 11.11.2019
3. Test Result :

Sl. No	Test Parameter	RPA/MRL/MRPL* (µg/kg)	Reporting Limit / CCβ (µg/kg)	Result	Method of Test
1.	Chloramphenicol	0.3	0.25	Negative	*ELISA* Screening (TMSOP/C 01)

*RPA: Reference Point of Action, MRL: Maximum Residue Limit, MRPL: Minimum Required Performance Limit

- **Comments (if any):**

11-11-19
Analyst
Md. Golam Mostofa
Technical Assistant
Quality Control Laboratory
Department of Fisheries
Chattogram

11-11-19
Technical Manager
Md Mezanur Rahman
Bsc Fisheries (Hons) MS BCS(Fisheries)
Fish Inspection & Quality Control Officer
Quality Control Laboratory
Department of Fisheries
Chattogram

This report is issued under following conditions:

1. This report represents the results of the tested samples.
2. Test Method is in-house validated as per recommended international standard.
3. Samples are drawn by the FIQC Personnel.
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6. These results can only be used for certification of the products not allowed to any advertisement.
7. Additional remarks (if any)

Government of the People's Republic of Bangladesh
Department of Fisheries
Quality Control Laboratory
Chittagong, Bangladesh.
Telephone No. +880-31-25808973
E-mail: qamctg@fisheries.gov.bd.com

Lab Code : F1(B1)

SL. No: PV-001

CHEMICAL TEST REPORT

1. Reference No.& Date : 29.10.2019

2. *Description of Sample* :
   - i. Sample Received From : Saifuddin Rana, MS Student ,CVASU.
   - ii. Date of Sample Received : 29.10.2019
   - ii. Type of Products : Fish.
   - iii. Sample Code : 1(1.1,1.2,1.3)
   - v. Date of Test Commencement : 06.11.2019
   - vi. Date of Test Completion : 07.11.2019
   - vii. Date of Report Submission : 07.11.2019

3. Test Result :

Sl.No	Test Parameter	ML* (mg/kg)	Result (mg/kg)	Method of Test
1.	Cd	0.05	Not Detected	(TMSOP/C 37)
2.	Cr	1.00	0.09	
3.	Hg	0.50	Not Detected	
4.	Pb	0.30	Not Detected	

* ML: Maximum Limit

Comments (if any):

07.11.2019
Analyst
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BCS (Fisheries)
Technologist
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This report is issued under following conditions:

1. This report represents the results of the tested samples.
2. Samples are drawn by the client of laboratory.
3. Report will not be used for any publications without prior permission of laboratory authority.
4. Test report shall not be reproduced partially or full without written approval of the authority.
5. These results can only be used for certification of the products not allowed to any advertisement.
6. Additional remarks (if any):

Chemical Test Report

Sl. No.	Sample Code	Sample Type	Test Parameter	Test Result	Comments
1	1.1	Fish (Poultry fish pond)	Chloramphenicol	Not Detected	Source of Sample: Poultry Fish Farm
			Nitrofuran Metabolites (SEM, AOZ, AHD, AMOZ	Not Detected	
			Heavy Metal (Pb, Cd, Cr, As, Hg)	Not Detected	
2	1.2	Fish (Non Poultry fish pond)	Chloramphenicol	Not Detected	Source of Sample: Poultry Fish Farm
			Nitrofuran Metabolites (SEM, AOZ, AHD, AMOZ	Not Detected	
			Heavy Metal (Pb, Cd, Cr, As, Hg)	Not Detected	
3	1.3	Fish	Chloramphenicol	Not Detected	Source of Sample: Non Poultry Fish Farm
			Nitrofuran Metabolites (SEM, AOZ, AHD, AMOZ	Not Detected	
			Heavy Metal (Pb, Cd, Cr, As, Hg)	Not Detected	
4	2.1	Poultry Feed	Chloramphenicol	Not Detected	Source of Sample: Poultry Fish Farm
			Nitrofuran Metabolites (SEM, AOZ, AHD, AMOZ	Not Detected	
			Heavy Metal (Pb, Cd, Cr, As, Hg)	Not Detected	
5	2.2	Fish Feed	Chloramphenicol	Not Detected	Source of Sample: Poultry Fish Farm
			Nitrofuran Metabolites (SEM, AOZ, AHD, AMOZ	Not Detected	
			Heavy Metal (Pb, Cd, Cr, As, Hg)	Not Detected	
6	2.3	Poultry feces	Chloramphenicol	Not Detected	Source of Sample: Poultry Fish Farm
			Nitrofuran Metabolites (SEM, AOZ, AHD, AMOZ)	Detected	
			Heavy Metal (Pb, Cd, Cr, As, Hg)	Not Detected	

