EFFICIENCY OF RICE-CUM-FISH CULTURE IN A SELECTED AREA OF MYMENSINGH DISTRICT

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This is to certify that the thesis entitled "EFFICIENCY OF RICE-CUM-FISH CULTURE IN A SELECTED AREA OF MYMENSINGH DISTRICT" submitted to the DEPARTMENT OF AGRICULTURAL ECONOMICS, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M.S.) in AGRICULTURAL ECONOMICS, embodies the results of a piece of bona fide research work carried out by SURAIYA AKTER, Registration. No. 07-02518 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 any help or sources of information received during the course of this investigation has duly been acknowledged.

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ABSTRACT

Rice and fish have been an essential part of life and culture of the people of Bangladesh. The rice-cum-fish culture is an innovative farming system in which, rice is the main enterprise and fish production is taken as additional means to secure extra income. The present study was designed to determine the profitability and resource use efficiency of rice-cum-fish culture. Mymensingh district was selected for the study on the basis of extensive cultivation of rice-cum-fish. Simple random sampling technique had been used for collecting data from 60 sample farmers through interview schedule. After analyzing the data, per hectare gross return, net return, and gross margin were found to be Tk. 240600, 116260, and 131560 respectively. Total cost of rice-cum-fish culture was calculated at Tk. 124340 per hectare. Benefit Cost Ratio (BCR) was found to be 1.94 for rice-cum-fish culture. Thus it was found that rice-cum-fish culture was highly profitable. The results of Cobb-Douglas production function showed that per hectare gross return from rice-cum-fish culture was significantly influenced by the use of human labor, seed, fingerling, feed, and pond preparation but insignificantly influenced by the use of fertilizer, irrigation, power tiller and insecticide cost. Resource use efficiency analysis revealed that farmers were not efficient in using resources in rice-cum-fish and most of the resources were underutilized except labor, irrigation and insecticide. This study also identified some of the constraints associated with rice-cum-fish culture. Finally on the basis of findings of the study, some recommendations were suggested for the development of rice-cum-fish culture in Bangladesh.

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ABBREVIATIONS AND ACRONYMS

ASA	: Association for Social Advancement
BBS	: Bangladesh Bureau of Statistics
BCR	: Benefit cost ratio
BER	: Bangladesh Economic Review
BRAC	: Bangladesh Rural Advancement Committee
CARE	: Cooperative for Assistance and Relief Everywhere
DoF	: Department of Fisheries
et al.	: and others (at all)
etc	: et cetra (others and so forth)
FY	: Fiscal Year
GDP	: Gross Domestic Product
GNP	: Gross National Product
ha	: Hectare
Kcl	: Kilocalorie
kg	: Kilogram
Km^2	: Square Kilometer
ln	: Natural log
MFC	: Marginal Factor Cost
mm	: Milimeter
MOP/MP	: Murate of Potash
MPP	: Marginal Physical Product
MT	: Metric Ton
MVP	: Marginal Value Product
NGOs	: Non – Government Organizations
No.	: Number
OC	: Operating Capital
OLS	: Ordinary Least Square
SPSS	: Statistical Package for Social Sciences
Sq.km	: Square Kilometer
Tk.	: Taka
TSP	: Triple Super Phosphate
ULO	: Upazila Livestock Officer
$	: United States Dollar
%	: percentage
^0C	: Degree Celsius

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Bangladesh is predominantly an agricultural country with the geographical area of 147570s.q kilometers and population of about 149.77 millions. The population density per km^2 is 976 people (BBS, 2013). Agriculture is the major dominating sector of the country. Agriculture occupies a key position in the overall economic sphere of the country in terms of its contribution to Gross Domestic Product (GDP). About 80 percent of its population lives in rural areas, where agriculture is the major occupation and 45.6 % labor force are engaged in agriculture (BBS, 2013). At present the contribution of agriculture to the total GDP (Gross Domestic Product) is 17.21% in which 10.05% comes from crops, 1.19% from forestry, 2.41% from livestock and 3.56% from fisheries (BBS, 2013). In the year (2009-10), Bangladesh earned $687.53 million by exporting agricultural products which is 4.24 percent of total export earnings (BBS, 2010). So agriculture plays vital roles for poverty alleviation and food security by increasing income level of rural population. The population growth rate is 1.36 percent per annum (BBS, 2013) which causes the decreases of farm size in a horrid manner. The extra population is a threat to the total production.

Agricultural development is still synonymous with the economic development of Bangladesh. Economic development of the country cannot be achieved unless there is a breakthrough in agriculture sector. At present, agriculture sector is largely dominated by the rice production. Rice is the staple food and major cereal crop of Bangladesh. Basically rice cultivation is the major source of livelihood of the people of Bangladesh. A small parcel of land not only acts as a constraint to profitable investment, but also deprives farmers of access to production inputs, formal credit and other institutional services required for improved agricultural practices.

In an agro-based country like Bangladesh, fisheries sub-sector is one of the most important and promising sub-sectors having vital contribution towards economic development. The contribution of fisheries sub-sector in Gross Domestic Product was 3.68 percent in FY 2012-13 and 3.69 percent in FY 2013-14, fisheries sub-sector contributed about 22.61 percent to the broad agricultural sector Gross Domestic Product

(BER, 2014). This sector plays a significant role in meeting the protein demand, earning foreign exchange and socio-economic development of the rural poor by reducing poverty through employment generation.

Over a long history, fish is cultivated in some wet rice fields, either concurrently or rotationally in Asia Region (Qingwen *et al*., 2009). Rice and fish have been an essential part of life and culture of the people of Bangladesh. Bangladeshi people were popularly referred to as *‘’Macche-Bhate Bangali’’*. Despite the fact that rice is still the staple food and that there is self-sufficiency in production to feed 160 million people (BBS, 2012). The total area of rice fields in Bangladesh is about 10.14 million hectare which can play an important role in increasing fish production (Haroon and pittman, 1997). The potential capacities of these lands and water bodies are not fully utilized but there exists tremendous scope for integrated aquaculture-agriculture system that is integration of fish with rice production for sustainability and improving productivity as well as profitability of the farms (Ali, *et al.*, 2002). The notion of rice-cum-fish culture originated with a view to ensure better return from rice for farmers through efficient use of scarce land resources.

1.2 Importance of Rice in the Economy of Bangladesh

Agriculture is the major dominating sector of the country. In the economy of Bangladesh, crop sector mainly rice plays an important role because large number of areas are devoted to it and a large number of farmers are engaged in rice production. A different variety of rice is cultivated in Bangladesh namely Aus, Aman and Boro. There are two types of Aman rice in Bangladesh that is broadcast Aman and transplanting Aman. The transplanting Aman rice holds the key position of the total Aman rice produced in the country and occupies about 46.30 percent of rice cultivated land (BBS, 2012). Currently a number of improved varieties are being transplanted such as BR-11, BR-22, BR-23 etc., which are increasing the production highly and are also helping to meet the surplus demand for food. Transplanted Aman is grown throughout Bangladesh and broadcast Aman is grown in low-lying areas. In recent years, crop production in Bangladesh has undergone some changes in terms of yields as well as crop distribution. Rice is by far the most important crop along with jute, wheat, potato, oilseeds, sugarcane, pulses, and tea (BBS, 2013).

Table 1.1 Productions of Major Agricultural Crops in Bangladesh (000’ Metric Tons)

Year	Aus	Aman	Boro	Wheat	Potato
2006/07	996	7867	14709	737	5167
2007/08	1099	7715	13552	844	5985
2008/09	1948	9075	12866	849	6648
2009/10	1316	9403	17844	901	7124
2010/11	1739	10142	15329	972	7457
2011/12	1963	10254	15597	995	7368
2012/13	1821	10437	15752	1255	8121
2013/14	2022	10662	15862	1303	8353

Source: BBS, 2014

Planting and harvesting time of crops are prolonged due to availability of irrigation facility, seedling raising, land, money, labor, etc. Aman rice sometimes requires irrigation. Their production often affected by natural calamities like drought and flood. The highest production of Aman was 10662 metric tons in 2013/14 and lowest production was 7715 metric tons in 2007/08. Due to environmental effect, Aus production is somewhat less than Aman production and Aman production is also less than the Boro production in 2013-14 (Table 1.1). It is evident from the table 1.1 that, the production of wheat and potato is increasing rapidly from the year of 2006/07 to 2013/14. In order to feed the increasing population, the present pace of food grain production needs to be sustained.

1.3 Importance of Fisheries Sub-sector in the Economy of Bangladesh

Bangladesh is an agro-based developing country. The population of the country is increasing day by day. With increasing population, the demand for food is also increasing. The government of Bangladesh has recognized this importance and for the year 1999-2000, 2004-2005 and 2009-2010 per capita daily fish consumption was estimated at 28.38, 31.32 and 33.46 gm, respectively against projected fish production targets of 15.02, 18.24 and 21.80 lakh tones (DoF, 2011). As a sub-sector of agriculture, fisheries ranked second in the position. Fisheries play a significant role in nutrition, employment, and foreign exchange earnings. In agriculture contributes 20.24 percent to the GDP and of this 3.74 percent comes from fisheries sub-sector. The contribution of this sub-sector to the national foreign exchange earnings is about 2.70 percent. Fishery industry in Bangladesh provides livelihood to 11.2 million full time fishermen and to 10 million part time fishermen (DoF, 2010). About 12.05 percent of the population directly or indirectly depends on fishing and ancillary occupation (BBS, 2010). Bangladesh has a long tradition of aquaculture. About 82 percent of total fish production come from inland sources and the 18 percent is contributed by others source (DoF, 2011).

Table 1.2 Annual Total Catch and Area Productivity by Sector of Fisheries for 2011-2012

Sector of fisheries **A. Inland fisheries**	**Water area (Ha)**	**Total catch (Tones)**	**% of total catch**	**Catch (kg/ha)**
Capture				
1.River and estuaries	853863	145613		171
2.Sundar ban	177700	21610		122
3.Beel	114161	85208		746
4.Kaptai lake	68800	8537		124
5.Flood land	2710766	696127		257
Capture total	3925290	957095	29.34%	1420
Culture				
1.Pond and ditch	371309	1342282		3615
2.Seasonal cultured	122026	182293		1494
3.Baor	5488	5186		945
4.Shrimp farm	275232	196306		713
Culture Total	774055	1726067	52.92%	6767
Inland Total	**4699345**	**2683162**	**82.26%**	
B. Marine fisheries				
1.Industrial fisheries		73386		
2.Artisanal fisheries		505234		
Marine Total		**578620**	**17.74%**	
Country Total		**3261782**	**100**	

Source: BBS, 2012.

Bangladesh has a long tradition in fish culture, more particularly in the field of inland fisheries cultivation, for example, ponds, rivers, canals, tanks, Beels, Haors and Baor etc. The contribution of the inland fisheries is 82.26 percent to the total catch while the marine contribution is 17.74 percent. Contribution of different sub-sectors of fisheries to total production (2011/12) is shown in Table 1.3.

Bangladesh has one of the highest man-water ratios in the world. At current level of population, it is 8:1 (Mazid, and Hossain, 2010). In other words, for every eight persons there is an acre water area. So, fisheries are a potential sub-sector in the economy of Bangladesh. About 12 million people are involved in fisheries sector. The exporting income from this sector is Tk. 4603.83 core (2010/11). The projection of producing 7.32 million tones of fish in which inland fish production had been estimated at 2.38 million tones (82.26 percent) of which open water body fish production was estimated at 1.03 million tones (29.34 percent). Close water body is 1.35 million tones (52.92 percent) (DoF, 2011). The country being a riverine one is characterized by vast fisheries resources. The potential for increased fish production from inland water in Bangladesh is enormous. The inland waters are fresh except in the southern region where the rivers meet with sea.

1.3.1 Nutritional Importance

Most of the people of Bangladesh depend on fish which is a principal source of animal protein. Indeed, fish is an important component of total human food consumption. Protein is essential for health and growth of the body. Fish alone shares about 60 percent of protein intake and contributes about 74 percent of animal protein. It is nutritionally equivalent to protein in meat, high in essential minerals and low in saturated fats (Islam, 1987). Fish is high in protein with balance proportions of amino acids, vitamin B12, essential fatty acid and low in cholesterol (Edwards and Kaewpaion, 1981).It also provides vitamin A which is vitally important to control blindness of children. Thus fish can make an outstanding contribution to the nutritional development of Bangladesh.

About 60 percent of the world populations receive lower than 2200 Kcal per day per capita and 80 percent have to be contented with less than 30 grams of animal protein per day. The fish species have also great use in medical remedies for common aliments in everyday life. Fish supplies are a valuable source of oil containing polyunsaturated fatty acids which are helpful in keeping down the cholesterol level of blood.

