FINANCIAL PROFITABILITY OF CARP POLYCULTURE IN SOME SELECTED AREAS OF MYMENSINGH DISTRICT

JANIKA ALAM

DEPARTMENT OF MANAGEMENT AND FINANCE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
SHER-E-BANGLA NAGAR, DHAKA -1207

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BY

JANIKA ALAM

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Approved by:

.....	.....
Dr. Md. Sadique Rahman,	**Abu Zafar Ahmed Mukul,**
Associate Professor & Chairman	**Assistant Professor**, Department of
Department of Management and Finance,	Management and Finance,
Supervisor	**Co-Supervisor**

.....

Dr. Md. Sadique Rahman

Chairman, Examination Committee

Department of Management and Finance

Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh

DEPARTMENT OF MANAGEMENT AND FINANCE

Faculty of Agribusiness Management
Sher-e-Bangla Agricultural University
Dhaka-1207, Bangladesh.

CERTIFICATE

This is to certify that the thesis entitled ***"FINANCIAL PROFITABILITY OF CARP POLYCULTURE IN SOME SELECTED AREAS OF MYMENSINGH DISTRICT"*** *submitted to the Department of Management and Finance, Faculty of Agribusiness Management, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of* ***MASTERS OF BUSINESS ADMINISTRATION in MANAGEMENT,*** *embodies the result of a piece of bonfire research work carried out by* ***JANIKA ALAM, Registration no. 12-05204*** *under my supervision and guidance. No part of the REPORT has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: June,2020
Place: Dhaka, Bangladesh

Dr. Md. Sadique Rahman
Associate Professor, Supervisor
Department of Management and Finance, Sher-e-Bangla Agricultural University

Website: www.sau.edu.bd, Email: mukul2012@sau.edu.bd, mukul_mgt@yahoo.com, Mobile: 01788-686911

Dedicated to My Beloved Parents

FINANCIAL PROFITABILITY OF CARP POLYCULTURE IN SOME SELECTED AREAS OF MYMENSINGH DISTRICT

ABSTRACT

This study was conducted in two Upazila namely; Bhaluka and Trishal of Mymensingh district. A total of 100 carp polyculture farms were selected randomly and fish farmers were interviewed from May, 2017 to September, 2018 to know the socio-economic status and determination of costs, returns, profitability and resource use productivity of the farmers practicing carp polyculture. A simple cost and return analysis was done to determine the profitability of carp polyculture. Apart from this, some tabular analyses were also done to achieve the major objectives of the study. The findings revealed that middle age (36-45) farmers were most involved in this occupation and most of respondents were secondary educated (45%). Medium families were higher (73%) in the studied area and only 45.55% respondents were involved in their primary occupation. Almost all fishermen received training facilities from DoF, NGOs or other organizations. Majority fishermen had own pond and land properties of 77% and 71%, respectively. 49% respondents had half buildings; 73% respondents used drinking water from their own tube-well and 56% fishermen used slab sanitary facilities. But the study revealed that carp polyculture was a profitable business. It was found that the average annual gross return per hectare per year was assessed Tk.1,37,745.00. Gross margin was estimated Tk. 83,762.00 per hectare and Net returns were estimated at Tk. 70,845.00 per hectare per year where as average cost-benefit ratio was recorded 2.36: 2.23. Most of the resources (inputs) were inefficiently utilized in the carp polyculture. The finding of the study clearly indicates that fingerlings cost and feed cost have significant effects on fish production and most of the farmers used excess human labour.

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The author
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CHAPTER 1

INTRODUCTION

1.1 Background

Bangladesh is rich in freshwater fish resources comprising 260 indigenous species and as many as 13 exotic species (IUCN, 2000). The importance of fish as a food of the Bangalee can easily understand by a Bangla proverb, “Maache-Bhate Bangali” which means, “A Bangalee thrives on fish and rice” (Dey *et.a.* 2013). Fish provides major contribution to the survival and health of a significant portion of the World's population. Fish is especially important in the developing world. Often referred to as "rich food for poor people," fish provides essential nourishment, especially quality proteins, fats, vitamins and minerals. For those involved in fisheries, aquaculture and fish trade, fish is a source of income (Nongmaithem and Ngangbam, 2009). Again, fisheries have a significant role in poverty mitigation, food security, nutrition supply, sources of income, employment opportunities, foreign exchange earnings and overall on the socio-economic development of Bangladesh (Rahman, *et.al* 2015).

Bangladesh is one of the world’s leading fish producing country with a total production of 42.77 lakh MT during 2017-2018, where the contribution of aquaculture to the national production is about 56.82%. In 2017, Bangladesh was the 3rd in world aquaculture production, which accounted for half of the country’s total fish production (FAO, 2018). However, Bangladesh is widely recognized to be one of the most climate vulnerable countries in the world. It experiences frequent natural disasters, which cause damage of life, infrastructure and economic assets, and adversely impacts on fish farming. Though, more than 10.47 million people of the total population of Bangladesh are directly or indirectly related to fish farming (DoF, 2016), but their farming practice and livelihood are now vulnerable to the adverse effects of climate changes, whether through changes in physical

environments, ecosystems or aquatic stocks, or through impacts on infrastructure, fishing or farming operations, or livelihood option.

Fisheries and aquaculture play a major role in nutrition, employment and foreign exchange earnings with about 1.3 million people are associated with the fisheries sector. There are 1.46 million fish farmers, 1.38 million inland fishermen and 0.08 million fry collectors (fish and shrimp) in Bangladesh (DoF, 2013) and it is estimated that fisheries and related activities support more than 7% of the country's population (DoF, 2013). On the basis of habitat fish production can classify two types of aquaculture being carried out in Bangladesh; freshwater and coastal aquaculture; and there is no marine aquaculture production currently. Freshwater aquaculture comprises mainly pond aquaculture especially the polyculture of both native and exotic species. On the other hand, coastal aquaculture is comprised mainly prawn and shrimp farming (DoF, 2013). In Bangladesh, aquaculture production systems are mainly extensive and improved extensive, with some semi-intensive and in very few cases intensive systems. Although the culture fishery contributes over 55% of inland fish production, it covers only about 11% of the total inland water resources. But the annual production are still low, 9280 kg/yr for rivers which is 1.35% of the total production, 687427 kg/yr for artificial hatchery production (DoF, 2018). Nevertheless, over last ten years, yield from closed water aquaculture has been increasing steadily.

1.2 Carp polyculture

Polyculture is the practice of culturing more than one species of aquatic organism in the same pond. The motivating principle is that fish production in ponds may be maximized by raising a combination of species having different food habits. The mixture of fish gives better utilization of available natural food produced in a pond. Polyculture began in China more than 1000 years ago. The practice has spread throughout southeast Asia, and into other parts of the world. The polyculture of major and exotic carps and monoculture of catfish (*P. sutchi*), Tilapia are the most widely practiced culture system in Bangladesh. Three Indian major carps namely, Rui, *Labeo rohita;* Catla, *Catla catla* and Mrigal, *Cirrhinus mrigala* and one exotic carp, *Hypopthalmichthys molitrix* now account for more than 78% of total pond

production (ICLARM, 2002). The concept of polyculture of fish is based on the concept of total utilization of different trophic and spatial niches of a pond in order to obtain maximum fish production per unit area. Different compatible species of fish of different trophic and spatial niches are raised together in the same pond to utilize all sorts of natural food available in the pond. The possibilities of increasing fish production per unit area, through polyculture, is considerable, when compared with monoculture system of fish. Different species combination in polyculture system effectively contribute also to improve the pond environment.

Among different techniques of fish culture, polyculture is one of the most important culture techniques. Polyculture is the practice of culturing more than one species of aquatic organism in the same pond. Polyculture gives higher production than monoculture in extensive systems because more available natural food is utilized by different fish species efficiently (Wahab, *et. al* 2001). Polyculture may produce expected results if fish with different feeding habits are stocked in proper ratio and combination (Halver, 1984). In Asian polyculture, a wide variety of fish species are cultured of which Rohu (*Labeo rohita*), Catla (*Catla catla*) and Mrigal (*Cirrhinus cirrhosus*) are very popular (Rahman, *et.al* 2006). The farmers prefer to stock Common carp as a bottom feeder instead of mrigal because common carp grows faster than mrigal and the overall production is higher when combined with rohu and catla in polyculture ponds (Wahab, *et.al* 2002). Polyculture is more productive, capital intensive and profitable activity compared to other culture systems (Dev, 2009). The basic principles of fish polyculture system rests on the idea that when compatible species of different feeding habits are cultured together in the same pond, the maximum utilization of all food sources takes place without any competition. Polyculture began in China over 1000 years ago. The practice has spreaded throughout South East Asia and into other parts of the world. Polyculture should combine fish having different feeding habits in proportions that effectively utilize the natural foods. As a result, higher yields are obtained. Efficient polyculture systems in tropical climates may produce up to 8,000 Kg of fish per hectare per year. Carp polyculture is the culture of more than one species of carps in a pond without overlapping their ecological niches.

1.3 Importance of carp polyculture

The fish species selection in polyculture is very important. The species to be selected which has its own food and feeding habit and therefore does not compete with other species for natural food (Tang, 1970) and thus increase fish yield per unit area. However, it has been shown that even in a balanced polyculture system, interactions among fish species may hinder or stimulate their growth (Yashouv, 1966; 1969). These interactions affect either the food resources or the environment and this ultimately affect the production. Polyculture management technique is based on the relationship between organisms at different levels of food chain and environment. It is a fact that polyculture may produce an expected result if species with different food habits are stocked in proper ratios, densities and combinations (Halver, 1984). Fertilization is the cheapest and simplest method for increasing aquatic productivity. Both organic and inorganic fertilizers are used in fish pond. Urea is a bio component nitrogenous fertilizer containing approximately 46% pure nitrogen. A combination of organic and inorganic fertilizers has been reported to be better than the application of only one of them (Rabanal, 1967).

Importance of carp polyculture to improve the fish production in Bangladesh is well documented (Azim and Wahab, 2003; Hossain and Bhuiyan, 2007; Asadujjaman and Hossain, 2016). The basic principle of fish polyculture system depends on the idea as compatible species of different feeding habits are cultured together in the same pond, the maximum utilization of all natural food sources takes place without harmful effects. The possibilities of increasing fish production through carp polyculture are found highest when compared with other systems (Talukdar, *et.al* 2012). Due to the progress in research and extension activities, aquaculture production in Bangladesh became almost double in last ten years and carp alone contributed 12% of total fish production in ponds (DoF, 2018). Also there are some constraints for the promotion of aquaculture in Bangladesh. One of the major constraints to increase fish production in Bangladesh is the non-availability of quality fish seed (Biswas, *et.al* 2008). Poor quality fish seed production is largely related to poor management of brood stocks, inbreeding, hybridization and negative selection (Mamun and

Mahamud, 2014). Keeping all other management same, use of quality seed could increase production even more than 30% (Barman, *et.al* 2012).

The aquaculture practices in Bangladesh mostly followed traditional extensive and improved extensive with some semi-intensive polyculture of Indian major carps and exotic carps fish. Numerous projects have promoted simple improved management strategies, such as regular application of fertilizers and feeds, and the stocking of fish species in combinations and stocking densities designed to move the production system from extensive to semi-intensive (Belton, *et.al* 2011). Composite fish culture with Indian major carps and Chinese carps together, utilizing all the ecological niches of a pond, has made it possible to increase the fish production many fold from fresh water ponds during the decade of seventy in different parts of India (Lakshmanan, *et.al* 1971, Chakraborty, *et. al* 1974, Chowdhury, *et.al* 1975, Das, *et.al* 1975, Sinha, 1976).

1.4 Justification of the study

Carp polyculture farming plays a crucial role on changing our farmer's living standard and achieves self-sufficiency in income. The traditional polyculture of indigenous Indian major carps in Bangladesh has been increasingly diversified over the past few decades through the introduction of exotic species of fish, initially carps and more recently Tilapia and catfish. Various phases in the evolution of this polyculture can be recognized in relation to socio-economic development and intensification. Many development projects funded by bilateral and multilateral agencies have helped promote improved small-scale carp polyculture in Bangladesh, but the Danish-funded Mymensingh Aquaculture Extension Project (MAEP) has probably had the most impact on raising the welfare of poor farming households through carp polyculture. This region is very important for fisheries production and most of the people are related with carp polyculture farming. Presently government and non-government organizations are extending scientific method to improve the production of carp polyculture. In order to increase the production of carp polyculture farming to the maximum possible extent, it was necessary to identify the factors behind the yield variations so that policy interventions might be made accordingly.

