PROFITABILITY AND WOMEN EMPOWERMENT OF PABDA FISH PRODUCTION IN MYMENSINGH DISTRICT OF BANGLADESH

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CERTIFICATE

This is to certify that thesis entitled, "**PROFITABILITY AND WOMEN EMPOWERMENT OF PABDA FISH PRODUCTION IN MYMENSINGH DISTRICT OF BANGLADESH.**" submitted to the faculty of **AGRIBUSINESS AND MARKETING**, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **AGRIBUSINESS AND MARKETING** embodies the result of a piece of genuine research work carried out by **SAMIA AKTER SINHA** bearing Registration no. **20-11107** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.

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

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ABSTRACT

In Bangladesh, the fish farming sector has the potential to achieve self-sufficiency in the food sector and to reduce poverty. It is necessary to increase fish production and more participation of women eventually increases fish production. The main objective of the present study was profitability and women empowerment of Pabda fish production in Bangladesh. Data were collected from 100 Pabda fish farmers in two villages namely, Koltapara and Ramgopalpur villages of Gouripur Upazilla under Mymensingh district where an adequate amount of Pabda farms were available. Data were collected by using a pre-tested interview schedule. The study found that gross return was Tk 2265088.73/hectare, net return Tk 988425.11 /hectare, gross margin was Tk 1110491.20 /hectare. BCR based on variable cost was 1.96, and BCR based on total cost was 1.77 which indicated that Pabda fish production was profitable in the study area. The study found that fingerling cost, salt and lime cost, feed cost, medicine cost, and water pumping cost had a significant impact on Pabda fish production. Production efficiency of Pabda fish was 96 percent. The study found that farmers wives involved in different agricultural activities including Pabda fish production. Women in Pabda fish farming still need to be empowered more and trained to enhance their capabilities and involved in Pabda fish system production. In this study number of problems were also identified which were classified as technical problems, economic problems, and social problems during Pabda fish farming. Some policy recommendations were also given at the end of the study which will be helpful to the Pabda fish.

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LIST OF ABBREVIATIONS AND ACRONYMS

BBS	Bangladesh Bureau of Statistics
BCR	Benefit cost ratio
FRSS	Fisheries Resources Survey System
BER	Bangladesh Economic Review
DoF	Department of Fisheries
et al.	and others (at all)
etc.	etcetera (others and so forth)
FY	Fiscal Year
GDP	Gross Domestic Product
GNP	Gross National Product
Ha	Hectare
Kg	Kilogram
Ln	Natural log
NGOs	Non – Government Organizations
No.	Number
SPSS	Statistical Package for Social Sciences
BDT	Bangladesh Taka
Sq. Km	Square Kilometer
Fig.	Figure

CHAPTER 1

INTRODUCTION

1.1. Background of the study

Bangladesh is world's one of the leading fish-producing countries with a total production of 46.21 lakh MT in FY 2020-2021, where aquaculture contributes 57.10 percent of the total fish production (Yearbook of Fisheries Statistics of Bangladesh 2020-2021). Over the last 12 years, with the fairly steady average fisheries growth of 4.82% and consistent average aquaculture growth of around 8.59%. Now, Bangladesh becomes a self-sufficient fish-producing country that supplements about 60% (with per capita of 62.58 g/day against the targeted 60 g/day) of the total daily animal protein intake of its people. According to the FAO report the State of World Fisheries and Aquaculture 2020, Bangladesh ranked 3rd in inland open-water capture production and 5th in world aquaculture production. Mymensingh district's total fish production is 3,57,816 metric tons which leads Mymensingh district to the first-ranked fish-producing district in Bangladesh. Bangladesh produced over one million (10.55 lakh) tons of capture fish, 0.46 million (4.61 lakh) tons of culture fish and 0.54 million (5.46 lakh) tons of marine fish during the FY 2010-11. Bangladesh produced over one million (10.55 lakh) tons of capture fish, 0.46 million (4.61 lakh) tons of culture fish and 0.54 million (5.46 lakh) tons of marine fish during the FY 2010-11 (Yearbook of Fisheries Statistics of Bangladesh 2019-20).

The enriched and diversified fisheries resources of the country are broadly divided into two groups Inland and Marine fisheries. Inland fisheries are again divided into two sub-groups as inland capture and inland culture fisheries. Inland culture includes mainly pond/ditch, baor, shrimp/prawn farm, seasonal cultured water-body, etc. covering an area of about 7.89 lakh ha and producing more than 55 percent of the total fish production. This output is contributed mainly due to the adoption of improved farming practices. Inland aquaculture of indigenous and exotic carp species, tilapia, pangas and Thai/Vietnam koi expanded massively. Besides, new interest grew in farming of indigenous species like koi, singh, magur, pabda, gulsha, mola etc. because they are getting scarce on open water areas but have high market demand and better contribution to household level nutrition supply. The catfish *Ompok pabda* locally called "Madhu pabda" is an indigenous, fresh water small fish. The Pabda fish (*Ompok pabda*) is a commercial species with high market value in Bangladesh that is largely produced in Mymensingh district. The total production of Pabda fish is only 144 metric ton from different water bodies of Bangladesh (Fisheries Resources Survey System, FRSS 2008). This is a delicious fish which contains 19.2 gm protein, 4.6 gm carbohydrate, 2.1 gm fat, 1.1 gm minerals, 310 mg calcium, 73 gm moisture and 114 kcal food energy per 100 gm fish (Institute of Nutrition and Food Science, INFS 1977).

1.2. The economic contribution of fish in Bangladesh

Fish, being the second most produced and valuable food in Bangladesh, play a crucial role in the livelihoods and employment of millions of people. The culture and consumption of fish therefore has important implications for national income and food security. Bangladeshi people are popularly referred to as "Mache Bhate Bangali" or "Fish and Rice makes a Bengali". Bangladesh earns a considerable amount of foreign currencies by exporting fish, shrimps and other fishery products that contributes 24% of the of the total national export earnings (EPB 2021).

Table1.1: Share of Agriculture to GDP of Bangladesh

Years	Contribution of different sub sector of agriculture to GDP of Bangladesh				
	Agriculture (%)	Crops (%)	Forestry (%)	Livestock (%)	Fisheries (%)
2007-08	19.01	11.52	1.43	2.30	3.76
2009-10	18.59	11.22	1.34	2.42	3.61
2011-12	17.38	10.01	1.78	1.90	3.68
2013-14	16.5	9.28	1.74	1.78	3.69
2015-16	16.01	8.78	1.72	1.73	3.69
2017-18	15.35	8.35	1.69	1.66	3.65
2018-19	14.23	7.51	1.62	1.53	3.56
2019-20	13.65	7.06	1.62	1.47	3.49
2020-21	13.35	6.76	1.64	1.43	3.52

Source: BBC (2016, 2017, 2021), BER (2019)

In 2020-2021 the country earns BDT 4088.96 crore by exporting almost 76.59 thousand MT of fish and fishery products despite the financial crisis in the Corona situation around the world which exceeds the 2019-2021 national export earnings when the country earned BDT 398515.00 lakh by exporting almost 70.95 thousand MT of fish and fishery products. Over the last three decades the total production of Bangladesh has been increase six times more- 7.54 lakh MT in 1983-1984 to 46.21 lakh MT in 2020-2021.

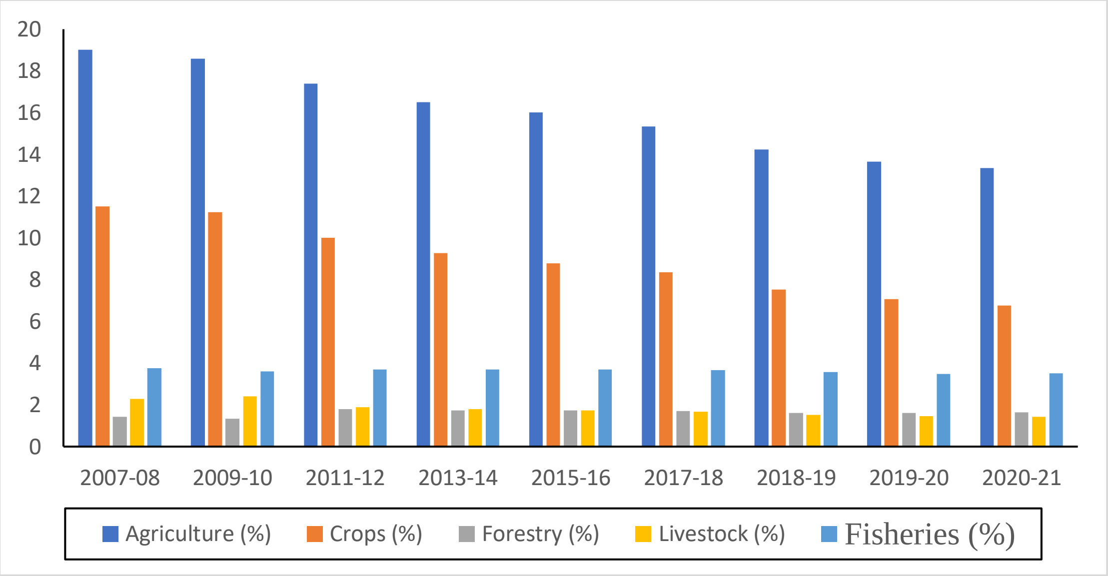

Figure 1.1: Percentage share to agricultural GDP (Source- BBS,2021)

Fish farming contributes significantly to the economy, creating employment opportunities in rural and urban areas, serving as a viable source of protein nutrients in Bangladesh households and improving national food security. In 2009, fish accounted for 16.6 percent of the world population's intake of animal protein and 6.5 percent of all proteins consumed (FAO, 2012).

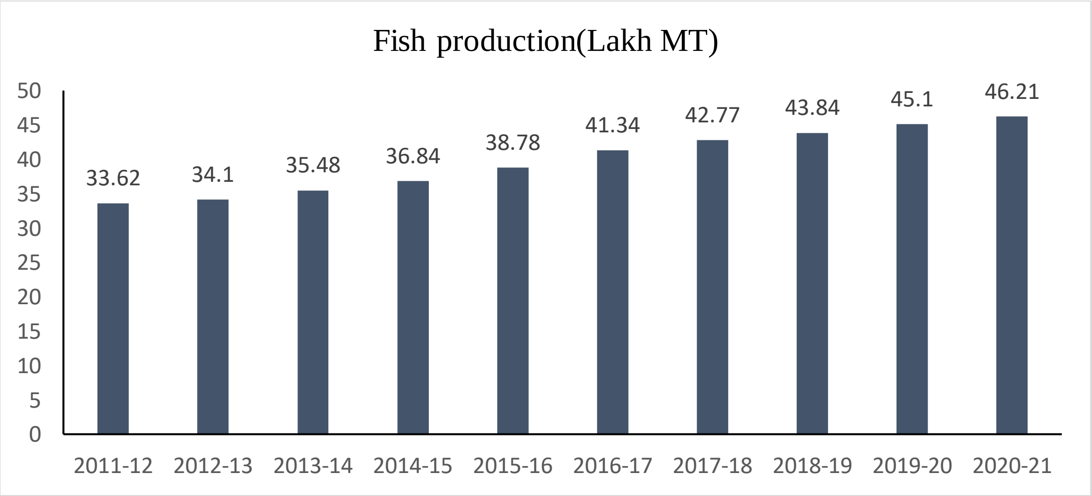

Figure 1.2: 10 years fish production in Bangladesh (Source: Yearbook of fisheries statistics of Bangladesh, 2020-21)

Fish culture is an efficient means of animal protein production. It provides nutrition for over one billion people, including at least 50 percent of animal protein for about 400 million people from the poorest countries (The World Bank Group, 2011). Globally, fish provides about 3.0 billion people with almost 20 percent of their intake of animal protein, and 4.3 billion people with about 15 percent of such protein (FAO, 2012). Increasing demand for fish products has resulted in the growth of fish farms to meet a substantial part of the world's food requirement (Olasunkanmi, 2012).