Demand for fish is also increasing rapidly because of increasing population and shortage of meat. It can be seen from table 1.4 that protein content of fish (fresh) is 16.6-22.8 gm per 100 gm of fish is more or less equivalent to other sources of protein i.e. mutton, beef, milk, egg, vegetables and pulses. The prospect for significantly increasing poultry and livestock products to meet the demand for meat is limited due to the continuous increasing pressure on land for the production of cereals. For this reason, fish plays a crucial role to meet the shortage of animal protein and elimination the malnutrition problem in Bangladesh.

Table 1.3 Nutrition Content of Selected Common Food Items in Bangladesh

Animal sources		**Plant sources**	
Nutrition items	**Protein content (per 100 gm)**	**Nutrition items**	**Protein content (per 100 gm)**
Chicken	25.9	Pulses	24.5-25.1
Beef	22.6	Wheat	12.1
Mutton	21.4	Rice	7.3
Fish	16.6-22.8	Banana	7.0
Egg	10.3	Betel leaf	3.1
		Vegetables	1.8-5.3
		Mango	1.0
		Sugarcane	0.1

Source: BBS, 2012

1.3.2. Economic Importance

The fisheries sector is one of the enormous importance to the economy of Bangladesh. This sector is now playing a vital role in poverty alleviation, generating employment opportunities, contributing animal protein, earning foreign currency and increasing Gross Domestic Product (GDP) and Gross National Product (GNP). Fish provides 60 percent of animal protein consumption and about 1.2 million people are directly employed in this sector (BBS, 2012). In addition fisheries generate part-time employment for people through subsistence fishing, whose numbers peak in the flood seasons from June to October, and through related activities such as net manufacturing, processing, marketing, seed collection and distribution, and other ancillary activities. Considering the scarcity of pasture land in this country, fish is the next best alternative to substitute animal protein, which is very essential for human body. At present the fisheries sector in Bangladesh represents as one of the most productive and dynamic sectors in the country. The growth rate of fisheries sub-sector to Gross Domestic product has increased from 5.75 percent in 2005-06 to 6.49 percent in 2012-13 (BER, 2014). Yet, its growth and economic return is far less than actual potential.

1.4 Concept of Rice-cum-Fish Culture

The introduction of fish rearing with rice farming creates an integrated agro ecological system. Rice is a globally important stable food crop, with a wide distribution and constituting diversified varieties. Rice-cum-fish farming systems constitute a unique agro-landscape across the world, especially in tropical and sub-tropical Asia. The basic principles involved in integrated farming are the utilization of the synergetic effects of integrated farming activities and the full utilization of farm waste. It is based on the concept that “There is no waste” and “Waste is only a misplaced resource which can become a valuable material for another product” (FAO, 1977). Integration of fish with other animal and crops is the most efficient way of increasing production from per unit area of land. Integration within the farm has been a practical necessity, where farmed fish have been economically and nutritionally most important. Integrated aqua-culture compliments and improves the overall yield in terms of labor input, efficiency and resource use. The most common forms of integration are those where there is a direct and simple link between activities, such as the use of animal, crop waste as fish feed and fertilizer. Rice-cum-fish is a common practice of integrated farming system in Bangladesh.

There are four basic type of rice agro-ecosystems: irrigated ecosystems, upland (terraces), lowland rain fed ecosystems and flood-prone (very deep water) ecosystems. Rice-fish culture enhances both rice and fish production, but production is high at low-medium intensities although the fish diversity is most in traditional and low intensity systems. Rice-cum-fish farming is innovative and adopting to changes in rice farming. There are basically two types of rice-fish or rice-cum- fish systems in Asia, concurrent (or mixed) and rotational, each with four intensities of production: traditional, low, moderate, and high intensity with cultured fish (Hossain et al., 2011).

i) Simultaneous or Integrated or Mixed Method

Under this method, fish and rice are simultaneously cultivated in the same field. This method is suitable for those moderately high lands that remain flooded by rain water for 4-6 months a year during the Aman season or for those lands that come under irrigation during the Boro season.

ii) Alternate or Rotational Method

Lands usually flooded during the rainy season and where no other variety of rice but deep water Aman rice can be cultivated, can be used for this type of fish culture during the

Aman season. As example, low lying areas of Tangail district and Bhaluka upazila of Mymensingh district can be referred for rotational method of fish culture. This type of land yields only Boro rice during the dry or Boro season and cannot be used for rice culture in the rainy season for excess water logging and therefore be used for fish culture only.

1.5 Goods and Services of the Rice-cum-Fish Culture

The rice-fish system provides multifunctional goods and services: food security (rice and fish production); nutrition and income generation (consumption and sale of fish); conservation of biodiversity (fish and associated species help to use less pesticides); pest regulation (fish feed on insects and cleans pathogen in water); pollination (fish hits rice plants and helps the rice pollination); carbon and nutrient cycles (fish reduces residues of plants and recycle nutrient by excrement, azolla on the surface of water and also fixes nitrogen) and soil and water conservation and restoration (rice fields retain water and harvest soil nutrient from the natural streams and canals).

1.6 Global Importance of Rice-cum-Fish Culture

Rice-fish farming systems are globally important in terms of food security and appear to be globally important in terms of three global environment issues: climate change, shared waters and biodiversity. Methane is a major greenhouse gas emitted by rice fields, with emission determined by farming practices, plant metabolism and soil properties. Irrigated systems tend to contribute more emissions than rain-fed systems. Irrigated rice-fish systems are therefore major concern for climate change and even though they may be under some form of public or private management, they need a subsidy for generating the information required for mitigation measures. There is scope for considering the applicability of global environmental subsidies from the global environment facility for generating this information where national developing economics are unable to allocate them the desire priority. From a biodiversity perspective, rice-fish farming systems embody low-moderate rice genetic diversity due to intense varietal selection primarily for yields and secondarily for system maintenance and economic viability; moderate-high fish species diversity for some protein production and secondary importance especially in subsistence production systems; and low-moderate aquatic biodiversity due to transformation of complex swamp systems into simple agro-ecosystems (Fernando, 1996). Fish species and aquatic biodiversity appear richer in traditional and low intensity rain-fed than in high intensity irrigated rice-fish systems. The adequacy of this biodiversity for different ecosystems functions, as in agro-ecosystems in general, needs careful examination in terms of global environment in comparison to natural swamp ecosystems.

1.7 Importance of Rice-Cum-Fish Culture in Bangladesh

In a country like Bangladesh where land is scarce, efforts should be made to increase food production through integration of various production systems like rice-cum-fish culture for efficient utilization of scarce resources and maximization of diversified production. The rice- cum-fish culture is an innovative farming system in which, rice is the main enterprise and fish production is taken as additional means to secure extra income. Therefore, huge rice cultivated area, especially in medium to medium-high land, where water holding capacity is high can be developed for rice-cum-fish culture following a simple management system. Rice-cum-fish ecosystem is giving an additional production from rice fields and at the same time fishes eat up harmful insects, egg and larvae from rice fields, leading to more production and less use of insecticide. Moreover, excrete of fishes becomes a potential source of organic fertilizer for rice plant nutrition, and fish movement in water diffuses more oxygen for better nutrient uptake of plants. So, this system is ecologically sound and environment friendly. On the other hand, poor families having small rice fields fit for rice-fish culture cannot utilize their limited resource for good harvest due to lack of financial capacity and technical know-how. This type of technology, if disseminated through training followed by credit assistance, might be the source of additional income and family nutrition. Culturing fish in rice fields through improved technology will help the poor farmers to increase their income and ensure food security in lean periods

1.8 Advantages of Fish Culture in Rice Fields

i. If fish is cultured with rice, one can get fish as additional yield from the same land
ii. Fishes eat up insects and pest harmful to rice and obstruct of weeds to grow. So, usually it is no necessary to use pesticides in the rice fields
iii. No need for additional capital except low cost incurred in buying fingerlings and feed
iv. Fish-feces play an important role as fertilizer in increasing fertility of soil. So, cost of fertilizer becomes relatively less
v. More yield of rice, so rate of profit is more and
vi. Increase employment opportunity.

1.9 Justification of the Study

Fish culture in rice fields have enormous prospects in Bangladesh and the present low yield could be increased to a considerable extent by adopting scientific management and practices. Thus both fish and rice production could be increased by adopting integrated rice-cum-fish culture.

While developing and transferring technologies, it is important to understand the farmer's resources which should be better utilized for minimizing input costs and optimizing returns. Technologies often developed for increased production, have proved technically feasible and economically visible in on-station research trials, but failed when taken to farmer's field for their adoption.

Fish culture in the rice field in the truest sense of the term is relatively new in Bangladesh. The traditional practice of wild rice-fish culture is still dominant. It is therefore, an urgent need to diffuse the technology among the rice farmers by highlighting the economics of rice-cum-fish culture. Thus an in depth study to investigate the economics of rice-cum-fish culture is timely.

Although this practice has gained remarkable popularity, the people do not adequately know the economic consequences of this practice. The study will determine profitability of raising rice-cum-fish culture by farmers in their field. Thus it is believed that the proposed study will contribute significantly in adding new knowledge in the field of agricultural production policy. The study deals with some hitherto uncovered issues and hence may be considered important both for farmers and policy makers in agriculture.

1.10 Objectives of the Study

i. To identify the major socio-demographic characteristics of rice-cum-fish farmers
ii. To assess the profitability of rice-cum-fish farmers
iii. To estimate the contribution of key inputs to the production processes of rice-cum-fish culture
iv. To measure the resource use efficiency of rice-cum-fish culture and
v. To identify the major constraints faced by rice-cum-fish farmers

1.11 Organization of the Study

This thesis is divided into nine chapters. Chapter 1 describes the introduction of the thesis. The relevant review of literature of the study is discussed in Chapter 2. Chapter 3 describes the research design of the study. Description of the study area is included in Chapter 4. Chapter 5 represents the socio-demographic profile of the selected farmers.

Profitability of rice-cum-fish production is shown in Chapter 6. Effects and resource use efficiency of inputs use are shown in Chapter 7. Constraints associated with rice-cum-fish culture are shown in Chapter 8. Summary and conclusion are shown in Chapter 9.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

This chapter presents the review of relevant literature with a view to understand the method and cause-effect relationship of past and present research work on rice-cum-fish culture. This would help in narrowing down the problem correctly and in selecting the most appropriate technique of analysis. Relatively little research has been done on rice-cum-fish culture in Bangladesh. Unfortunately a few number of economic studies are available in our country. This chapter reviews studies concerning the socio-economic aspects, problems and profitability of rice-cum-fish culture, which have so far been made by different researcher and organizations.

Kabir (2000) conducted an experiment on integrated rice-fish culture and rice mono culture. The average net return per hectare of integrated rice-fish farming were Tk. 12528 while the per hectare net return from HYV Boro paddy were Tk. 9199. However, integrated rice-fish farming has been playing a significant role in view of contribution towards self-sufficiency in food grains and nutritional security, generating self-employment and income.

Mondol (2001) conducted an experiment on the culture of dhela (*Rohtee cotio)* in combination with mola (*Amblypharyngodon mola)* and mirror carp (*Cyprinus carpio)* in rice fields and he found that the yield of rice grain and straw were found to increased by 9.02-17.29 percent and 9.80-18.85 percent respectively in treatments with fish than without fish.

Miah (2001) conducted a study showed that four different farming systems were practiced such as, year round shrimp farming, alternative shrimp-salt farming, alternative shrimp-rice farming and rice production throughout the year. In year round shrimp farming per hectare total cost, production and net returns of shrimp were Tk. 47779.00, 275 kg and Tk. 77226.00 respectively. In case of alternate shrimp-salt farming, per hectare total cost, shrimp production, salt production and net return were Tk. 92117.00, 1245 kg, 66120 kg and Tk. 155048.00 respectively. In case of alternate shrimp-rice farming, per hectare total cost of shrimp production, shrimp and rice production and net return were Tk. 28470.00, 207 kg, 1280 kg and Tk. 2300.00 respectively. In rice production throughout the year per hectare total cost was Tk. 15062, rice production

(Aman + Boro paddy) was 6180 kg and net return was Tk. 29698.00. It also reveals that alternate shrimp-salt farmers used more inputs compared to the farmers of other farming systems and it was more profitable than the other farming systems.