Though the aquaculture production rate has been increased much in recent time in Bangladesh, but still not satisfactory in comparison to most other Asian countries due to existence of some constraints and problems in culture system. But in Bangladesh, research on the financial profitability aspect is not satisfactory. The present study was conducted with a view to showing the financial profitability status of carp polyculture system in some areas of Bangladesh.

1.5 Objectives of the study

Therefore, the present study has been designed to fulfill the following objectives:

1. To know the socio-economic profile of the fish farmer; and
2. To estimate the cost and return of carp polyculture

CHAPTER-2
REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

The purpose of this chapter is to review the past research works which are related to the present study. The most common and relevant studies, which have been conducted in the past, are discussed below:

Sultana (2001) found that the farmers of Trisal Upazila, made profits from both polyculture and carp nursery technologies. The study however, revealed that the carp nursery was more profitable (Tk 10,444 ha^{-1}) than the production of polyculture (Tk 50, 0 21 ha^{-1}). The study has also identified some major problems associated with economic, technical and social aspects that have currently been facing by the producers in adopting polyculture and carp nursery technologies.

Alam, *et.al* (2002) revealed the socio-economics status, growth and cost benefit ratio of over-wintered findings of Rui, Catla and Mrigal in polyculture at three stocking densities. The stocking densities were 2250; 3250; 4250 fish/ha. Fish in all ponds were fed with rice bran and mustered oilcake at the ratio of 3:1. Fish production obtained in three treatments were 2523±74.75, 2620±49.66 and 2982±171.52 Kg/ha.

Roy, *et.al* (2003) studied of the economics of polyculture of Indian major carps with small indigenous fish species (SIS) mola and chela. The culture strategies consist of stocking the ponds with only carp (T1), carps with mola (T2) and carps with chela (T3). The economic feasibility of three different combinations was analyzed on the basis of the expenditure incurred and total return from sale price of fish in the local market. The net benefits per hectare per 7 months for only carps, carps plus mola and carps plus chela polyculture systems were Tk. 94,925, 88,330 and 68,270 respectively which largely reflected the gross fish production levels of 2,560, 2,412 and 2,176 kg ha-1. However, only carp polyculture system

provided higher benefit (Tk. 94,925 ha-1), followed by carps-mola polyculture (Tk. 88,330 ha^{-1} with non-significant difference but the net benefit in carp-chela polyculture was significantly ($P<0.05$) lower than others. Benefit-cost ratio was obtained higher in only carp polyculture, followed by carp-mola and carp-chela polyculture systems.

Ahmed (2003) conducted a study mainly to assess the different culture practices and to determine the relative profitability of pond fish production in Mymensingh district. He observed the average stocking density of carp fingerlings to be 9,537-10,445 ha^{-1}. The average fish production cost was estimated at Tk 23,210- Tk 24,790 ha-1. While the net return was found to be Tk. 59,119-56,484 ha-1 yr-1. He stated the carp polyculture is a profitable business and 71% farmers have improved their socio-economic condition through the income of fish farming. Lack of money, lack of technical knowledge, non-availability of quality seed and poor institutional support were the major problems of sustainable development of carp polyculture.

Alam, *et.al* (2004) studied to determine the costs, returns, profitability and resource use productivity of the farmers practicing carp polyculture. Samples were collected from Sharsha, Jhikargacha, and Sadar upazilas of Jashore district. Seventy farmers were randomly selected for the study. The findings revealed that carp polyculture was a profitable business. It was found that the average annual per hectare production of crap polyculture was 3602 kg. Gross margin perfect are was Tk. 93662. The finding of the study clearly indicates that fingerlings cost and feed cost have significant effects on fish production and most of the farmers used excess human labor.

Saha and Islam (2005) conducted an experiment to determine the factors affecting adoption of pond polyculture in six villages of three districts namely Mymensingh, Bogura and Narshingdi in Bangladesh. In Mymensingh, 75% pond owners adopted carp polyculture technology whereas in Bogura and Narshingdi only 16% and 25% pond owners, respectively

adopted this technology for fish production. The production of fish per unit area was found to be 5 to 10 times higher in Mymensingh compared to that of Bogura and Narshingdi. Fish farmers identified three main problems affecting the adoption of pond polyculture viz. lack of input used in aquaculture, low fish yield and lack of credit facilities for pond polyculture. The technological awareness of the farmers directly contributed towards use of inputs in culture ponds. The positive impact of technological dissemination found on input use, fish yield and uplifted socio-economic condition.

Sarker, *et.al* (2005) revealed the fish production and net economic return in silver carp (*Hypophthalmichthys molitrix*) with pangasiid catfish (*Pangasius hypophthalmus*) in monoculture and polyculture with farmer's ponds were assessed. The ponds were stocked with 30,000 fishes per hectare. In treatment 1 (T1) pangasiid catfish only, in treatment 2 (T2) pangasiid catfish and silver carp at the ratio of 1:1, and in treatment 3 (T3) pangasiid catfish and silver carp at the ratio of 2:1 were stocked. At harvest, production of fish was found significantly ($p<0.05$) different among the treatments, highest in T1 and lowest in T2. Though the total biomass production and total economic return was significantly highest in T1 than in T2 and T3, the net economic return was lowest because of the required highest input costs especially for supplemental feed and fingerlings, resulted the highest cost per unit yield (CPY in Tk/kg) in T1. Highest cost for supplemental feed required in T1 was due to highest quantity of feed required for the highest number of pangas catfish stocked in that treatment. The findings of the present study suggest that though monoculture of pangasiid catfish give higher fish biomass production but polyculture with silver carp is environmentally good and economically profitable.

Islam, *et.al* (2008) conducted a research designed entitled of "Carp culture: Cost-return and profit analysis of Rajshahi district, Bangladesh". Where he assessed the total investment, cost and total returns of carp polyculture in Rajshahi district.

Akhter (2009) found in the Trishal area that farmers practiced intensive, semi intensive and extensive polyculture of carps where average annual stocking density was 17,843 fingerlings/ha. The average annual production of carp farming was Tk. 2, 27, 132/ha.

Mohsin *et.al* (2012) were conducted an experiment entitled "Cost-benefit analyses of carp polyculture in ponds: a survey study in Rajshahi and Natore districts of Bangladesh" where he assessed the production, cost and benefit of polyculture of carp fishes. Maximum 33% costs were spent during post stocking management. The average cost-benefit ratio was recorded 1:1.05.

Hossain, *et.al* (2013) revealed the present status of Carp-SIS polyculture in Dinajpur district of Bangladesh since August, 2011 to September, 2012. The study sites were selected randomly among the four upazilla of Dinajpur District. The computer software SPSS (Statistical Package for Social Sciences) was used to analyze the data. Pond size was categorized in three different sectors, small, medium and large according to decimals. Initially the villagers and households were selected by observing the status of Carp-SIS Poly-culture and their indigenous knowledge of fish culture. Most of the respondents (93.53%) had short period (4 days) training experience from WorldFish Center (WFC) about Carp SIS polyculture. But 2.75 and 0.62% respondents had medium and long training experience. An undeveloped type of aquaculture system was practiced maximum (31.0%) in the medium pond size category of the respondents whereas it was followed by 4.0% in the large and small pond size category. The highest income of the respondents (6.89%) was found in the large pond category and 12.64% from the medium pond size category. The lowest income of the respondents was found (4.59) in the large pond category on the basis of technology practice in these region. Among the cultured species Silver carp contributes highest (98.5%) followed by Rui (95%), Mola (91.5%), Prawn (89.3%) and Bighead carp (85.4%) accomplished among the respondents. This practice has satisfied the family protein

requirement, reduced buying cost and also has high growth rate of profit level as well as higher market demand.

Yin, *et.al* (2014) reported that polyculture is commonly practiced in pond aquaculture where several fish species are reared together, creating a multi output production structure. This study examines the technical (TE), allocative (AE) and economic efficiency (EE) of the most widely practiced fish-producing polyculture system in the coastal area of Yancheng city, China, which deals mostly with the production of crucian carp alongside silver carp and bighead carp. Data envelopment analysis is used to measure the efficiencies, while Tobit regression is applied to identify the factors affecting efficiencies. The estimated TE, AE and EEs are 0.92, 0.96, and 0.88 respectively. Crucian carp polyculture is characterized by moderate technical inefficiencies, necessitating the development and dissemination of new technology to increase the productivity of these farmers. On average, small ponds were found to be more technically efficient while large ponds were found to have higher allocative and scale efficiencies. Additionally, to bit regression revealed a positive effect between farm size and efficiencies. These findings provide some support for the current standardized pond program in China. The use of hired labor decreased technical efficiencies of fish farmers. Fingerling size had a significant positive effect on efficiencies. In order to manage constantly expanding crucian carp polyculture, farmers should be provided with information on sizable fingerlings, economic pond sizes, and employee supervision, among other factors.

Karim, *et.al* (2016) reported the economic viability and profitability ratio of small scale farming of Indian major carps, i.e., *Cattla cattla*, *Labeo rohita* and *Cirhinus mrigala* in polyculture system was evaluated. Carps were treated with twelve different formulated diets having four different sources of protein in re-circulatory concrete raceways. At the end of the trial, gross margin analysis and various profitability ratios were used to calculate the cost and returns of carp fish farming, while production utility was employed to find out the output of the farm. The result of the analysis revealed that the mean total cost per kilogram of fish was

Pakistan Rs. 102.00 and the mean total revenue per kg was Pakistan Rs. 188.00. This gives a gross margin of Pak Rs. 121.00 per kilogram of fish produced. The mean benefit cost ratio (BCR) was obtained as 1.91:1, which confirms the capability and potential of carp′s aquaculture to contribute to sustainable livelihoods and to generate good income support even in concrete raceways as flow-through and re-circulating systems to raise production of fish, considerably in a small area in contrast with systems in earthen pond.

Kobir, *et.al* (2017) reported carps poly-culture technique, pond management and cost analysis in Mohanpur, Rajshahi region of Bangladesh. The study was conducted for a period of four months (October 2010 to February 2011). It provides an overview on the guiding principles, aspects and tasks, and presents the applicable production techniques and patterns of carp polyculture. It is expected that this publication will help identify resources and contribute to the successful planning and realization of fish production by those fish pond owners and operators who need to strengthen and improve their knowledge on the subject.

Rahman, *et.al* (2017) conducted an experiment of different carp fishes (*Labeo rohita, Catla catla* and *Cirrhina mrigala*) and (*Hypophthalmichthys molitrix, Ctenopharyngodon idella* and *Cyprinus carpio*) were reared in polyculture under fertilized and supplementary feeding conditions for a period. Treatments were: T1) the fertilizers viz. urea+TSP+cow dung+ poultry droppings were applied weekly at the rate 35 kg/ha, 12 kg/ha, 230 kg/ha and 60 kg/ha respectively; T2) the supplementary feeds given to fishes were consisting of rice bran (30%), mustard oil cake (25%), fish meal (10%) and maize bran (35%) at the rate of 3-5% of the body weight per day. There were statistically significant differences in the production of fish between two treatments (2360 kg/ha in T1 and 4022.5 kg/ha in T2). The cost and return were Tk.132500 and Tk. 192275 in T1 and Tk. 177500 and Tk. 335812.5 in T2 respectively. The benefit-cost ratio was 1:0.45 in T1 and 1:0.89 in T2.

Siddiqa, *et.al* (2018) investigated the production economics and profitability of aquaculture practicing in southwest Bangladesh. The study shows aquaculture in southwest Bangladesh is feasible and profitable with a cost-benefit ratio of 1:1.71, 1:1.54, 1:1.30 for commercial fish culture, commercial shrimp culture and homestead aquaculture respectively. The per hectare total cost of production of commercial fish culture, commercial shrimp culture and homestead aquaculture are BDT 225615.46, 242860.17 and 185799.52 respectively and the corresponding total revenue are BDT 384767.00, 374662.62 and 242100.29. The per hectare net returns of commercial fish culture, commercial shrimp culture and homestead aquaculture are BDT 159151.54, 131802.45 and 56300.77 respectively. However, the farmers made the highest profit from commercial fish culture. The Cobb-Douglas production function analysis indicates that per hectare net returns are significantly influenced by input costs. These factors are directly or jointly responsible for influencing the per hectare net returns of all types of aquaculture. The sensitivity analysis shows that the variable costs including cost of fertilizers, fish feeds and fish seeds are the main factors affecting profitability.

Khan, *et.al* (2018) revealed the production performances and economics of carp polyculture using wild and hatchery produced seeds in ponds in Faridpur district, Bangladesh. Native (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*) and non-native carps (*Hypophthalmichthys molitrix*, *Ctenophryngodon idella*, *Aristichthys nobilis* and *Cyprinus carpio*) from four different sources were tested in feed and fertilizer based polyculture ponds.