1.3. Women's involvement in fisheries sector

Fisheries sector most productive and dynamic of high potential to contribute for the economic development of the country where women are directly involved (DoF, 2012). Fisheries is the second-sub sector of agriculture in Bangladesh. Fishing has become a way of life and the primary occupation of the coastal dwellers, men and women that depend on it for their livelihood and subsistence. Fisheries have a greater promising and maintaining a steady rise in contribution of GDP. One fundamental contribution of fish to food security and nutrition derives from its "cash crop" function for fish-dependent communities (Béné et. al 2009). It is estimated that between 660 and 820 million people like workers and their families depend totally or partly on fisheries, aquaculture and related industries as a source of income and support (Allison et al, 2013). About half (49.96%) of the population in Bangladesh are female (BBS, 2011) and maximum of them live in the rural areas. Rural women are absolutely contributing to seasonal fish drying, processing and many other assorted types of work associated with fisheries. However, one of the major problems is the socio-cultural taboos against women who strive to earn their livelihood in rural areas and these give rise to gender bias in fish culture activities. Women play a critical role in every link of the value chain in small-scale fisheries; their best-known roles are in processing and marketing of fish and other fishery products. Pond fisheries activities of women contribute to the family income considerably; ensure constant supply of much needed family nutrition; generate an opportunity for self-employment; uplift their overall socio-economic condition; and contribute to become more skilled. Pond fish culture will be helpful to explore the socioeconomic status of women particularly rural women, their level of income and participation in farm activities, their problems and potentials and their contributions to agricultural and household decisions. So, the information of different activities of women, their decision-making capacity and problems faced by them in fish culture is essential for policy makers as well as to fisheries development.

1.4. Objectives of the study:

The general objective of this study is to determine the profitability and women empowerment of Pabda fish farms of Mymensingh district in Bangladesh. The specific objectives are:

i. To investigate the profitability of Pabda fish and identify the major problems of Pabda fish production.
ii. To investigate the technical efficiency of Pabda fish production.
iii. To examine the women decision making in fish production.

1.5. Justification of the study

Recent knowledge shows that the world's natural stocks of fish and shell fish, though renewable, have finite production limits, which cannot be exceeded even under the best management regimes. For most of our lakes, rivers and oceans, the maximum sustainable fishing limit has been exceeded. Therefore, fish production will depend on aquaculture to bridge the gap of fish supply (Oladejo, A.J. 2010). The average growth rate has been 8.9% per year since 1970, compared to only 1.2% for capture fisheries and 2.8% for terrestrially meat production over the same period (Brink, 2001). It also has the potential of contributing more to the gross domestic product (GDP) of the country. In 2017, global per capita consumption of fish was estimated at 20.3 kg, with fish accounting for about 17.3 percent of the global population's intake of animal proteins and 6.8 percent of all proteins consumed. Globally, fish provides about 3.3 billion people with almost 20 percent of their average per capita intake of animal protein, and 5.6 billion people with 10 percent of such protein. Preliminary estimates for 2019 indicate a further growth in per capita consumption to about 20.5 kg, with the share of aquaculture production in total available food fish supply overtaking that of capture fisheries. There haven't been many studies conducted in this arena that shows the technical efficiency and women involvement in Pabda fish production. This study examines the profitability of Pabda fish Production as well as identifies the major problems of pabda fish production. It also explores women decision making in different fish production activities. The results of this study are expected to give direction for policy makers in designing appropriate public policies to increase the fisheries productivity. In the past, this fish was abundantly available in open waters but due to over-exploitation and various ecological changes in its natural habitat it is now in the verge of extinction. During the recent past decades, hatchery and nursery developed very rapidly which helped commercializing of this fish. The development of artificial breeding technique and larval rearing methods are important tools to develop pond culture techniques of this species. Very few researches were done by Pabda fish and it is necessary to investigate the profitability of this fish in the selected area.

The results of this study are expected to give direction for policy makers in designing appropriate public policies to increase fisheries productivity. It will provide a useful guide to international and local donor agencies interested in fish production and resource management studies.

CHAPTER 2
REVIEW OF LITERATURE

2.1. Introduction

Review of literature is an essential part of any research as it provides a scope for reviewing the stock of knowledge and information relevant to the proposed research. The purpose of this chapter is to review the previous research works which are related to present study. There are a lot of socio-economic studies of fisheries sector, because growth of fisheries sector increased day by day in Bangladesh. Different evaluation committees and research organizations in this country encourage all to do research work in this sector. Despite the fact that many studies have been done on pond fish culture. It was found that a few limited numbers of works conducted in Bangladesh which was particularly related to this research. However, in this chapter only the most common and relevant studies which have been conducted in the recent past are reviewed.

2.2. Theoretical review of literature

Arifa (2021), conducted a study on the 'Economic feasibility of Pabda and stinging catfish culture in recirculating aquaculture systems (RAS) in Bangladesh'. In this study an experiment was conducted to see the economic feasibility in the recirculating Pabda and Shing productions, the payback periods were 15 years and 4 months and 6 years and 2 months, respectively. The NPV value was positive for Shing production and negative for Pabda. On the other hand, the PI was lower than one for Pabda production and higher than one for Shing production. Therefore, the results showed that the Shing production in the RAS facility could be economically feasible; however, Pabda production may not be viable in RAS due to lower production and longer culture period. This study may suggest that by increasing the production capacity of the farm and market price of the product through the proper supply chain and by decreasing the initial investment, cost of fingerlings and feed, profitability can be achieved in RAS in Bangladesh.

Nova (2019), in this study on the 'Evaluation of technical efficiency of Pabda (Ompok-Pabda) catfish production in Pabna district, Bangladesh: Stochastic Frontier Approach.' This study evaluated the technical efficiency of pabda fish production which resulted in 85% of mean technical efficiency level. The results of the determinants of technical inefficiency indicate that farmers socio-economic variables should be considered as significant factors influencing in Pabda fish production.

Hossain at el., (2019) studied on ‘Aquaculture practice and production performance of Pabda Ompok pabda (Hamilton, 1822) in Northern region of Bangladesh’ and it was found that all the farmers (100%) in the selected areas usually practiced polyculture system. Results showed that farmers cultured 13 fish species under five polyculture systems namely (i) Carp polyculture; (ii) Carp with pabda and gulsha (iii) Carp with pabda and tilapia; (iv) Carp and pabda, and (v) Carp with pangas and tilapia in the study area. Current study reveals that Pabda with carp and gulsha polyculture gives the highest profit in this area. In particular, market price is very significant factor in commercial aquaculture. Pabda fetches a relatively higher market price than other species available in the market in this region. Considering its higher market price and consumer demand, pabda polyculture can elevate the overall farm profit.

Kohinoor et al., (2011), studied on ‘Production performance of pabda (Ompok pabda) and gulsha (Mystus cavasius) with GIFT strain (Oreochromis niloticus) in on-farm management system’ and observed in three stocking densities of pabda and gulsha were tested keeping the GIFT strain constant stocking density. Each stocking density of pabda and gulsha was considered as treatment (T) with three replications. Fingerlings of pabda and gulsha were stocked at the rate of 25,000 and 50,000; 37,500 and 62,500 and 50,000 and 75,000/ha in T1, T2 and T3, respectively. The percentage of survival of gulsha and pabda were found to vary with the stocking densities. The highest survival was obtained in T1 where the stocking density of pabda and gulsha were 25,000 and 50,000/ha, respectively. The survival rate showed significant ($p<0.05$) differences among the treatments. Survival was found to be negatively influenced by stocking densities. The aquaculture of endangered small fish like pabda (O. pabda) and gulsha (M. cavasius) with GIFT strain would add social benefit. The fish farmer would get opportunity to sell the high valued pabda and gulsha at a higher price in the market. They would get an opportunity to consume the relatively available low valued fish GIFT rather sell if there were enough opportunities. It was found that polyculture of pabda, gulsha and GIFT is feasible.

Sarker et al. (2022) in the studied ‘Cost-benefit ratio analysis of freshwater aquaculture in selected area of Southern Bangladesh’ to determine the financial health of the fish farms. The purpose of this study was to estimate the financial viability of fish pond farming and to ascertain its advantages and disadvantages. From the Taltoli Upazila in the Barguna area, sixty pond fish breeders were randomly selected. These figures allowed them to calculate the gross cost of producing pond fish per hectare to be 1378806 BDT, the gross return to be 2125023 BDT, and the net return to be 746217 BDT. The findings of this study proved that pond fish farming was a profitable endeavor in the region that was being studied. The Cobb-Douglas production function was further employed in order to better comprehend the part that each variable in the production of pond fish plays. The majority of the taken into account factors were demonstrated to have a considerable impact on fish productivity.

Haque. et al., (2003) conducted a research entitled to determine the costs, returns and relative profitability of pond fish and nursery fish production. In order to attain this objective, a total of 70 producers: 35 producing pond fish and 35 producing nursery fish were selected on the basis of purposive random sampling technique from 6 villages under two Upazilas (Sujanagar and Santhia) of Pabna district. It was estimated that per hectare per year gross cost of pond fish production was Tk 65,918 while gross return and net return were Tk. 91,707 and Tk. 25,789 respectively. Per hectare per year gross cost of nursery fish production was Tk. 87,489 while gross return and net return were Tk. 1,39,272 and Tk. 51,783 respectively. The findings revealed that nursery fish production was more profitable than pond fish production. Cobb-Douglas production function was applied to realize the specific effect of the factors on pond fish and nursery fish production.

Choudhury et al. (2017) conducted a study on ‘Women's empowerment in aquaculture: Two case studies from Bangladesh’. The fisheries sector, including aquaculture, provides employment to 17.8 million people, out of which women constitute 1.4 million. The shrimp industry alone employs over one million people in its processing factories, out of which 88.64 percent are women. While women play a significant role in aquaculture production in Bangladesh, their contributions remain under-reported. While there is some empirical information regarding women's roles in and outcomes from aquaculture in Bangladesh, much of it is project-based (regarding homestead aquaculture) or worker's rights-based (regarding shrimp factory employment). More fundamentally, there is a dearth of information regarding women's empowerment in relation to aquaculture, and the associated enabling and constraining factors. This study addresses this gap by exploring women's empowerment in aquaculture in Bangladesh, including positive outcomes and limitations.

Ahmed et al. (2012) conducted a study on ‘Participation of Women in Aquaculture in Three Coastal Districts of Bangladesh: Approaches Toward Sustainable Livelihood.’ The study focused on the women’s participation in Danish International Development Assistance (DANIDA) assisted small scale aquaculture projects in three coastal Districts of Bangladesh. The findings reveal that in most projects women’s role is significant. Women have more knowledge in terms of the management of the production for example, scheduling, harvesting, feeding frequency, removal of unused feeds, etc. Women also have been found directly involved in preparation of cage and maintenance, identification of male and female prawn, procuring of good quality seed and stocking of fish. Women in some programs are also found to be selling fish on their own. Most of the women sell by the farm-gate, local bazaar and to the middlemen. The most important positive aspect of change is that now women participants’ family income has increased which is mostly used for food, health and education. Women’s participation in project, according to the findings, ensures certain extent of social and economic empowerment in the rural societies.

Pushpalatha et al., (2020) conducted a study on ‘Production trends and technical efficiencies of culture-based fisheries in five tropical irrigation reservoirs: A case study from Sri Lanka’. In this study production trends of five irrigation reservoirs of Sri Lanka before and after the introduction of CBF were investigated and apparently optimal CBF yields were not realized. Hence, the stochastic frontier production function (SFPF) was employed to quantify technical efficiencies (TE) of CBF.

Shil et al. (2021) conducted a study on the ‘Determinants of adoption behavior of the fish farmers of Pabda fish culture in Tripura, Northeast India.’ This study aims at assessing the extent of adoption of the scientific culture practices of Pabda fish in different phases (pre-stocking, stocking, and post-stocking) of culture and identifying the factors influencing the adoption behavior. The study was conducted in ex-post-facto research design in Tripura, a northeastern state in India with 100 sample respondents, determined by Cochran’s formula. The adoption behaviour was quantified with scores assigned 2 and 1 for full and partial adoption respectively, while 0 for discontinuance or rejection. An exploratory factor analysis model was administered to identify the factors. The study unfolds that experienced farmers (48%) had higher adoption levels, and young farmers (12%) were lesser involved.