Das (2002) conducted two sets of experiments, one with mola (*Amblypharyngodon mola)* in different stocking densities and another with dhela (*Rohtee cotio)* in combination with silver barb *(Barbodes gonionotus)* and mirror carp (*Cyprinus carpio).* He stated that yield of rice grain and straw increased by about 5.9013.24 percent and 5.61-14.05 percent respectively by rice- fish culture than rice culture alone.

Duong and Ollevier (2002) conducted a study on the effect of fish on rice-cum-fish fields. Some of them show increased rice yields, others show no effects or even decreased yields. In order to verify the impact, they used eight independent variables such as season, water depth, rice variety, rice sowing rate and the effective stocking density of silver carp, nile tilapia, common carp and snakeskin gourami. Season had the biggest impact on nearly all dependent variables. Rice yields in the wet season were on the average 2.42 t/ha lower compared to the yield during the dry season. Higher water levels decreased the number of panicles and rice yields. Rice sowing rate affected the yield component variables but had no impact on the rice fields. Increased water level and reduced rice arable area, the main two requirements from rice-fish culture, result in lower rice yields from rice-fish systems as compared to mono culture system.

Ali *et al.* (2002) conducted their study on rice-fish farming in Mirzapur thana of Tangail district. They obtained that the yield from rice was 8.0 t/ha and the average income from rice was found Tk. 29037. They also found that the net benefit from fish was Tk. 4900 per hectare from rice-fish experiment.

Islam and Rashid (2004) evaluated the Aquaculture Extension Projects (AEPs) of different NGOs. They found that almost all farmers practiced culture and management to some to achieve higher yield and economic return. But as a whole, their fish production yet not reached up to desired level. Regarding sustainability of aquaculture, most of the farmers had goal to earn more income with increased production of fish. They also pointed out that aquaculture income contributed to household income that provided food security and compensated other household expenditure. Finally, the study suggested for support services and institutional credit to make the production system sustainable and effective.

Roy (2005) conducted a study on an economic analysis of rice-fish farming under the North West fisheries extension project in some selected areas of Dinajpur district. Activity budgets were prepared to find out the profitability of integrated rice-fish culture. Cobb-Douglas production function was applied to determine the profitability of integrated rice-fish culture. Per hectare cost of production for integrated rice-fish culture stood at Tk. 27287. Per hectare rice and fish yields were 3035 kg and 696 kg respectively. Net return from integrated rice-fish farming was Tk. 25780 per hectare.

Parvin (2005) conducted an experiment on an economic study on fish based farming systems in some selected areas of Mymensingh district. The study was designed to assess the relative profitability and factor share of income from fish based alternative farming system. For this study, farms were classified into three categories such as Alternate Rice-Fish (A-R-F), Rice-Cum-Fish (R-C-F) and Only Rice Farming (O-R-F) systems. She found that per hectare gross cost of production of A-R-F, R-C-F and O-R-F farming systems were Tk. 102403, Tk. 103916 and Tk. 50248 respectively. Per hectare gross return were Tk. 172809, Tk. 125395 and Tk. 53859 and net returns were Tk. 70406, Tk. 21479 and Tk. 3611 for the same farming systems respectively.

Alam (2006) conducted a research on rice-fish culture in one-hectare area of rice field in Dhaka district. He demonstrated that farmer can get 3-5 tons of rice and 234 kg of fish from one hectare of land. The net benefit obtained from fish component was Tk. 1350 while the same from the rice component was Tk. 35500. The author showed that rice -fish integration is quite attractive.

Ahmed and Bamboo (2008) conducted an experiment to measure the suitability of integrated rice-cum-fish culture in some selected areas of Paikgacha thana under Khulna. Mixed and mono culture of rajpunti (*Puntius gonionotus)* and mirror carp (*Cyprinus carpio)* attained the highest average individual weight 160gm and survival 81.06 percent with respect to biomass and income. The highest average fish production and net profit per ha were 306.74 kg and Tk. 8177.9 obtained in mix culture of rajpunti and mirror carp.

Haque *et al.* (2008) conducted a study to examine the relative profitability of rice-cum-fish culture and rice mono crop production. The results of the study showed that rice-cum-fish farming was more economically rewarding than the rice mono crop farming. Both farming activities were found profitable over cash as well as full costs. In addition to extra earning, there is minimum extra cost for fish. Rice-cum- fish farming also reduced variability in yield and return from rice.

Yesmin (2009) conducted a study on impact of rice and rice-cum-fish culture on income and livelihood of farmers in some selected areas of Mymensingh district. The major findings of the study indicated that total per hectare costs of rice and rice-fish production were estimated at Tk. 47657.44 and Tk. 61173.42. Again average gross return, gross margin and net returns per hectare of rice and rice-fish farming were estimated at Tk. 86400, Tk. 47307, Tk. 38742.56 and Tk. 117280, Tk. 52184, Tk. 56108 respectively. The additional net change of income by introducing fish with rice in their farming was estimated at Tk. 17364.02.

Ahmed (2009) examined the impact on fish culture in Deep-Water Rice (DWR) environment using net pen and polder system. In net pen, rui and Thai silver barb were cultured, whereas a 5 species combination (rui, marital, common carp, grass carp and Thai silver barb) were cultured with BR3 rice variety and DWR. In polder system 2.8 tone/ha of fish and 7.33 tone/ha of rice were produced with 5 species combinations.

Mazid and Hossain (2010) had given a brief account of the integrated rice-fish farming technology developed by BFRI. This technology is an alternative source of income and at the same time provides family nutrition for the resource poor farmers in the country. Fish species such as Rajpunti *(Puntius gonionotus),* Mirror carp *(Cyprinus carpio)* or Nile Tilapia *(Orcochromis niloticus)* can be stocked. Per hectare net return obtained from the fish component and rice were Tk. 10000 and Tk. 4000.

Hossain *et al.* (2011) examined the impact of rice-fish culture in farmers' fields at the Kazirshimla under Trishalthana of Mymensingh district and at the Agronomy field laboratory of the Bangladesh Agricultural University. The net incomes obtained at the Agronomy field laboratory and farmer's field were Tk.11.4093.75 and Tk. 2672.0 respectively.

Billah (2012) conducted a study on an economic analysis of rice-cum-fish farming in some selected areas of shyamnagar upazila under Satkhira district. The major finding of the study was total per hectare cost of rice-cum-fish production was estimated at Tk. 88120. Per hectare variable cost of rice-fish production was Tk. 71537. Total gross return, gross margin and net returns per hectare of rice-fish farming were estimated at Tk. 172400, Tk. 100863 and Tk.84280 respectively.

2.2 Concluding Remarks

From the above discussion it is clear that several studies were conducted in Bangladesh concerning the issue related to comparative profitability of rice-cum-fish culture. But no studies were accomplished to focus on the effects of input to the production process and on the resource use efficiency of different inputs used. Therefore, this study has attempts to analyze the profitability, input output relationship, and resource use efficiency of rice-cum-fish culture in the study area. It is believe that the present study will contribute significantly to generate new knowledge in the field of the assessment of aquaculture technology.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter presents a detailed sequential steps of research work for instance, selection of the study area, preparation of survey schedule, selection of sample, period of data collection and analysis of data.

The study was conducted to measure profitability and resource use efficiency of rice-cum-fish culture in a selected area of Bangladesh and also to determine socio-economic characteristics of farmers. Necessary data were collected from the farmers of the selected areas and analyzed in terms of the objectives set for the study.

3.2 Selection of the Study Area

The selection of the study area is an important step, which largely depends upon objectives set for the study. According to Yang (1965), "the area in which a farm business survey is to be conducted relies on the particular purpose of the survey and possible cooperation from the farmers and other respondents." The aim of the present study is to determine profitability and resource use efficiency of rice-cum-fish culture. For selection of the study area, the researcher visited several villages namely Goyati, Baulia bazar and Chandorati under Bhaluka upazila of Mymensingh district. These three villages have similar types of land and soil characteristics and grow rice and fish in the same field. These areas were selected for some other reasons such as:

i. Availability of a large number of small farmers
ii. This type of study was conducted previously in the study area
iii. Easy accessibility and good communication facilities in these villages and
iv. Researcher herself was fairly well known to the local customs and practices and was able to speak the farmers' language. A good cooperation was expected from the respondents.

3.3 Sources of Data

Data required for the present study were collected from primary and secondary sources. Primary data were collected from sample farmers and secondary data were collected from various published sources. Secondary sources were Bangladesh Bureau of Statistics

(BBS), Bangladesh Economic Review (BER), Department of Fisheries (DoF) and other related agencies in Bangladesh.

3.4 Selection of Sample

The main purpose of sampling is to select a small group which will represent a reasonably true picture of the population. The size of the sample depends on a number of factors like variability in local conditions, degree of precision required, types of tabulation desired, the funds, the personnel and the time available for research. However, two factors need to be considered before selecting a sample. First one relates to the sample size which should be large enough to allow for adequate degrees of freedom in the statistical analysis. On the other hand, administration of field research, processing and analysis of data should be manageable within the limitation imposed by physical, human and financial resources (Mannan, 2001).

So, the selection of sample size was one of the crucial aspects for the study. A reasonable size of sample was followed in this study to collect relevant data and information. There are several methods of collecting this basic information. For this study data were collected by the survey method. The word “survey” refers to a method of study in which an overall picture of a given universe is obtained by systematic collection of all available data on the subject (Efferson, 1963). It is a method of data collection based on communication with a representative sample of individuals. The main reasons why the survey method was preferred:

- Survey through sacrificing a certain details, enables quick investigation of a large number case
- Survey entails much less cost (Efferson, 1963) and
- Survey provides quick, inexpensive, and efficient measurement.

Survey method was followed to collect production related data while, simple random sampling technique was used to select the rice-cum-fish farmers. A total of 60 farmers were selected from the selected villages.

3.5 Preparation of Survey Schedule and Pre-testing

The survey schedule was designed in accordance with the objectives of the research. Data were collected from the operating farms by survey method through personal interview with the farmers for which necessary schedules were to prepare. Information about farmers fixed resources, farm income and detailed information about rice-cum-fish culture such as acreage grown, use of inputs such as labor, seed, fingerling, manures, fertilizers, water, pesticides including their prices were collected. The schedules were tested prior to implementation and were improved for applicability in the actual field conditions.

3.6 Period of Data Collection

Data were collected by the researcher herself through personal interviews with the respondents. Data were collected during the period from January to mid February, 2014. Prior to final data collection the interview schedule was pre-tested by collecting information from selected samples.

3.7 Data Collection and Accuracy of Data

Generally most of the farmers did not keep their written records on annual, monthly or daily transaction and activities. It was very difficult to collect actual data. Because the information was supplied from their memory and the researcher had to rely solely on the memory of the farmers. To overcome this problem, all possible efforts were made by the researcher herself to ensure collection of reasonably accurate information from the field on recall basis. So, it had not been possible to apply any other method of investigation such as cost or financial accounting which would require detailed and accurate information based on properly kept records and accounts. Survey method has the advantage that it facilitates quick investigation and involves less cost. In order to collect relevant information before taking interview, the whole academic purpose of the study was clearly explained and made clear to the sample respondents. The researcher herself collected the relevant data from the selected farmers through face to face interview. At the time of interview, the researcher asked questions systematically and explained whenever felt necessary. So, collected data were checked and verified in the field for accuracy and consistency.

3.8 Editing and Tabulation of Data

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 SPSS and STATA programs were used. It might be observed here that information was collected initially in local units and after checking the collected data, it was converted into standard units. Finally, a few relevant tables were prepared according to necessity of analysis to meet the objectives of the study.

3.9 Analysis of Data

Collected data were classified, tabulated and analyzed in terms of the objectives set for the study. Both tabular and statistical techniques were used to find important relationships among the relevant variables.

3.9.1 Tabular Technique

Tabular technique of analysis is generally used to find out the crude association or difference between two variables. In this study tabular technique was used to illustrate the whole picture of analysis. The sum, gross returns etc. of this technique is based on arithmetic average.

The advantages of tabular analysis are:

- Computation of data involves less work and
- It illustrates the whole picture of analysis as well as the results of analysis

3.9.2 Statistical Technique

3.9.2.1 Profitability Analysis

Nine variables such as cost of human labor, seed/seedling, fingerling, fertilizer, insecticide, power tiller, irrigation, feed, pond preparation in rice-cum-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,

$$\text{Profi } (\pi) = \sum_{i=1}^{n} \left(P_{yi}.\, Y_i\right) - \sum_{i=1}^{n} \left(P_{xi}.\, X_i\right) - \text{TFC}$$

Where,

Π= Net Return,

P_{yi}= Price per unit of the ith produce

Y_i= Quantity of the ith produce

P_{xi}= Price per unit of the ith inputs

X_i = Quantity of the ith inputs

TFC= Total Fixed Cost.

