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ECONOMIC COMPARISON OF TILAPIA AND CARP AQUACULTURE IN BANGLADESH

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ABSTRACT

Information on economic viability of aquaculture is crucial for farmers and entrepreneurs when assessing different aquaculture practices; such information has been scarce in Bangladesh. This paper compares economics of carp polyculture and tilapia (GIFT, all male) monoculture in Bangladesh produced in semi-intensive system. For this purpose, an 800 m^2 pond is used as the basis for analysis since it is the average size used by most private fish farmers in Bangladesh. A one pond production model and ten pond production model were developed for tilapia and carp aquaculture. Assumptions for this evaluation were based on data from the annual fish production report of Integrated Agricultural Productivity Project (IAPP) of the Rangpur region in Bangladesh. Other information came from the author's experience in the aquaculture extension service and as a farm manager of a government fish farm service delivery. This evaluation finds that both tilapia and carp aquaculture practices were viable, although with different degrees of success. In both one pond and ten pond production models, tilapia aquaculture shows more profits and more yields than carp aquaculture. It is more profitable and results in higher yields to operate ten ponds than one pond due to economics of scale. However, the success of aquaculture in Bangladesh will not only depend on the use of higher yields gained through aquaculture technologies, but also on the confidence of farmers or investors. For this reason, the Department of Fisheries (DoF) in Bangladesh needs to have appropriate information available to farmers to assist them in making economic decisions on aquaculture practices.

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1 INTRODUCTION

Fisheries and aquaculture is a source not just of health but also of wealth. Employment in the sector has grown faster than the world's population. The sector provides jobs to tens of millions and supports the livelihood of hundreds of millions. Fish continues to be one of the most traded food commodities worldwide. It is especially important for developing countries, sometimes worth half the total value of their traded commodities (FAO, 2014).

Bangladesh is uniquely rich and diverse in water resources. Due to favourable climatic conditions, the water bodies are highly productive, and aquaculture is an important commercially viable activity (DoF, 2013a). Bangladesh's inland waters rank fourth after China, India and Myanmar in terms of fish biomass production (FAO, 2014). Income-generating opportunities for rural households are the most promising in the fisheries sector (MoP, 2005; DoF, 2006).

1.1 World fisheries

Fisheries play an increasingly important role in world food production. It provides a source of food, employment, recreation and economic benefits both for present and future generations all over the world (FAO, 1995). Aquaculture remains a growing, vibrant and important production sector for high protein food (FAO, 2010). Rural diets in many countries may not be particularly diverse and, thus, it is vital to have good food sources that can provide all essential nutrients in people's diets. The demand for fish is growing and there are still huge numbers of hungry and malnourished people in the world. Aquaculture plays an essential role in meeting these challenges (FAO, 2014).

According to FAO estimation, global fish production has grown steadily in the last five decades (Figure 1), with food fish supply increasing at an average annual rate of 3.2%, outpacing world population growth, which is 1.6%. Worldwide fish consumption per capita increased from an average of 9.9kg in the 1960s to 19.2kg in 2012 (FAO, 2014). This impressive development has been driven by a combination of population growth, rising incomes and urbanization, and facilitated by the strong expansion of fish production and more efficient distribution channels (FAO, 2014).

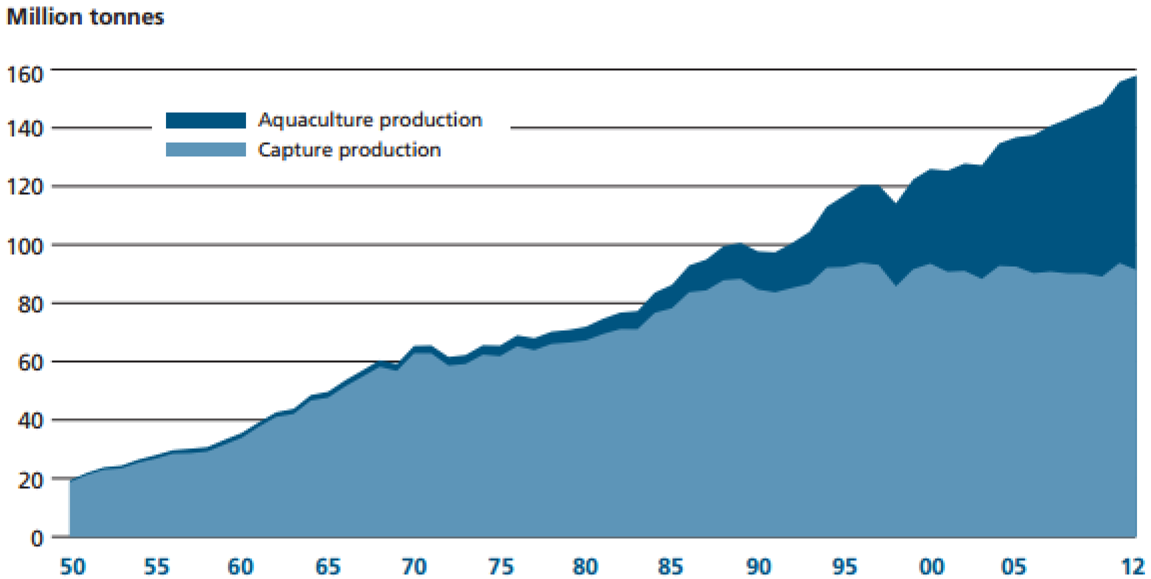

Figure 1: World capture fisheries and aquaculture production (FAO, 2014).

Fish products are essential to food security, providing over 1 billion people with their main source of protein and more than 4.3 billion people with about 15% of their average per capita animal protein intake (FAO, 2012). Fish provides nutrients and micronutrients that are essential to cognitive and physical development and is an important part of a healthy diet (World Fish, 2015). Fish proteins are particularly important for preschool-aged children and pregnant women (World Fish, 2011). Fish is usually low in saturated fats, carbohydrates, and cholesterol and provides not only high-value protein but also a wide range of essential micronutrients, including various vitamins, minerals, and polyunsaturated omega-3 fatty acids (FAO, 2012).

Micronutrient deficiencies affect hundreds of million people, particularly women and children in the developing world. More than 250 million children worldwide are at risk of vitamin A deficiency, 200 million people suffer from goitres (with 20 million have learning difficulties as a result of iodine deficiency), 2 billion people (more than 30% of the world's population) are iron deficient, and 800,000 child deaths per year are attributable to zinc deficiency (FAO, 2014).