Quddus et al., (2016) conducted a study on Gender role in pond fish culture in terms of decision making and nutrition security. In that study it is observed that among the women who participated in fish farming about 40 percent of the farm women were educated at SSC level and above and 67% women had farming experiences more than 5 years. Average participation of women was 2.83 hours per week and 24 percent of which for feeding the fishes. About 60 percent of the rural farm women regularly fed the fishes and 23.3% of them regularly processed the fish. Only 55 percent women had attitudes to use of scientific methods of fish culture, 76.7 percent to fish processing regularly and 51.7 percent had decision making capacity with their husbands for fish production activities. But in the study area 47 percent respondents had lack of technical knowledge, 53 percent had inefficient knowledge and facilities of disease control and 70 percent women did not get extension services and rural women were not interested to contact with extension worker. Women's growing participation in aquaculture has been a significant indicator of increased empowerment at the household level as well as society. With increased participation in aquaculture, women's socioeconomic conditions within the households and communities have risen significantly. This has begun to change giving women increased decision-making power on household management and income generation activities.

Brugere (2017). Profile: Women in Aquaculture, in his study reviewed that Gender research, carried out in multidisciplinary programs, could shed light on the most critical gender inequality issues, especially on what makes women lose (or retain) control over their activities as the scale, intensity and economics of aquaculture production grows. A fine-grain analysis of the dynamics of the relationship between aquaculture intensification and women's empowerment is becoming urgent – or women will become the losers of the aquaculture boom.

Koralagama et al., (2017) studied 'Inclusive development from a gender perspective in small scale fisheries' in which it was stated that the absence of a gender-aware perspective in fisheries research is often justified from the premise that fisheries are a male-dominated sector. Although millions of women are engaged in small-scale fisheries their work has been systematically discounted and devalued. This paper reviews the gender literature on small-scale fisheries to elaborate on the gender discrimination on; labor division, accessibility, and power relations, which hinder the sustainability and development process in marginalized communities.

Torre et al., (2019) conducted a study on the 'Women's empowerment, collective actions, and sustainable fisheries: lessons from Mexico'. In the study it was documented how women's roles are changing when collective actions are implemented to increase fisheries sustainability. Women as cooperative leaders, collaborative decision-makers, and entrepreneurs have become active promoters of good practices, including (1) fishery and ecosystem restoration, (2) environmental monitoring, and (3) marine conservation. Through these actions, women are also empowered in different ways. They have acquired resources (e.g., knowledge, opportunities) and decision-making power, facilitating project developments (e.g., research, cooperatives) that promote fisheries sustainability.

2.3. Literature Gap

This review of the existing literature has outlined some gaps or weaknesses. The specific gaps were outlined in the chapter. The general gaps are summarized below-

- To learn about the productivity growth, it is important to know the benefit cost ratio and technical efficiency. Most of the earlier studies perform on only economic or production efficiencies.
- Earlier studies capture either Technical efficiency of Pabda Production. Moreover, most of these early studies have focused merely on the likely others catfish production.
- Previous studies using time series data have not focused on Pabda. Moreover, the results from those studies were not robust because of insufficient statistical and diagnostic tests.
- In the case of Bangladesh, there are no empirical studies on pabda production efficiency.
- In case of Mymensingh district, no research work has been conducted on the present issues.

2.4. Concluding remarks

The above review and discussion indicate that a limited number of studies on Pabda fish farming were conducted. The result of these studies varies widely in different reasons. The review of literature was helpful to re-design methodological aspects with a view to overcome the limitations of previous studies. From the above studies the researcher felt the need of conducting and analyzing the productivity of Pabda fish farming in Bangladesh within the current development context, which will help the policy makers to understand the current situation. On the other hand, researcher believed that the findings of this study would provide useful updated information, which would help the policy makers and researcher for further investigations.

CHAPTER 3
METHODOLOGY

3.1. Introduction

Research methodology is a way to study the various steps that are generally adopted by a research in studying the research problems systematically along with the logic, assumption and rational behind them. Farm management research depends on the proper methodology of the study. Proper methodology is a prerequisite of a good research. This chapter highlights the research methodology, which is followed throughout the research study, and the descriptive of data that are collected from primary sources for the purpose of analysis. A combination of analytical tools was employed in this study. It is designed in a way so that it correspondent to achieve the objectives of the study. Use of improper methodology very often leads to erratic results.

3.2. Selection of the study area

Selection of the study area is an important task for researcher of the thesis work. Mymensingh district is well known for the fish production in Bangladesh. Keeping in view the main objectives the study was conducted in two villages namely, Koltapara and Ramgopalpur village of Gouripur upazila under Mymensingh district.

3.3. Sources of data

Primary data regarding research work was collected by face-to-face interview. Before preparing the final survey schedule, a draft survey schedule was prepared in accordance with the objectives of the study. Then the draft was pre-tested to verify the relevance of the questions and the nature of responses of the sample of the producers. Two types of questionnaire were used. One questionnaire was for the fish farmer and another one for the fish farmer’s wife to determine their role in the farming. Fish production, culture areas, number of fish farmers involved and other related information were collected from various organizations. These data were also verified with data from other sources. Literature reviews were also performed with several reports published by BFRI and the World Fish Centre.

3.4. Selection of sampling technique and sample size

The collection of necessary information for a research study from each and every elements of population become costly and time consuming. So, the selection of sample size was one of the crucial aspects for the study. A reasonable size of sample to achieve the objectives of the study was considered. A sample of representative farms is therefore chosen in such a way that the information meets the purpose of the study. Farmers were selected by simple random sampling technique from the study areas. A full list of farmers was collected from Upazila agriculture office and a sample size of 100 fish farmers was selected.

3.5. Period of data collection

Data were collected by the researcher herself through personal interviews with the respondents. Data were collected during the period from June to July 2021. Prior to final data collection the interview schedule was pre-tested by collecting information from selected samples.

3.6. Data collection

As the Pabda fish farmers do not keep any record of their activities they rely on their memory and at first, they hesitated to share the information of their activities. However, all possible efforts were made to ensure the collection of reasonably accurate data from the field. Data were collected from the sample producer by direct interview with a set of interview schedules designed for this study. During the interview, each respondent was given a brief introduction about the nature and purpose of the study. Sample questions and required data tables were printed out initially and taken interview in a systematic manner, few new records were also added during interview time which was initially unknown to researcher therefore not available in sample question paper. After completion of each interview schedule were checked and verified to be sure that answer to each question was properly recorded. If any data appeared to be inconsistent then farmers were again interviewed for relevant answers. In order to minimize errors, data were collected in local units then converted into a standard unit.

3.7. Data analysis

After collection of primary data, the filled schedules were edited for analysis. These data were verified to eliminate possible errors and inconsistencies. All the collected data were summarized and scrutinized carefully. For data entry and data analysis, the Microsoft Excel programs, and SPSS programs were used. Initially information was collected by local units and after checking the collected data, these were converted into standard units. Finally, to meet the objectives of the study, a few relevant tables were prepared according to necessity of analysis.

3.8. Analytical techniques

Data were analyzed with the purpose of fulfilling the objectives of the study. Both descriptive and statistical analysis was used for analyzing the data.

3.8.1. Descriptive analysis

Tabular technique of analysis was generally used to find out the socio-demographic profile of the respondent, to determine the cost, returns and profitability of Pabda farm enterprises. It is simple in calculation, widely used and easy to understand. It was used to get the simple measures like sum, average, count, percentage etc.

3.8.2. Statistical technique

In this study, the production function technique was applied as a supplement to the tabular technique. It is expected to be a compromise among (i) adequate fit of the data, (ii) computational feasibility and (iii) sufficient degrees of freedom unused to allow for statistical testing with the help of samples. One of the most widely used production function for empirical estimation is the Cobb Douglas production.

Moreover, the special advantage of using Cobb- Douglas production function was that the regression under Ordinary Least Squares (OLS) in logarithm, yields coefficients which stand for production elasticities and if all the inputs related to the production are taken into account as the independent variables, the sum of the production elasticities demonstrates whether the production process as a whole yield increasing, decreasing or constant returns to scale.

3.8.2.1 Profitability analysis

Eight variables such as cost of human labor, fingerling cost, fertilizer, lime and feed cost, electricity and water pumping cost, input transportation and land rental in Pabda fish farming were considered for Profitability analysis as well as Cobb-Douglas production function. Profit function of the following algebraic form was used in this study-

$$\text{Profit } (\pi) = \sum_{i=0}^{n} (\text{Pyi.Yi}) - \sum_{i=0}^{n} (\text{Pxi.Xi}) - \text{TFC}$$

Where, π = Net Return,

Py_i= Price per unit of the i^{th} produce, Y_i= Quantity of the i^{th} produce, Px_i= Price per unit of the i^{th} inputs,

X_i = Quantity of the i^{th} inputs, TFC= Total Fixed Cost.

3.8.2.2: Specification of the Cobb-Douglas production function

For determining the effect of variable inputs to the production of Pabda fish, Cobb-Douglas production function chosen based on best fit and significance result on output. In this model, yield per hectare was considered as the dependent variable.

The functional form of the multiple regression equation is as follows:

Y=a$X_1b_1X_2b_2X_3b_3X_4b_4X_5b_5Xb_6X_7b_7X_8b_8X_9b_9X_{10}b_{10}X_{11}b_{11}ui$

For the purpose of the present empirical exercise, the Cobb-Douglas production function was converted into the following logarithmic (Double log) form:

$lnY=lna+b_1lnX_1+b_2lnX_2+b_{3l}nX_3+b_{4l}nX_4+b_5lnX_5+b_6lnX_6+b_7lnX_7+b_8lnX_8+b_9lnX_9+$
$b_{10}lnX_{10}+ b_{11}lnX_{11}+Ui$

Where,

Y = Gross Production (kg/ha)

X_1= fertilizer used (kg/ha); X_2= Feed used (kg/ha); X_3= Lime used (kg/ha);

X_4= Salt used (kg/ha); X_5= Electricity cost (Tk./ha); X_6= Water pumping cost (Tk./ha); X_7=Inputs transportation cost (Tk./ha); X_8=Hired labor used (number/ha); X_9 = Family labor used (number/ha); X_{10} = Fish harvesting cost (Tk./ha); X_{11}= Land rent cost (Tk./ha).

Ina = Constant or intercept of the function

Coefficient of respective variables= b_l, b_2, b_3, b_4, b_5, b_6, b_7, b_8, b_9, b_{10}, b_{11} i = 1, 2, 3...n.

ln = Natural logarithm; and U_i= Error term.

3.9. Specification of variables

3.9.1. Cost of fingerlings

In the study area, it was observed that Pabda fish producers purchased the fingerlings for further use. The costs of fingerlings were calculated at the actual market prices paid by the farmers in the locality.

3.9.2. Cost of human labor

Human labor is one of most of the important inputs in pond fish farming. From stocking to harvesting of fish, human labor is required in different operations and management, liming, fingerlings collection, application of feed, providing fertilizers, security netting, harvesting, and selling. Both family and hired labor were used in the fish fanning. In working out the cost of labor wages of labors were considered.

3.9.3. Cost of feed

Supplementary feed is the most important factor which means of increasing the growth and survival of pond fishes. Its doses vary according to intensity of culture. In the study area, it was observed that the producers used different types of supplementary feeds which are maximum ready-mix feed. Small group of farmers used homes supplied food which ware normally purchased and processed. There was no fixed rate for buying these feed items in the study area. However, major cost was incurred by feed cost of this fish culture.

3.9.4. Cost of fertilizers

Most of the Pabda fish farmers used fertilizers like TSP, salt, Lime etc. Cost of these Fertilizers were estimated at the prevailing marketing price in the study area. Uses of manure are strictly prohibited in Pabda fish production. If fish pond is attacked by any diseases, then different medicine is used by taking help from fisheries officers. Cost of these medicines are estimated at given market prices.

3.9.5 Interest on operating capital

Interest on operating capital was determined based on opportunity cost principle. The operating capital represented the average operating cost over the period because all costs were not incurred at the beginning or at any single point of time. Interest on operating capital was charged for 6 months at the rate of 6 percent per annum. It was assumed that if farmers would deposit money in the bank, they would have received interest at that rate. Interest on operating capital (OC) was calculated by using the following formula:

Interest on operating capital = Al × i × t Where,

$$Al = \frac{\text{total investment}}{2}$$

i = interest rate which was assumed at 6 percent; and t = length of the period of fish production (6 month).