3.9.2.2 Multiple Regression Analysis

The general purpose of multiple regression analysis is to learn more about the relationship between several independent or predictor variables and a dependent or criterion variable. For example, the yield of rice-cum-fish per hectare depends upon quantity of seed, human labor, fingerling, fertilizer, irrigation water, insecticide, feed used etc. It enables us to study the individual influence of these variables on yield. The most common form of multiple regression analysis i.e., Cobb-Douglas production function which had been used in the present research.

Cobb-Douglas Production Function

For determining the effect of variable inputs to the production of rice-cum-fish, Cobb-Douglas production function chosen on the basis of 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:

$$Y = aX_1^{b_1}X_2^{b_2}X_3^{b_3}X_4^{b_4}X_5^{b_5}X_6^{b_6}X_7^{b_7}X_8^{b_8}X_9^{b_9}e^{u_i}$$

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

$$\begin{aligned} ln\,Y = lna + b_1 lnX_1 + b_2\,lnX_2 + b_3 lnX_3 + b_4 lnX_4 + b_5 lnX_5 + b_6 lnX_6 + b_7 lnX_7 \\ + b_8 lnX_8 + b_9 lnX_9 + U_i \end{aligned}$$

Where,

Y = Gross return (Tk./ha)

X_1= Cost of human labor (Tk./ha)

X_2= Cost of seedlings (Tk./ha)

X_3= Cost of fingerlings (Tk./ha)

X_4= Cost of fertilizers (Tk./ha)

X_5= Cost of Insecticide (Tk./ha)

X_6= Cost of power tiller (Tk./ha)

X_7 = Cost of irrigation (Tk./ha)

X_8= Cost of feed (Tk./ha)

X_9 = Cost of pond preparation (Tk./ha).

In a = Constant or intercept of the function

b_1, b_2, …, b_9= Coefficient of respective variables;

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

ln = Natural logarithm; and

U_i= Error term.

Cobb-Douglas form of production function has the following advantages.

- $\frac{dy}{dxj} = \frac{bj}{xj}$ y [ify = f(xj)];
- Elasticity of Y upon xj can be easily read out from bj;
- In Cobb-Douglas production function, returns to scale can be easily calculated by simply summing up the elasticity of Y with respect to Xj and
- This form of production function explains that agricultural production operates under either constant increasing or decreasing returns to scale

Production function analysis was done to determine the resource use efficiency and productivity of rice-cum-fish farmers. Cobb-Douglas function was fitted to determine the impact of selected inputs on productivity of rice-cum-fish farming. Marginal productivity of selected inputs was calculated to ascertain the level of efficiency of individual input use.

3.9.2.3 Efficiency of Resource Allocation

In order to test the efficiency, the ratio of Marginal Value Product (MVP) to the Marginal Factor Cost (MFC) for each input was computed and tested for its equality to 1.i.e; $\frac{MVPxi}{MFCxi} = 1$

The marginal productivity of a particular resource represents the additional to gross returns in value term caused by an additional one unit of that resource, while other inputs are held constant. When the Marginal Physical Product (MPP) was multiplied by the product price per unit, the marginal value product (MVP) was obtained. The most reliable, perhaps the most useful estimate of MVP is obtained by taking resources (Xi) as well as gross return(Y) at their geometric means (Dhawan and Bansal, 1977).Since all the variables of the regression model were measured in monetary value, the slope co-efficient of those explanatory variables in the function represented the MVPs, which were calculated by multiplying the production co-efficient of given resources with the ratio of Geometric Mean (GM) of gross return to the Geometric Mean (GM) of the given resources i.e.

$$ln\, Y = lna + b_i lnX_i$$

$$\frac{dy}{dx_i} = b_i \frac{Y}{X_i}$$

$$MV \quad (X_{i)} = b_i \frac{\overline{Y}(GM)}{\overline{X_i}(GM)}$$

Where,

Y = Mean value (GM) of gross return in Taka;

Xi = Mean value (GM) of the ith variable input in Taka;

i = 1, 2, 3, 4, 5, 6, 7, 8 and 9

$\frac{dy}{dxi}$ =Slope of the production function as well as MVP of the ith input

Marginal factor cost (MFC) is the price of per unit of input. If the marginal factor costs of all the inputs expressed in terms of an additional, Taka, in calculating the ratio of MVP to MFC, the denominator will always be one, and therefore, the ratio will be equal to their respective MVP. In order to identify the status of resources use efficiency it was compared that a ratio equal to unity indicates the optimum use of that factor, a ratio more than unity indicates that the gross return could be increased by using more of that resource and a value of less than unity indicates the unprofitable level o f resource use which should be decreased to minimize the losses.

3.10 Specification of Variables

This required specification and measurement of variables in the form of input used and output received in the production of rice-cum-fish farming. Inputs used included human labor, seed, different materials used and output was yield per hectare of crop and by-product. Different input and output figures were multiplied by the average price to get cost and return figures for producing rice-cum-fish but since no cash payment was made for the home-supplied inputs, the costs of these inputs were stir by using opportunity cost principle.

3.10.1 Cost of Human Labor

Human labor was found to be the major input in rice-cum-fish culture. There were two types of human labor, family and hired labor. Family labor consists of the farm operator himself and other family members. Human labor for rice-cum-fish culture included total man-day spends on various operation for producing the crop and fish such as land preparation, sowing/planting of seed, weeding, manuring, fertilizering, insecticide application, feeding fish, digging ditch, harvesting, threshing, carrying, etc. One man day consists of eight hours of work, by an adult man. Child and woman labor was converted into man equivalents by assigning appropriate ratios. This was as follows (Yang, 1965):

1 adult man = 1.5 adult woman = 2 children

Total man-days used per unit of land was multiplied by the market wage rate to arrive at human labor cost for rice-cum-fish culture. Thus opportunity cost of unpaid family labor was considered equal to the market wage rate for calculating human labor cost.

3.10.2 Cost of Seed/Seedling

In the study area, farmers used both home supplied and purchased seedling. The cost of purchased seed/seedling was calculated on the basis of actual price paid by the farmers. The cost of home supplied seedling was estimated at the prevailing market price.

3.10.3 Cost of Fingerling

Fingerling is a major input for rice-cum-fish culture. The farmers purchased fingerling from fry collectors and hatchery. Fingerling cost included per piece price of fingerling. The cost of purchased fingerling was calculated on the basis of actual price paid by the farmers.

3.10.4 Cost of Fertilizer

In three sampled villages farmers used different kinds of fertilizers for higher yield. They normally used Urea, Triple Super Phosphate (TSP), and Muriate of Potash (MP). Costs of these fertilizers were estimated according to the price paid by the farmers. For rice-cum-fish culture farmers used cow dung as manure application. In this study area farmers mainly used home supplied cow dung. The cost of cow dung was calculated at the prevailing local market prices.

3.10.5 Cost of Insecticides

In rice-cum-fish culture, a few number of insecticides was used because a large number of insecticide application might harmful for fish. But some insecticide was needed for rice, which applied at beginning period of rice sowing. In the study area, rice-cum-fish growers used pesticides, such as Dimecrone, Dia than, Furadan, etc. The costs of insecticides were computed on the basis of the actual price paid by the farmers.

3.10.6 Cost of Power Tiller

In the study area land preparation is mainly done by power tiller in rice-cum-fish culture. Power tiller was used by almost all farmers. There was a competitive rate for using power tiller in the study areas. The farmers paid the charge for power tiller used at a fixed rate prevailing in the study area.

3.10.7 Cost of Irrigation

In the study area farmers mostly used motor pump for irrigation. The cost of water was charged at fixed rate for the season on the basis of per unit of irrigated land for power pump.

3.10.8 Cost of Feed

Supply of artificial supplementary feeds, which can compliment nutritional deficiency, is important to increase fish production. In the study area rice-cum-fish farmers mostly used rice bran and oil cake, as supplementary feed for fish. Cost of feeds was computed at the prevailing market price.

3.10.9 Cost of Pond Preparation

In rice-cum-fish culture it is necessary to digging a ditch for rearing fish. Both family and hired labor were used to digging the ditch. At first, labors dig a ditch, clean the weeds from here and then use lime to prepare the ditch for rearing fish. Lime is an important factor to rice-cum-fish culture which prolongs healthy and productive environment for fish. Total man-days used per unit of pond preparation were multiplied by the market wage rate to arrive at human labor cost. Cost of lime was charged at the price actually paid by the farmers.

3.10.10 Interest on Operating Capital

Interest on operating capital was determined on the basis of opportunity cost principle. The operating capital actually 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 10 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 = (total investment)/2;

i = interest rate which was assumed at 10 percent; and

t = length of the period of rice production (6 month).

3.10.11 Land Use Costs

In the study area the cost of land was different to plots depending on location, topography and fertility of the plots. It also varies from one season to another, i.e., from Kharif to Rabi season. Land use cost was calculated on the basis of opportunity cost of the use of land per hectare for the cropping period of six months. In this study, the cost of land use was considered as cash rental value of land.

3.11 Calculation of Returns

3.11.1 Gross Return

Per hectare gross return was calculated by multiplying the total amount of product and by-product by their respective per unit prices.

3.11.2 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

3.11.3 Net Return

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

$$\text{Net return} = \text{Total return} - \text{Total production cost}$$

3.11.4 BCR (Benefit Cost Ratio)

The undiscounted benefit cost ratio (BCR) is a relative measure which is used to compare benefits per unit of cost. It helps to analyze the financial efficiency of the farms.

BCR was calculated by using the following formula-

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

3.12 Problems Encountered in Collecting Data

The researcher had to face 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.

CHAPTER 4

DESCRIPTION OF THE STUDY AREA

4.1 Introduction

The description of the study area is important because it provides a brief, clear, and unambiguous description of the study area to identify farmers' level of living and the silent features of the area. The description of the study area includes location, physical features, topography, climate, temperature and rainfall, occupation of the villagers, communication and marketing facilities. This information is essential for better understanding of the facts and findings of the research and for the selection of the study area.

4.2 Location of the Study Area

Mymensingh zila is bounded on the north by India, on the east by Netrokona and Kishoreganj zilas, on the south by Gazipur zila and on the west by Tangail, Sherpur and Jamalpur zilas. The total area of the zila is 4363.48 sq. km (1684.75 sq. miles) of which 106.71 sq. km (41.20 sq. miles) is under forest. The zila lies between 24º15' and 25º12' north latitudes and between 90º04' and 90º49' east longitudes. The Mymensingh zila consists of 12 upazilas, 146 unions, 2201 mauzas, 2700 villages, 8 paurashavas, 84 paura wards, and 217 Mahallahs. The areas selected for the study were Goyati, Baulia bazar and Chandorati villages of Bhaluka Upazila in Mymensingh district. Bhaluka upazila ranks 2nd in area measuring scale out of 12 upazilas of Mymensingh zila. The Bhaluka upazila occupies an area of 444.05 sq km. including 92.76 sq. km. forest area. It is located between 24º16' and 24º29' north latitudes and between 90º14' and 90º29' east longitudes. The upazila is bounded on the north by Fulbaria and Trishal upazilas, on the east by Gaffargaon upazila, on the south by Sreepur upazila of Gazipur zila and on the west by Shakhipur upazila of Tangailzila (BBS, 2011).