Fish contributes to the nutritional security of poor households in developing countries in various ways. These include consumption pathways, where direct consumption of fish boosts intakes of micronutrients, and cash-income pathways, where commercialization of fish contributes to wider product distribution, economies of scale and higher overall food consumption. Thus, fish can be effective in addressing food and nutritional security among the poor and vulnerable populations around the globe (World Bank, 2013).

World fish resources also play a key role in maintaining and expanding employment levels. Over 140 countries have marine fisheries that provide employment for local and foreign workers. In 2010, wild fisheries and aquaculture provided incomes and livelihoods for an estimated 54.8 million people engaged in the primary sector of fish production.

Apart from the primary production sector, fisheries and aquaculture provide numerous jobs across the supply chains, in activities such as processing, packaging, marketing and distribution, manufacturing of fish-processing equipment, net and gear making, ice production and supply, boat construction and maintenance, management, research and administration. This is estimated to support the livelihoods of 660 to 820 million people, or 10% to 12% of the world's population (FAO, 2012).

1.2 Bangladesh fisheries

After agriculture, fish is the second most valuable crop in Bangladesh (DoF, 2015a). Fish production contributes to the livelihoods and employment of millions of people. Therefore, the culture and consumption of fish has important implications for national income and food security. A popular saying in Bangladesh is "Mache Bhate Bangali" or "fish and rice makes a Bengali."

In Bangladesh, fisheries, including both capture fisheries and fish farming, is the second most valuable production industry after the garment industry. Fisheries plays a significant role providing food, nutrition, income, livelihood, employment and foreign exchange earnings to the economy of Bangladesh (Dey *et al.*, 2010). Fisheries accounts for 3.7% of the national GDP and 22.6% of the agricultural GDP and more than 2% of foreign exchange earnings (Azad, 2015). Out of a population of 160 million people, 16.5 million are directly or indirectly involved in the fisheries sector and earn their livelihoods from fisheries related activities (DoF, 2013b).

The present per capita annual fish consumption in Bangladesh stands at about 17.5 kg/year against a recommended minimum requirement of 20.4 kg/year (DoF, 2015b); hence there is still a need to improve fish consumption in the country (Toma & Mohiuddin, 2015). The fisheries resources of Bangladesh are highly diverse and include marine capture fisheries and inland fisheries. In 2013-2014 marine fisheries contributed to 17% and the inland fisheries 83% to the total fisheries production (DoF, 2015b).

Inland fisheries are further divided into two sectors, including capture and culture fisheries. Inland fisheries cover an area of about 4.6 million hectares of which aquaculture comprises more than 0.5 million hectares (DoF, 2010). For the last two decades, growth of fish production from inland open waters has been very slow due to a variety of natural and man-made reason (DoF, 2013c). The World Bank (1991), Lewis (1997), Ministry of Planning (1998), identified (1) overfishing caused by population pressure, (2) indiscriminate killing of juveniles and destruction of spawning grounds, (3) obstruction of migration routes, shrinkage of floodplain due to construction of irrigation structures, (4) siltation, (5) flood prevention control and (6) use of agrichemicals as the main reasons for declining inland open water fish production.

However, due to a changing aquatic ecosystem, soil erosion, siltation in rivers, construction of dams to control flood and irrigation, indiscriminate use of agro-chemicals, destructive fishing practices and over fishing, fish production from inland open water has been decreasing (Joadder *et al.*, 2013) and inland capture fisheries have been under heavy pressure.

Environmental pollution from pesticides is also one of the major causes for the reduction of open water fish production (Showler, 1989). Therefore, Bangladesh has focused its attention on aquaculture, which has a high potential for development (Hussain & Mazid, 2005).

The Department of Fisheries (DoF) of Bangladesh, in 2013-2014 inland capture fisheries contributed to 28% whereas culture fisheries contribution was 55% of the total fisheries production and that was almost 2 million tons as illustrated in Figure 2 (DoF, 2015b).

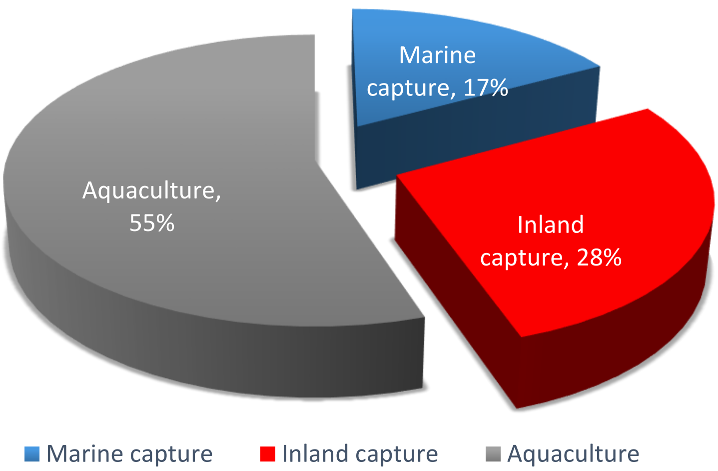

Figure 2: Sector-wise fisheries production in Bangladesh in 2013-14 (DoF, 2015b).

1.3 Aquaculture of Bangladesh

Aquaculture production of Bangladesh is increasing dramatically (Figure 3). Aquaculture has played a significant role in providing fish supply since the mid-1980s. The production growth rate is the highest in aquaculture.