3.9.6. Land use costs

In the study area the leased cost of pond was different to plots depending on location, topography and fertility of the pond. In this study, the cost of pond use was considered as cash rental value of land. If the pond fish producers have rented out their ponds for one year, they could have got money for it, which they would have received was considered as rental value of the pond.

3.10 Calculation of returns

3.10.1 Gross return

Gross return is the monetary value of fish production which was calculated by multiplying the total quantity of production by their respective market prices. In this study, gross return was calculated by summing up all the returns earned. Per hectare gross return was calculated by multiplying the total amount of products price.

3.10.2 Gross margin

Gross margin is defined as the difference between gross return and variable costs. Generally, farmers want maximum return over variable cost of production. The argument for using the gross margin analysis is that the farmers are interested to get returns over variable cost. Per hectare gross margin was obtained by subtracting variable costs from gross return. That is, Gross margin = Gross return – Variable cost.

3.10.3 Net return

Net return was calculated by deducting the total production cost from the total return or gross return. That is, Net return = Total return – Total production cost

3.10.4 BCR (Benefit cost ratio)

The undiscounted benefit cost ratio (BCR) is a relative measure which is used to compare benefits per unit of cost.

BCR was calculated by using the following formula-

$$\text{BCR} = \frac{Gross\ return}{Total\ cost}$$

$$\text{BCR on Cash Cost} = \frac{Gross\ return}{Total\ variable\ cost}$$

3.11. Calculating Technical efficiency

3.11.1 Defining Efficiency

The concept 'efficiency' implies the success with which a farm best utilizes its available resources to produce maximum levels of potential outputs. A farm is efficient if and only if it is not possible to increase output (decrease inputs) without decreasing output (cooper et al., 1995). Failure to obtain this potential maximum output results in inefficiency. The neoclassical theory of production defines the production function based on the notion of efficiency that gives the maximum possible output for given amounts of input. It is not realistic to recognize this 'maximum output' simply by observing the actual amount of output unless the observed output is assumed to be a maximum: different farm produce different output among farmers can be explained through difference in efficiency.

The production process of a farm may reflect technical inefficiency, allocative inefficiency or both. A farm is technically efficient if it produced a maximum output, given the amount of inputs and technology. Thus, the production frontier is associated with the maximum obtainable level of output, given a level of inputs, or the minimum level of inputs required to produce a given output. In other words, it is the locus of maximum attainable output for each input mix. Technical inefficiency is attributed to a failure of the farm to produce the frontier level of output, given the quantities of input.

Allocative inefficiency arises if farms fail in allocating inputs which minimize the cost of production a given output, given relative input prices. This results from not allocating inputs in the most efficient manner, i.e., there exists resources misallocation or allocative inefficiency. Failure in allocating resources optimally results in increase cost and decreased profit. In particular, a farmer is said to be allocative inefficiency if the marginal rate of technical substitution between any two inputs is not equal to the corresponding minimizing inputs mixes. This can be attributed to sluggish adjustment to price changes and regulatory constraints. Thus, allocative efficiency is defined as the ability of farmer to adjust inputs and outputs to reflect relative prices, given the production technology. The distinction between technical and allocative efficiency provides four ways for explaining the relative performance of farms.

First, a farm might show both technical and allocative inefficiency; Second, it may be technically efficient but allocative inefficient; Third, it may display allocative efficiency but technical inefficiency; and Fourth, it may be both technically and allocative efficient. Economic efficiency combines technical and allocative efficiency that reflects the ability of a farm to produce output at minimum cost. Thus, either one of the efficiencies may be necessary but not sufficient conditions to ensure economic efficiency for a farm. The simultaneous attainment of both efficiencies gives the sufficient condition to ensure economic efficiency.

Even though there is some similarity between terms production efficiency and technical efficiency however, they are not same. The simplest way to differentiate production and technical efficiency is to think of productive efficiency in terms of cost minimization by adjusting the mix of inputs, Whereas TE is output maximization form a given mix of inputs (palmer and togreson, 1999). According to Coelli (1995) in analyzing efficiency, fitting a frontier model performs better than ordinary least square (OLS) regression. The two main benefits of estimating the frontier function, rather than average (e.ge OLS) functions, are that:

1. Estimation of an average function will provide a picture on the shape of technology of an average firm, while the estimation of the frontier function will be most heavily influenced by the best performing firm and hence reflect the technology they are using.

2. The frontier function represents a best practice technology against which the efficiency of firms within the industry can be measured. It is this second use of frontier, which leads to widely application of estimating frontier function.

3.11.2 Approaches of measuring efficiency

Basically, there are two approaches in measuring efficiency: input oriented and output oriented. The output-oriented Approach deals with the question "by how much output could be expanded from a given level of input?" Alternatively, one could ask "by how much can input of quantities be proportionally reduced without changing the output quantity produced?

"This is an input-oriented measure of efficiency. However, both measures will coincide when the technology exhibits constant returns to scale, but are likely to vary otherwise (Coelli and Battese, 2005).

Input oriented measure

In his first work on efficiency, Farrell (1957) illustration his idea about measuring efficiency with figure, as follow. The SS' is an isoquant, representing technically efficient combination of inputs, X_1 and X_2, used in producing output Q. SS' is also

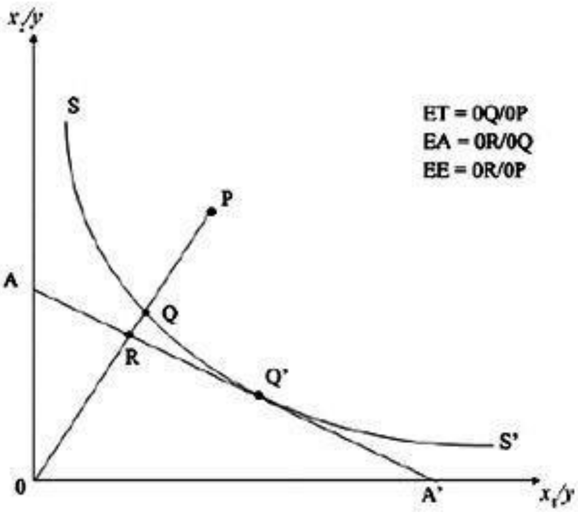

Figure 3.1: Input oriented measure of technical, Allocative and Economic efficiency (Source: Coelli, 1995)

known as the best practice production frontier. AA' is a cost line, which shows all combination of inputs X_1 and X_2 to be used in such a way that the total cost of inputs is equal at all points. However, any firm intending to maximize profits has to produce at

Q’, which is a point of tangency and representing the least cost combination of X_1 and X_2 in production of Q. At point Q’ the producer is economically efficient.

Given figure 3.1 suppose a farmer is producing his output depicted by isoquant SS’ with input combination level of (X1 and X2). If a given firm use quantities of input combination at point P to produce a unit of output, the technically inefficiency of that farm could proportionately reduce without a decline in output. In other words, the farmer can produce at any point on SS’ with fewer inputs (X1 and X2), in this case at Q in an input-output space. The degree of TE of such a farm is measured as OQ/OP, which is proportional in all inputs that could theoretically be achieved without reducing the output, hence all farmers that produce along the isoquant are 100 percent technically efficient

$TE = \frac{OQ}{OP}$ …………………………… (1)

The value of TE ranges between 0 and 1, and represent the degree of technical efficiency. If TE is equal to 1, telling the farm produce with fully technical efficiency. For example, at point Q farm could gain full technical efficiency because point Q lies in the efficient isoquant curve. If the input price ratio, represent by the slope of the iso cost line, AA’ is also known, allocative efficiency (AE) at P can be calculated and identified by the ratio:

$AE = \frac{OR}{OQ}$………………………….. (2)

The decrease in production cost with the distance from Q to R would happen if production is performed at the allocative and technically efficient point Q’ instead at the technically efficient, but allocative inefficient point Q.

The total economic efficiency (EE) is defined to be the ratio:

$EE = \frac{OR}{OP}$ ………………………. (3)

The distance from P to R also represents the cost cut in production if a farm produces at the point R with technical efficiency and allocative efficiency instead of at the point P with technical inefficiency and allocative inefficiency. Economic efficiency is to combine technically efficiency end allocative efficiency.

Output oriented measure

In the output-oriented perspective, efficiency is evaluated keeping inputs constant. According to Farrell (1995), output oriented measures can be illustrated by considering the case where Production involves two outputs (Y1 and Y2) and a single input (X). If the input quantity is held fixed at a particular level, the technology can be represented by a production possibility curve in two dimensions as follows:

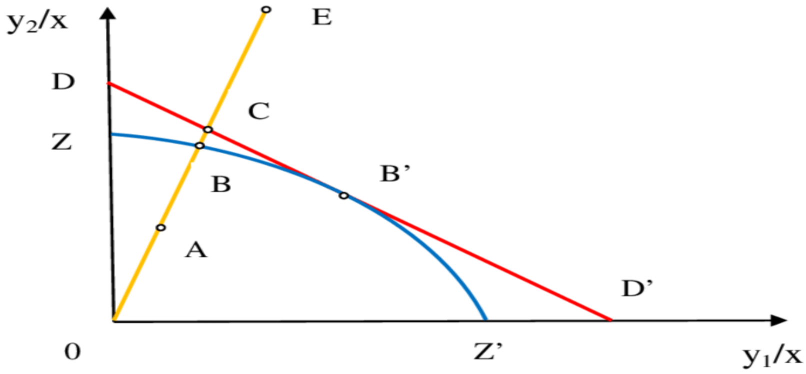

Figure 3.2: Output-oriented measurement of technical, allocative and economic efficiency (Source: Coelli, Rao, and Battese, 1998)

The production possibility curve is represented by the ZZ' in figure 3.3 which represent technically efficient combination of production of output y2/x and y1/x. Given same level of input (X), it is not efficient to produce at point A. considering a firm situated at point A, TE can be calculated as OA/OB. Alternatively, all farmers producing along the production possibility curve are 100 percent efficiency.

3.12. Method of analysis

Technical efficiency is the maximum possible output obtained from a given set of inputs. According to Farrell, M J. (1957), within a given level of inputs and technology the maximum possible output of a firm can be shown by the frontier production function. The present study uses stochastic frontier production function for measuring technical efficiency of Pabda fish farming in the study area. In order to arrive at a meaningful result, and so as to achieve the main objectives of the study, data has been analyzed in following analytical techniques.

3.12.1 Theoretical model for estimation of Technical efficiency

According to Farrell's (1957) model, Technical efficiency (TE) is defined as the ability of farm to obtain the best production from a given set of inputs (output-increasing oriented), or alternatively as the measure of the ability to use the minimum feasible amount of inputs to produce a certain level of output (input-saving oriented) (Greene, 1980; Atkinson and Cornwell, 1994). Consequently, technical inefficiency is defined as the extent to which firm fail to reach the optimal production. Farrell (1957) proposed to measure TE of a farm by comparing its observed output to the output which could be produced by a fully efficient farm, given the same bundle of inputs. Aigner et al. (1977) and Meeusen and van den Broeck (1977) independently proposed the stochastic frontier (SF) production function to an account for the presence of measurement errors and other noise in the data, which are beyond the control of managers. Farmers in general operate under uncertainty and therefore, the present study employs a stochastic production frontier approach for measuring TE. Following Battese and Coelli (1995), the following stochastic frontier production function and inefficiency effects model are estimated simultaneously using single stage with the computer program, FRONTIER 4.1. developed by Coelli (1996).

Following their specification, we specify the general SF model defined as:

Yi = f (Xi; β) + εi i= 1, 2, ……Where …. N   (4)

Where, Yi is the output value from Pabda for ith farm, Xi is the vector of k inputs (or cost of inputs), β is a vector of unknown parameter to be estimated, f is the suitable functional form for the frontier (Cobb- Douglas, trans log or quadratic), εi is an error term, and N is the total number of observations. The stochastic frontier production is also called "composite error" model, because it postulates that the error term εi is decomposed into two components: a stochastic random error component (random shocks/ white noise) and a technical inefficiency component define as follows:

$\varepsilon_i = V_i - U_i$…………………………………………… (5) Where V_i is a symmetrical two sided normally distributed random error that capture the stochastic effects outside the farmers 'control (for example, weather, natural disasters, omitted variables, luck, exogenous shocks, measurement errors, and other statistical noise). It is identically, independently and normally distributed, N (0, σ^2v) independent of the U_i. Thus, V_i, allows the production frontier to vary across farms, or over time for the same farms and therefore, the production frontier is stochastic in nature.