Alam and Rahman (2018) identified the input-output relationships and economics of pangas monoculture and carp-pangas polyculture in Bangladesh. By analyzing the data collected from 50 pangas farms and 55 carp-pangas farms, the study has investigated the production systems of two technologies and the effects of fingerling stocking and applications of feed and fertilizer on fisheries income. The data were collected from the fishermen of Trishal and Bhaluka of Mymensingh district, and Kahaloo and Adamdighee of Bogura district during

2001-02. For Pangas monoculture, the stocking density was 31,561 per ha while it was 55,017 per ha in carp-pangas polyculture. Most of the farmers used urea, TSP and lime before stocking. Rice and wheat bran happened to be the most common feed ingredients for both types of culture in general. Other important ingredients used were mustard oil-cakes, rice polish, wheat flour, fish meal, bone meal, soybean meal and poultry litter. In terms of quantities, rice bran and wheat bran dominated the farmers list. Rice and wheat bran together constituted about 60% of all studied feeds. Feed cost constituted 59.13% of total costs for pangas monoculture and 67.44% for carp-pangas polyculture. Per ha productions of pangas and carp-pangas in a single culture cycle were 15,508 kg and 19,745 kg, respectively. Per ha gross profits were estimated to be Tk. 310,311 and Tk. 464,418 for pangas monoculture and carp-pangas polyculture, respectively. Net profit appeared to be Tk. 264,216 per ha for pangas monoculture and Tk. 416,509 per ha for carp-pangas polyculture. The BCRs calculated were 1.46 and 1.68 for monoculture and polyculture, respectively. The break-even costs per kg of fish were estimated at Tk. 36.93 for pangas and Tk. 30.93 for mixed species which was much lower than the prices the producers received Break-even productions were estimated at 10,702 kg per ha for pangas monoculture and 11,784 kg per ha for carp-pangas polyculture. Fingerling and feed cost, and pond size significantly explained the variation of income from pangas monoculture. These factors have significantly influenced the income from the crop. Functional analysis shows that 1% increase in the feed cost might increase 0.51% of pangas income and 0.41 % in carp-pangas income. No other inputs had shown this much of responses to increasing income from a fish.

Rahman, *et.al* (2020) studied to identify the socio-economic characteristics, and analyze profitability of Tilapia-carp polyculture, and credit profile of the selected farmers from Sherpur district in Bangladesh. The findings revealed that 36% of the respondents belonged to the age group of 25-29 years, 68% belong to medium family size (5 to 6 people), 44% respondents' education level was higher secondary, 44% respondents' primary occupation was fish farming and 46 % of were belonged to in annual income level of Tk. 150001-200000

(1770−2360). Average fingerlings released in the Tilapia-carp polyculture were 24240 per hectare per year. Most of the fingerlings collected from private hatcheries. The annual per hectare production of tilapia and carp were 8028 kg and 11085 kg. respectively. Per hectare per year gross cost, gross margin, gross return and net return were Tk. 1093008 (12897), Tk.759447 (8961), Tk. 1735455 (20477) and Tk. 642447 (7580), respectively. The BCR of Tilapia-carp polyculture for cash cost was 1.78 and full cost was 1.59. About 20% of the respondents took loan from different sources and they received 84.51% of their applied amount and 84.73 % of the loan money used in productive purposes. Mortality of fingerlings, the high price of the ingredient, low price of fish, high interest rate and non-availability of good quality fingerlings at proper time were identified to be the major problems in conducting pond fish production. Government and other agencies should come forward to provide subsidized feed, technical supports and credit facilities for the Tilapia-carp fish farmers to make the enterprise effectively.

CHAPTER-3
MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

This study deals with the profitability of carp polyculture in different Upazila of Mymensingh district. The design of the present study involved some necessary steps, which are described below:

3.1 Study areas

This study was conducted in selected two upazilas: Bhaluka and Trishal of Mymensingh district, Bangladesh due to availability of carp farmers.

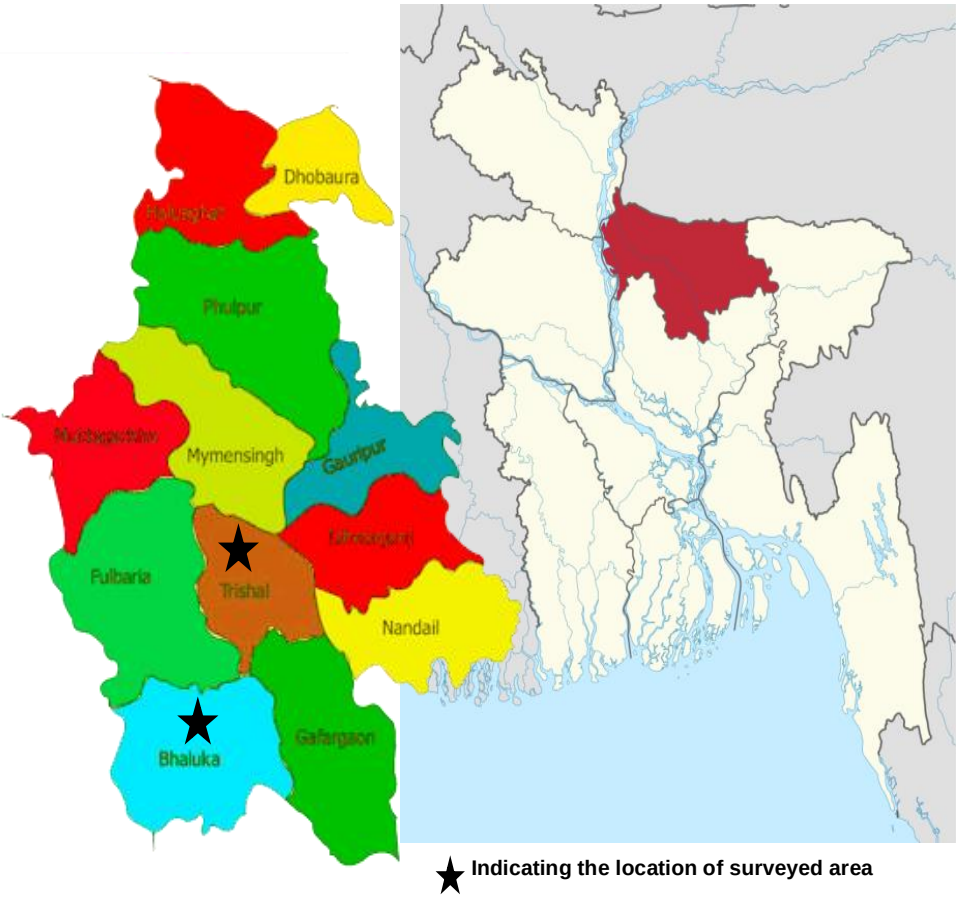

Figure 1: Maps of the study areas

3.2 Sample size

A total of hundred (100) carp polyculture farmers were selected to achieve the objectives.

3.3 Data Collection

The study used the data of a project entitled "Impact of Improved Aquaculture Technologies on Productivity and Livelihood of Fish Farmers in Bangladesh" funded by NATP-2. The project started in started in May, 2017 and completed in September, 2018.

3.4 Data processing and analysis

After data collection from the field, data were verified to sort out errors and in consistencies. Then the results obtained in the study were subjected to statistical analysis. MS Excel used to store all the data. MS Excel was also used for presentation of the tables and graphs obtained from different types of data.

3.5 Profitability analysis

3.5.1 Gross return (GR): Gross return was calculated by multiplying the total volume of output by the average price during the harvesting period.

The following equation was used to estimate GR = $\sum_{i=1}^{n} QiPi$

Where,

GRi= Gross return from i-th product (Tk./ha)

Qi = Quantity of i-th product (kg/ha)

Pi= Average price of the i-th product (Tk./kg)

i = 1, 2, 3 ....., n

3.5.2 Gross margin (GM): Gross margin has given an estimate of the difference between total return and variable costs. That is,

$$GM = GR - TVC$$

Where,

GM = Gross Margin

GR = Gross return

TVC = Total variable costs

3.5.3 Total cost (TC): Total cost was calculated as summation of total variable cost and fixed cost.

$$TC = TVC + FC$$

Where,

TC = Total cost

TVC = Total variable costs

FC = Fixed costs

3.5.4 Net return (NR): Net return was calculated by deducting all cost (Total cost) from gross return-

$$NR = GR - TC$$

Where,

NR= Net return

GR = Gross return

TC = Total cost

CHAPTER-4
RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

This chapter deals with the findings and interpretation of the results. In accordance with the objectives of the study, findings have been presented in two sections. The first section deals with socio-economic characteristics of the fish farmers; and the second section deals with cost return analysis of carp poly culture. The outcomes will demonstrate the profitability of carp poly culture and present status of socio-economic conditions of fish farmers.

4.1 Selected socio-economic characteristics of Fish Farmers

The relevant data were collected on the socio-economic characteristics included age group, education, marital status, family sizes, occupational status, earning members, training facilities, pond properties, land Properties, housing condition, drinking water facilities, sanitary facilities, farmer's children education status, size of the pond of fish farmers and feed types preferred by the fish farmers etc. The salient features of selected socio-economic characteristics of the fish farmers have been presented below:

4.1.1 Age group

The fish farmer's age varied from <25 to >60 years. The respondents were classified into five categories, such as less than 25 age, 25-35 age, 36-45 age, 46-60 age and greater than 60 age. The numbers of respondents were 100. It was observed that the highest numbers of the farmer's age were 36 to 45 (31%) and lowest (6%) were above 60. It indicates that the middle age groups are involved in fishing activities. Rana (1996) in his study in Sirajgong district found that 70% of the fish farmers were in the age group of 18-43 years which was agreed with the present findings. Ahmed (1996) in Tangail also reported the same results. This information implies that the majority of the fish farmers were in active age group of 36-45 years indicating that they provided more physical efforts for fish farming.

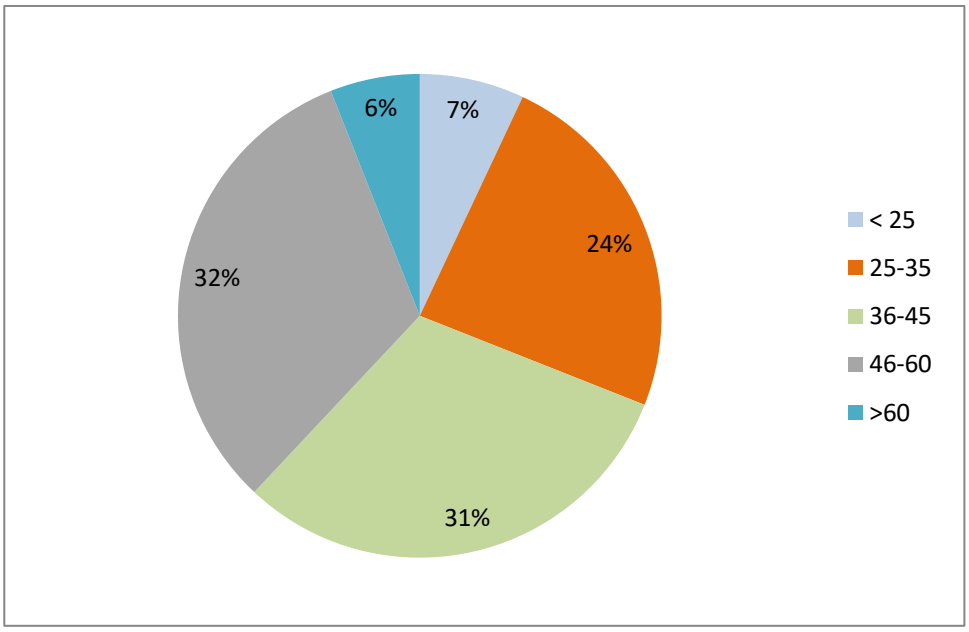

Figure 2: Distribution of fish farmer's based on age

4.1.2 Educational level

The education score of the fish farmers ranged from 0-16 based on their education scores. The respondents were classified into five categories namely, illiterate (0), primary education (1-5), secondary education (6-10), higher secondary (11-12) and graduate (above-12). Most of the farmer's were secondary educated (45%), while some were graduated (13%). About 6% of the farmer's had no education. Ali *et al.* (2008) found that 50% of the fish farmer had education up to S.S.C. level and only 6% fish farmer were illiterate which is almost similar to our findings.