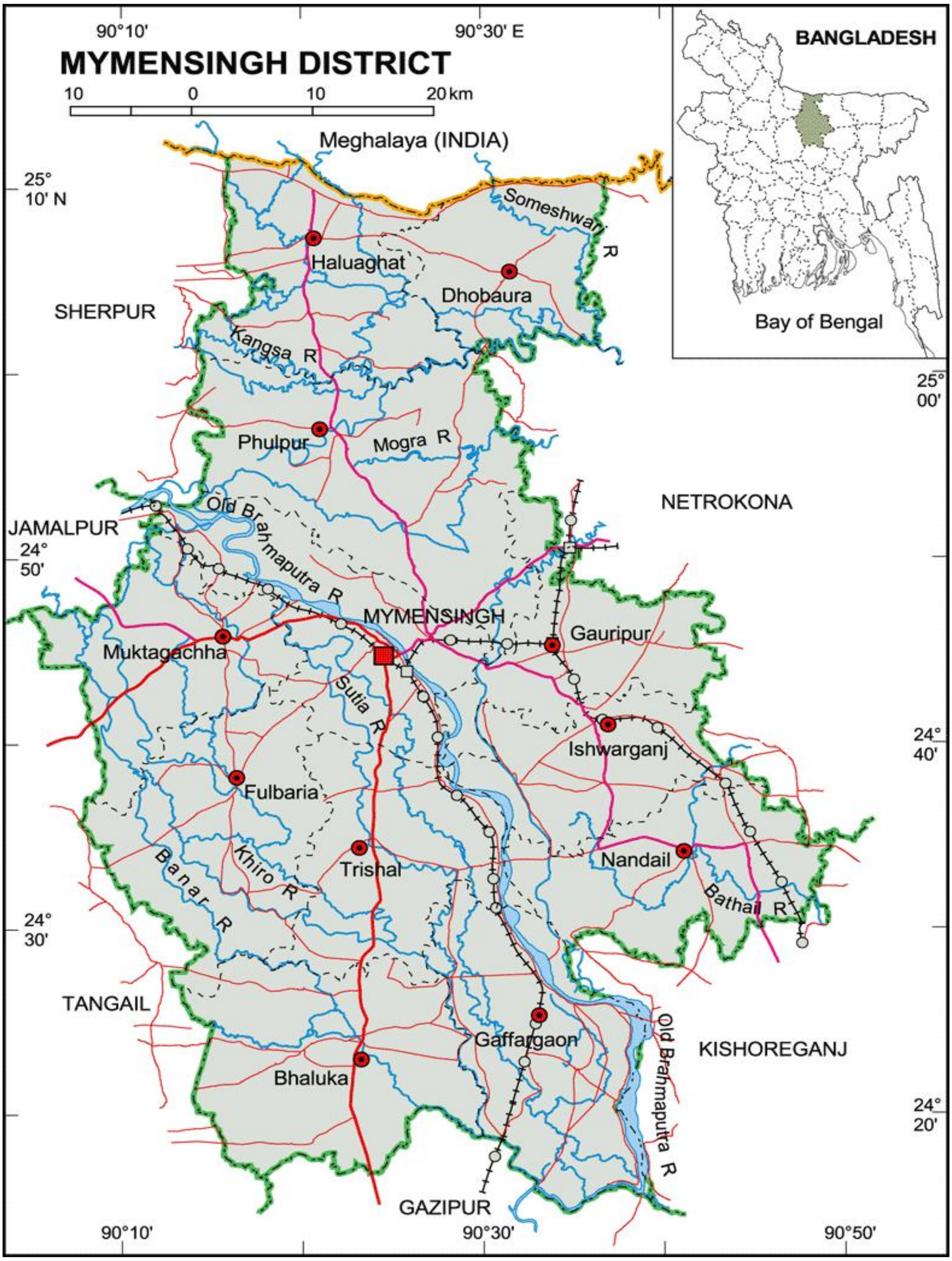

Figure 4.1: Geo-Code of Mymensingh District

Source: Adapted from Banglapedia.com

Figure 4.2: Geo-Code of Bhaluka Upazila

Source: Adapted from Banglapedia.com

4.3 Land Utilization Pattern

The Bhaluka upazila occupies 31395.31 hectares of cultivable land among which 30.08 percent was single cropped area, 56.91 percent was double cropped area, and 13.01 percent was treble cropped area. The main crops of the study area were paddy, jute, sugarcane, wheat, mustard seed and pulse. Total fallow land was 4416.43 hectares (BBS, 2011).

4.4 Area, Population and Literacy Rate

The Bhaluka upazila occupies an area of 444.05 sq km. Total population of this upazila was 430320, out of which 50.46 percent were males and 49.54 percent were females. The population growth rate was 3.32 percent. Muslim population comprises of 94.90 percent, Hidu population 4.65 percent, Christian population 0.12 percent, Buddhist 0.06 percent and other religions constitute 0.27 percent of the total population in the Upazila (BBS, 2011).

The average literacy rate of Bhaluka upazila was 49.1 percent, whereas the literacy rate of male was 52.0 percent and female was 46.2 percent. The Upazila consists of 5 colleges, 26 high schools, 17 junior schools, 34 madrasas, 94 government primary schools, 33 non-government primary schools, 22 community schools, 7 satellite schools and 11 technical schools (BBS, 2011).

Table 4.1 Area, Population and Literacy Rate of Bhaluka Upazila

Area in (Sq Km)	Land area	Reserve forest	Riverine area	Population	Male	Female	Literacy rate (%)
444.05	350.11	92.75	1.19	430320	50.46	49.54	49.1

Source: BBS, 2011

4.5 Household, Village, Union and Mauza

Total numbers of households of Bhaluka upazila were 106935. The Upazila consists of 110 villages, 87 mauza, 11 union, 1 municipality and 18 mahallas (BBS, 2011).

Table 4.2 Household, Village, Union/ward &Mauza of Bhaluka Upazila

No. of Households	No. of Mauza	No. of Union	No .of Village	No. of Mahalla	No. of Municipality
106935	87	11	110	18	1

Source: BBS, 2011

4.6 Occupational Status

About 63.9 percent people of the study area were engaged in agriculture where fishing 1.06 percent, agricultural labors16.19 percent, wage labors 2.63 percent, commerce 5.85 percent, service 2.74 percent and others 7.63 percent (BBS, 2011).

4.7 Livestock and Poultry

The farmers of the study area were raised cattle, goat, sheep, chicken and duck. According to the opinion of the Upazila Livestock Officer (ULO), chicken and duck population were gradually increasing in the study area. This was due to intervention of improved breed management and regular vaccination programme which reduced mortality.

4.8 Climate, Temperature and Rainfall

The climate condition of the area was considered not to be different from that of other parts of the district, because of its proximity to the Garo hill. The climatic condition was relatively cooler due to heavy rainfall. Summer was also often cooler.

Table 4.3 Monthly Average Temperature, Humidity and Rainfall of the Study Area in 2011

Months	Maximum Temperature (°C)	Minimum Temperature (°C)	Average Humidity (percent)	Rainfall (mm)
Jan	24.1	12.1	84	000
Feb	28.9	18.4	80	000
March	31.3	19.0	68	000
April	31.3	22.0	75	173
May	31.9	24.0	77	300
June	31.4	26.0	85	278
July	32.1	26.9	84	429
Aug	32.7	26.4	79	365
Sep	31.5	26.4	83	308
Oct	32.3	22.8	86	027
Nov	29.1	18.2	84	000
Dec	26.3	13.6	87	000

Source: BBS, 2011

The table 4.3 shows that maximum and minimum temperature in the study area ranged 32.7°C to 12.1°C. The average maximum temperature was the highest in August which was 32.7°C and the average minimum temperature was recorded in January which was 12.1°C. The highest humidity percentage was recorded as 87.00 percent in December and lowest humidity percentage was recorded as 68.00 percent in March. The rain was usually started from late April and continues up to September. The maximum average rainfall was about 2250 mm with the lowest during the month of January and the highest during the month of July (BBS 2011).

4.9 Non-Government Organization

At present, a number of important non-government organization (NGOs) such as BRAC, Proshika, SESAUS, Caritas, Gonoshahajjo Sangstha, ASA, CARE, Grameen Bank, Gana Chetana etc. were operating in the study area in recent years. NGOs were help to providing technical training on poultry and cattle rising, handicraft, livestock rearing and homestead gardening to the people of the study area. They also provide bank loans to poor women and landless farmers (BBS, 2011).

4.10 Transportation, Communication and Marketing Facilities

Transportation is an important part in agricultural and economic development of a country. Without well development transportation facilities, it is impossible of the rural people to enjoy the facilities of modern technology. There were 40 km Pucca road, 30km semi Pucca road, 1113 km mud road and 17 nautical miles waterways (BBS, 2011).

Marketing facilities are crucial to the modem economic life and play a vital role to rural development. The marketing facilities of villages in the study area were good. Formal marketing system locally called 'Hat' was present here. Total number of hats and bazars were 50. Main export products were banana, jack fruit, guava, sugarcane, vegetables, cotton, egg, chicken etc. The villagers were generally buy and sell their agricultural products and also purchased all other daily necessaries from these markets. There were 4 fish processing factory, 1 sugar mill, 9 rice mills, 15 iron mills, 40 goldsmiths, 1 salt production unit, 1 health centre, 51 cottage industries, 6 family planning centers and 1 public library (BBS, 2011).

CHAPTER 5

SOCIO-DEMOGRAPHIC PROFILE OF RICE-CUM-FISH FARMERS

5.1 Introduction

This chapter deals with the socioeconomic characteristics of the sample farmers. Socioeconomic characteristics of the farmers are important in influencing production planning. People differ from one another in many aspects. Behavior of an individual is largely determined by his/her socioeconomic characteristics. There are numerous interrelated and constituent attributes that characterize an individual and profoundly influence development of his/her behavior and personality. It was, therefore, assumed that enterprise combination, consumption pattern, purchase pattern, and employment pattern of different farm household would be influence by their various characteristics. The major characteristics considered in present study were age distribution, family size, level of education, occupation, annual income and land ownership pattern of rice-cum-fish farmers. A brief discussion of these aspects is given below.

5.2 Age Distribution of the Sample Farmers

Age of farmers have an influence on the production and in the better management of the farming system. Some researchers think that the older farmers are more experienced and more efficient in resources use. Other researchers comment that younger farmers are eager to adopt improved technology than older.

Table 5.1 Age Distribution of the Selected Farmers

Age group	Rice-cum-fish farmers	
	No.	Percent
Up to 30 years	12	20.0
31- 40	15	25.0
41- 50	23	38.3
Above 50	10	16.7
Total	60	100

Source: Field survey, 2014

In the present study, all categories of farmers of the study area were classified into different age groups as presented in table 5.1. The rice-cum-fish farmers were classified into four groups: up to 30 years, 31- 40 years, 41- 50 years and above 50. Out of the total sample farmers 20.0 percent belonged to the age group of up to 30 years, 25.0 percent belonged to the age group of up to 31-40 years, 38.3 percent belonged to the age group of up to 41-50 years and 16.7 percent fell into the age group of above 50. It is evident from the table that most of the farmers were middle aged in the study area.

5.3 Age Distribution of Farm Family Members

Figure 5.1 shows the age structure of the family members. In the present study, family members of selected farms were classified into different age groups such as below 15 years, 16 to 30 years, 31 to 45 years, 46 to 60 years and above 60 years. It was found that highest 28.27 percent of family members of sample farmers belonged to the age group below 16-30 years.

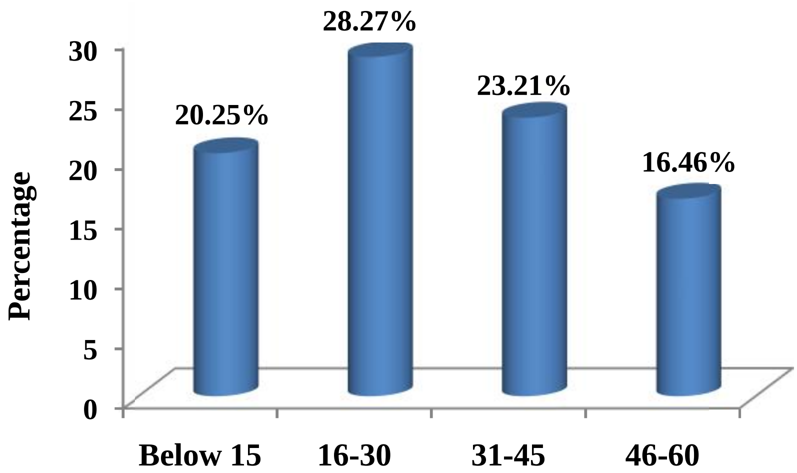

Figure 5.1 Age Distribution of Farm Family Members

5.4 Family Size and Male-Female Ratio

The farm family includes wife, sons, unmarried daughters, unmarried sisters, brothers, parents etc. The total numbers of persons of all families were classified into two groups such as: male and female.

Table 5.2 Gender Wise Distribution of Family Members

Gender group	Rice-cum-fish farmers	
	No.	**Percent**
Male	139	59
Female	98	41
Total	237	100
Family size	3.95	
Male-female ratio	1.42	

Source: Field survey, 2014

Table 5.2 indicates that 59 percent male and 41 percent female of the total number of family members were involved in rice-cum-fish farming. Family size was 3.95 and male-female ratio was 1.42.

5.5 Educational Status of the Respondents

Education is an inevitable prime prerequisite for progress in any field. It plays a critically important role in reducing poverty and inequality, improving health, enabling the use of new knowledge. Education of farmers may help to increase productivity. Literate farmers have better access to the relevant technical information for improvement of rice-cum-fish culture and can make rational production decision.