The term U_i (asymmetric non-negative error term) is a one-sided (U_i>0) efficiency component that capture the technical inefficiency of the ith farmer. This may follow a half-normal, exponential, truncated-normal or gamma distribution (Stevenson, 1980; Aigner et al., 1977; Meeusen and Broeck, (1977). In the study, we assumed that U_i follows the half-normal distribution symbolically N (0, σ^2u) as was done in various published studies in applied stochastic frontier literature. It is obtained by the truncation at zero of the normal distribution with mean μ, and variance (σ^2u). If μ is pre-assigned to be zero, then the distribution is half- normal. Besides, two error components (V and U) are also assumed to be independent of each other.

Other vital parameters estimated under this analysis include sigma square (σ^2s), gamma (γ) And log-likelihood ratio. σ^2s indicates the goodness of fit of the model used, and gamma gives the proportions of the deviation of the Pabda output from the production frontier caused by technical inefficiency. For example, if γ = 0, it indicates that U_i is about in the model. If γ = 1, it mean all deviations from the frontier are due to technical inefficiency. The log -likelihood ratio is used to test for the significant presence of technical inefficiency effects in farmers ‘production. The variance parameters of the model are parameterized as:

The variance parameters of the model are parameterized as:

$\sigma^2 = \sigma^2 + \sigma^2$, $\gamma = \sigma^2 \div \sigma^2$ so that $0 \leq \gamma \leq 1$.............................. (6)

Where,

σ^2 = Variance parameters of sample statistic

σ^2 = Variance of the error term due to noise

σ^2 = Variance of the error term resulting from technical inefficiency

The parameter γ must lie between 0 and 1. Here, σ^2 denotes the total variation in the dependent variable due to technical inefficiency (σ^2u) and random shocks (σ^2v) together. The gamma (γ) parameter explains the impact of inefficiency on output. The maximum likelihood estimation (MLE) of equation (1) provides consistent estimators for β, γ and σ^2 parameter. Aigner et al. (1977) expressed the likelihood function in terms of the two variance parameters,

$\sigma^2 = \sigma^2 + \sigma^2$ and $\gamma = \sigma / \sigma$. Battese and Coelli (1977) suggested that the parameter, $\gamma = \sigma^2 / \sigma^2$, be used because it has a value between 0 and 1. This property permits to obtain a suitable starting value for an iterative maximization process, Whereas the γ parameters could be any non-negative value. A value of γ closer to zero implies that much of the variation of the observed output from frontier output is due to random stochastic effects, whereas a value of γ closer to one implies proportion of the random variation in output explained by inefficiency effects or differences in technical efficiency.

The function determining the technical inefficiency effect is defined in its general form as a linear function of socio economic and management factors:

Ui = F (Zi)……………. (7)

The more detail about dependent and independent variables is given in empirical model.

According to Aigner et al, 1977, as cited be Ahmadu and Erhabor (2012), technical efficiency of the farmer is expressed below

TE $=\frac{Yi}{Yi*}$ … … … … … … … ….(8)

Where, TE_i = technical efficiency of the ith farmer

Yi = observed output of the ith farmer (tk)

Yi * =Potential output (tk)

This is technical efficiency (TE) which is defined as the ratio observed output to maximum feasible output which is called frontier output. When TE=1, it shows that a farmer obtains maximum feasible output, while if TE<1 means a shortfall of the observed output to the frontier output.

3.12.2. Model specification and estimation

The technical efficiency of Pabda farmers was estimated using the stochastic frontier production function proposed by Aigner et al. (1977) and Meeuesn and Van den Brock (1977). The general from of the stochastic frontier function is-

$\ln(Yi) = \alpha_0 + \alpha_k \sum \ln X_{ki} + \upsilon_i - \mu_i$ ……………………… (9)

Where Y_i is per m^2 Pabda yield (kg) for the i^{th} farmer X_{ki} s indicate input, variables used by the i^{th} farmer. The α◦ and αk are unknown parameters to be estimated, υ_i is usual error term which may result due to errors in the production of wheat, weather conditions, economic adversities or plain luck, or the aggregate effect of input variables not included in the production function. V is assumed to be independent and identically distributed N (0, σ^2) random variables. While, μ_i is non- negative (one-sided) error term that captures inefficiency, such as faults in management. For the inefficient farmer, the actual yield is less than (or equal to) the potential yield. Therefore, the ratio of actual and potential yield can be treated as a measure of technical efficiency. Using equation (2), technical efficiency (TE) of the i^{th} farm is derived as:

$TE_i = e\varkappa p(-\mu_i) = Y_i/Y_i^*$………………………… (10)

Where Yi* is the maximum possible yield and Yi is the actual yield obtained by i^{th} farmer. To study the effect of socioeconomic factors on inefficiency, it was observed that it is better done in a single- step rather than in two-step procedures (Wilson and Hadley, 1998; Battese and Coelli,1995). The error term associated with technical inefficiency of Pabda production of Pabda farmers is assumed to be independently distributed, such that the technical inefficiency effect for the i_{th} farmer; and is obtained by truncation (at zero) of the normal distribution with mean μ_i and variance σ^2 such that:

$\mu_i = \delta_0 + \delta_m \sum I_{mi} + \omega_i$ ……………… (11)

where I_{mi} are socioeconomic characteristics of the farmers. The δ_s are unknown parameters to be estimated, and ω_i are unobservable random variables which are assumed to be independently distributed, obtained by truncation of the normal distribution with zero mean and constant variance (σ^2) Review of literature revealed that stochastic frontier production functions of CD and trans-log specifications of stochastic frontier production model is most commonly used in analyzing technical efficiency in crop sector. The CD form has advantage over the trans-log specification, as inclusion of square and interaction terms of the input variables in the production model results into multicollinearity problem, especially when the sample size is comparatively small.

3.12.3 Efficiency model

Starting from the first empirical application of Farrell (1957) several different approaches of frontier estimation and efficiency score calculation have been developed. Efficiency measurements basically are carried out using frontier methodologies, which shift the average response function to the maximum output or to the efficient firm. Essentially there are two main methodologies for measuring TE: The econometric (parametric) approaches, and the mathematical (non- parametric) approaches. The parametric model is estimated based on econometrics model (Coelli, Rao, and Battese, 1998) and the non- parametric methods are measuring productive inefficiency are broadly speaking dependent upon classification of quantitative and qualitative variables under the well-known methodology of Date Envelopment Analysis (Burhan et al, 2009). Efficiency measure assume as production function of the daily efficient firm is known. But this is not possible in the reality; hence the efficient isoquant must be estimated from the sample data taking the relatively best performing firm as fully efficient (Coelli et al, 1998). Given parametric approaches is used in this study; I have reviewed the current literatures on parametric frontier models very briefly as follows.

Parametric frontier model can further be classified into deterministic and Stochastic Frontier Production (SFP) model. The very basic different between the two models is on their assumption about the error team. The deterministic model assumes that any deviation from the frontier is due to inefficiency, while the stochastic allows for statistical noise.

3.13. Problems Encountered in Collecting Data

The researcher faced the following problems in collecting data from the field:

- Most of the respondents initially did not feel comfortable to answer questions since they thought that the investigator might use the information against their interest. To dispel this confusion a good deal of time was spent to gain their confidence.

- The farmers did not keep records of their farming business. Therefore, the author had to depend upon their memory.
- Some of the respondents were illiterate which was another hindrance for data collection to the researcher. Sometimes respondents could not answer to questions accurately and to the point.
- The farmers usually remain busy with field work. So, the researcher had to visit some of them even at the field. The researcher sometimes also had to pay more than two visits to meet the farmer in cases they were not found either at houses or in the field nearby at first visit.

3.14. Conclusion

This chapter examines the concept of the production and Profitability analysis which is the technical relationship between output and inputs which describe the maximum output obtainable for a given set of inputs resulting in net profit margin. We discuss the concepts of efficiency. The efficiency implies the success with which a farm produces maximum output utilizing its available resources with minimum cost. In other words, a production function describes the maximum cost results in inefficiency. Efficiency consists of technical and allocative components; technical efficiency reflects the capability to produce maximum output with a given input mix utilizing the existing technologies; allocative efficiency reflects the capability to use cost-minimizing input proportions, given input prices; in other words, failure to produce with the least-cost input combination result in allocative inefficiency. The economic efficiency measure combines the two. Moreover, technical efficiency is the ratio of technical efficient cost to observed cost, economic efficiency is the ratio of frontier cost to observed cost, and allocative efficiency is the ratio of frontier cost to technically efficient cost.

CHAPTER 4
RESULT AND DISCUSSION
PROFITABILITY ANALYSIS

4.1. Introduction

To start any business or production process farmers must consider first the overall costing which was incurred to run that business. Costing played a pivotal role to market the right decision on every business. In this chapter author provided details estimation and analysis regarding costing of Pabda fish production in the study area. In this analysis two types of cost have been considered: variable costs and fixed costs whereas hired human labor, fingerling, feed cost, fertilizer, salt, lime cost, input transportation cost, marketing electricity and water pumping are considered as variable cost. On the other hand, land use cost, electric equipment cost, family labor cost, interest on operating capital cost are considered as fixed costs. On the return side, Gross Return, Net Return, Gross Margin and Benefit-cost ratio are estimated. In this study, a brief account is showing how the individual costs and return are illustrated below.

4.2. Variable costs

4.2.1 Cost of fingerlings

Fingerlings cost was considered one of the most essential costs in Pabda fish production. Cost of fingerlings depends on the size, market demand and availability of fingerlings. There was a variation in the per unit price of fingerling from location to location and time to time. In the study area, it was observed that major Pabda fish farmers normally purchase fingerlings from different hatchery. Therefore, Stocking density terms should be considered which was per-unit stocking amount or stocking rate, refers to the quantity of fry or fingerlings per unit of water area. In this study area per hectare Pabda quantity was almost 19.54 kg fingerlings where average per kg fingerlings price was Tk.475 costing an average of Tk. 9271.74 per hectre.

4.2.2 Human labor cost

Human labor was required for most of the operations during Pabda fish production which was one of the most important variables in production process. Human labor has been measured in man-day where man-day is equal to 8 hours. Farmers actually paid to the hired labor for working a man-day. The labor of women and children was converted into man-equivalent day by presenting a ratio of 2 children day = 1.5 women days = 1-man equivalent day (Miah, 1987). Human labor can be classified as family supplied, hired and operator himself for different operations. Pabda fish production comprises various form of activities like pond preparation (reconstruction of pond, fertilizer application, liming, grading, chemical application, raising dyke, stocking of fingerlings etc.- average Tk. 500/man day was estimated (intercultural operation, feed application, security netting and harvesting.

Table 4.1: Per hectare variable cost of inputs (Tk.)

Input wise cost (Tk./ha)	Per unit cost	Input use (Kg)	Total value
Fingerlings cost	474.31	19.5	9271.74
Feed cost	82.11	11955.15	981637.01
Hired labor cost (per man day)	500	88.9	44446.50
Fertilizer cost (TSP)	452.68	60.6	27433.49
Salt cost	32.373	0.15	4950.94
Lime cost	19.85	427.2	8479.53
Electricity cost			7894.00
Water pumping cost			9481.19
Input transportation cost			13969.55
fish harvesting cost			44201.39
fish marketing cost			2832.20
Total variable cost			46058.88

Source: Farmer's household survey, 2021

Here in Pabda fish production family labor and hired labor has been required whereas hired labor was considered variable cost. For avoiding complexity, average rate has been considered. Use of human labor and its relevant cost incurred were shown in Table 4.1. Hired labor cost was Tk. 44446.50/ha.