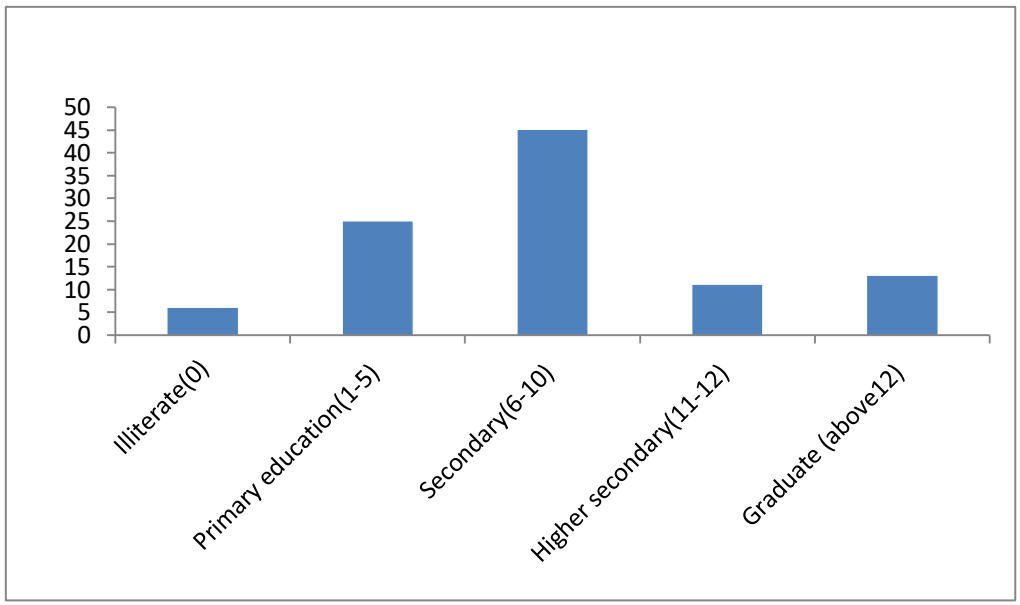

Figure 3: Distribution of fish farmer's according to their educational level

4.1.3 Marital status

The marital status of the fish farmers was classified into three categories and they were based on single married, double married and triple married. The respondents fishermen were 100 and highest number (90%) was recorded as single married. Our finding is similar to Siddiqua,

et,al (2019) who observed highest percentage (88%) of fishermen was single married. Hossain (2009) showed the similarity results in his studies.

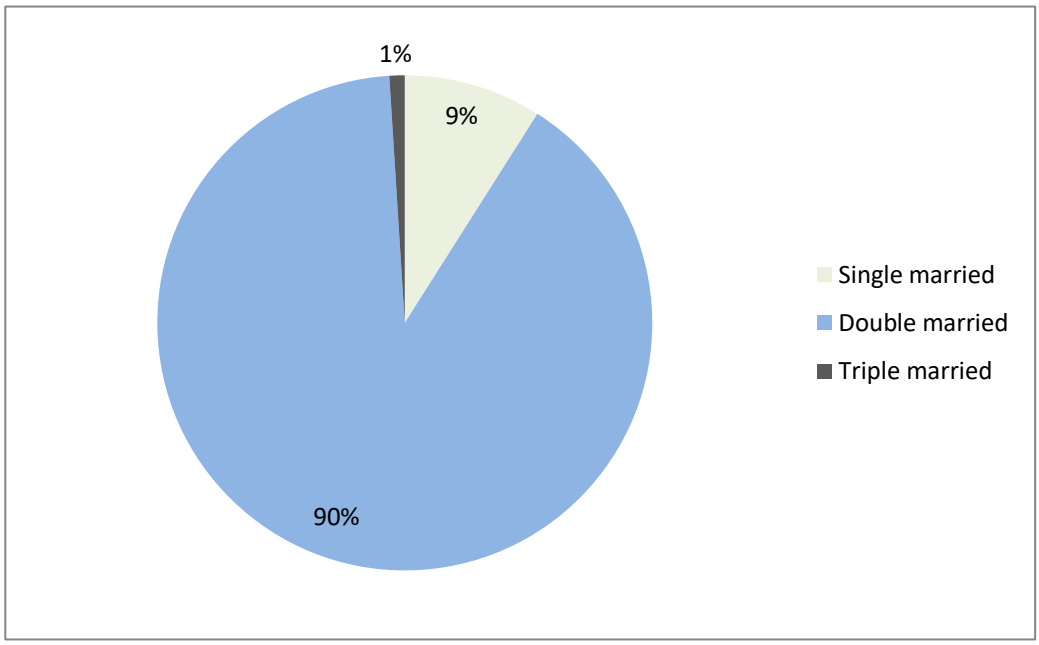

Figure 4: Distribution of fish farmers on the basis of marriage

4.1.4 Family sizes

In rural Bangladesh, families are classified into three categories: 1) Small family- married couples with one children; 2) Medium family- married couples with more than two children or related by blood members or by law; and 3) Large family- married couples with three or four children or blood related family members of three or more generations. The study showed that 73% medium families were highest percentage whereas small and large families were 23 and 4 respectively (Fig. 5). Our findings is almost similar to Ali, *et.al* (2008) who got medium family was the highest percentage (45%) and large family was lower number. Siddiqua, *et.al* (2019) found the similar results in Habigonj Sadar Upazila under Habigonj district, Bangladesh.

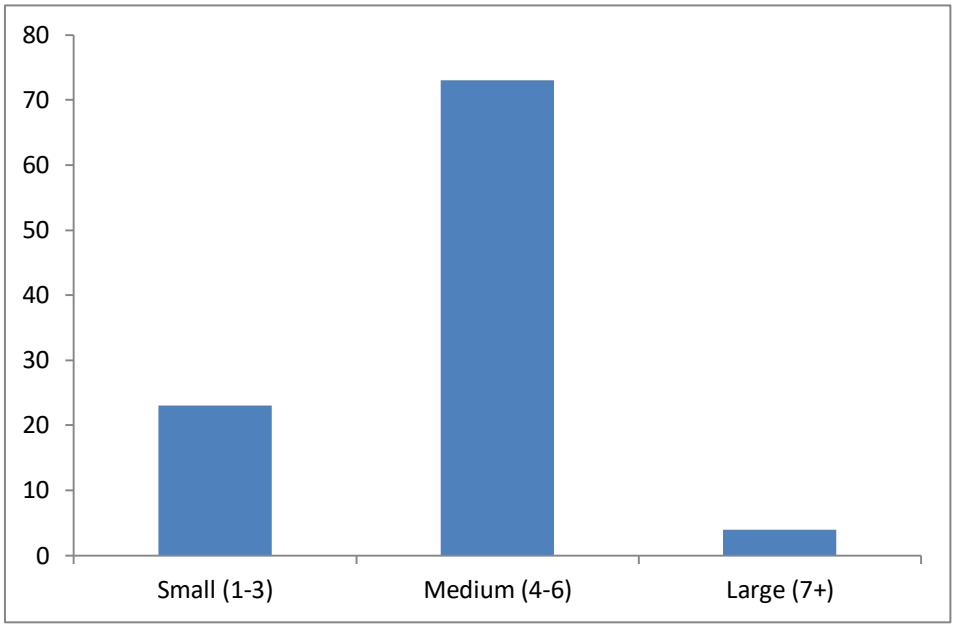

Figure 5: Distribution of fish farmer's according to their educational level

4.1.5 Occupational status

Rural fish farmers are classified into two categories according to their occupation: 1) Main occupation- Fish farmers who are involved directly on fish farming and the fish farmers were considered from which most of the income was earned. In the study, around 55.45% farmers reported fishery is their primary occupation; and 2) Other occupation- Fish farmers who are engaged directly or indirectly on part time of fish farming. Around 45.55% farmers were occupied in business, agriculture as well as fish farming. Our present finding is more or less similar to findings of Ali, *et.al* (2010).

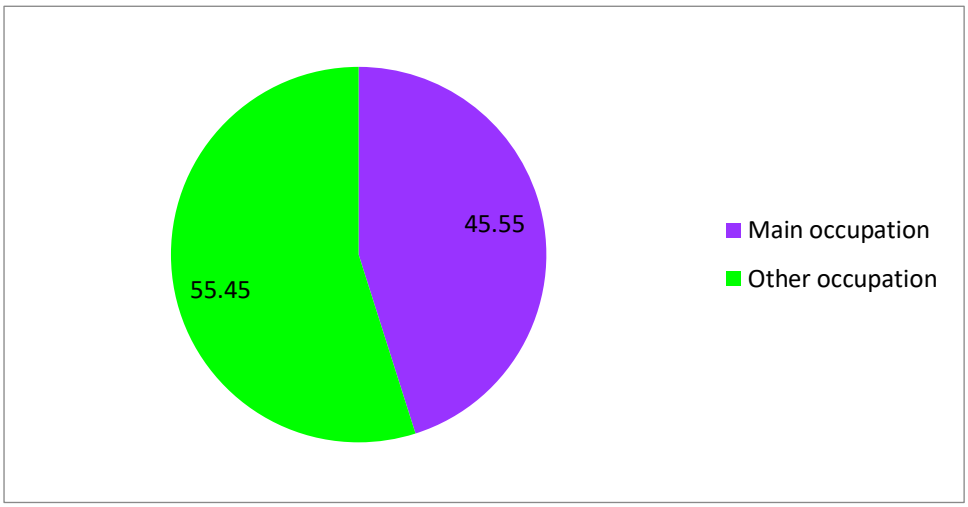

Figure 6: Distribution of fish farmers' based on their occupation

4.1.6 Earning member

In the study area, the selected fish farmer's were grouped into three categories based on earning such as 1) single earning member 2) double earning member ; and 3) triple earning member. The results revealed that 77% families had single earning member; 19% families had double earning member; and only 4% families had triple earning member. Our results are more or less similar to Ibrahim, *et.al* (2018) who observed 88% single earning member in his study area.

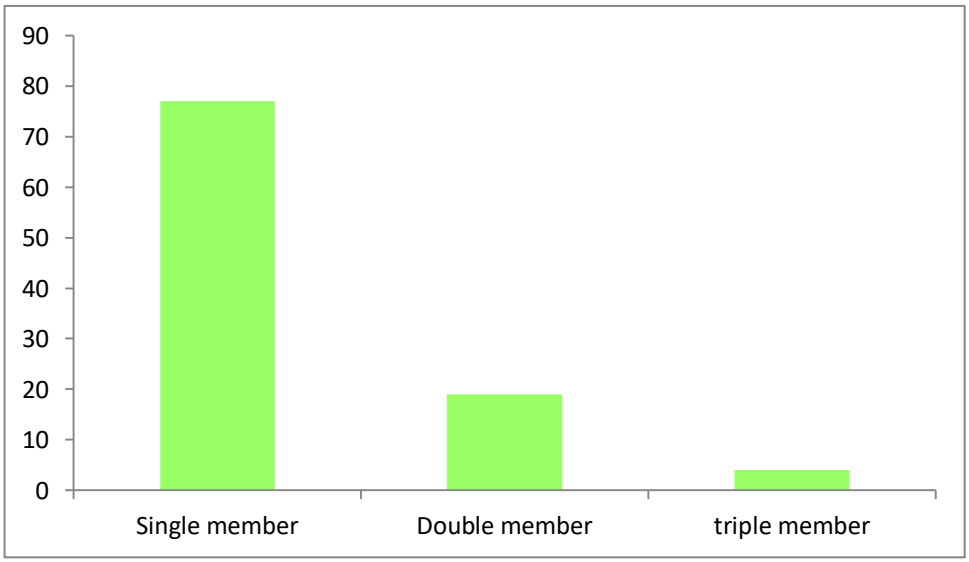

Figure 7: Distribution of fish farmer's based on their earning member

4.1.7 Training facilities

From the survey, it was found that 62% of the fish farmers received single technical assistance or advice on aquaculture from DoF, NGOs or other organizations. On the other hand, about 38% of the fish farmers' acquired twice or more technical knowledge on fish farming. Our finding is similar to Azad, *et.al* (2010) who got 55% single training facilities and rests of them received double or more. That also showed the similarity with Ali, *et.al* (2008).