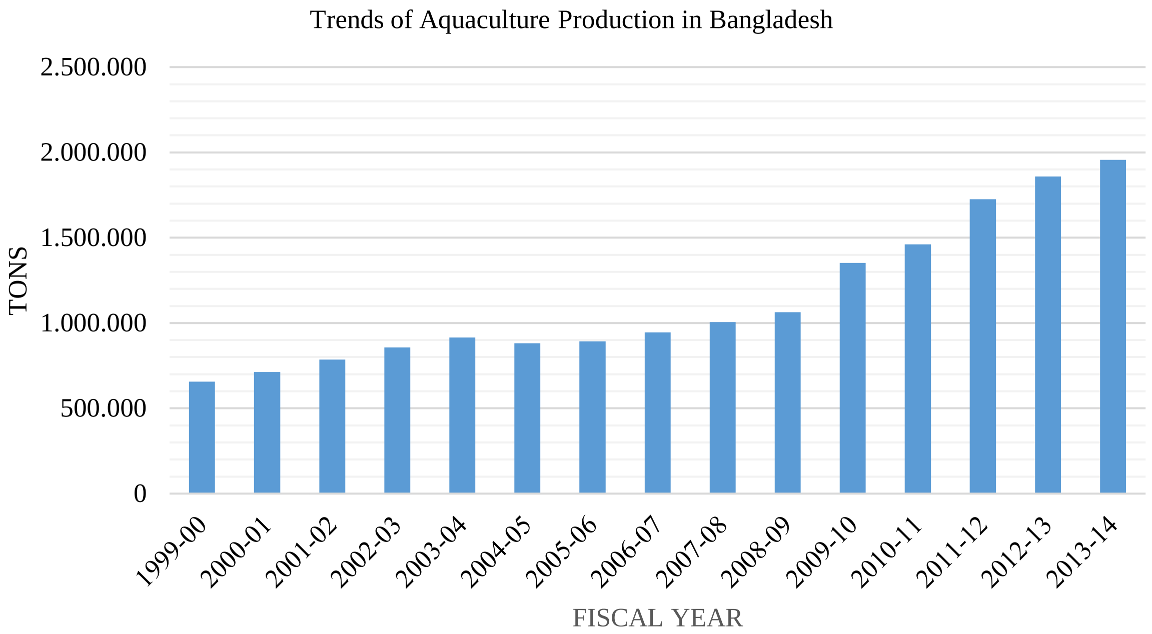

Figure 3: Trends of aquaculture production in Bangladesh during the last 15 years (DoF, 2015c).

Several aquaculture technologies have been developed by the Bangladesh Fisheries Research Institute (BFRI) and the Department of Fisheries (DoF) of which culture of carp, prawn, exotic catfish pangas and tilapia are important. But most of the aquaculture systems mainly revolve around the polyculture of various species of carps (both Indian and Chinese carps) and monoculture of tilapia in varying combinations and densities depending on the availability of seed and feed (Hussain, 2009).

Pond culture is dominated by production of carp which is mainly done as mixed culture or polyculture of the semi intensive system enriched with a significant number of indigenous and exotic carp fishes. There are at least 13 endemic and 8 introduced species of carp which are of interest to aquaculture in Bangladesh (Hussain & Mazid, 2005). The various carp species are generally grouped on the basis of the geographical locations as the Chinese carp, which include the grass carp, *Ctenopharyngodon idella*; the silver carp, *Hypophthalmichthys molitrix* and the bighead carp, *Aristichthys nobilis* and the Indian major Carp, which comprise of catla, *Catla catla*; rui, *Labeo rohit*a; and mrigal, *Cirrhinus mrigala*. Other species include the common/mirror carp, *Cyprinus spp.* and thai punti, *Puntius gonionotus*.

Tilapia has a long history of farming in Bangladesh. The Mozambique tilapia (*Oreochromis mosambicus)* was first introduced to Bangladesh from Thailand in 1954 (Ahmed *et al.*, 1996). However, this species was not widely accepted for aquaculture because of its early maturation and prolific breeding lead to overcrowd ponds. The Chitralada strain of Nile tilapia (*O. niloticus)* a far superior farmed tilapia, faster growing and more manageable than the Mozambique tilapia, was then introduced to Bangladesh from Thailand by UNICEF in 1974 (ADB, 2005). Nevertheless, Nile tilapia farming was slow to develop as most farmers were interested to growing carp, the most popular species in Bangladesh. Gradually, the red tilapia hybrid of *O. mosambicus* and *O. niloticus* was imported to Bangladesh from Thailand. The Bangladesh Fisheries Research Institute (BFRI) reintroduced Nile tilapia and red tilapia from Thailand in 1987 and 1988 (Gupta *et al.*, 1992). Genetically Improved Farmed Tilapia (GIFT) was introduced to Bangladesh by International Centre for Living Aquatic Resource Management (ICLARM, currently WorldFish Center) and BFRI in 1994 (Hussain *et al.*, 2000). Performance of GIFT proved to be significantly superior to that of tilapia previously introduced. Technology was also developed to produce all male tilapia or sex-reversed GIFT locally known as monosex tilapia, because the male tilapia grow faster than females, and the unwanted reproduction, overcrowding and harvest of undersized fish are avoided (ADB, 2005). Now, mostly semi intensive (primarily depend upon supplementary quality feed) monoculture of Tilapia (GIFT) is done in ponds. Lime, fertilizer, supplementary feed and low density, with 40,000-60,000 fingerlings per hectare used in small-scale semi intensive culture (Hussain, 2009). Moreover, tilapia became popular gradually to the farmers and hatcheries have been established in different places of the country, it was administered for mass production of tilapia seed. More than 90% of the grow-out tilapia farmers stock their ponds with monosex BFRI super GIFT strain (Dr. Kohinoor, pers. com). Presently more than 400 monosex tilapia hatcheries have been established in Bangladesh. These hatcheries produce over 4.0 billion fry every year (DoF, 2015c).

2 PROJECT STATEMENT

2.1 Justification

In Bangladesh, capture fish production cannot meet the increasing demand of the human population. The total population in Bangladesh was last recorded at 160.1 million people in 2015, up from 50.1 million in 1960, a change of 220% during the last 50 years, as shown in Figure 4 (BBS, 2015).