To examine the educational status of rice-cum-fish farmers, the sample farmers were divided into four categories. These were illiterate, primary, secondary and above secondary level of education. These who cannot sign, read and write were considered as illiterate. The level of education of the respondents is given in figure 5.2. It is evident from figure 5.2 that out of 60 farmers, 13.3 percent rice-fish farmers were illiterate, 30 percent farmers had primary education, 41.7 percent had completed secondary education and last of all only 15 percent farmers had above secondary level education.

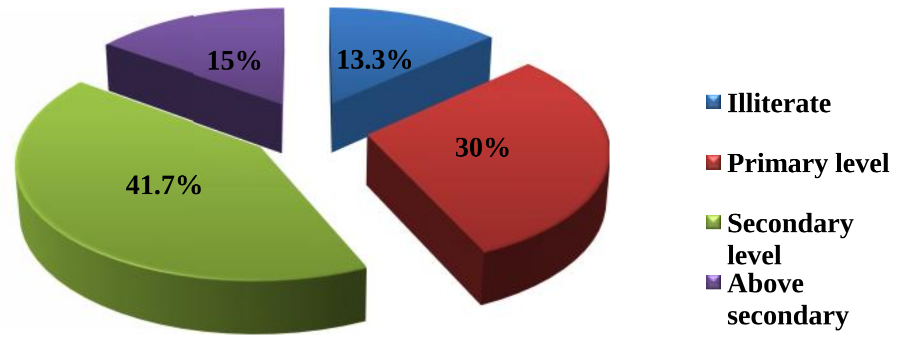

Figure 5.2 Educational Status of the Respondents

5.6 Educational Status of the Respondents Family Members

Socio-economic status of a family largely depends on the education level of the family members. It's not only depends on household head education level but also their family members educational status. Education improved their standard of living as well as their household income. Table 5.4 shows the educational status of the sampled farmers family members.

Table 5.3 Education Level of the Family Member

Education	No.	Percent (%)
Illiterate	56	23.62
Signature only	42	17.72
Up to Primary	54	22.79
Secondary	60	25.32
HSC and Above	25	10.55
Total	237	100

Source: Field survey, 2014

From the above table it observed that the highest number of family members of all sampled farmers received secondary level education which stood at 25.32. At the same time, about 23.62 percent of family members including respondent were illiterate in the study area. It revealed that 22.79 percent of the respondent's family members were completed up to primary level education

5.7 Occupation

Agriculture is the main occupation of most of the farmers in the study area. Besides agriculture, some farmers were engaged in other occupations like, small business, services, fishery, and others.

Table 5.4 Occupational Status of the Rice-cum-fish Farmers

Main occupation	Rice-cum-fish farmers		Subsidiary occupation	Rice-cum-fish farmers	
	No.	Percent		No.	Percent
Agriculture	38	63.33	Agriculture	20	33.33
Small business	10	16.67	Small business	13	21.67
Service	8	13.33	Service	6	10
Fishery	4	6.67	Fishery	5	8.33
Other			Other	16	26.67
Total	60	100	Total	60	100

Source: Field survey, 2014

Table 5.5 shows that 63.33 percent rice-cum-fish farmers were engaged in agriculture while 16.67 percent were engaged in small business, 13.33 percent in service and 6.67 percent in fishery as their main occupation. But in case of subsidiary occupation, only 33.33 percent rice-cum-fish farmer depend on agriculture. Whereas 21.67 percent, 10 percent and 8.33 percent rice-cum-fish farmers engaged with small business, service and fishery respectively as their subsidiary occupation.

5.8 Average Annual Income

Table 5.6 reveals that, the average annual income of rice-cum-fish farmers was Tk 123000. The main and subsidiary income of rice-cum-fish farmers were 79.04 percent and 20.96 percent.

Table 5.5 Average Annual Income of Sample Farmers

Source	Rice-cum-fish farmers	
	Amount(Tk./year)	Percent
Main	97200	79.04
Subsidiary	25800	20.96
Total	123000	100

Source: Field survey, 2014

5.9 Land Ownership Patterns

In this study, the land holding of the sample farmers was defined as the sum total of all types of land possessed by the farmers and having legal right on it. Farm size is measured by the entire land area operated by the farmers. It is computed by adding the area rented and mortgaged in from others and deducting the area rented and mortgaged out to others.

Therefore, the farm size was measured by using the following formula:

Total Land = Own land (homestead + pond + own cultivated + Garden) + (Rented in + mortgaged in) **–** (Rented out + mortgaged out)

Table 5.6 Average Land Holding of Sample Farmers

Types of land	**Land area(decimal)**
	Rice-cum-fish farmers
Homestead land	35
Own cultivable land	232
Rented in land	15
Rented out land	12
Mortgage in land	60
Mortgage out land	0.00
Total land	354

Source: Field survey, 2014

Above table reveals that the average land holding of rice-cum-fish farmers was 354 decimal.

CHAPTER 6

PROFITABILITY OF RICE-CUM-FISH PRODUCTION

6.1 Introduction

For every production process, cost plays a vital role for making right decision of the farmer. Considering its importance, the present study placed emphasis on different cost items. The items of costs involved in rice-cum-fish production were human labor, seedling, fingerling, fertilizer, power litter, irrigation, feed, pond preparation, insecticide, interest on operating capital and land use cost. There are two types of costs: variable costs and fixed costs. In this study, variable cost items included were human labor, seedling, fertilizer, power tiller, irrigation, insecticide, fingerling, pond preparation, feed and interest on operating capital. On the other hand, fixed cost was land use cost. On the return side, per hectare yield, gross return, gross margin, net return and undiscounted benefit-cost ratio also estimate and analyze. A brief account showing how the individual costs and return were estimated in the present study is presented below.

6.2 Variable Costs

6.2.1 Cost of Human Labor

One of the most important inputs of rice-cum-fish production was human labor. It was required for different operations like land preparation, transplanting, weeding, fertilizer application, insecticide application, fish feeding, digging ditch, harvesting, threshing etc. In this study, human labor was measured in terms of man-days, which usually consisted 8 hours of work by an adult man. For women and children, man equivalent day was estimated. This was computed by converting all women and children day into man equivalent day. This was performed as follows (Yang, 1965) :

1 adult man = 1.5 adult women = 2 children.

In the study area, the average wage rate was Tk. 300 per man-day during the study period. The costs of family labor had been calculated according to the wage rate at which the farmers could hire labor. Per hectare total cost of hired labor was calculated from per hectare labor used in different operations multiplied by wage rate. Table 6.1 shows that, per hectare cost of human labor were Tk. 39750 for rice-cum-fish culture which comprising 31.97percent of total cost.

Table 6.1 Per Hectare Total Cost of Rice-cum-Fish Production

Cost items	Unit	Cost (Tk.)	Percent
(A) Variable Cost	**Tk.**	**109040**	**87.70**
Human labor cost	Tk.	39750	31.97
Family labor	Tk.	8700	6.99
Hired labor	Tk.	31050	24.98
Seedling cost	Tk.	6550	5.27
Fingerling cost	Tk.	15180	12.21
Fertilizer and manure cost	Tk.	12100	9.73
Urea	Tk.	3640	2.93
TSP	Tk.	3980	3.20
MP	Tk.	2160	1.74
Cow dung	Tk.	2320	1.87
Insecticide cost	Tk.	1800	1.48
Power tiller cost	Tk.	7750	6.23
Irrigation cost	Tk.	1550	1.25
Feed cost	Tk.	13350	10.74
Oil-cake	Tk.	6450	5.19
Rice bran	Tk.	6900	5.54
Pond preparation cost	Tk.	8350	6.72
Digging ditch	Tk.	7200	5.79
Lime	Tk.	1150	0.93
Interest on operating capital	Tk.	2660	2.14
(B) Fixed Cost	**Tk.**	**15300**	**12.30**
Land use cost	Tk.	15300	12.30
Total Cost (A+B)	**Tk.**	**124340**	**100**

Source: Field survey, 2014

6.2.2 Cost of Seedling

In the study area, farmers used both home supplied and purchased seeds. The costs of home supplied seedlings were determined at the ongoing market rate in the study area and costs of purchased seedling were calculated on the basis of actual prices paid by the farmers. In rice-cum-fish culture, per hectare cost of seedlings for rice-fish was Tk. 6550 which was 5.27 percent of the total cost (Table 6.1).

6.2.3 Cost of Fingerling

Fingerlings cost is one of the most important costs of fish production in rice fields. Cost of fingerlings depends on the price of fingerlings. There was a variation in the per unit price of fingerling from location to location and time to time. But the cost of fingerlings was calculated on the basis of actual prices which were paid by the farmers. For analytical simplicity, the price of fingerlings was considered as Tk. 1.50 per fingerling. The rice-fish farmers cultured several species of fingerling namely rui, katla, sarputi, carpio, mirror carp, mola, dhela, Vetke, and tilapia. Table 6.1 shows that, per hectare average cost of fingerlings were estimated at Tk. 15180 which constituted 12.21 percent of the total cost.

6.2.4 Cost of Fertilizers and Manure

Fertilizer is an important input for rice-cum-fish culture. The farmers used different types of fertilizers and namely Urea, TSP, MP and cow dung as manure. Uses of these fertilizers influence in increasing the production. The cost of fertilizer and manure were computed by using the prevailing market rate which was actually paid by the farmers. The cost of fertilizer was assumed to be same in all categories of farm. Per hectare total cost of Urea, TSP, and MP were Tk. 3640, 3980, 2160 respectively for rice-cum-fish culture. In the study area it was found that farmers also used cow dung as manure. For rice-cum-fish culture the total cost of manure was Tk. 2320 per hectare. The estimated costs of fertilizer are shown in table 6.1. It was observed that per hectare costs of fertilizer was Tk. 12100 which representing 9.73 percent of the total cost.

6.2.5 Cost of Insecticides

The cost of the insecticides was calculated according to the market price. In rice-cum-fish culture, a few number of insecticides was used because a large number of insecticides application might be harmful for fish. But some insecticide was needed for rice, which applied at beginning period of rice sowing. Per hectare cost of insecticide was Tk. 1800 which was 1.48 percent of the total cost (Table 6.1).

6.2.6 Cost of Power Tiller

In the study area, power tiller has widely been used for land preparation. For fish culture in rice field, the average per hectare power tiller cost was Tk. 7750. In percentage terms it shared 6.23 percent of total cost.

6.2.7 Cost of Irrigation

In the study area, rice-cum-fish farmers produce Aman rice which depends on rain water. So, irrigation was not much more needed for rice-cum-fish culture in the study area. But some irrigation water was important for survival of fish when rain water was not sufficient. Per hectare cost of irrigation was Tk. 1550 of rice-fish production which represented 1.25 percent of the total cost (Table 6.1).

6.2.8 Cost of Feed

It is important to supply of artificial supplementary feeds, which contribute to increase fish production. In the study area rice-cum-fish farmers mostly used rice bran and oil cake, as supplementary feed for fish. The cost of feed was charged at the prevailing market price. Table 6.1 shows that in rice-fish culture per hectare cost of oil-cake was Tk. 6450 and rice bran was Tk. 6900 which constituted 5.19 and 5.54 percent of total cost respectively.

6.2.9 Cost of Pond Preparation

In case of integrated rice-cum-fish culture, farmers had to prepare a dig for fish rearing. After dig a ditch farmers used lime to neutralize acidity in the soil and pond water which helps to prevent diseases of fish. Lime assists in the release of nutrients from the soil and promotes bacterial breakdown of organic material including manure. Both family and hired labor were used to digging the ditch. Table 6.1 shows that per hectare average cost of digging ditch and lime were Tk. 7200 and Tk. 1150 which represented 5.79 and 0.93 percent of total the cost.

6.2.10 Interest on Operating Capital

Interest on operating capital was computed at the rate of 10 percent for a year. It was assumed that if the farmers would deposit the money in a bank, they would have received interest at that rate. It was computed by using the following formula:

$$\text{Interest on operating capital} = \text{Al} \times i \times t$$

Where,

Al = (total investment)/2;

i = interest rate which was assumed at 10 percent; and

t = length of the period of rice production (6 month).

Table 6.1 shows that interest on operating capital for rice-fish culture was Tk. 2660 per hectare which shared 2.14 percent of total cost.

6.2.11 Total Variable Cost

The total variable cost of rice-cum-fish culture was Tk. 109040 per hectare. In percentage terms total variable cost covered 87.70 percent.

6.3 Fixed Costs

6.3.1 Cost of Land Use

The cost of land use was different from one plot to another depending upon location, distance and topography. In the present study, the cost of land use was estimated on the basis of cost rental value. The land use cost per hectare was Tk. 15300 which was 12.30 percent of the total cost (Table 6.1).