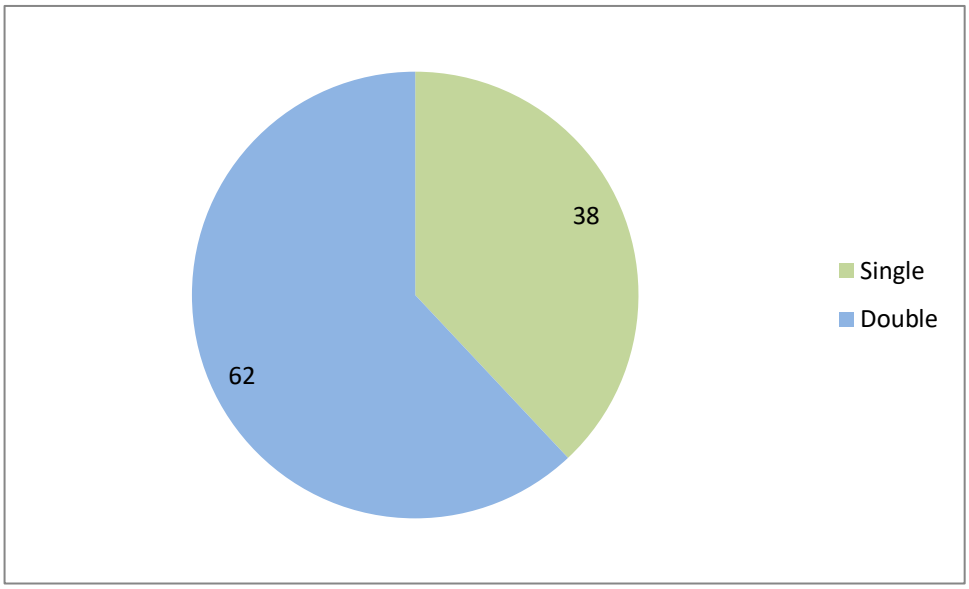

Figure 8: Distribution of fish farmer's based on their training facilities

4.1.8 Pond properties

Suitable pond selection is very crucial for culture system and also for profitable production. Fish production depends on the soil quality, fertility and interaction of soil particles. From the survey, it was found that 77% of the fish farmers had own pond properties and rest of farmers (23%) took lease for carp polyculture production. Ali, *et.al* (2010) found that 70% of the fish farmers had own pond properties and other 30% fish farmers took lease. Rahman, *et.al* (2012) found that 82% of the fish farmers had own pond and other 23% fish farmers took lease carp polyculture production in Hatiya upazila under Noakhali district of Bangladesh.

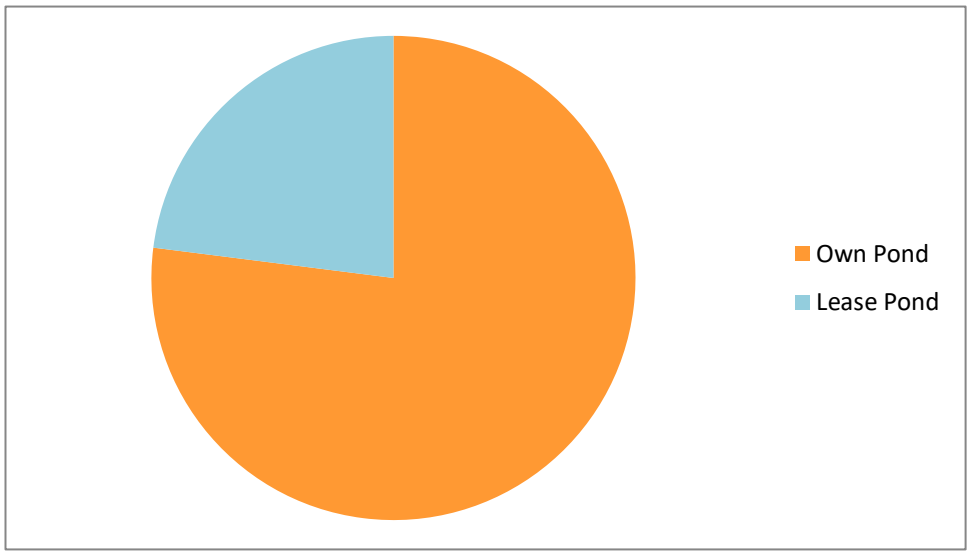

Figure 9: Distribution of fish farmer's on the basis of pond properties

4.1.9 Land Properties

Pattern of land tenure was one of the determinants of social and security situation and economic security (Khan, *et.al* 2013). Majority of the farmer's (71%) had own land, while 29% farmer's were landless. Usually the landless farmer's live in Government land (khas land) and they were unable to buy land due to very low income. Islam, *et.al* (2013) found that 2% fishermen were landless and land owned by the fishermen was 0.02 to 1.57 ha in Monirampur upazila of Jashore district, Bangladesh. Rahman, *et.al* (2012) found that average homestead area of fishermen were 8.75 decimal in Hatiya upazila under Noakhali district of Bangladesh. Halder, *et.al* (2011) found that 82% fishermen had less than 31decimal land including homestead in Rajoir upazila of Madaripur district, Bangladesh.

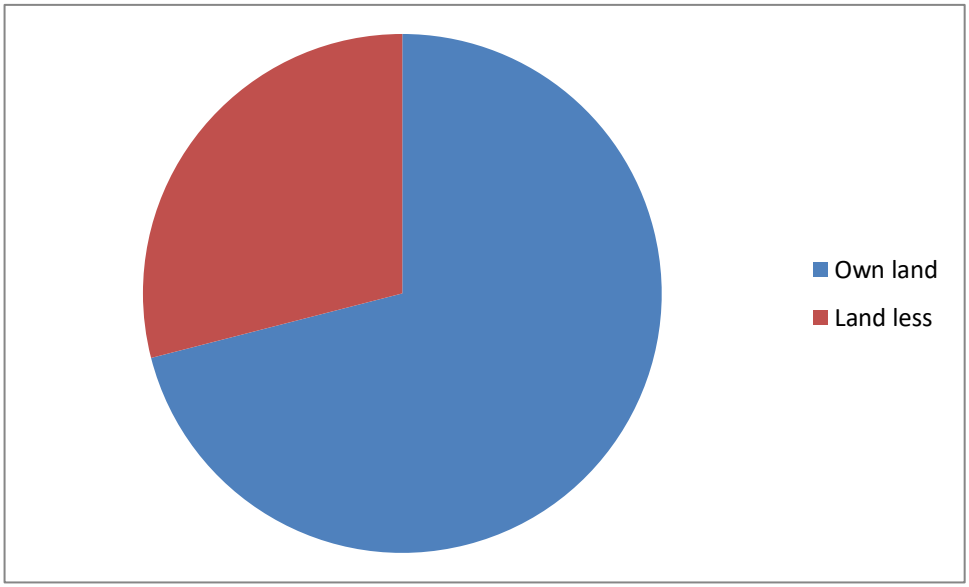

Figure 10: Distribution of fish farmers on the basis of land properties

4.1.10 Housing condition

Housing condition of the farmer's were categories as four main types: i) Tin shed with bamboo, only roof was tin, ii) Tin shed with tin, both roof and surroundings built by tin and iii) Kacha, straw completely built by straw houses iV) paka housing condition of the fishermen were dominated by Tin shed with bamboo (31%), followed by Tin shed with roof (49%), kacha (4%) and paka 16%. No farmer's was found to have building house (Figure 11). Paul, *et.al* (2013) found 72% and 32% fishermen in Birulia and Boroibari had kacha house while 28% and 68% farmer's in Birulia and Boroibari had tin-shed house, respectively. Abdullah-Bin-Farid, *et.al* (2013) found housing condition was dominated by kacha (74%) where Kabir, *et.al* (2013) founded that majority of farmer's in Old Brahmaputra River (83%) had kacha and 17% had semi pakka housing facilities. Khan, *et.al* (2013) explored that the great majority (83%) had kacha and 17% had semi pakka house.

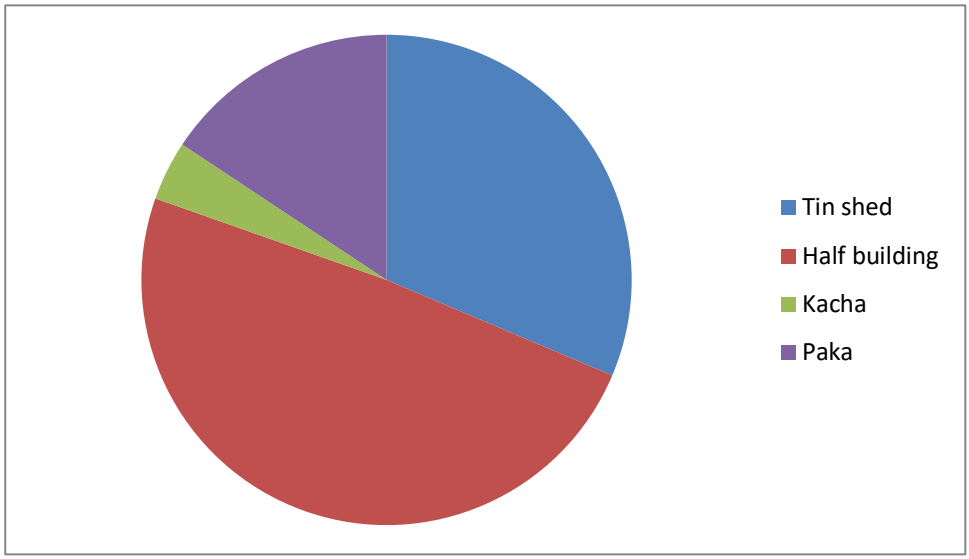

Figure 11: Distribution of fish farmer's on the basis of housing condition

4.1.11 Drinking water

The provision of clean and safe drinking water is considered to the most valued elements in the society. The study showed that 100% of the farmer's households used tube-well and water pump for drinking purposes and among them 73% farmer's used their own tube-well, 25% used water pump and remaining 2% used neighbors tube-well as a source of water for drinking (Figure 12). Abdullah-Bin-Farid, *et.al* (2013) found in Baluhar Baor, Jhenidah district that household of 100% fishermen used tube-well water for drinking and among them, 96% household used owned tube-well, and remaining 4% used neighbors tube-wells. Bappa, *et.al* (2014) showed that 82% farmer's used deep tube-well water while remaining 18% collected water from other sources such as river, canal water etc. in Marjat Baor at Kaligonj in Jhenidah district, Bangladesh. Kabir, *et.al* (2013) found that 40% fishermen had their own tube-well, 50% used shared tube-well and remaining 10% used neighbors tube-well.

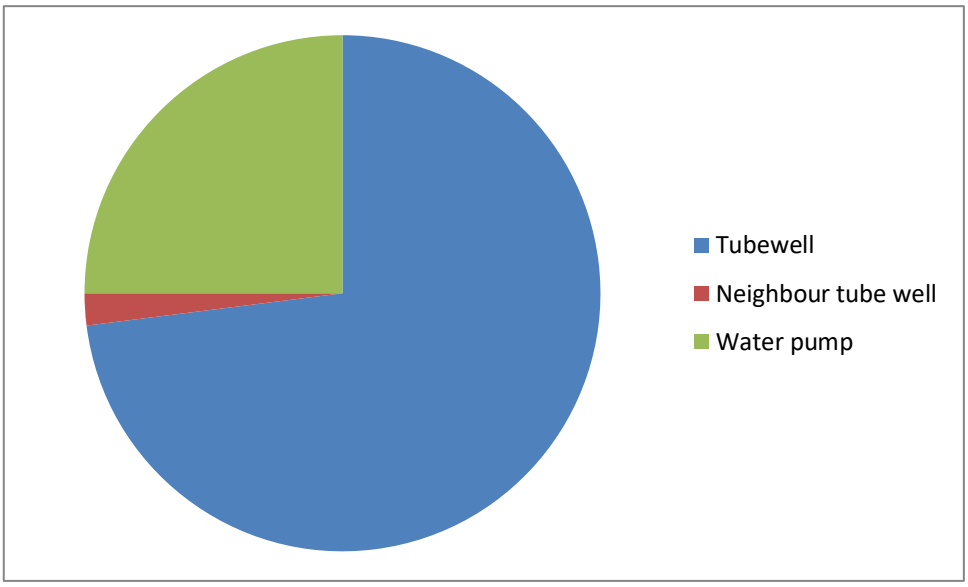

Figure 12: Distribution of fish farmer's on the basis of drinking water

4.1.12 Sanitary facilities

It observed that sanitary conditions of the farmer's were very poor. Four types of toilets were used by farmer's: i) kacha- made of bamboo with leaf and inadequate drainage disposal and ii) open iii) slab or semi pakka- made of brick with leaf or tin and inadequate drainage disposal iV) paka- made of bricks with roof of tin. In the study, it revealed that 34% of the toilets were kacha, 56% toilets were slab or semi pakka; 9% were paka and 2% of the farmer's had no sanitary facilities (Figure 13). The present study revealed that the sanitary conditions of the farmer's were not satisfactory in the study area where Kabir, *et.al* (2013) found in their study that 60% of the farmers had semi pakka, 30% had kacha and 10% had no sanitary facilities in the Old Brahmaputra River fishing community. Ali, *et.al* (2010) found that 62.5% of the farmers had semi-pakka, 25% had kacha and 12.5% had no sanitary facilities in the Mymensingh district and Khan, *et.al* (2013) was also found similar result that 60% farmer's had kacha and 10% had semi-pakka toilet and 30% had no sanitary facility in the Tista River fishing community.