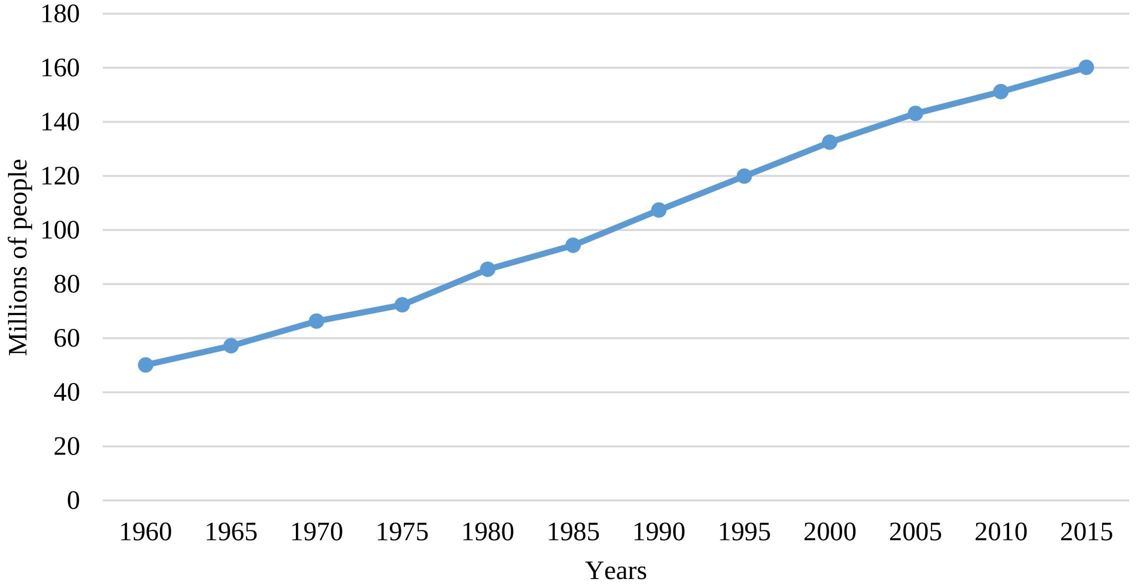

Figure 4: Population growth in Bangladesh (BBS, 2015).

Because of rapidly increasing human population, there is intense pressure on food production systems, including aquaculture to enhance the production. Given the limitations in habitat and increasing fishing pressure on inland capture fisheries in Bangladesh, people look to aquaculture as a solution to produce more fish. Therefore, more productive aquaculture systems are necessary to increase the production per unit area. For farmers to increase their production, they will not only need to produce more fish, they will also need to make a profit to maintain sustainable operations.

Bangladesh has hundreds and thousands of small water bodies in the form of ponds, ditches, shallow road side canals, barrow pits and which have tremendous potential for aquaculture. Small scale aquaculture is difficult due to seasonal waterbodies, low depth of water, unavailability of water, and low marginal profits. Under such characteristics most of the small-scale fish farmers like carp polyculture because of easy culture method, low investment cost, and availability of seed and feed of carp. But some farmers who know about profit of tilapia culture prefer to farm tilapia even given the comparatively higher feed cost.

Most fish farmers in Bangladesh lack appropriate information to make informed investment decisions. This is attributed to inadequate research information on aquaculture economics in Bangladesh. Therefore, the farmers have invested in aquaculture with unrealistic expectations. This has led to failures and frustration among the farmers as well as investors and has been a hindrance to aquaculture development. Lack of economic information on the feasibility of aquaculture affects decision making when evaluating possible investment options, accessibility to financing needed for investment and it makes insurance of such investments difficult. These factors will impact negatively on aquaculture investment and therefore development.

The aim of this study is to make an economic comparison of small-scale tilapia aquaculture and carp aquaculture under the environmental and financial conditions in Bangladesh. Earlier, the small-scale fish farmers did not take their farming as a business but now fish farmers are slowly adopting scientific technologies instead of ancient culture methods. Therefore, there is a need for economic comparison of different culture species and techniques because proper fish species can contribute more fish and profit.

It is expected that more profitable fish farms will, in the future, increasingly supply more fish to the local market. This will improve the per capita fish consumption in the country. Further, it is anticipated that a successful and vibrant small-scale aquaculture industry could trigger a commercial aquaculture industry in the country. In addition, the small-scale farmers might grow in capital and knowledge and transform themselves into medium and eventually large scale farmers resulting more fish and profit.

Increased biomass production has potential to supply fish to the market and thus will increase the annual intake of protein from fish of the population of our country and could ultimately increase export volume for earning foreign currency.

The findings of this study will help the policy makers, extension workers and fish producers make decisions to lead toward more profitable aquaculture farming and provide useful information on how to develop aquaculture to a commercial level and production for large scale markets and export.

This study was carried out to develop an economic comparison of tilapia and carp aquaculture and determine which is the most profitable with the aim to increase the production per unit area.

For this purpose, 800 m^2 ponds were used as the basis for the analysis because this is the average size used by most private fish farmers in Bangladesh. This study calculated and compared

a. Economics of one pond production model of tilapia and carp aquaculture,
b. Economics of ten ponds production model of tilapia and carp aquaculture,
c. Economics of tilapia aquaculture one pond and ten ponds production model, and
d. Economics of carp aquaculture one pond and ten ponds production model.

2.2 Anticipated benefits

A production comparison model for small scale tilapia and carp fish farming was developed. The results of the study can be used as a guideline for prospective and existing fish farmers in Bangladesh. The information generated will provide farmers with appropriate tools to determine better production and profit of their farms and also help lending institutions to better assess the potential of aquaculture projects.

The methodology developed here can easily be adapted to compare any type of investment for instance fish farming enterprises of other species or fishery operations.

3 MATERIAL AND METHODS

3.1 Data collection and assumptions

Data on tilapia monoculture and carp polyculture in Bangladesh were obtained from the annual fish production report of Integrated Agricultural Productivity Project (IAPP) funded by the Global Agricultural Food Security Program (GAFSP) and the Bangladesh Government directed by the Ministry of Agriculture and the Ministry of Fisheries and Livestock of Bangladesh. The aim of IAPP was:

- To generate and release to farmers new varieties that give a higher yield and or provide technological solutions to production problems under specific agro-ecological conditions.
- To improve productivity through production and supply of quality seed and breeding materials.

In Bangladesh, IAPP is working at Rangpur and Barisal region (Figure 5). Data for this study was gathered from 64 farms in the Rangpur region; 32 of which specialise in tilapia while 32 produce carp. The farmers were selected through Participatory Rural Appraisal (PRA) method. Selected farmers had prior training after which their ponds were visited by DoF officials. Roadside ponds were selected for tilapia or carp demonstration.

Figure 5: IAPP working area map of Bangladesh.

Each of selected pond owners or leases had been supplied with lime, fertilizer, fingerlings and some feed as subsides. These subsides were equivalent with 19,000 BDTk. Field workers of DoF frequently visited these farms and collected information that was forwarded to the IAPP regional office.