4.2.3. Feed cost

Supplementary feeding is one of the main practices of fish culture. The purpose of supplementary feeding is to provide the nutrients and maintain well growth of the fish during production process. To get a good production farmer has to maintain the healthy environment since diseases can easily hamper the Pabda fish and almost all the fish in a pond can die within one or two days. Therefore, quality feed plays a vital role in Pabda fish production. In the study area, to get an optimum production rate almost all the farmers use ready mix feed from market instead of normal process fish food. The quantity of supplementary feeding differs from size, weight and quantity of the fingerlings. In this study, cost of feeds was estimated at the available market price. Average per kg feed cost was Tk. 82.11. Considering that feed cost per hectare average costs of feed were calculated as Tk. 981637.01 per hectare (Table 4.1).

4.2.4. Cost of fertilizer

Fertilizer is generally used in the fishpond to create a better environment which facilitates to increase fish production. The estimation of nutrient requirement for a pond fertilization program depends on the pond morphology, environment, soil and water quality, types of fish cultured and on the types of fertilizer employed. Fertilizer requirements vary from one location to another depending on the pond characteristics (Wahab, 1997). The cost of fertilizer is estimated by using the prevailing market rate which is actually paid by the farmers. Lime, potassium (k), and salt are used as fertilizers during Pabda fish production. On an average the per hectare cost of potassium, lime and salt was Tk. 27433.49, Tk.4950.94 and Tk.8479.53 respectively (Table 4.1).

4.2.5. Total variable cost

The cost which has been changed over at a given period by a farmer and that may be varied with the volume of production are considered as variable cost. In this study area, fingerling cost, labor cost, feed cost, fertilizer, salt and lime are considered as variable costs. The total variable cost of Pabda fish production was Tk. 1154597.54 per hectare.

Table 4.2: Per hectare total fixed cost of Pabda fish production

Input wise cost (Tk./ha)	Value
Land rental cost	46058.88
Interest on operating capital @ 6% for 6 months	23091.9507
Family labor cost	52915.25

Source: Farmer's household survey, 2021

4.3. Fixed cost

Fixed cost is such cost which does not depend on the volume of production that means over a period of production it will remain same. In this study, total fixed cost is considered as the summation of land use cost, family labor and Interest on operating capital.

4.3.1. Land rental cost

Among the fish farmers many of them used the land as per conditions of leasing arrangement. The term leasing cost means the cost which was required for Pabda fish farmers to take land lease which would be used for the production of Pabda fish to a fixed period. 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. in the study area almost majority of the farmers have their own fishpond; therefore, authors have considered the land use cost as opportunity cost. Pond use cost for Pabda farming was estimated at the available rental value per hectare in the study area. The rental value of per hectare land was estimated at Tk. 46058.88.

4.3.2. Interest on operating capital

Interest on operating capital (IOC) is calculated based on opportunity cost principle. The operating capital represented the investment on different farm operation over the period since all the cost is not used at the beginning or at any single point of time. The cost is incurred throughout the whole production period. Therefore, at the rate of 6 percent per annum interest on operating capital for six months is calculated for Pabda fish production (Interest rate is taken according to the bank rate prevailing in the market during the study period). Interest on operating capital is determined by using the following standard formula (Miah, 1992).

Where, Al= Total investment /2,

t = Total time period of a cycle

i= interest rate which was 6 percent per year during the study period.

The interest on operating capital was estimated at Tk. 23091.951/ha (Table 4.2).

4.3.3. Human labor (family labor) cost

For Pabda fish production family labor and hired labor has been required, where family labor is considered fixed cost. For avoiding complexity, average rate has been considered. Use of human labor and its relevant cost incurred were shown in Table 4.2. The per hectare hired labor cost was Tk. 52915.25 per hectare.

Table 4.3: Per hectare total cost of Pabda fish farming

Cost Items	Amount (Tk.)
Total Variable Cost	1154597.54
Total Fixed Cost	122066.08
Total Cost	1276663.62

Source: Farmer's household survey, 2021

Table 4.4: Table containing the value of Pabda fish production and its market value

Pabda fish production and market value	Value
Unit price of pabda fish (Tk./kg)	347.18
Unit cost of production (Tk./kg)	195.68
Yield (Kg/ha)	6524.25
Market value of pabda fish (Tk./ha)	2265088.73

Source: Farmer's household survey, 2021

4.4. Total cost

The total costs were calculated by adding up total variable cost and total fixed cost. In the study per hectare total cost of Pabda fish farming was calculated at Tk.1276663.62 (Table 4.3).

4.5. Return from Pabda fish production

In this section, gross return, gross margin, net return and benefit-cost ratio from Pabda fish production culture have been calculated. Gross return is the monetary value of fish production which was calculated by multiplying the total quantity of production by their respective market prices. In this study, gross return was calculated by summing up all the returns earned. Per hectare gross return was calculated by multiplying the total amount of products price. Total per hectare gross return from Pabda fish production was Tk. 1110491.20 (Table 4.5).

Table 4.5: Per hectare gross margin and benefit cost ratio of Pabda fish farming

Serial No	Items	Amount
A	Gross Return	2265088.73
B	Total Variable Cost	1154597.54
C	Total cost	1276663.62
D	Net Return	988425.11
E	Gross Margin	1110491.20
F	BCR based on total variable cost	1.96
G	BCR based on total cost	1.77

Source: Farmer's household survey, 2021

4.5.1. Net return

In general net return is termed as entrepreneur's income. To evaluate the profitability of Pabda fish production, net return is the main aspect. Net return is the difference between gross return and total costs. Per hectare net return was estimated at Tk. 988425.11 which indicates that Pabda fish production is profitable farming for the Pabda fish farmers (Table 4.5).

4.5.2 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. Moreover, fixed cost items are reusable, and its depreciation cannot be measured by the farmers. Therefore, the gross margin analysis has been considered to calculate the relative profitability of Pabda fish farming. The gross margin of Pabda farming was estimated at Tk. 1110491.20 (Table 4.5)

4.5.3 Benefit cost ratio on cash cost

Benefit cost ratio on cash cost was estimated based on division of gross return by variable cost. Since some of the fixed cost items can be reused in other seasons therefore, by estimating this factor actual figure of the firm can be realized. In the study area, benefit cost ratio on cash cost was calculated for 1.96 implying that Tk. 1.96 would be earned from variable cost Tk. 1.00 for Pabda fish production which is profitable business for a fish farmer in the study area (Table 4.5).

4.5.4 Benefit cost ratio on full cost

Benefit cost ratio was estimated by dividing gross return by gross cost or total cost which is expressed the return of per taka invested. It helps to analyze financial efficiency of the farm. From the study area it was found that the benefit cost ratio of Pabda fish farming was accounted for 1.77 implying that Tk. 1.77 would be earned by investing Tk. 1.00 for Pabda fish production. Hence, the Pabda fish farming was found to be profitable for farmers (Table 4.5).

4.6. Concluding remarks

From this study, it can easily be concluded that per hectare return from Pabda fish farming really encourages the new fish farmers which provides higher returns to the farmers. Pabda fish production is profitable in the study area. Sample farmers showed their opinion that higher yield and income encouraged them to continue Pabda fish production.

CHAPTER 5

ANALYSIS OF TECHNICAL EFFICIENCY

5.1. Introduction

We focus on the estimation of technical efficiency of Pabda fish Production in Mymensingh district of Bangladesh using Cobb-Douglas stochastic production frontier model in a single-stage estimation procedure by maximum likelihood method (MLM), Given the specification of the technical inefficiency effects model. Technical inefficiency model as a function of socioeconomic characteristics and factors and thus this single-stage method simultaneously identifies the factors associated with technical inefficiency.

5.2. Result of the Cobb-Douglas production frontier for Pabda fish production

The maximum likelihood estimates of the parameters of Cobb-Douglas frontier are estimated using frontier 4.1 (Coelli, 1996). These are presented in Table 5.1. for Pabda catfish production. We expect the signs of all of the coefficients are positive.

5.3. Effects on economic factors on production

From the maximum likelihood estimates of the stochastic frontier model we get the coefficients and respective P value for each of the variables. That is shown in table 5.1 These are explained in details in below:

5.3.1. Fertilizer (β_1)

The estimated coefficient for fertilizers was found -0.84 and the coefficient is significant at 1% level. Other things remaining constant, if 1% increases in fertilizer then Pabda fish production will decrease 0.84%. Pabda catfish production. This implies that fertilizer had negative significant impact on pabda fish production.

5.3.2. Feed (β_2)

The estimated coefficient for feed was 0.11 and the value is positive. The estimated coefficient for feed is insignificant. This implies that feed had no significant impact on pabda fish production.

Table 5.1: Maximum likelihood estimates of the stochastic Cobb-Douglas frontier production function and technical efficiency model for Pabda fish production

Independent variables	Parameters	Coefficient	Robust Standard error	P value
Stochastic frontier:				
Constant	β_0	-0.34	1.74	0.847
Ln Fertilizer	β_1	-0.84***	0.32	0.009
Ln feed	β_2	0.11	0.09	0.192
Ln lime	β_3	0.12	0.16	0.438
Ln salt	β_4	0.49***	0.15	0.001
Ln electricity (Tk./ha)	β_5	0.01	0.03	0.822
Ln water pumping (Tk./ha)	β_6	0.93***	0.31	0.003
Ln input transportation cost (Tk./ha)	β_7	0.02	0.03	0.568
Ln total hired labor	β_8	-0.06***	0.02	0.006
Ln total family labor	β_9	-0.21***	0.07	0.005
Ln fish harvesting cost (Tk./ha)	β_{10}	-0.07	0.05	0.111
Ln land	β_{11}	0.01	0.01	0.140

(Note: ***, ** and * indicates significance at the 1%, 5% and 10% levels respectively)

5.3.3. Lime (β_3)

The estimated coefficient for lime was 0.12 and the value is positive. The estimated coefficient of lime is insignificant. This result implies that lime had no significant impact on pabda fish production.

5.3.4. Salt (β_4)

The estimated coefficient for salt was 0.49 and it is positive. The coefficient indicates a positive relation with the output. Other things remaining constant, if farmers increase the salt 1%, then Pabda catfish production will increase by 0.49%. This result implies that salt had positive significant impact on pabda fish production.

5.3.5. Electricity (β_5)

The estimated coefficient for electricity is 0.01 and the value is positive and it is insignificant. This result implies that electricity had no significant impact on pabda fish production.

5.3.6. Water pumping (β_6)

The estimated coefficient for it is 0.94 indicates positive relation with output and significant at 1% level of significance. Pabda catfish production will increase by 0.94%. This result implies that water pumping had positive significant impact on pabda fish production.

5.3.7. Input transportation cost (β_7)

The estimated coefficient of input transportation is 0.019 and the transportation coefficient is positive and insignificant. This result implies that transportation cost had no significant impact on Pabda fish production.

5.3.8. Hired labor (β_8)

The estimated coefficient for hired labor is -0.06 that means that the Pabda catfish production has a negative relation with total fish production value and the coefficient is significant at 1% level. Other things remaining constant, if farmers increase 1% of hired labor, the fish production value will decrease by 0.06%. The result implies that hired labor had negative significant impact on Pabda fish production.

5.3.9. Family labor (β_9)

The estimated coefficient for family labor is -0.21 that means that the Pabda catfish production has a negative relation with total fish production value and the coefficient is significant at 1% level. Other things remaining constant, if farmers increase 1% of family labor, the fish production value will decrease by 0.21%. This result implies that family labor had negative significant impact on pabda fish production.

5.3.10. Fish harvesting cost (β_{10})

The estimated coefficient for fish harvesting cost is -0.07, the value is negative. The estimated coefficient of fish harvesting cost is insignificant. This result implies that fish harvesting had no significant impact on Pabda fish production.

5.3.11. Land cost (β_{11})

The estimated coefficient for land cost is 0.01, the value is positive. The estimated coefficient of land cost is insignificant. This result implies that land cost had no significant impact on Pabda fish production.

5.4. Inefficiency variables of Pabda fish production

Among the inefficiency factors, the coefficient of farmer's education, farming experience and farmers organizational behavior is significant.

5.4.1 Age of the Farmers (δ_1)

The estimated coefficient of farmer's age is positive and insignificant. The result showed that farmer's age had no significant impact on Pabda fish production.