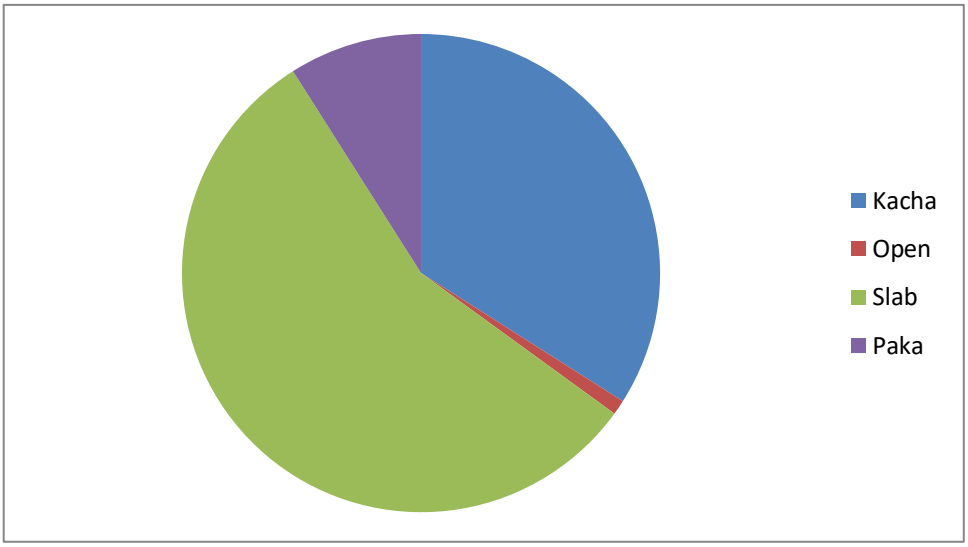

Figure 13: Distribution of fish farmer's on the basis of sanitary

4.1.13 Farmer's children education status

It was found that almost all farmers were married and had one or two children. In the study area, 18% farmer's children had primary education, 66% farmer's children had secondary level, 12% farmer's children had higher secondary level and rest 24% farmer's children had bachelor level of education. Hossain, *et.al* (2015) investigated in Rajshahi that 64% of fishermen were found to send their children to school whereas 36% did not send children for schooling. These results are similar with our present studies (Asif, *et.al.*, 2015).

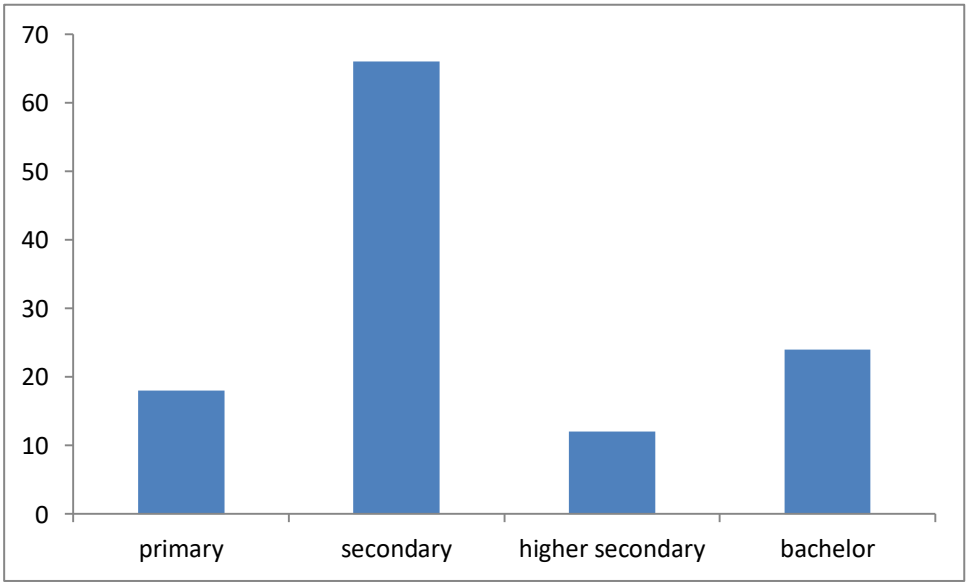

Figure 14: Distribution of farmer's children education

4.1.14 Size of the pond of fish farmer's

Among all the respondents farmer, most of them 32% had ponds with size of 34-66 dec. On the other hand, 26% farmer's had 15-33 dec ponds, 28% had up to 100 dec, 10% had 101-330 dec and 4% had above 330 decimal ponds. Khatun, *et.al* (2013) revealed that the average pond size was 0.13 ha in Sreemongal upazila of Maulvibazar district which is not to similar to the present study. Islam (2011) reported that the average pond size was 0.16 ha with a range from 0.04 to 0.81 ha in some selected areas of Maulvibazar district. All the studies are more or less similar with the present study (Asif, *et.al* 2014).

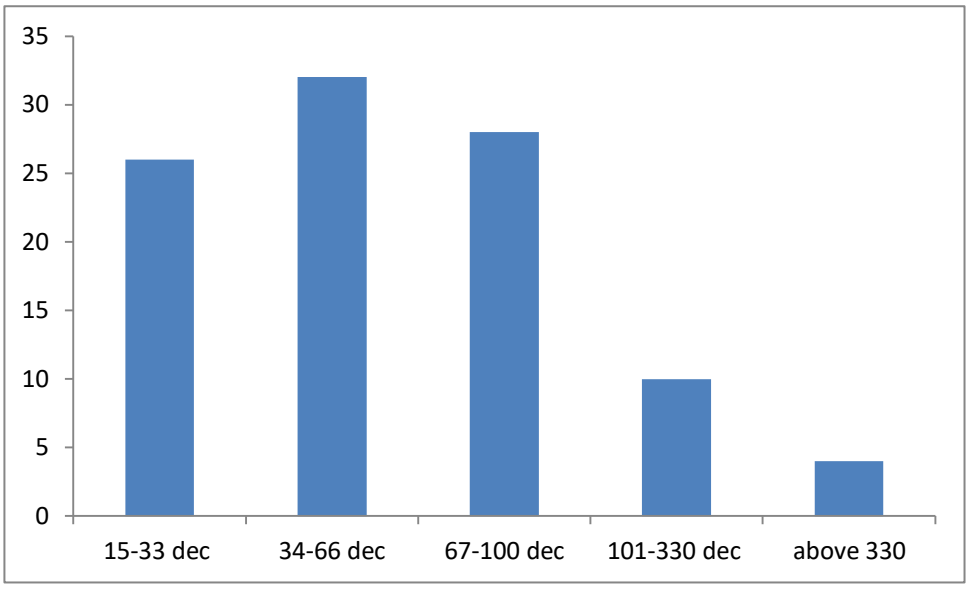

Figure 15: Distribution of size of the pond of fish farmer's

4.1.15 Feed types preferred by farmers

Among all the respondents, it was found that 65% of the fish farmers applied both commercial and homemade feed prepared with rice-bran and mustard oil cake, 20% used only supplementary and homemade feed and 15% farmers used only company made commercial feed. Provakar, *et.al* (2013) found in Shahrasti upazila of Chandpur district that 95% of the farmers applied supplementary feed such as rice bran, mustard oil cake and commercially manufactured feed and rest 5% of farmers depended on the natural food in the

pond. Alam (2006) found that 80% of the farmers applied supplementary feed such as rice bran and mustard oil cake.

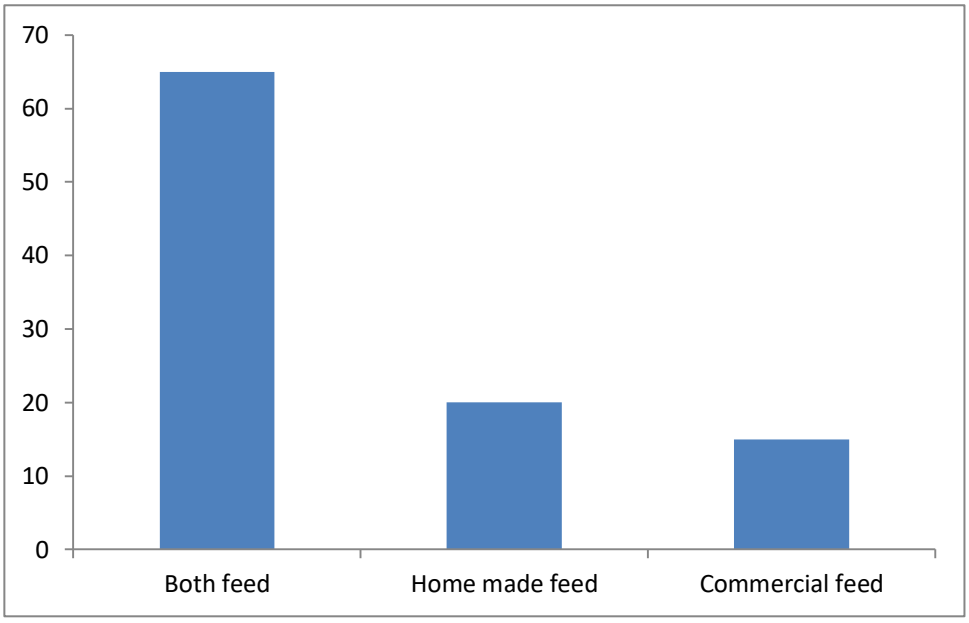

Figure 16: Distribution of feed supplied of fish farmers

4.2 Profitability of carp poly culture

The production costs including the cost of feed, fingerlings, labour cost, land rent, fertilizer cost, water treatment cost and other operational cost etc. Human labour is needed for most of the operations of fish culture and it is one of the most important variables in the production process of fish farmer's. Fish production comprises various forms of activities like pond preparation (reconstruction of pond, weeding, fertilizer application, liming, cow dung application, chemical application, water moving, oil cake application, stocking of fingerlings), intercultural operation (feed application, security netting) and harvesting (catching and netting) etc. Total variable cost such as feed (Tk. 8,929.00), fingerlings (Tk. 31,460.00), labour (Tk. 9,304.00), water treatment (Tk. 2,279.00), fertilizer (Tk. 2,011.00) cost estimated per hectare per year comprised 80.69% (Table 1) which has claimed the highest of the total cost.

Table 1. Per hectare costs, returns and profitability of carp polyculture

Items	**Amount (TK/ha/yr)**	**Percentage of total cost**
Gross Return (A)	1,37,745.00	
Variable cost (cash cost)		
Feed cost	8,929.00	13.34
Fingerlings	31,460.00	47.02
Labour cost	9,304.00	13.91
Water treatment cost	2,279.00	3.41
Fertilizer cost	2,011.00	3.01
Total variable cost (B)	53,983.00	80.69
Fixed cost		
Land rent	10,655.00	15.93
Interest on operating capital	2,262.00	3.38
Total fixed cost (C)	12,917.00	19.31
Total cost (D)	66,900.00	100
Gross margin (A-B)	83,762.00	-
Net return (A-D)	70,845.00	-
Benefit cost ratio (BCR)	2.36	-

Fish farming cost may also vary from location to location and should take all necessary steps before production. Estimation of land rent (Tk.10,655.00) equipment or other operational cost (Tk. 2,262.00) were presented in tabular form of Table 1.

4.2.1 Labour cost

Human labor is one of the most important variable inputs in the production process. Human labor is required for various activities and management of the selected farms such as- farm

preparation, raising dyke, weeding, sorting, grading, harvesting etc. Human labor was classified into: (a) hired labor and (b) family labor. It is easy to calculate hired labor costs. To determine the cost of family labor, the opportunity cost concept was used. Use of human labour and its relevant cost incurred were shown in table 1. The per hectare labor cost was Tk. 9,304.00 which constituted 13.91% of total variable cost.

4.2.2 Fertilizer cost

Fertilizer is an important input for carp polyculture fish farming. Fertilizers mainly uses to influence the growth performances of carp fishes. The purpose of using fertilizer in the farm is to create a condition which facilitates to increase in production of good quality natural feeds, thereby increasing the fish production. The cost of fertilizer was estimated by using the prevailing market rate which was actually paid by the farmers. The prices of these fertilizers were assumed to be same in all categories of farms. Fertilizer requirements may vary from one location to another depending on the pond characteristics. In the study area, carp producers used Urea, TSP (Triple Super Phosphate), MoP (Muriate of Potash) and Cow dung as fertilizer. Cost of these fertilizers and chemicals were computed at the rate of prevailing market prices. It is evident that the rate of application of Urea, TSP and MoP were 55.13 kg, 12.99 kg and 16.68 kg per hectare per year respectively. The total fertilizer was used to the extent of 3203.2 kg per hectare per year comprising the costing of 3.01% of the total production cost.