Appendix-F: Seed associated cost/year

Farm No	Seed source	Total Area (Decimal)	Total Seed (Kg)	Seed Purchase Cost (BDT)	Transportation cost/year (BDT)	Total seed cost (BDT)
1	Nurserer	35	100	18000	3000	21000
2	Nurserer	120	180	45000	4000	49000
3	Nurserer	80	80	16000	2000	18000
4	Chattogram, Nurserer	100	360	141000	5000	146000
5	Nurserer	280	400	88000	4000	92000
6	Cumilla	120	20	100000	10000	110000
7	Cumilla, Nurserer	360	75	85800	16000	101800
8	Nurserer	120	50	10000	1100	11100
9	Cumilla, Nurser	500	230	231000	17000	248000
10	Nurserer	80	250	53750	5000	58750
11	Cumilla, Nurserer	210	310	114000	24000	138000
12	Cumilla	400	20	200000	18000	218000
13	Cumilla, Nurserer	350	260	120000	15000	135000
14	Nurserer	120	40	14000	3000	17000
15	Lakshmipur	640	10	55000	26000	81000
16	Nurserer	70	100	16000	1200	17200
17	Cumilla, Nurser	170	62	27200	7000	34200
18	Nurserer	80	40	10000	1000	11000
19	Nurserer	145	120	14400	2000	16400
20	Nurserer	50	20	4000	500	4500

Appendix-G: Feed associated cost/year

Farm No	Floating feed Cost	Total Area (Decimal)	Sinking feed cost	Supplementary feed cost	Transportation cost	Total feed (kg)	Total Feed cost
1	16500	35	0	5000	300	375	21800
2	44000	120	0	10000	4000	1000	58000
3	0	80	28500	3000	700	600	32200
4	11000	100	38000	30000	1800	1050	80800
5	0	280	76000	20000	1200	1600	97200
6	33000	120	0	80000	10000	750	123000
7	132000	360	47500	0	7500	4000	187000
8	22000	120	66500	0	4800	1900	93300
9	165000	500	285000	100000	30000	9750	580000
10	88000	80	95000	0	2500	4000	185500
11	22000	210	190000	20000	3750	4500	235750
12	110000	400	475000	100000	25000	12500	710000
13	165000	350	190000	150000	5000	7750	510000
14	33000	120	66500	0	5000	2150	104500
15	22000	640	28500	50000	1800	1100	102300
16	22000	70	28500	60000	2500	1100	113000
17	0	170	0	80000	1000	0	81000
18	11000	80	0	10000	1000	250	22000
19	11000	145	28500	5000	1500	600	30000
20	0	50	0	10000	500	0	10500
Total	**907500**	**4030**	**1643500**	**733000**	**109850**	**54975**	**3377850**

Appendix-H: Culture techniques and species

SL No	Farming technique	Fish species
1	Polyculture	Carp, Tilapia, Pangus, Sarpunti, Mrigel
2	Polyculture	Carp,Rui, Tilapia, Katla
3	Polyculture	Carp, Tilapia
4	Polyculture	Rui, Katla, Tilapia, Mrigel, Sarpunti, Pangus, Shing, Magur
5	Polyculture	Rui, Katla, Tilapia
6	Nursing	Rui, Katla, Tilapia, Shing, Mrigel
7	Nursing	Tilpaia, Carp, Shing
8	Polyculture	Carp, Tilapia
9	Mixed	Carp. Pangus. Tilapia. Sarpunti. Mrigel, Katla, Shing, Rui, Kalibasush
10	Polyculture	Rui, Katla, Tilapia, Pangus, Carp, Mrigel
11	Polyculture	Rui, Katla, Tilapia, Pangus
12	Mixed	Tilapia, Pangus, Carp, Rui, Mrigel, Kalibaush, Katla
13	Nursing and polyculture	Tilapia, Pangus, Carp, Mriel, Rui, Katla
14	Polyculture	Tilapia, Pangus, Carp
15	Nursing and polyculture	Carp, Tilapia
16	Polyculture	Carp
17	Polyculture	Carp, Sarpunti
18	Polyculture	Pangus, Rui, Tilapia, Katla
19	Polyculture	Pangus, Rui, Tilapia, Mrigel
20	Polyculture	Silver carp, Bighead carp, Rui, Katla