5.4.2 Education (δ_2)

The coefficient of education is negative and significant at the 1% level. This result implied that farmers' education had a negative significant impact on the inefficiency of pabda fish production. If farmer's education increases, their inefficiency in Pabda fish production decreases.

5.4.3Family size (δ_3)

The estimated coefficient of farmer's family size is positive and insignificant. The result showed that farmers family size had no significant impact on Pabda fish production.

5.4.4 Farming experience (δ_4)

The coefficient of farming experience is negative and significant at 5% level. This result implied that farmers' farming experience had negative significant impact on the inefficiency of pabda fish production. If farmers' farming experience increase, their inefficiency in pabda fish production decreases.

5.4.5 Organization participation(δ_5)

The coefficient of organizational participation is negative and significant at 5% level. This result implied that farmers' organizational participation had negative significant impact on the inefficiency of Pabda fish production. If farmers' organizational participation increases, their inefficiency in pabda fish production decreases.

Table 5.2: Inefficiency variables of Pabda fish production

Inefficiency variables	Parameters	Coefficient	Robust Standard error	P value
Age	$\boldsymbol{\delta}_1$	0.133	0.103	0.19
Education	$\boldsymbol{\delta}_2$	-0.53^{***}	0.162	0.001
Family size	$\boldsymbol{\delta}_3$	0.348	0.300	0.245
Farming experience	$\boldsymbol{\delta}_4$	-0.43^{**}	0.206	0.037
Organizational participation	$\boldsymbol{\delta}_5$	-2.61^{**}	1.190	0.028
Diagnostic statistics				
Number of observations	100			
Probability of chi^2	0.00			
Log pseudolikelihood	71.88			
Wald chi^2	77.06			
Sigma square-v ($\sigma^2 v$)	4.15		0.097	
Sigma square-u ($\sigma^2 u$)	-12.61		0.101	
Lamda ($\lambda = \boldsymbol{\delta}_{\mathbf{v}}/\boldsymbol{\delta}_{\mathbf{u}}$)	0.0145		0.006	

(Note: ***, ** and * indicates significance at the 1%, 5% and 10% levels respectively)

Source: Farmer's household survey, 2021

Table 5.3: Summary of Pabda fish farmers technical efficiency

Efficiency level	**Technical efficiency**	
	Frequency	**Percentage**
0.81-0.90	8	8
0.91-0.95	20	20
0.96-0.99	72	72
Mean efficiency	0.96	
Maximum efficiency	0.99	
Minimum efficiency	0.81	

Source: Farmer's household survey, 2021

5.5 Summary of Pabda fish farmers technical efficiency

The technical efficiency (TE) was range between 0.81 and 0.99, with a mean of 0.96. This result showed that most of the Pabda fish farmers were efficient in Pabda fish production.

5.6 Conclusion

The chapter provides all estimated results if the present study. In case of technical efficiency significant variation is found among the farmers. The mean technical efficiency of Pabda catfish farmer in the study area is 0.96. Results of the determinants of technical inefficiency indicate that farmers "socio-economic variables should be considered as significant factors influencing inefficiency in Pabda production. If farmers education and organizational participation increase then farmers inefficiency in Pabda fish production decrease whereas the increase in farming experience will increase the pabda fish production to some great extent. Conclusion from these findings is that in the recent time period Pabda fish production is highly efficient in the study area.

CHAPTER 6

WOMEN DECISION MAKING IN AGRICULTURAL PRODUCTION

6.1. Introduction

A full understanding of the role of women in sustainable fisheries development is significant in assuring food security, income generation, trades, and improved living standards in many developing countries. Their involvement in pond fish culture is one issue that needs to be addressed when dealing with rural communities and poverty alleviation among the rural women. Demographic information is useful to get an insight into the profile of the household and the intervention for planning for development. Socio-demographic background and characteristics of farm women have a vital role in farm activities to a great extent.

6.2. Socio-demographic characteristics of the farm women

Education is an important factor to increase income and educational status affects the implementation of appropriate technology and fish production. Women have limited access to education, skills, resources and opportunities lead to gender inequality in all spheres of women's lives.

Table 6.1: Socio-economic characteristics of farmers and their wives.

Characteristics	Value	
	Wife	**Husband**
Age (years)	29.48	35.37
Education (years)	6.48	11.18
Agricultural training (no.)	0.23	1.08
Ownership of mobile phone (%)	100	100
Access to internet (%)	54.0	97.0

Source: Farmer's household survey, 2021

Average age of the women was 29.48 years in the study area. Women had 6.42 years of formal education. On an average, women had 0.23 number of agricultural training. The entire women had mobile phone. 54.0% of the women had internet access in the study area. Women have limited access to education, skills, resources and opportunities lead to gender inequality in all spheres of women lives.

Table 6.2: Participation of farmers and their wives in different agricultural activities.

Activities	Participation percentage (%)	
	Wife	Husband
Food crop farming	86.0	100
Cash crop farming	33.0	100
Livestock raising	52.0	40.0
Non-farm economic activities	48.0	35.0
Wage and salary employment	15.0	90.0
Fishing or fish pond culture	71.0	96.0

Source: Farmer's household survey, 2021

6.3. Activities and income generation

Table 6.2 shows the women participation in different agricultural activities where highest level of participation is 86.0% in food crop farming and the lowest level of participation is in wage, 33.0% of women participated in cash crop farming, 52.0% of women participated in livestock raising, 48.0% of women participated in non-farm economic activities and salary employment which is 15.0%.Women participation in fish pond culture is expected in the study area and 71.0% of women participated in fishing and pond culture.

6.4. Decisions making power of farmers and their wives

In decision making we can see that the larger percentage are the husband and women has contribution to a great extent but without the decision-making power we can’t say that women are empowered. In food crop farming, cash crop farming, livestock raising, non-farm economic activities, wage and salary employment, fishing or fish pond culture farmers got major percentage in decision making.

Table 6.3: Decision making power regarding production and income generating activities

Production and income generating activities	Decision	
	Husband (%)	Wife (%)
Food crop farming	56.0	44.0
Cash crop farming	85.0	15.0
Livestock raising	70.0	30.0

Non-farm economic activities	60.0	40.0
Wage and salary employment	90.0	10.0
Fishing or fish pond culture	65.0	35.0

Source: Farmer's household survey, 2021

6.5. Asset ownership by farmers and their wives

In Table 6.4, we can see that asset ownership in terms of small livestock and chicken, ducks, turkeys etc., women are the majority owner but in other assets like land, equipment husband owns the majority.

Table 6.4: Asset ownership by men and women

Assets	Ownership (%)		
	Husband	Wife	Both husband and wife
Agricultural land	80.0	10.0	10.0
Large livestock	70.0	25.0	5.0
Small livestock	-	90.0	10.0
Chicken, ducks, turkeys etc.	-	100.0	-
Fish pond or fish equipment	90.0	5.0	5.0
Farm equipment	97.0	-	3.0

Source: Farmer's household survey, 2021

6.6. Time spent by women in fisheries activities

Fisheries activities are commonly perceived as men's work but in our subsistence rural economy, women play a vital role in producing fish. However, while there exist difficulties of different magnitude for women to be fully involved in fisheries, there are also vast potentials for women to contribute meaningfully in the fisheries sector.

Table 6.5: Time spent by women in fisheries activities

Activities	Women(minutes)	Men(minutes)
Fingerling sorting (per month)	92.0	98.0
Feed application (per day)	64.2	70.1
Fish harvesting (per two month)	169.4	225.9

Source: Farmer's household survey, 2021

Traditionally, women have played a major role in agriculture, however, studies on various development endeavors have also endorsed the fact that female members of farm-based households are playing a significant role in fish farming. Together with their male counterparts, women are engaged in activities like making fishing nets, gears, repairing or maintaining the gears, sorting of fingerlings, fish processing, transportation and marketing. Men and women both contribute an adequate amount of time in fisheries activities which brings the efficient result we could see in the profit ratio.

6.7. Conclusion

Women in aquaculture increased production as women could take routine work for pond management. Pond fisheries activities of women contribute to the family income considerably; ensure constant supply of much needed family nutrition by food crop farming; generate an opportunity for self-employment by working in the fish farm; uplift their overall socio-economic condition; and contribute to become more skilled. Their problems, potentials and contributions to agricultural and household decisions impacts significantly on the overall fish production value.

CHAPTER 7

PABDA FISH FARMERS PROBLEMS AND POSSIBLE SOLUTIONS

7.1. Introduction

Fisheries sector plays an important role in the livelihood of the village people which has been an age-old practice for thousands of fishermen in Bangladesh. Moreover, in recent days young, energetic people are also coming forward and try to do this farming scientifically. However, these fish farmers are facing an ample amount problem. In this study, an attempt had been made to identify and analyze the major problems and constraints faced by the farmers which act as main barriers in running the business of Pabda fish farming which are broadly categorized as Technical Problem, Economical Problem and Social Problem.

7.2. Technical problem

7.2.1 Fish affected by parasites and diseases

Pabda fish diseases are one of the main threats of Pabda fish farming. shadowy surroundings, lack of oxygen in water and excess ammonia gas in the bottom of the pond can lead different diseases of the Pabda fish. Dangerous part of Pabda fish farming is, one disease can destroy the fish of whole pond within one night. Almost 33 percent of producing farmers reported that attack of Pabda fish disease hampered the production of Pabda (Table 7.1). To overcome this problem, scientific use of chemicals should be ensured. Maintain good oxygen level, proper water P^H (Between 7-8.5), sunny surroundings, reducing ammonia in time should be implemented scientifically.

7.2.2 Lack of scientific and technical knowledge

Scientific knowledge and advance technology are important for Pabda fish culture. However, a few numbers of farmers have sufficient scientific knowledge with the help of proper training. In this study, about 59 percent Pabda fish farmers mentioned that, they had lack of scientific knowledge and technology. Due to the lack of scientific knowledge farmers are less likely to adopt new farming techniques.

7.2.3 Non-availability of fingerlings in proper time

Lack of quality fingerlings is another problem area in this study area. Farmers didn't have access to quality full fingerlings at the right time therefore which results in great loss. Almost 13% Pabda fish farmers mentioned they face such problem.

Table 7.1: Problems faced in Pabda fish farming

Problems	**Value (%)**
Technical problem	
Fish affected by parasites and diseases	33.0
Lack of scientific and technical knowledge	59.0
Non-availability of fingerlings in proper time	13.0
Economic problem	
Lack of credit facility	56.0
Low price of pabda	35.0
High price of inputs	87.0
Lack of marketing facilities	35.0
Poisoning the water of the Pond	7.0
Social problem	
Theft of Fish from Pond	15.0

Source: Farmer's household survey, 2021

7.3 Economical problem

7.3.1 Lack of credit facility

In the study area most of the farmers are middle class and some of them are lower middle class. They are not economically solvent to run the farm smoothly without any financial support. Moreover, they did not get sufficient loan from financial institution to purchase adequate feed for the fingerlings. Sometimes, they had to borrow money from local NGO's at higher interest rate. 56% of Pabda fish farmers reported this financial issue.

7.3.2 Low price of pabda

A few Pabda fish farmers also claimed that they did not receive expected price from market. Some local syndicates are responsible for such issues. Some farmers had to sell their products at home at lower price due to transportation related problems. About 35% Pabda fish farmers faced such problems. This study indicated that BCR was little high and price of output was also better. Therefore, we understand that there was some inconsistency in their answer.

7.3.3 High price of inputs

For pabda fish production varieties of inputs are required. Mostly these inputs are costly. As maximum fish farmers are middle class, they find the production cost unbearable to produce a profitable outcome. Among the Pabda fish farmers 87% of them have said that the price of the inputs is high.

7.3.4 Lack of marketing facilities

Lack of marketing facilities was one of the crucial problems faced by the farmers in pabda fish production. 35% of the total farmers has faced this problem.

7.3.1 Poisoning the water of the pond

Number of farmers also reported about such problem in this study area. It is often noticed that either closed acquainted people or relatives did such types of crimes. They did such crimes due to jealousy which hampered overall production in a pond. About 7% of Pabda fish farmers reported such problems as major problems. Farmers should look after their Pabda fish farm at a regular basis either by security guard or close circuit camera. Social security must be provided by the local government.