4.2.3 Feed cost

Supply of artificial supplementary feeds, which can compliment nutritional deficiency, is important to increase the carp production. In the study area carp polyculture farmers used rice bran, wheat bran, pulse bran and different types of oil cake, as supplementary feed for increasing the growth performance. Cost of feeds was estimated at the prevailing market price. Feed cost was estimated at Tk. 8929.00 per hectare per year, which constituted 13.34% of total variable costs in the study area.

4.2.4 Water treatment cost

Water management is very essential for pond carp polyculture. Water is needed at the appropriate time for the proper growth of carp fishes and its survival. The pond fish producers used extra water in dry season. Water treatment cost was estimated at Tk. 2,279.00 per hectare per year, which constituted 3.41% of total variable costs in the study area.

4.2.5 Land rent

The farmers used the land as per conditions of leasing arrangement. The term land rent cost means the cost which was required for carp poluculture farmers to take land lease which would be used for carp polyculture fish production to a particular period of time. Leasing cost varies from one place to another depending on the location, soil fertility, topography of the soil and distance from the sources of water etc. Land use cost for carp polyculture farming was estimated at the rate of prevailing cash rental value of per hectare pond in the study area. Land rent value was estimated at Tk. 10,655.00 per hectare per year/ which constituted 15.93% of the total production cost.

4.2.6 Interest on operating capital

Interest on operating capital was determined on the basis of opportunity cost principle. The operating capital actually represented the investment on different farm operation over the period because all the cost was not incurred at the beginning or at any single point of time. The cost was incurred throughout the whole production period. Interest on operating capital was calculated by using the following standard formula (Miah, 1992).

Interest on Operating Capital (IOC) = Alit

Where,

Al= Total investment /2,

t = Total time period of a cycle,

i= interest rate which was 8 percent per year during the study period,

Interest on operating capital was found to be Tk. 2262.00 which was constituted 3.38% of gross costs (Table 1).

4.2.7 Total fixed cost

In the study area, it was estimated that per hectare total fixed cost for year round carp polyculture fish farming was Tk. 12,917.00 which comprised of 19.31% of total cost (Table 1).

4.2.8 Total cost

The total costs were calculated by adding up total variable cost and total fixed cost. Total costs per hectare were estimated at Tk. 66,900.00. The total variable costs constituted about 80.69% of the total cost. Total variable cost and other cost during the study period were presented in table 1.

4.2.9 Gross return

Gross return is the pecuniary value of total product. Per hectare gross returns were calculated by multiplying the total amount of production by their respective market prices. In the study area, per hectare average yield of carp production was 860.90 kg and its money value was Tk. 1,37,745.00.

4.2.10 Net return

In general net return is termed as entrepreneur's income. To evaluate the profitability of carp polyculture fish production, net return is an important aspect. Net return is the difference between gross return and total costs. Per hectare net return was estimated at Tk. 70,845.00 which indicates that carp polyculture fish production is profitable business for the farmers (Table 1).

4.2.11 Gross margin

Farmers usually want to gain maximum return over variable cost of production. The probable reason is that estimation of fixed cost of production is difficult to determine. Thus the gross margin analysis has been taken into account to calculate the relative profitability of carp polyculture fish farming. The gross margin of carp polyculture fish farming was estimated at Tk. 83,762.00

4.2.12 Benefit cost ratio

Gross return was estimated Tk. 1,37,745.00 per hectare per year. Gross cost was assessed Tk. 66,900.00 per hectare per year. The benefit cost ratio (BCR) was measured by Net return/ Total cost which is presented in table 1. A benefit-cost ratio (BCR) is a ratio used in a cost-benefit analysis to summarize the overall relationship between the relative costs and benefits of a proposed project. If a project has a BCR greater than 1.0, the project is expected to deliver a positive net present value to a firm and its investors. If a project's BCR is less than 1.0, the project's costs outweigh the benefits, and it should not be considered. Carp polyculture BCR were indicated 2.36 hectare per year. Our finding is higher than Islam et al. (2008) who recorded BCR of 1.54 in case of carp grow out ponds. Another authors Alam, *et.al* (1995) and Awal, *et.al* (2001) who have reported BCR of 3.83 and 2.73 respectively.

CHAPTER-5
SUMMARY AND CONCLUSION

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SUMMARY

One of the major sectors of Bangladesh agriculture is represented by the fisheries sector. Being a deltaic land with numerous rivers and inland haors and beels (lakes and lowland areas of considerable size), and also ponds that are dug in populated areas for the purpose of bathing, washing and often as a source of drinking water, fish became an integral part of the food culture. In the past hardly any need was felt for fisheries education and research, because population was low and fish in plenty. This sector contributes in meeting almost 60% of total animal protein supply, earning foreign exchange and socio-economic development of the rural poor by reducing poverty through employment generation. Sustainable, productive fisheries and aquaculture improve food and nutrition security, increase income and improve livelihoods status, promote economic growth and protect our environment and natural resources. In 2017-18, this sector contributes 3.57% to the national GDP and more than one-fourth (25.30%) to the agricultural GDP. More than 11% of total population of Bangladesh is engaged in this sector on full time and part time basis for their livelihoods. In 2017-18, the country earns BDT 430994.00 lakh by exporting almost 68.94 thousand MT of fish and fishery products. Over the last three decades, the fish production is increased more than five times (7.54 MT in 1983- 84 to 42.77 lakh MT in 2017-18). The ecology of the country is appropriate for the growth and production of the fisheries resources. Fish production in ponds, lakes, burrow pits, floodplains, oxbow lakes, and semi-closed water bodies are increasing day-by-day with the blessings of modern technology. Fish production has increased to 42.77 lakh MT in 2017-18, which was 25.63 lakh MT in 2007-08. Where aquaculture production contributes 56.24 percent of the total fish production. It is believed that if the increasing trend of fish production continues, it will be possible to achieve the projected production target of 45.52 lakh MT by 2021. According to FAO report The State of

World Fisheries and Aquaculture 2018, Bangladesh ranked 3rd in inland open water capture production and 5th in world aquaculture production. Currently Bangladesh ranks 4th in tilapia production in the world and 3rd in Asia.

With respect to the socio-economic features of the study area, the findings revealed that very few persons were involved in fish farming below age 25. The carp polyculture producing farmers were classified into five age groups: <25, 25-35, 36-45, 46-60 and 60+ ages. Out of the total fish farmers 7% belonged to the age group of <25 years, 24% belonged to the age group of 25-35 years, 31% belonged to the age group of 36-45, 32% belonged to the age group of 46-60 and 6% fell into the age group more than 60. Most of the farmer's were secondary educated (45%), while some were graduated (13%). About 6% of the farmer's had no education. Single marital status was highest (90%) in the study area. Medium families were the top (73%), whereas large families were found only 4%. The main occupation of carp polyculture farming was 45.55% and rest of them involved in multiple occupations. Most of the families had single earning members and majority farmer's took single training facilities. Majority respondents had own pond and land properties of 77% and 71%, respectively. 49% respondents had half buildings; 73% respondents used drinking water from their own tube-well and 56% farmer's used slab sanitary facilities.

To determine the profitability of carp polyculture farming both the inputs and outputs were valued at market price during the study period. For analytical advantages, the cost item were identified as human labour, fingerlings, fertilizer, feed, lime, water treatment cost, land rent cost and other operating capital. Cost and returns were worked out to estimate profitability of carp polyculture production. Per hectare total cost, gross return, net return and gross margin were Tk. 66900.00, Tk. 137745.00, Tk. 70845.00 and Tk. 83762.00 respectively.

CONCLUSION

The main objective of this study was to examine the financial profitability of carp poly culture. The study shows that carp, poly culture was highly profitable business. If fishery is to properly contribute, then farmer's must be provided with adequate knowledge of carp production. Mere substitution of abundant inputs for scarce/material input will not bring desirable result. Rather, right kind and quality of inputs should be allocated in carp production for increasing efficiency. Better marketing facilities, fair price of their product, good quantity of fingerlings should be ensured.

REFERENCES

REFERENCES

Abdullah-Bin-Farid, B.M.S., Mondal, S., Satu, K.A., Adhikary, R.K. and Saha, D. 2013. Management and socio-economic conditions of fishermen of the Baluhar Baor, Jhenidah, Bangladesh. *Journal of Fisheries*. Vol. 1(1): 30- 36

Ahmed, F. 2003. Comparative studies on carp polyculture practices of three different NGOs in Mymensingh district. MS Thesis. Department of Fisheries Management, BAU, Mymensingh. pp. 65.

Ahmed, M. N. U. 1996. Reports on the fishermen's socioeconomic survey. Fisheries Survey and Monitoring Program, Department of Fisheries, Tangail; pp. 4.

Akhter, M.M. 2009. Farming system and economic of carp production in rural Bangladesh, MS Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh.

Alam, M. P. and Rahman, M.O. 2018. Input-output relationship and economics of pangas monoculture and carp-pangas polyculture in two districts of Bangladesh. *Bangladesh Journal of Fisheries Research*. Vol. 9(1): 105-106.

Alam, G. 2006. Status of fish farming and livelihoods of fish farmers in some selected areas of MithapuqurUpazila in Rangpur district, M.S. 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 Resources.* Vol. 6(2): 117-124.

Alam, M.S., Khan, M.A. and Bashar, M.A. 2004. Profitability and factors affecting production in carp polyculture in jessore district. *Progressive Agriculture*. 15: 1-8

Alam, M.S., Miah, M.S., Neazuddin, N., Gupta, M.V. and Shah, M.S. 1995. Studied on fish production in farmer's pond in carp polyculture system in eastern Bangladesh. *Bangladesh Journal of Agricultural Science.* Vol. 22(2):161-166.

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 Bangladesh Agricultural University*. Vol. 6(2): 367-374.

Ali, M.M., Asif, A.A., Shabuj, M.A.I., Vaumik, S., Zafar, M.A. and Sharif, B.M.N. 2010. Status of polyculture *Pangasius hypophthalmus* with carps in Jhikargacha Upazila of Jessore District, Bangladesh. *International Journal of Fisheries and Aquatic Studies*. Vol. 4(1): 423-430.

Asadujjaman, M. and Hossain, M.A. 2016. Fish growth, yield and economics of conventional feed and weed based polyculture in ponds. *Journal of Fisheries*. Vol. 4(1): 353–360.

Asif, A.A., Samad, M.A., Rahman, B.M.S., Rahman, M.A., Rahman, M.H., Yeasmin, S.M. and Nima, A. 2014. Study on management of fish fry and fingerling marketing of Jessore in Bangladesh. *International Journal of Business, Social and Scientific Research.* Vol. 2(2): 127-135.

Asif, A.A., Samad, M.A., Rahman, M.H., Farid, M.A., Yeasmin, S.M. and Rahman, B.M.S. 2015. Socio-economic condition of fish fry and fingerling traders in greater Jessore region. *International Journal of Fisheries and Aquatic Studies.* Vol. **2**(4): 290-293.

Awal, M.A., Ali, M.A. and Mia, M.G.F. 2001. Fisheries resources and utilization patterns in some selected areas of Jamalpur and Sherpur district. *Bangladesh Journal of Training and Development.* Vol. 14(1 and 2): 183-190.

Azad, M. A. K., Anisuzzaman, M., Chowdhury, M.M.R., Hoque, M. and Shariful, M.I. 2010. Livelihood status of the fish farmers in some selected areas of Tarakanda Upazila of Mymensingh district. *Journal of Agroforesty and Environment*. Vol. 3(2): 85-89 .

Azim, M.E. and Wahab, M.A. 2003. Development of a duckweed-fed carp polyculture system in Bangladesh. *Aquaculture*. 18: 425–438.

Bappa, S.B., Hossain, M.M.M., Dey, B.K., Akter, S. and Hasan-Uj-Jaman, M. 2014. Socio-economic status of fishermen of the Marjat Baor at Kaligonj in Jhenidah district, Bangladesh. *Journal of Fisheries*. Vol. 2(2): 100-105.

Barman, B. K., Kunda, M. and Wahab, M. A. 2012. Technologies for improving quality carp seed production in Bangladesh. In: Book of abstracts, fifth fisheries conference and

research fair 2012, Bangladesh Fisheries Research Forum (BFRF), 18–19 January 2012, Dhaka, Bangladesh, pp. 182.

Belton, B., Karim, M., Thilsted, S., Jahan, K. M., Collis, W. and Philips, M. 2011. Review of aquaculture and fish consumption in Bangladesh. Studies and Reviews 2011-53. Penang: The WorldFish Center.