Information was also collected based on aquaculture pamphlets, literature, and professional experience in the aquaculture extension service.

Production characteristic data from the following types of aquaculture production practices under evaluation was obtained; semi-intensive monoculture of Tilapia (GIFT, monosex all male) and semi intensive mixed-culture of carp.

The following data for various investment type was collected:

A. Operational cost that included:
- i. Quantities of inputs used in production,
- ii. Cost of inputs of production,
- iii. Lease value of the ponds,
- iv. Salaries and wages expenditures.

B. Operational income that included:
i. Products and production quantities,
ii. Selling prices of the products.

3.2 Assumptions on production parameters

The evaluation was based on the assumption that farmers were using semi-intensive operation systems and that products from the farms were to be marketed locally as whole fish.

Assumptions on production characteristics were based on information from the aquaculture handouts for farmers. For a stocking density of 5 fingerlings per m^2 for semi-intensive production of tilapia monoculture and 50 fingerlings per 40 m^2 for semi-intensive production of carp polyculture, the manual recommends pellet feeds as supplementary food and fertiliser to bring the total nitrogen and phosphorus to full recommended rates. Feeding calculations for culture of tilapia and carp were based on the full recommended rate used by the DoF. A full list of assumptions is given in Table 1.

Table 1: Assumptions used in the development of production schedule for tilapia and carp culture of one pond and ten ponds in Bangladesh.

Characteristics	Unit	Assumed value per year			
		1 pond		10 Ponds	
		Tilapia	Carp	Tilapia	Carp
Pond area	M^2/pond	800 m^2	800 m^2	800 m^2	800 m^2
Pond lease value	BDTk/pond	3,000	3,000	3,000	3,000
Stocking rate	Fingerlings /m^2	5	1.25	5	1.25
Cost of fingerlings	BdTk/individual	1.25	2.4	1.25	2.4
Survival at harvest	%	75	70	77	72
1 Cycle length	Months	4.5	9	4.5	9
Harvest weight	Grams	170	700	170	700
Tilapia price	BDTk/kg	87	110	87	110
FCR of feeds	Ratio	1.0	1.5	1.0	1.5
Yields	Kg/pond/year	1,020	385	1,047	413

*1 US$ = 80 BDTk

The assumed values were based on information from Aquaculture Handbook of Department of Fisheries (DoF, 2015c) of Bangladesh and the author's experience after 16 years as a fisheries extension officer. Assumptions regarding inputs for tilapia culture are given in Table 2, and assumption relating to inputs for carp culture are given in Table 3.

The cost of the lime, fertilizer and feed were based on information from the annual production plan (revised) of fish seed production farm of Sadar, Lalmonirhat of Bangladesh (DoF, 2015c).

3.3 Production planning model

To perform an economic comparison, it is necessary to start with a production model that describes the operations of production cycles over the period of one year. This was done for carp and for tilapia. The production models were based on the biological assumptions given earlier (growth rate, survival rate, FCR. etc.) and the results regarding the operating costs and the expected annual returns.

Table 2: Assumptions on lime, fertilizer and feed used for tilapia culture in Bangladesh.

Item		Characteristics	Unit	Assumed value per year	
				1 pond	**10 ponds**
Limestone		Quantity	Kg	40	400
		Cost	BDTk/kg	20	20
Cow dung		Quantity	Kg	600	6,000
		Cost	BDTk/kg	1.5	1.5
Urea		Quantity	Kg	12	120
		Cost	BDTk/kg	20	20
TSP		Quantity	Kg	6	60
		Cost	BDTk/kg	24	24
FEED	Nursery-1 Floating	Quantity	Kg	80	800
		Cost	BDTk/kg	51	51
	Nursery-2 Floating	Quantity	Kg	160	1,600
		Cost	BDTk/kg	48	48
	Grower Floating	Quantity	Kg	580	5,800
		Cost	BDTk/kg	46	46
	Finisher Floating	Quantity	Kg	200	2,280
		Cost	BDTk/kg	44	44
	Total feed	**Quantity**	**Kg**	**1,020**	**10,480**

Table 3: Assumptions on lime, fertilizer and feed used for carp culture in Bangladesh.

Item		Characteristics	Unit	Assumed value per year	
				1 pond	**10 ponds**
Limestone		Quantity	Kg	20	200
		Cost	BDTk/kg	20	20
Cow dung		Quantity	Kg	1000	10000
		Cost	BDTk/kg	1.5	1.5
Urea		Quantity	Kg	15	150
		Cost	BDTk/kg	20	20
TSP		Quantity	Kg	7.5	75
		Cost	BDTk/kg	24	24
FEED	Rice bran	Quantity	Kg	180	1850
		Cost	BDTk/kg	20	20
	Wheat bran	Quantity	Kg	40	450
		Cost	BDTk/kg	25	25
	Maize bran	Quantity	Kg	100	1100
		Cost	BDTk/kg	14	14
	Mustard oil cake	Quantity	Kg	220	2400
		Cost	BDTk/kg	29	29
	Fish meal	Quantity	Kg	40	400
		Cost	BDTk/kg	100	100
	Total feed	**Quantity**	**Kg**	**580**	**6200**

3.3.1 Tilapia monoculture production model in one pond and ten ponds.

Based on the assumptions in Table 1, a one pond ($800m^2$) production model was developed or similarly same size (each $800m^2$) ten ponds model was also developed for one cycle.

The ponds previously limed at a rate of 2.5 tons/ha or 20 kg per pond, are stocked with 4,000 tilapia fingerlings (4-7 g) per pond or 50,000 per ha. To stimulate initial growth of plankton, the pond is fertilized with triple super phosphate (TSP) (IAPP, 2012). The fertilizer is applied once before stocking. After stocking, the pond was fertilized again with urea at a rate of 9 kg/ha or 750g per pond and triple super phosphate (TSP) at a rate of 4.5 kg per ha or 325g per pond once weekly (DoF, 2013b). Inorganic fertilizer (cow dung) provides an alternative or supplemental source of nitrogen and protein through phytoplankton conversion.