7.4 Social problem

7.4.1 Theft of fish from pond

Though major fish farm has night guard still they had tension of theft. About 15% of farmers reported that this problem was hampering their total production. To overcome this problem close circuit camera should be installed. Law enforcement team should also come forward to solve this issue.

7.4.2 Possible solutions

Farmers suggested few possible solutions regarding the problems they face in Pabda fish farming. It is possible to solve those issues by applying these solutions to some extent.

Table 7.2: Possible suggestions suggested by farmers to solve their problems

Solutions	Value (%)
Need meeting with Upazila fisheries officers	74.0
Water pump availability	80.0
Availability of fingerlings	65.0
Availability of taking precautions beforehand	61.0

i. **Need meeting with Upazila fisheries officers**: Farmers should meet the Upazila fisheries officers to get proper guidelines on farming techniques and to solve the problems faced in the farming process. Among the farmers 74% suggested that they need to meet Upazila fisheries officers for solving their problem.

ii. **Water pump availability:** In fish cultivation water pumping is on the most necessary inputs which helps in maintaining accurate water level. To reduce the water pumping cost, 80% of the farmer suggested that efficient technique of water pumping needs to introduced.

iii. **Availability of fingerlings**: Farmers often face the unavailability or short of fingerlings which is not beneficial for the fish farming business and 65% of the fish farmer needed available fingerlings. Fingerlings needs to nurtured in suitable environment in the hatchery to maintain its quality and survivability.

iv. **Availability of taking precautions beforehand**: Disease transfer, pollution, pond infrastructures are common problems in Pabda fish farming. Precautions are needed to take beforehand to mitigate the problems was suggested by 61% of the total farmers.

7.5. Concluding Remarks

Numerous problems are faced by Pabda fish farmer which affects the productivity of the fish. Pabda fish farmers suggested different solution of their problems and it is necessary to take initiative to solve their problems.

CHAPTER 8

SUMMARY, CONCLUSION AND POLICY RECOMMENDATION

8.1. Introduction

Bangladesh is one of the most suitable countries in the world for aquaculture due to agroclimatic conditions. The demand for fish in Bangladesh is increasing rapidly because of increasing population. Aquaculture is a crucial sector for economic growth and development of Bangladesh. It provides food for the people as well as raw materials to the aquaculture-based industries that help forming capital. It is one of the largest sources of employment and income generation of the people in Bangladesh.

This study analysis the profitability and women empowerment of Pabda catfish farming in Mymensingh district of Bangladesh. It has also analyses the key determinants of technical efficiency of Pabda production. The Cobb-Douglas stochastic frontier production function approach is applied to estimate the technical efficiency. Thus, the core point of this research is to study the productivity and profitability of pabda fish production in Mymensingh district in Bangladesh.

8.2. Major findings and conclusion

In Bangladesh aquaculture sector has been recognized as the prominent sector of the economy and the fish sector has been regarded as the main strength of aquaculture. Sustainable development in aquaculture depends upon economic use of pond, labor, drug, lime and others factors. Again, this can be made possible through adoption of modern but appropriate technology with efficient management and cultural practices. However, the findings of this study obtained from the previous chapters are noted below.

This research starts with an introductory discussion in chapter one. In this chapter the researcher tries to find out the scope for the study in the context of Bangladesh, the background of the study, the economic contribution, women participation, objectives of the study and the justification of the study are discussed in this chapter.

Chapter two of the present study reviews the relevant literature on technical efficiency of aquaculture sector. By reviewing the literature comprehensively, it is found that pabda fish production can be profitable, here is a relationship between technical efficiency and key inputs of Pabda production and women are directly involved with

Pabda fish production. By investigating the previous literature, it has become possible to portray o foundation for the undertakings of econometric techniques of the measurement of the technical efficiency. Moreover, reviewing the literature, it has become feasible to identify the gaps inherent in these studies.

In chapter three, the methodology has been adopted for the present study and the data analysis has been depicted in order to measure the profitability of Pabda production. Cobb-Douglas production function analysis was used to examine the effect of input use and resource use efficiency. Keeping in mind the objectives of the study and considering the effect of explanatory variables on output of Pabda fish farming, explanatory variables were chosen to calculate the quantitative effect of inputs on output and the input were Fingerling cost, Human Labor cost, feed cost and Cost of fertilizer and cost of salt and lime, electricity and pumping cost.

Chapter four it is observed that the Costs and returns were calculated to determine the profitability of Pabda fish farming. Fingerling cost was Tk. 9271.74/ha, Human Labor cost was Tk. 97361.75/ha, Feed cost was Tk. 981637.01/ha, fertilizer cost was Tk. 27433.49/ha, salt cost was Tk. 4950.94/ha, and lime cost was Tk. 8479.53 /ha. Cost of Interest on operating capital was Tk. 23091.95 and land use cost, family labor and interest on operating capital were considered as fixed cost which total worth was Tk. 122066.08.

Therefore, in this study we found gross return (GR) was Tk. 2265088.73/ha, Net Return Tk. 988425.11/ha Tk/Hectare, Gross Margin as 1110491.20 Tk/Hectare and BCR on total variable cost and BCR on total cost were 1.96 and 1.77 respectively which indicated that Pabda fish culture was highly profitable. Cobb-Douglas production function analysis was used to examine the effect of input use and resource use efficiency. It showed 96% mean technical efficiency. Gender role in decision was also shown in the result and discussion where we could see that 15% of decision making in production and income generating activity were women, which means women empowerment should be given more importance. In this study researcher also found some of major problems faced by farmers ware attack of Pabda fish diseases. Lack of scientific knowledge, lack of quality fingerlings, lack of extension services, lack of quality feeds, over flooding problems which were considered as technical problem. lack of sufficient fund, low market price, were considered as economical problem. Theft of fish from pond were found as social problems.

8.3. Conclusion

It can be concluded that Pabda fish farming is highly profitable fish culture which we can easily realize by focusing on Benefit Cost Ratio which was 1.77 and Benefit cost ratio on cash cost was 1.96. High input price is one of the prime concerns in Pabda fish production, to avoid such losses modern production technology should be implemented. Feed costs play a significant role in Pabda fish production, therefore quality feed with low price should be established. There is a huge future potential market and demand for Pabda fish which can also fulfil the nutritional shortage of the people in Bangladesh. Farmers play a vital role in national GDP by fish farming therefore, a well-planned production program from national level should be established.

8.4. Policy recommendations

Enormous opportunities are available to improve per hectare Pabda fish production. To enhance the productivity, efficiency, and effectiveness in pabda farming, the following recommendations are made as a part of present study which acts as a formulating strategy for enhancing Pabda fish production in Mymensingh district.

i. Need to be in close contact with the Upazilla fisheries officer to optimize the efficiency of the fish farms.
ii. Application on scientific method should be ensured and production data should be preserved for future production. Moreover, they should take help from fisheries officers. Different training program should be arranged form government fisheries office or private agencies.
iii. Need to establish Strong market network for better fingerlings and feeds supply, Government is already provided subsidy on different fertilizer but need to be ensured that others input should get at a reasonable price.
iv. Transportation and marketing facilities should be improved in the study area.
v. Close circuit cameras can be installed to maintain security on large projects. Moreover, Law enforcing agencies should be vigilant in the study area to minimize the social tension in the study area.

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APPENDICES

Questionnaire-1

Department of Agribusiness and Marketing

Sher-e-Bangla Agricultural University, Dhaka-1207

Survey Schedule for Pabda fish farmer

Research title: Profitability and women empowerment of Pabda fish in Mymensingh District of Bangladesh

Serial no: Date:

1.Name: 2. Spouse Name:

3.Contact Number:

4.Address:

Village: Union:

Upazilla: District:

5.Occupation

Primary: Secondary:

[Code: 1=Agriculture, 2=Employment, 3=Day labor, 4=Petty businessman, 5=Others]

6.Types of farmer

1=Owner operator, 2=Pure tenant, 3=Owner cum tenant

7. Farm type(acre):

Small (0.5-2.49) =1, Medium (2.5-7.49) =2, Large (7.50+)

8.Pabda fish production: Yes/No

9. Different characteristics of farmer

Characteristics	Value
1.Age (years)	
2.Education (years)	
3.Family size (number)	
4.Father's Education (years)	
5.Mother's education (years)	
6.No. of agricultural training (Per year)	
7.No. of extension contact (Per year)	
8.Years of farming experience (year)	
9.Organizational participation (NGO's, Cooperatives)	Yes/No
10.Farmers have access to TV	Yes/No
11.Farmers have mobile phone	Yes/No
12.Do you use agricultural apps in your mobile phone?	Yes/No
13.Farmers have internet in the mobile phone	Yes/No
14.Homestead area (acre)	
15.Farm size (acre)	
16.Pabda fish production land (acre)	
17.Farmers used fingerlings	Yes/No

10.Cost of Commercial Pabda fish production (per acre)

Cost items	Unit	Quantity	Tk./Unit	Total cost
Fingerlings	No			
Fertilizer	Kg			
Feed	Kg			
Lime	Kg			
Salt	Kg			
Electricity				
Water pumping				
Mention other technology if used in the pond				
Mention other technology if used in the pond				
Input transportation				
Hired Labor (Pond preparation)	Man/Day			
Fish Harvesting Cost				
Fish Marketing Cost				
Miscellaneous cost				
Family labor	Man/Day			
Land use cost				

11. Revenue from Pabda fish production

Items	Value
Selling price	
Yield (kg/acre)	
Total revenue (Tk)	

12. Problems of Pabda fish production mentioned by farmer

Problems	Please give a tick mark
Water poisoning	
High prices of inputs	
Lack of credit facilities	
Low price of Pabda fish	
Lack of marketing facilities	
Non-availability of fingerlings in proper time	
Fish affected by parasites and diseases	
Insufficient water in the dry season	
Lack of market information	
Lack of scientific and technical knowledge	

13. Possible suggestions suggested by farmers to solve their problems.

Possible Solution	Tick Mark
Need meeting with Upazila fisheries officers	
Water pump	
Availability of fingerlings	
Availability of taking precautions beforehand	

Signature of the interviewer

Questionnaire-2

Department of Agribusiness and Marketing

Sher-e-Bangla Agricultural University, Dhaka-1207

Survey Schedule for Pabda fish farmer's wife

Research title: Profitability and women empowerment of Pabda fish in Mymensingh District of Bangladesh

1. Serial no: Date:
2. Name:
3. Spouse Name:
4. Mobile Number:
5. Different characteristics of farmer's wife

1. Socio-economic characteristics of farmer's wives

Characteristics	Value
1.Age (years)	
2.Education (years)	
3.Family size (number)	
4.Father's Education (years)	
5.Mother's education (years)	
6.No. of agricultural training (Per year)	
7.No. of extension contact (Per year)	
8.Years of farming experience (year)	
9.Organizational participation (NGO's, Cooperatives)	Yes/No
10.Farmers have access to TV	Yes/No
11.Farmers have mobile phone	Yes/No
12.Do you use agricultural apps in your mobile phone?	Yes/No
13.Farmers have internet in the mobile phone	Yes/No
14.Homestead area (acre)	
15.Farm size (acre)	
16.Pabda fish production land (acre)	
17.Farmers used fingerlings	Yes/No

2. Participation of farmers and their wives in different agricultural activities

Activities	Participation (Give tick mark)	
	Wife	Husband
Food crop farming		
Cash crop farming		
Livestock raising		
Non-farm economic activities		
Wage and salary employment		
Fishing or fish pond culture		

3. Decision making power regarding production and income generating activities

Production and income generating activities	Decision (Give tick mark)	
	Husband	Wife
Food crop farming		
Cash crop farming		
Livestock raising		
Non-farm economic activities		
Wage and salary employment		
Fishing or fish pond culture		

4. Asset ownership by farmers and their wives

Assets	Ownership (Give tick mark)		
	Husband	Wife	Both husband and wife
Agricultural land			
Large livestock			
Small livestock			
Chicken, ducks, turkeys etc.			
Fish pond or fish equipment			
Farm equipment			

5. Time spent by women in fisheries activities (per month)

Activities	Husband (minutes)	Wife (minutes)
Fingerling sorting (per month)		
Feed application (per day)		
Fish harvesting (per two month)		

Signature of the interviewer