Biswas, B.K., Shah, S., Takil, K. and Kumali, 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*. Vol. 56(2): 245–251.

Chakraborty, R.D., Murty, D.S., Sen, P.R., Nandy, A.C. and Chakraborty, D.P. 1974. Periodic harvesting to enhance production in composite culture of Indian and exotic carps. *Indian Journal of Inland Fisheries Soc*iety. 4: 167-71.

Chowdhury. H., Chakraborty, R.D., Sen, P.R., Rao, N.G.S. and Jena, S. 1975. Record yields by composite fish culture in freshwater ponds. *Aquaculture.* Vol. 6(4): 343-355.

Das, P., Kumar, D., Guha, M.K. and Roy, B. 1975. National demonstration on Composite Fish Culture in West Bengal. *Indian Journal of Inland Fisheries Society*. 7: 112-115

Dev, M. 2009. Polyculture of carps with tilapia, MS Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh. pp. 25.

DoF (Department of Fisheries) 2013. Jatio Matshay Pakkah Saranika-2013 Department of Fisheries, Bangladesh, Ministry of Fisheries and Livestock, Government of People's Republic of Bangladesh, Ramna, Dhaka, Bangladesh.

Dey, M.M., Spielman, D.J., Haque, A.B.M.M., Rahman, M.S. and Valmonte-Santos, R. 2013. Change and diversity in smallholder rice–fish systems: recent evidence and policy lessons from Bangladesh. *Food Policy*. 43: 108–117.

DoF 2016. National Fish Week Compendium. Department of Fisheries, Ministry of Fisheries and Livestock, Government of the People’s Republic of Bangladesh. pp. 148.

DoF. 2017. Yearbook of Fisheries Statistics of Bangladesh 2016-2017. Fisheries Resources Survey System (FRSS), Department of Fisheries, Bangladesh: Director General. 34: 129.

FAO 2018. Food and Agricultural Organization of the United Nations, The State of World Fisheries and Aquaculture 16 FAO, Rome, Italy.

Halder, P., Ali, H., Gupta, N., Aziz, M.S.B. and Monir, M.S. 2011. Livelihood status of fresh fish, dry fish and vegetable retails at Rajoir upazila of Madaripur district, Bangladesh. *Bangladesh Research Publications Journal*. Vol. 5(3): 262-270.

Halver, J.E. 1984. Special methods in pond fish husbandry. Akademiai Nyomda, Budapest. pp. 146.

Hossain, F.I., Miah, M.I., Hosen, M.H.A., Pervin, R. and Haque, M.R. 2015. Study on the Socio-Economic Condition of Fishermen of the Punorvaba River under Sadar Upazila, Dinajpur. *Journal of Fisheries.* Vol. **3**(1): 239-244.

Hossain, M.A. 2009. Socio-economic Condition of Fish Farmers in Jessore District, Khulna, B.Sc. Thesis, Fisheries and Marine Resource Technology Discipline, Khulna University, Khulna.

Hossain, M.A. and Bhuiyan, M.T.I. 2007. Effects of silver carp and the small indigenous fish mola, *Amblypharyngodon mola* and punti, *Puntius sophore* on fish polyculture production. *Aquaculture.* 273: 520-531.

Hossain, M.A., Alam, M.R., Haque, M.R. and Mehbub, M.F. 2013. Study on present status of carp-sis polyculture in Dinajpur district of Bangladesh. *Bangladesh Research Publications Journal*. 123-130.

Ibrahim, M., Khan, M.E., Hasan, M.M. and Khanam, R. 2018. Livelihood condition of fishermen at Amtali Upazila, Barguna, Bangladesh. *International Journal of Fisheries and Aquatic Studies*. Vol. 6(3):13-24.

ICLARM, (International Center for Living Aquatic Resources Management) 2002. The Worldfish Center and its relevance for integrated irrigation and aquaculture. *In* M. Halwart & A.A. van Dam, eds. *Integrated irrigation and aquaculture in West Africa: concepts, practices and potential*, pp. 161–164. Rome, FAO. pp. 181.

IUCN. 2000. Red book of threatened fishes of Bangladesh. IUCN - The World onservation Union.

Islam, M.R., Hoque, M.N., Galib, S.M. and Rahman, M.A. 2013. Livelihood of the fishermen in Monirampur upazila of Jessore district, Bangladesh. *Journal of Fisheries*. Vol. 1(1): 37-41.

Islam, N., Haque, E. and Mohsin, A.B.M. 2008. Carp culture: Cost-return and profit analysis of Rajshahi district, Bangladesh. *Journal of Fisheries International.* Vol. 3(3): 52-55.

Islam, S. 2011. Studies on pond fish farming and livelihoods of rural farmers in some selected areas of Maulvibazar District. MS Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh.

Kabir, K.M.R., Adhikary, R.K., Hossain, M.B. and Minar, M.H. 2013. Livelihood status of fishermen of the old Brahmaputra River, Bangladesh. *World Applied Sciences Journal*. Vol. 16(6): 869-873.

Karim, A. Shoaib, M. and Khwaja, S. 2016. economic viability and cost benefit analysis of small scale polyculture of carps. *International Journal of Biological Research*. Vol. 4(1): 14-16, 2016.

Khan, M. R. I., Parvez, M. T., Talukder, M. G. S., Hossain, M. A. and Karim, M. S. 2018. Production and economics of carp polyculture in ponds stocked with wild and hatchery produced seeds. *Journal of Fisheries.* 6(1): 541–548.

Khan, M.A.R., Miah, M.I., Hossain, M.B., Begum, A., Minar, M.H. and Karim, R. 2013. Fish biodiversity and livelihood status of fishing community of Tista River, Bangladesh. *Global Veterinaria*. Vol. 10(4): 417-423.

Khatun, S., Adhikary, R.K., Rahman, M., Sikder, M.N.A. and Hossain, M.B. 2013. Socio-economic status of pond fish Farmers of charbata, Noakhali, Bangladesh. *International Journal of Life Science Biotechnology and Pharma Research.* Vol. 2(1): 356-365.

Kobir, M.H., Hossain, R.H., Hossain, M.A., Dey, S.K. and Sultana, S. 2017. Carps polyculture technique in Mohanpur, Rajshahi region of Bangladesh. *Asian-Australasian Journal of Bioscience and Biotechnology*. Vol. 2(1): 100-105.

Lakshmanan, M.A.V., Sukumaran, K.K., Murty, D.S., Chakraborty, D.P. and Philipose, M.T. 1971. Preliminary observations on intensive fish farming in fresh water ponds by the

composite culture of Indian major and exotic species. *Journal of the Inland Fisheries Society India.* 3: 1-21.

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*. Vol. 9(3): 92–108.

Miah, M.T.H. 1987. Appraisal of deep and shallow tubewell irrigation projects in the Tangail district in Bangladesh. M.E. Dissertation University of New England, Armodal.

Mohsin, A.B.M., Islam, M.N., Hossain, M.A. and Galib, S.M. 2012. Cost-benefit analyses of carp polyculture in ponds: a survey study in Rajshahi and Natore districts of Bangladesh. *Bangladesh Journal of Environmental Science.* Vol. 23: 103-107.

Nongmaithem, B. and Ngangbam, A.K. 2009. Fish and Human Nutrition Part-1. Department of Microbiology, UNESCO Centre for Marine Biotechnology, College of Fisheries, Mangalore. Home>> education>> Scientific Papers>> Fish and Human Nutrition 2.

Paul, B., Faruque, H. and Ahsan, D.A. 2013. Livelihood status of the fishermen of the Turag River, Bangladesh. *Middle-East Journal of Scientific Research.* Vol. 18(5): 578-583.

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 Environmental Science.* Vol. **13**(3): 391-397.

Rabanal, H.R. 1967. Inorganic fertilizers for pond fish culture. *FAO Fisheries publication* 44: 164-173.

Rahman, M., Rahman, M.M., Hasan, M.M., and Islam. M.R. 2012. Livelihood status and the potential of alternative income generating activities of fisher's community of Nijhum Dwip under Hatiya upazila of Noakhali district in Bangladesh. *Bangladesh Research Publications Journal*. Vol. 6(4): 370-379.

Rahman, M.A., Mondal, M.N., Hannan, M.A., Habib, K.A. 2015. Present status of fish biodiversity in Talma River at northern part of Bangladesh. *International Journal of Fisheries and Aquatic Studies*. 3**:** 341-348.

Rahman, M.A., Toky, M.T., Islam, M.S. and Mukta, M.A. 2020. Economic analysis of tilapia-carp polyculture in a selected area of Bangladesh. *Archives of Agriculture and Environmental Science.* Vol. 5(3): 354-362.

Rahman, M.M., Das S., Samad, M.A., Tanu, I.A. and Mofasshalin M.S. 2017. Growth, production and economics of carp polyculture in fertilizer and feed based ponds. *International Journal of Natural and Social Sciences*. Vol. 4(3): 01-09.

Rahman, M.M., Verdegem, M.C.J., Nagelkerke, L.A.J., Wahab, M.A., Milstein, A. and Verreth, J.A.J. 2006. Growth, production and food preference of Rohu *Labeo rohita (H.)* in monoculture and in polyculture with Common carp *Cyprinus carpio (L.)* under fed and non-fed ponds. *Aquaculture.* 257: 359–372.

Rana, M.S. 1996. An economic analysis of pond fish culture in some selected areas of Sirajgong district. MS Thesis, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh. pp. 83.

Roy, N.C., Wahab, M.A., Khatoon, H. and Thilsted, S.H. 2003. Economics of Carp-SIS Polyculture in Rural Farmer's Pond. *Pakistan Journal of Biological Sciences.* Vol. 6(1): 61-64.

Saha, N.C. and Islam, M.S. 2005. Factors affecting the adoption of carp polyculture in Bangladesh. *Bangladesh Journal of Fisheries Research*. Vol. 9(1): 81-82.

Sarker, S.C. 2005. A Study on the Manorial Effects on the Growth Rate of Fishes, MS Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensingh.

Siddiqa, A., Shahroz, M. H., Barman, B. K., Ahmed, M. U. and Chakraborty, B. K. 2018. Production Economics and Profitability Analysis of Aquaculture in Southwest Bangladesh. *International Journal of Oceanography & Aquaculture*.Vol. 2(6): 151-156.

Siddiqua, N.S., Uddin, M.S., Ahamed, G.S., Alam, M.T. and Dey, T. 2019. Assessment of the livelihood status of fish farmers and aquaculture conditions in Habigonj Sadar Upazila under Habigonj district, Bangladesh. *International Journal of Fisheries and Aquatic Studies.* Vol. 7(4): 105-109.

Sinha, V.R.P. 1976. Project Coordinators Report. Third workshop of All India Coordinated Research Project on Composite Fish Culture and Fish Seed Production, Pune.

Sultana, S. 2001. Socioeconomic impact of the adoption of BFRI evolved polyculture and carp nursery technologies in some selected areas of Trisal Upazila in Mymensingh district. M.S. Thesis, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh, pp. 101.

Talukdar, M.Z., Shahjahan, H. and Rahman, M.S. 2012. Suitability of duckweed (*Lemna minor*) as feed for fish in polyculture system. *International Journal of Agriculture, Innovation & Technology*. Vol. 2(1): 42–46.

Tang, Y.A. 1970. Evaluation of balance between fishes and available fish foods in multispecies fish culture ponds in Taiwan in nursery ponds. *Bangladesh Journal of Fisheries.* Vol. 11(1): 83-88.

Wahab, M.A., Islam, M.L. and Thilsted, S.H. 2001. Culture potentials of mola, *Amblypharyngodon mola,* chela, *Chela cachius* and punti, *Puntius sophore* under monoculture system. *Bangladesh Journal of Fisheries.* 5: 123-134.

Wahab, M.A., Rahman, M.M. and Milstein, A. 2002. The effect of common carp *(Cyprinus carpio)* and Mrigal *(Cirrhinus mrigala*) as bottom feeders in Major Indian carp polycultures. *Aquaculture Research.* 33: 547–556.

Yashouv, A. 1966. Increasing fish production in ponds. *Trans American Fisheries Society* Vol. 92(3): 292-297.

Yashouv, A. 1969. The fish ponds as an experimental model for study of interactions within and among fish populations. *Verhandlungen des Internationalen Verein Limnologie.* 17: 582-593.

Yin, X., Wang, A., Zhou, H., Wang, Q., Li, Z. and Shao, P. 2014. Economic Efficiency of Crucian carp (*Carassius auratus gibelio*) Polyculture Farmers in the Coastal Area of Yancheng City, China. *Turkish Journal of Fisheries and Aquatic Sciences*. 14: 429-437.