6.4 Return from Rice-Cum-Fish Culture

In this section, gross return, gross margin, net return and benefit-cost ratio from rice-cum-fish culture were calculated.

6.4.1 Gross Return

Gross return is the money value of total output. In this study, gross return was calculated by summing up all the returns earned from selling rice, fish and rice straw. Per hectare gross return was calculated by multiplying the total amount of products and by products with the farm- gate price. Total gross return from rice production was Tk. 135000 while the fish production was Tk. 105600 and by product was Tk. 20000. Per hectare gross return from rice-cum-fish production was Tk. 240600 (Table 6.2).

6.4.2 Gross Margin

Gross margin is defined as the difference between gross return and variable costs. The argument for using the gross margin analysis is that the farmers are interested to get returns over variable cost. Table 6.3 reveals that gross margin for producing rice-cum-fish was Tk. 134220.

Table 6.2 Per Hectare Gross Return from Rice-cum-fish Production

Particulars	Main product				
	Qty(kg)	Price (Tk./kg)	Value (Tk.)	Value of by product (Tk.)	Gross return (Tk.)
Yield of rice	5750	20	115000	20000	135000
Yield of fish	1320	80	105600		105600
Yield of rice-fish					240600

Source: Field survey, 2014

6.4.3 Net Return

In general net return is termed as entrepreneur’s income. Net return is the difference between gross return and total costs. Table 6.3 reveals that per hectare net return from production of rice-cum-fish was Tk. 116260 which indicates that rice-cum-fish culture is profitable business.

Table 6.3 Per Hectare Net Return and BCR for Rice-cum-Fish Production

Particulars	Total value (Tk.)
A. Gross Return	240600
B. Variable Cost	109040
C. Total Cost	124340
D. Gross Margin(A-B)	131560
E. Net return(A-C)	116260
F. BCR(Undiscounted) (A/C)	1.94

Source: Field Survey, 2014

6.4.4 Benefit-Cost Ratio (BCR)

Benefit cost ratio was calculated by dividing the total return or gross return by the total cost. It implies return per taka invested. Here benefit cost ratio (undiscounted) was used to derive the profitability of production. Table 6.3 shows that benefit cost ratio of rice-cum-fish was 1.94 which implying that Tk. 1.94 would be earned by investing Tk. 1.00 for rice-cum-fish culture.

6.5 Concluding Remarks

On the basis of above discussion, it could be concluded that the cultivation of rice-cum-fish production is profitable. So, most of the farmers of the selected area have a tendency to cultivate the integrated rice-cum-fish.

CHAPER 7

EFFECTS AND RESOURCE USE EFFICIENCY OF INPUTS USED

7.1 Introduction

In this chapter, an attempt has been made to identify and measure the effects of major variables on rice-cum-fish culture. For this purpose, Cobb-Douglas production function was chosen to determine the contribution of key variables on the production process of rice-fish culture.

7. 2 Factors Affecting Production of Rice-cum-Fish

For rice-cum-fish culture different kind of inputs, such as human labor, seed, fingerling, fertilizer, power tiller, irrigation, feed, pond preparation etc. were employed which were considered as a prior explanatory variables responsible for variation in rice-cum-fish production. Some other factors which also might affect production were management, farm size, land quality, soil condition, time of sowing, period of harvesting, etc. The use of these inputs was not made because of data limitation. Accordingly, multiple regression analysis was employed to understand the possible relationships between the production of rice-cum-fish and the inputs used.

7.3 Method of Estimation

For determining the effect of variable inputs to the production of rice-cum-fish, Cobb-Douglas production function was chosen on the basis of best fit and significance result on output. Moreover, use of Cobb-Douglas production function enables one to obtain the returns to scale directly. This model is also popular in applied work. The functional form of the multiple regression equation is as follows:

$$Y = aX_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} X_6^{b_6} X_7^{b_7} X_8^{b_8} X_9^{b_9} e^{u_i}$$

By taking log in both sides the Cobb-Douglas production function was transformed into the following logarithmic form, because it could be solved by the ordinary least squares (OLS) method.

$$\begin{aligned} ln\,Y = lna + b_1 lnX_1 + b_2\, lnX_2 + b_3 lnX_3 + b_4 lnX_4 + b_5 lnX_5 + b_6 lnX_6 + b_7 lnX_7 \\ + b_8 lnX_8 + b_9 lnX_9 + U_i \end{aligned}$$

Where,

Y = Gross return (Tk./ha)

X_1= Cost of human labor (Tk./ha)

X_2= Cost of seedlings (Tk./ha)

X_3= Cost of fingerlings (Tk./ha)

X_4= Cost of fertilizers and manure (Tk./ha)

X_5= Cost of Insecticide (Tk./ha)

X_6= Cost of power tiller (Tk./ha)

X_7 = Cost of irrigation (Tk./ha)

X_8= Cost of feed (Tk./ha)

X_9 = Cost of pond preparation (Tk./ha)

In a = Constant or intercept of the function

$b_l, b_2, \ldots, b_9$= Coefficient of respective variables;

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

ln=Natural logarithm; and

U_i= Error term.

7.4 Estimated Values of the Cobb-Douglas Production Function

Estimated values of the coefficients and related statistics of the Cobb-Douglas production functions for rice-cum-fish are presented in Table 7.1. I found the presence of heteroskedasticity in the given data since the value of χ^2 were 79.02 that was significant at one percent level. Therefore, the robust standard error had been used in the study.

The following features were noted:

1. F-value was used to measure the goodness of fit for different types of inputs
2. The coefficient of multiple determinations (R^2) indicates the total variations of output explained by the independent variables included in the model
3. Coefficients having sufficient degrees of freedom were tested for significance level at 1 percent, 5 percent and 10 percent levels of significant
4. Stage of production was estimated by returns to scale which was the summation of all the production elasticity of various inputs.

Table 7.1 Estimated Values of Co-efficient and Related Statistics of Cobb-Douglas Production Function Model

Explanatory Variables	Coefficient	Standard Error (Robust)
Constant	4.784	(1.334)
Human labor cost (X_1)	0.114***	(0.027)
Seed/Seedling cost (X_2)	0.388*	(0.198)
Fingerling cost (X_3)	0.110*	(0.059)
Fertilizer and manure cost (X_4)	0.207	(0.217)
Insecticide cost (X_5)	0.000	(0.047)
Power tiller cost (X_6)	0.154	(0.161)
Irrigation cost (X_7)	-0.030	(0.022)
Feed cost (X_8)	0.209***	(0.040)
Pond preparation cost (X_9)	0.178***	(0.036)
R^2	0.989	
F value	439.012***	
Returns to scale Σb_i	1.33	

Source: Field survey, 2014

Note: Robust standard errors in parentheses

*(*** denotes Significant at 1 percent level; ** denotes Significant at 5 percent level; * denotes Significant at 10 percent level).*

7.5 Interpretation of Results

Human Labor Cost (X_1)

The regression coefficient of human labor was 0.114 (Table 7.1) which was positive and significant at one percent level. It indicates that one percent increase in the cost of human labor, keeping other factors constant, would increase the gross return of rice-cum-fish production by 0.114 percent.

Seed Cost (X_2)

The magnitude of the regression coefficient of seed was 0.388 (Table 7.1) which was positive and significant at 10 percent level. It indicates that one percent increase in the cost of seed, keeping other factors constant, would increase the gross return of rice-cum-fish production by 0.338 percent.

Fingerling Cost (X_3)

The estimated coefficient of fingerlings was 0.110 with positive sign (Table 7.1), which was statistically significant at 10 percent level of significance. This suggests that an additional one percent increase in spending on fingerling would enable the farmers to earn 0.110 percent more gross return from rice-cum-fish culture.

Feed Cost (X_8)

The value of production coefficient of feed was 0.209 with positive sign (Table 7.1), which was highly significant at one percent level. It implies that one percent increase in the cost of feed as additional expenditure, remaining other factors constant, would increase the gross return of rice-cum-fish production by 0.209 percent.

Pond Preparation Cost (X_9)

The magnitude of the regression coefficient of pond preparation was 0.178 with positive sign (Table 7.1), which was statistically significant at one percent level of significance. This implies that an increase in the cost on this factor by one percent, keeping other factors constant, would increase the gross return by 0.178 percent.

Irrigation Cost (X_7)

The regression coefficient of irrigation was 0.030, which was negative and statistically insignificant (Table 7.1). It implies that one percent increase in the cost of irrigation, remaining other factors constant, would decrease gross return by 0.030 percent.

Fertilizer and Manure (X_4), Power Tiller (X_6) and Insecticide (X_5) Cost

The magnitude of the regression coefficient of fertilizer, power tiller, and insecticide were 0.207, 0.154, and 0.000 respectively with positive sign (Table 7.1). These coefficients were statistically insignificant.

Coefficient of Multiple Determinations (R^2)

It is evident from Table 7.1 that the value of the coefficient of multiple determinations (R^2) was 0.989. It indicates that about 99 percent of the total variation in the gross return could be explained by the included explanatory variables of the model.

Goodness of Fit (F-value)

The F-statistics was computed to denote the overall goodness of fit of any fitted model. The F value of the estimated production function was 439.012, which was highly significant at one percent level of significance (Table 7. 1). It implies that the model was good fit for the rice-cum-fish production. That is, all the explanatory variables included in the model were important for explaining the variation in gross return of rice-cum-fish production.

Returns to Scale (Σ*bi*)

The summation of all the production co-efficients (production elaticities) of rice-cum-fish culture was 1.33 (Table 7.1). This indicates that production function for rice-cum-fish culture exhibits increasing returns to scale. This means that, if all the variables specified in the production function were increased by one percent, gross return would also be increase by 1.33 percent.

7.6 Resource Use Efficiency

From the analysis of the regression equation, we can study the ability of farmers to allocate resources in rice-cum-fish production. In order to test efficiency the ratio of Marginal Value Product (MVP) to the Marginal Factor Cost (MFC) for each input is computed and tested for its equality to 1,

i.e.

$$\frac{MVPxi}{MFCxi} = 1$$

In order to test resource use efficiency, it was considered that a ratio equal to unity indicated the optimum use of that factor, a ratio more than unity indicated that the yield could be increased by using more of the resources. A value of less than unity indicated the unprofitable level of resource use, which should be decreased to minimize the losses because farmers over used this variable. The negative value of MVP indicated the indiscriminate and inefficient use of resource. The ratio between MVPs and MFCs are shown in Tables 7.2.

Table 7.2: Estimated Resource Use Efficiency of Rice-Cum-Fish Culture

Variables	GM	Coefficient	MVP	MFC	MVP/MFC	Comment
Gross Return	225600					
Labor	38950	0.114	0.66	1	0.66	Over utilized
Seed	6400	0.388	6.62	1	13.68	Under utilized
Fingerling	14880	0.110	1.67	1	1.67	Under utilized
Fertilizer and manure	11960	0.207	3.90	1	3.90	Under utilized
Insecticide	1650	0.000	0.00	1	0.00	Over utilized
Power tiller	7650	0.154	4.54	1	4.54	Under utilized
Irrigation	1460	-0.030	-4.64	1	-4.64	Over utilized
Feed	13250	0.209	3.56	1	3.56	Under utilized
Pond preparation	8200	0.178	4.89	1	4.89	Under utilized

Source: Field survey, 2014.

Note: MVP = Marginal value product; MFC = Marginal Factor cost;

GM = Geometric mean.

The ratio of MVP and MFC of labor for rice-cum-fish culture was positive and less than one, which indicated that in the study area use of labor for rice-cum-fish culture was over used (Table 7.2). So, farmers should decrease the use of labor to attain efficiency considerably.

Table 7.2 showed that the ratio of MVP and MFC of seed for rice-cum-fish culture was positive and more than one, which implied that in the study area use of seed for rice-cum-fish culture was under used. So, farmers should increase the use of seed to attain efficiency level.
The ratio of MVP and MFC of fingerling for rice-cum-fish culture was positive and more than one, which indicated that in the study area use of fingerling for rice-cum-fish culture was under used (Table 7.2). So, farmers should increase the use of fingerling to attain efficiency considerably.

The ratio of MVP and MFC of fertilizer and manure for rice-cum-fish culture was positive and more than one, which indicated that in the study area use of fertilizer and manure for rice-cum-fish culture was under used (Table 7.2). So, farmers should increase the use of fertilizer and manure to attain efficiency in rice-cum-fish culture.

Table 7.2 showed that the ratio of MVP and MFC of insecticide for rice-cum-fish culture was positive and less than one, which implied that in the study area use of insecticide for rice-cum-fish culture was over used. So, farmers should decrease the use of insecticide to attain efficiency level.