The model assumed that the fish were fed daily on a supplementary floating pellet balanced feed. After every two weeks, the ponds were sampled for fish growth measurements. Mean body weights (g) and percentage survival rates were determined. This was used to compute biomass of the fish in the ponds after every two weeks. Based on this biomass, the fish were fed daily over a culture period of 30 weeks. At the end of the 16^{th} to 18^{th} week the fish were harvested from the pond and net production determined. They were then sold. The main costs incurred during the operation were calculated and subtracted from the revenue (sales) at the end of the production period, see further in Appendix 1.

3.3.2 Model of carp mixed-culture in one pond and ten ponds.

The information from the tilapia monoculture model were used to prepare a production model for one and ten ponds carp mixed-culture farm. Liming and fertilizing process were same as the tilapia monoculture model, here ponds were stocked with 1,000 carp fingerlings per pond or 12,350 per ha.

The model assumes that the fish were fed daily on a supplementary feed. After every two weeks, the ponds were sampled for fish growth measurements. Mean body weights (g) and percentage survival rates were determined. This was also used to compute biomass of the fish in the pond after every two weeks. Based on this biomass, the fish were fed daily over a culture period of 37 to 40 weeks. At the end of the 37^{th} to 40^{th} week the fish were harvested from the pond and net production determined. They were then sold. The main costs incurred during the operation were calculated and subtracted from the revenue (sales) at the end of the production period, see further in Appendix 1.

3.4 Economic analysis

Popular methods of economic comparison include fixed cost, variable cost, operating cost and net profit contribution. EBITDA is also used as an important indicator of economic comparison.

Fixed costs are associated with the long-term operation of an aquaculture farm. Examples include: taxes (on property), insurance, depreciation, interest, the rent of the pond, wage of permanent employees, amortization payments (for repayment of borrowed money). These costs are often overlooked but must be considered in assessing the financial situation of an aquaculture farm.

Variable costs are cost factors that change when production quantities change. The variable cost factors in the present case include the acquisition of fingerlings, feed, chemicals, fertilizers, fuel and/or power and harvesting costs.

In a fish farm, operating costs are composed of fixed and variable costs. Therefore, operating cost is the sum of variable costs added to fixed costs.

Net profit contribution is an income statement in which all variable expenses are deducted from the selling price to arrive at a contribution margin for the specific period. Thus, the arrangement of expenses in the income statement corresponds to the nature of the expenses. Net profit contribution is an important form of presentation, because the contribution margin clearly shows the amount available to cover fixed costs. Therefore:

Net profit contribution = Revenue-Variable cost
Where, Revenue =Fish quantity X per unit sales price

In essence, if there are no sales, net profit contribution statement will have a zero-contribution margin, with fixed costs clustered beneath the contribution margin line item. As sales increase, net profit contribution will increase in conjunction with sales, while fixed costs remain the same. Fixed costs will increase if there is a step cost situation, where a block of expenses must be incurred to meet the requirements of an increase in activity levels.

A farm's earnings before interest, taxes, depreciation and amortization, commonly called EBITDA, can be used as an approximate measure of a farm's operating cash flow based on data from the farm's income statement. This is calculated through earnings before the deduction of interest expenses, taxes, depreciation, and amortization. EBITDA shows how much profit it makes with its present assets and its operations on the products it produces and sells, as well as providing a proxy for cash flow.

Therefore, the formula is:

EBITDA = Revenue – Operating cost (excluding interest, taxes, depreciation and amortization)
Or,
EBITDA = Net profit contribution-Fixed cost (excluding interest, taxes, depreciation and amortization).

3.5 Economic comparison

Financial ratios are used to give an indication, not only of how likely a project is to return a profit, but also how that profit relates to other important investment characteristics of the project. These ratios are used to assess a business's ability to generate earnings as compared to costs incurred during a specific operational period. They provide a comparison of profits generated and what has been invested in a project. For most of these ratios, having a higher value is an indication that the investment is good (Curtis & Howard 1993). Such ratios are including operating cost, net profit contribution and most important is EBITDA ratio.

However, an economic comparison of tilapia and carp aquaculture was developed based on the result of EBITDA (earnings before interest, taxes, depreciation and amortization) which was compared by

a. EBITDA of one pond production model of tilapia and carp aquaculture,
b. EBITDA of ten ponds production model of tilapia and carp aquaculture,
c. EBITDA of tilapia aquaculture one pond and ten ponds production model and
d. EBITDA of carp aquaculture one pond and ten ponds production model.

4 RESULTS

The four aquaculture scenarios discussed in the last section were calculated based on a combination of production characteristics for the fish species and pond number under consideration and estimated costs of investment.

4.1 Operational analysis

Total fixed operating costs for monoculture of tilapia and mixed-culture of carp are the same because of same land size and labour effort but total variable investment costs for monoculture of tilapia are estimated higher than mixed-culture of carp due to different production characteristics.

Total fixed costs for tilapia or carp farming in 1 pond production models are comparatively lower than 10 ponds production model farming because of higher salary of additional labour needed for 10 ponds model farm. The variable costs for tilapia or carp farming in 1 pond production model are higher than 10 ponds production model farming because of comparatively lower transportation and harvesting cost of 10 ponds production model farm. The estimated results are shown in Tables 4 and 5.

Table 4: Estimations of variable costs (BDTk) per year (where, 1 US$=80BDTk).

Item	Tilapia		Carp	
	1 pond model	**10 ponds model**	**1 pond model**	**10 ponds model**
Fertilizer	2,084	20,840	2,380	23,800
Fish fingerling	10,000	100,000	2,400	24,000
Feed	47,240	484,720	16,380	173,250
Vitamin	500	5,000	250	2,500
Harvesting	1,000	4,000	500	2,000
Feed transportation	1,000	3,000	500	1,500
Fish transportation	1,000	3,000	500	1,500
Medicine	800	6,000	400	2,000
Total variable cost	**63,624**	**626,560**	**23,310**	**230,550**

Table 5: Estimations of fixed operating costs (BDTk) per year.

Item	Tilapia		Carp	
	1 pond model	**10 ponds model**	**1 pond model**	**10 ponds model**
Pond lease value	3,000	30,000	3,000	30,000
Labour (own/additional)	4,000	50,000	4,000	50,000
Total fixed cost	**7,000**	**80,000**	**7,000**	**80,000**

Table 6 below shows the estimation of fish production per year for the different models. In the one pond model fish production or yields per year are 1,020 and 385 kg for tilapia and carp respectively. In the 10 ponds model yields are 10,472 and 4,125 kg for tilapia and carp respectively. While in the 10 ponds model farming, yields per year per pond are 1,047.2 kg and 412.5 kg for tilapia and carp respectively

Table 6: Estimations of fish production or yields per year.