Appendix-I: Cost and profit/Year

S.L No	Lease cost	Lime, Fertilizer and Medicine cost	Seed cost/ year	Feed cost	Harvest cost/year	Electricity, Labor & Miscellaneous cost	Total Cost	Fish production	Fish sell	Net
1	0	5000	21000	21800	2000	2000	51800	650	100000	48200
2	0	0	49000	58000	3500	1000	111500	1000	200000	88500
3	8000	0	18000	32200	0	0	58200	600	80000	21800
4	15000	8000	146000	80800	5000	5000	259800	1700	350000	90200
5	0	8500	92000	97200	5000	2000	204700	1350	250000	45300
6	0	20000	110000	123000	2000	0	255000	1800	400000	145000
7	40000	12000	101800	187000	4000	5000	349800	4000	720000	370200
8	15000	2000	11100	93300	2000	2000	125400	1200	160000	34600
9	100000	25000	248000	580000	20000	200000	1173000	13000	1700000	527000
10	30000	5000	58750	185500	0	3000	282250	3000	450000	167750
11	40000	10000	138000	235750	5000	5000	433750	4000	600000	166250
12	0	20000	218000	710000	50000	50000	1048000	12000	1560000	512000
13	30000	5000	135000	510000	10000	20000	710000	7000	840000	130000
14	0	2000	17000	104500	1000	5000	129500	1500	250000	120500
15	0	10000	81000	102300	2000	4000	199300	2500	360000	160700
16	0	0	17200	113000	0	1000	131200	1500	250000	118800
17	0	1000	34200	81000	34200	0	150400	1200	180000	29600
18	0	3000	11000	22000	1000	1500	38500	500	60000	21500
19	12000	0	16400	46000	3000	1000	78400	800	150000	71600
20	0	0	4500	10500	1000	1000	17000	200	30000	13000
Total	**290000**	**136500**	**1527950**	**3393850**	**150700**	**308500**	**5807500**	**59500**	**8690000**	**2882500**

Appendix-J: Water quality parameters

Sl. No	Type	Temperature (^{0}C)	DO (mg/L)	pH	NH_3 (ppm)	TSS (mg/L)	TDS (mg/L)	Transparency (cm)	Water Iron (ppm)	Sediment Organic Carbon (%)	Sediment Organic Matter (%)	Phyto-plankton Cell Count (104 Cells/mL)
1	Non-poultry	31.6	9.20	7.0	0.35	16.91	58.01	35.30	0.80	0.4470	0.7706	1.65
2	Non-poultry	29.4	7.18	7.8	0.47	14.82	81.45	37.00	1.21	0.4704	0.8109	2.20
3	Non-poultry	28.8	7.60	8.0	0.74	18.53	76.05	35.60	1.34	0.4552	0.7847	1.70
4	Non-poultry	30.9	6.68	8.5	0.59	29.15	51.65	33.70	1.20	0.6940	1.1964	2.04
5	Non-poultry	30.7	9.90	8.7	0.61	29.37	47.40	29.10	0.34	0.4020	0.6930	2.15
6	Non-poultry	30.4	8.40	8.4	0.73	26.04	64.40	31.90	0.90	0.7095	1.2230	1.73
7	Non-poultry	31	7.70	8.1	0.87	24.47	57.63	45.80	0.14	0.6992	1.2054	2.01
8	Non-poultry	30.1	9.97	9.2	0.94	23.63	61.26	38.00	0.89	0.4090	0.7050	1.81
9	Non-poultry	29.2	8.10	7.5	0.29	21.56	73.13	42.50	1.23	0.5090	0.8875	2.13
10	Non-poultry	28.7	7.27	7.9	0.33	30.33	53.63	34.90	1.26	0.5172	0.8916	1.75
11	Non-poultry	28.3	8.37	8.1	0.27	15.32	53.36	36.54	0.89	0.4553	0.8316	1.93
12	Non-poultry	30.6	7.39	8.7	0.41	21.79	51.25	33.95	0.72	0.5223	0.7862	1.05
13	Non-poultry	30.4	7.43	7.8	0.39	19.37	59.47	42.13	1.26	0.4602	1.2387	2.08
14	Non-poultry	31.2	9.13	9.2	0.27	27.53	72.31	31.84	0.79	0.4831	0.7394	1.13
15	Non-poultry	29.7	8.47	8.6	0.37	29.47	67.89	38.73	0.67	0.4023	0.6973	1.87
16	Poultry	30.6	7.80	9.5	1.02	48.3	118.70	23.60	2.14	1.4460	2.4929	4.15
17	Poultry	30.3	8.10	8.6	0.79	56.52	127.20	27.30	1.93	1.0799	1.8617	3.89
18	Poultry	31.3	9.20	9.3	0.89	45.87	133.00	24.90	1.86	0.7159	1.2342	4.35
19	Poultry	29.8	6.50	7.9	0.37	58.03	152.12	23.10	1.32	1.5507	2.6734	3.30
20	Poultry	29.6	7.85	8.2	1.31	49.25	125.72	32.50	1.53	0.7230	1.2476	3.70

BRIEF BIOGRAPHY OF THE AUTHOR

Saifuddin Rana, son of Mr. Kamal Uddin and Mrs. Amena Begum, was born at March, 7, 1994 in Feni, Bangladesh. He passed the Secondary School Certificate Examination in 2011 and Higher Secondary Certificate Examination in 2013. He graduated in 2018 from the Faculty of Fisheries, Chattogram Veterinary & Animal Sciences University (CVASU) Khulshi-4225, Chattogram, Bangladesh. Now, he is doing his MS in Fisheries Resource Management, Faculty of Fisheries, CVASU. He is looking forward to carrying out research in his area of interest and enormous enthusiasm to develop his skills and expertise in the area of sustainable management of different aquatic bodies. He is also keen to deliver his intense observation for drawing outline of different new based aquaculture management systems in near future.