The ratio of MVP and MFC of power tiller for rice-cum-fish culture was positive and more than one, which indicated that in the study area use of power tiller for rice-cum-fish culture was under used (Table 7.2). So, farmers should increase the use of power tiller to attain efficiency considerably.

The ratio of MVP and MFC of irrigation for rice-cum-fish culture was negative and less than one, which indicated that in the study area irrigation for rice-cum-fish culture was over used and inefficiently used (Table 7.2). So, farmers should decrease irrigation use to attain efficiency in rice-cum-fish culture.

Table 7.2 showed that the ratio of MVP and MFC of feed for rice-cum-fish culture was positive and more than one, which implied that in the study area use of feed for rice-cum-fish culture was under used. So, farmers should increase the use of feed to attain efficiency level.

The ratio of MVP and MFC of pond preparation for rice-cum-fish culture was positive and more than one, which indicated that in the study area use of pond preparation for rice-cum-fish culture was under used (Table 7.2). So, farmers should increase pond preparation use to attain efficiency considerably.

CHAPTER 8

CONSTRAINTS ASSOCIATED WITH RICE-CUM-FISH CULTURE

8.1 Introduction

In this chapter, an attempt has been made to identify the major problems and constraints of integrated rice-cum-fish culture in the study area. Farmers was faced many problems and constraints in integrated rice-cum-fish culture. The problems were classified into three categories:

a) Economic problems

b) Technical problems and

c) Social problems.

8.2 Economic Problems

Economic problems related with rice-cum-fish culture were identified as lack of sufficient fund, high price of input and low price of output.

8.2.1 Lack of Sufficient Fund

Most of the farmers were not economically solvent to run the farm smoothly without any financial support. They did not get sufficient loan from financial institution. They had to borrow money from local NGO's at higher interest rate for conducting a rice-cum-fish culture. About 65 percent rice-cum-fish farmers reported that lack of sufficient fund was one of the major problems for them (Table 9.1).

8.2.2 High Price of Input

Input is one of the most important factor for rice-cum-fish culture. High input price create constraints to successfully run rice-cum-fish culture. About 50 percent rice-cum-fish farmers complained that high price of input was one of the most important problems for them (Table 9.1).

8.2.3 Low Price of Output

Low price of output was considered as another important problem reported by 55 percent of rice-cum-fish farmers (Table 9.1). Most of the farmers had to sell their products at home or at local market at lower price for transportation problem.

To overcome these problems, immediate measures should be taken such as group should be formed to buy and stock seeds, feed and fertilizers when these are available. The government should also take some measures for ensuring availability of inputs at reasonable prices at proper time.

8.3 Technical Problems

Technical problems are related to lack of scientific knowledge and technology, lack of good quality seeds and fingerlings, lack of extension services and attack of diseases.

8.3.1 Lack of Scientific Knowledge and Technology

Scientific knowledge and advance technology is important for rice-cum-fish culture. But a few numbers of farmers have sufficient scientific knowledge. In the study areas, about 45 percent rice-cum-fish farmers claimed that, they had lack of scientific knowledge and technology (Table 9.1).

Table 8.1 Constraints in Rice-Cum-Fish Culture

Problems and Constraints	No. of respondent	Percent (%)
(a)Economic problems		
i. Lack of sufficient fund	28	65
ii. High price of input	20	50
iii. Low price of output	22	55
(b) Technical problems		
i. Lack of scientific knowledge and technology	18	45
ii. Lack of good quality seeds and fingerlings	24	60
ii. Lack of extension services	12	30
iii. Attack of disease and pests	16	40
(c)Social problems		
i. Problems of theft	4	35

Source: Field survey, 2014

8.3.2 Lack of Good Quality Seeds and Fingerlings

In the study area, lack of quality seeds and fingerlings was one of the main problems for rice-cum-fish culture. About 60 percent of rice-cum-fish farmers complained about absence of quality seeds and fingerlings (Table 9.1)

8.3.3 Lack of Extension Services

Integrated rice-cum-fish culture is a new concept of farming systems. So, the farmers of rice-cum-fish culture need sufficient service from extension agencies. About 30 percent of rice-cum-fish farmers reported this type of problem (Table 9.1).

8.3.4 Attack of Disease and Pests

About 40 percent of rice-cum-fish farmers reported that their rice and fish were attacked by diseases and pests (Table 9.1).

To overcome these problems, training programme should be arranged to upgrade the knowledge on scientific fish culture. Scientific use of chemicals should be ensured.

8.4 Social Problems

Social problems were related to theft of fish and rice from the fields.

8.4.1 Problems of Theft

It was found that some of the fields were located far away from home in the study areas. Proper care and supervision was a major problem for this location. About 35 percent of rice-cum-fish farmers complained such problem (Table 9.1). It becomes a threat for the farmers.

8.5 Concluding Remarks

The above mentioned constraints, of course, are interrelated with one another and hence, need to be removed comprehensively through an integrated programme for the overall development of rice-cum-fish culture.

CHAPTER 9

SUMMARY, CONCLUSION AND RECOMMENDATIONS

9.1 Introduction

This chapter discusses the summary, conclusion and policy recommendations of the study. This chapter summaries on Introduction (Chapter 1), Methodology (Chapter 3), Socio-economic characteristics (Chapter 5), Cost and returns (Chapter 6), Effect of input use on rice-cum-fish culture (Chapter 7) and Constraints of rice-cum-fish culture (Chapter 8), Finally Chapter 9 presents Policy recommendations and Conclusion of the study.

9.2 Summary

Bangladesh is one of the developing countries in the world. Rice and fish are the staple foods in Bangladesh. Rice and fish have been an essential part of life and culture of the people of Bangladesh. The rice-cum-fish culture is an innovative farming system in which, rice is the main enterprise and fish fingerlings are taken as additional means to secure extra income. On the basis of seasonal classification, three types of rice are grown in Bangladesh, namely Aus, Aman and Boro. Boro rice covered the largest portion of the total rice production of the country. It is remarkable that fish is one of the major sources of earning income. So, rice as well as fish cultivation can make the economy viable and stable by providing more food for the people and by earning more income for purchasing necessary things. Unfortunately, the per hectare rice-cum-fish production is very low in this country due to unscientific method of fish cultivation. Therefore, there is an ample scope of increasing fish production through intensive and scientific farming.

Keeping this in view, the present study made an attempt to conduct an economic study on the production of rice with fish with the following objectives:

i. To identify the major socio-demographic characteristics of rice-cum-fish farmers
ii. To assess the profitability of rice-cum-fish farmers
iii. To estimate the contribution of key inputs to the production processes of rice-cum-fish culture
iv. To measure the resource use efficiency of rice-cum-fish culture and
v. To identify the major constraints faced by rice-cum-fish farmers
vi. The study was mainly based on primary data, which were collected by the researcher herself through direct interviewing of the sample farmers. The villages of Bhaluka Upazila of Mymensingh district were selected for fulfilling the objectives of the study. Three villages namely Goyati, Baulia bazar and

Chandorati were selected for collecting information. These villages were selected because it possesses similar socio-economic attributes and homogeneous physiographic conditions. For this study, 60 rice-cum-fish farmers were selected. Simple random sampling technique was followed in the present study.

The field survey was conducted over the period from January to mid February; 2014. The tabular and different statistical analysis was done to examine the objectives.

In this study, an attempt had been made to identify the socioeconomic characteristics of the sample farmers. About 25 percent of the rice-cum-fish farmers fell into the 30-40 years of age group and 38.3 percent were belonged between 40-50 years which was more prominent group. Secondary level of education was the prominent level of education among rice-cum-fish farmers. Percentage of graduate was few. It was found that family size of the respondents was 3.95 and male-female ratio was 1.42. Agriculture was the main occupation of most of the farmers in the study area. About 63.33 percent rice-cum-fish farmers were engaged in agriculture. Besides agriculture, some farmers were engaged in other occupations like, small business, services, fishery, and others.

In this summary and conclusion section, attention had been focused to present the research finding in terms of objectives of the study. Costs and returns were calculated to determine the profitability of rice-cum-fish culture. Per hectare human labor, seed, fingerling, fertilizer, insecticide, power tiller, irrigation, feed, pond preparation cost and interest on operation capital was Tk. 39750, Tk. 6550, Tk. 15180, Tk. 12100, Tk. 1800, Tk. 7750, Tk. 1550, Tk. 13350, Tk. 8350 and Tk. 2660 respectively. Per hectare land use cost was Tk. 13500. Per hectare total cost of rice-cum-fish culture was Tk. 124340 and per hectare variable cost of rice-cum-fish culture was Tk. 109040. Per hectare gross margin of rice-cum-fish culture was Tk. 131560 and gross return was Tk. 240600 for rice-cum-fish culture. Individually the byproduct of rice was Tk. 20,000. Per hectare net returns was Tk. 116260 and per hectare BCR calculate for rice-cum-fish culture was 1.94 which indicated that rice-cum-fish culture was highly profitable.

Cobb-Douglas production function analysis was carried out for examined the effect of input use and resource use efficiency. In most of the cases the co-efficients of human labor, seed/seedling, fingerling, feed and pond preparation appeared to be significant. But the co-efficients of fertilizer, insecticide and power tiller were insignificant. The co-efficient of irrigation was negative and insignificant. The sum of the co-effecients of different inputs were greater than one (1.33) indicated that the production functions exhibited increasing returns to scale which indicated that more profit can be obtained by increasing each input included in production function.

In case of input use efficiency, the coefficient of seed, fingerling, fertilizer, power tiller, feed and pond preparation appeared to positive and greater than one which implied that these inputs were underutilized and they had high productivity in rice-cum-fish culture and more profit can be obtained by increasing investment in these inputs. The coefficients of labor and insecticide were positive but less than one which implied that these inputs were over utilized and inefficiently used. But the coefficient of irrigation was negative so it indicated indiscriminate and inefficiently used of resource which needs to be adjusted to bring it closer to unity.

With regard to the major constraints faced by the farmers, the findings revealed that lack of sufficient funds; lack of good quality seeds and fingerlings; high price of input; low price of output; lack of scientific knowledge and technology; lack of extension services; attack of disease and pests; problems of theft etc were the major obstacle of rice-cum-fish culture.

To overcome these problems, immediate measures should be taken, such as group formation to buy and stock seed, feed & fertilizers; arranging training programme to upgrade the knowledge on scientific fish culture; ensuring scientific use of chemicals; educating the people to develop social consciousness by strengthening local security service through private and public initiatives. The government should also take some measures for ensuring availability of inputs at reasonable prices at proper time.

9.3 Conclusion

It may be concluded that rice-cum-fish farming is profitable. If modern inputs and production technology can be made available to farmers in time, yield and production of rice-fish may be increased which can help the farmers to increase income and improve livelihood conditions. The rice-fish farming can help in improving the nutritional status of the rural people. The present and future potential market and demand for rice-cum-fish should be determined through a comprehensive study in order to take up a well-planned production programme at national level.

9.4 Recommendations

With a view to improving rice-cum-fish culture, the following recommendations are made as a part of formulating strategy for intensifying rice-cum-fish culture development in Mymensingh District. The following recommendation should be forwarded:

- Application of scientific method in rice-cum-fish farming should be ensured
- Modern practices need to be popularized among the farmers
- Re-orient extension and training program and
- Establish strong market network for better inputs (seed, feed) supply and outputs (rice, fish) supply.

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Appendix 1

Robust Linear Regression

Number of obs = 60
F(9, 50) = 439.02
Prob > F = 0.0000
R-squared = 0.9887
Root MSE = .07983

		Robust				
y	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
x1	0.114426	0.026677	4.29	0.000	0.060844	0.168008
x2	0.388371	0.197703	1.96	0.055	-0.00873	0.785469
x3	0.10974	0.059357	1.85	0.07	-0.00948	0.228961
x4	0.206667	0.216892	0.95	0.345	-0.22897	0.642307
x5	0.000144	0.046862	0.00	0.998	-0.09398	0.09427
x6	0.154182	0.160538	0.96	0.341	-0.16827	0.476632
x7	-0.02954	0.022107	-1.34	0.188	-0.07394	0.014864
x8	0.209028	0.040288	5.19	0.000	0.128108	0.289949
x9	0.177586	0.036147	4.91	0.000	0.104983	0.250188
_cons	4.783699	1.333964	3.59	0.001	2.104353	7.463044

Appendix 2

Test for Heteroskedasticity

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance
Variables: fitted values of y

chi2(1) = 5.15
Prob > chi2 = 0.0233