Characteristics	1 pond model		10 ponds model	
	Tilapia	Carp	Tilapia	Carp
Yields kg /year	1,020	385	10,472	4,125
***Yields kg /pond/ year**	1,020	385	1,047.2	412.5

*Where, 1 pond =800 m^2

Table 7 below shows an operational statement for tilapia and carp aquaculture practices in the one and ten ponds in one year of operation. Gross income for the culture practices are mainly dependent on the market price and quantity of products.

Table 7: Operation statements (all cost in BDTk).

Culture practice	Tilapia 1 pond model	Carp 1 pond model	Tilapia 10 ponds model	Carp 10 ponds model
Sales quantity (Kg /year)	1,020	385	10,472	4,125
Sales Price (BDTK /kg)	87	110	87	110
Gross Income (BDTk)	88,740	42,350	911,064	453,750
Variable cost	63,624	23,310	626,560	230,550
Fixed cost	7,000	7,000	80,000	80,000
Operating cost	70,624	30,310	706,560	310,550
Net profit contribution (gross income – variable cost)	25,116	19,040	284,504	223,200
EBITDA* (gross income – operating cost)	18,116	12,040	204,504	143,200

*EBITDA=earnings before interest, taxes, depreciation and amortization.

Generated details statements of operations, productions, net profit contribution, and EBITDA for each of the four culture practices are presented in Annex II.

4.2 Production analysis

Fish production analysis (Figure 6) indicated that in the one pond production model, tilapia production showed a higher yield compared to the carp. In the ten-pond production model, tilapia production showed the highest yield per pond per year compared to other production models.

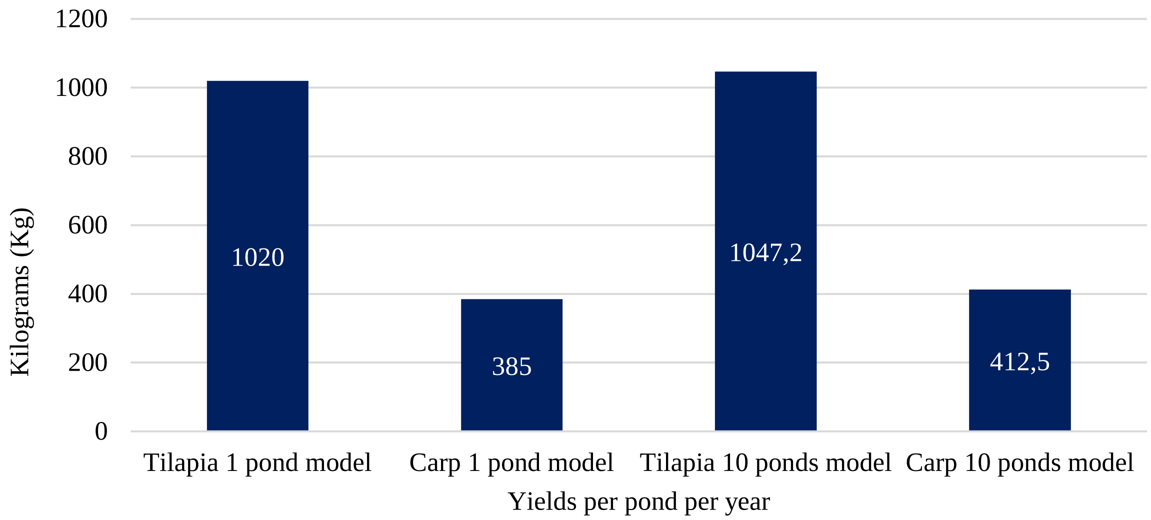

Figure 6: Yields (kg) of tilapia and carp aquaculture per pond per year.

Table 8 shows that the highest yields are estimated from ten ponds production model of tilapia farm and the yields was 10,472 kg/pond/year.

Table 8: Comparison of yields between tilapia and carp aquaculture.

Yields	Tilapia	Carp	Difference in yields of tilapia and carp
1 Pond* model (kg year^{-1})	1,020	385	**635**
10 Ponds model (kg year^{-1})	10,472	4,125	**6,347**
Difference in yields of 10 ponds and 1 pond production model**	**272**	**275**	

* 1 pond = 800 m^2
** 10 ponds model yields- (1 pond model yields x 10)

4.3 Economic analysis

In the one pond model, tilapia production showed a higher EBITDA due to higher value of the products compared to the carp. Similarly, in the ten-pond model, tilapia production also showed a higher EBITDA compared to the carp. Market price of carp is higher than tilapia, however the quantity of tilapia produced is more than that for carp production. Due to the additional production resulting from tilapia monoculture it had higher gross income compared to mixed culture of carp.

However, tilapia culture in the ten-pond model showed higher value of EBITDA per pond compared to the one pond model, as illustrated in Figure 7. For the same reason, similar results were estimated for carp culture where the ten-pond culture model show higher value of EBITDA per pond compared to the one pond model.

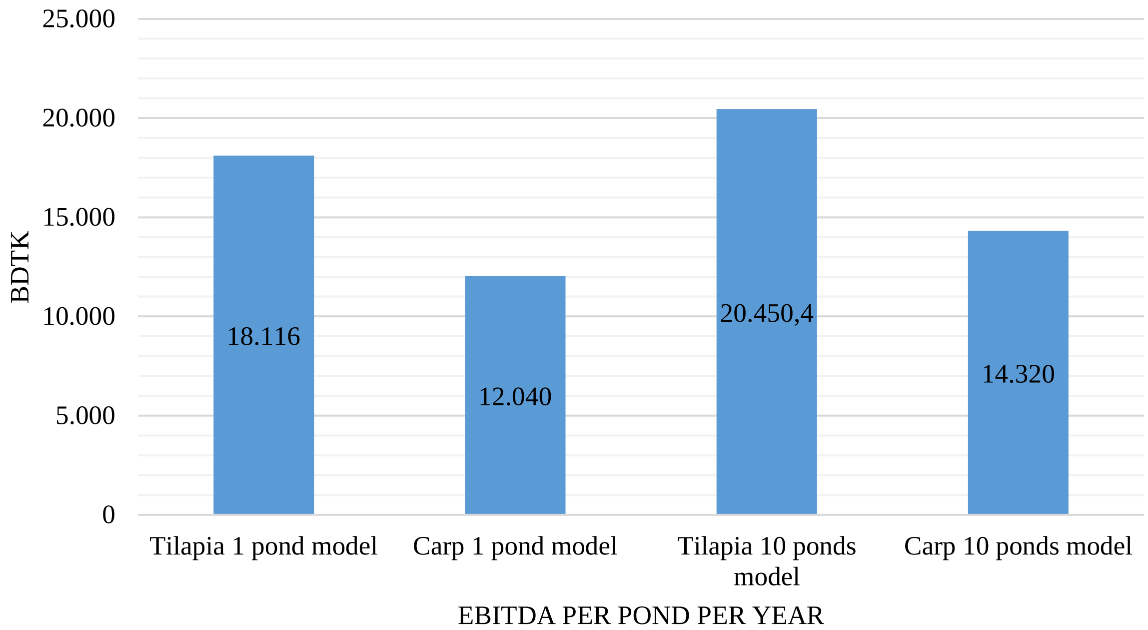

Figure 7: EBITDA (BDTk) of tilapia and carp aquaculture per pond per year (1US$=80 BDTk).

All the culture practices show a positive operational surplus or EBITDA although in varying amounts, as shown in Table 9. Tilapia production has a higher operating surplus compared to the carp, indicating that although its total production cost is higher, the gross income generated is high enough to cover for all costs and still have higher operational surplus or EBITDA available for continued operations.

Table 9: Comparison of EBITDA between Tilapia and Carp aquaculture.

Description	Tilapia		Carp		Comparison Tilapia and Carp	
	BDTK	US$**	BDTK	US$	BDTK	US$
1 Pond model EBITDA	18,116	226	12,040	151	**6,076**	**76**
10 Ponds model EBITDA	204,504	2,556	143,200	1,790	**61,304**	**766**
Comparison* 10 ponds model and 1 pond model	**23,344**	**292**	**22,800**	**285**		

* 10 ponds model EBITDA- (1 pond model EBITDA x 10)
** Currency exchange Rate 80 BDTK=1US$

Overall, tilapia the ten-pond model farming has much higher accumulated profits compared to the other culture practices. This is followed by the one pond tilapia model and the carp ten pond, model and lastly by the carp one pond model.

5 DISCUSSION

Bangladesh is facing the problem of unemployment, hunger and poverty. Capture fisheries are far from covering the needs of our increasing population in terms of fish harvesting and consumption. As a way to solve these problems, we have to define a long-term development goal to increase the production and profit of aquatic products progressively and at the same time to reduce poverty, hunger and unemployment by using aquaculture because our land is very suitable for aquaculture.

The purpose of this study was to economically compare tilapia and carp aquaculture in Bangladesh at different scales of production. Such studies have never been conducted, and it is critical for farmers and investors to understand how to calculate and interpret the economical comparison of aquaculture businesses. It is envisaged that the economic comparison process will become a valuable management tool to aquaculture farmers and investors and help facilitate a more market-driven production management. The information generated will provide prospective and existing fish farmers with appropriate tools to determine the economic comparison of their aquaculture system and help lending institutions better asses the viability of aquaculture projects.

In this study, an economic comparison of fish farming in Bangladesh was developed. It is important for aquaculture farmers to understand that a considerable amount of capital is needed for operating a fish farm in general. Also, the operation must be able to return the capital with more profit. Seed, feed, labour and other inputs are needed to produce fish. The amount and kind of needs depends on the size of land. But, it is more important for aquaculture farmers and investors to understand which species are most profitable. Therefore, measuring EBITDA (earnings before interest, taxes, depreciation and amortization) is one of the main tools for economic comparison.

This study shows that if one 800 m^2 pond is used to culture tilapia then it can provide EBITDA 113 US$ in one cycle of 4.5 months and two cycles are considered per year this number doubles to EBITDA 226 US$ which was similar with the findings of Toma (Toma, et al., 2015) for small–scale tilapia farming in Bangladesh, but the same pond size of carp culture can provide EBITDA 151 US$ per year. So, according to the EBITDA measurements, it was estimated that tilapia farming was more profitable than carp where pond number and size was one and 800 m^2 respectively.

If ten ponds of 800 m^2 each are used to culture tilapia then it can provide EBITDA 2,556 US$ per year which was similar with the findings of Toma (Toma.et al, 2015) for medium tilapia farming in Bangladesh but if one pond of 800 m^2 is used to same culture practice then it can provide EBITDA 226 US$ in one year. It was found that ten times EBITDA of one pond (800 m^2) tilapia culture was lower than EBITDA of ten ponds (each of 800 m^2) tilapia culture. So, according to the EBITDA measurements, it was estimated that comparatively large-scale tilapia farming was more profitable than small-scale farming.

If ten ponds of 800 m^2 size each are used to culture carp, then it can provide EBITDA 1,790 US$ per year but if one pond of 800 m^2 size is used to same culture practice then it can provide EBITDA 151 US$ in one year. It was also found that ten times EBITDA of one pond (800 m^2) carp culture was lower than EBITDA of ten ponds (each of 800 m^2) carp culture. So, according to the EBITDA measurements, it was estimated that ten ponds (each 800m^2) farming was more profitable than one pond (800m^2) farming and it is assumed that 20 ponds farming would be more profitable than 10 ponds farming. Large-scale farms need more seed and feed and generally they get better discounts from seed hatcheries and also feed industry. Thus, economics of scale might reduce cost per unit production, resulting in a further increase in profit.

If ten ponds of 800 m^2 each are used to culture tilapia then it can provide EBITDA 2,556 US$ per year but if same size and number of pond are used to carp culture, then it can provide EBITDA 1,790 US$ per year. So, according to the EBITDA measure it was estimated that comparatively in large-scale farming tilapia was more profitable than carp.

In the same way, it was estimated that yields of ten ponds model tilapia farming was 10,472 kg/year (table 8) which was more than the yields of ten ponds carp farming (4,125 kg/year) or even more than the yields of ten times of one pond tilapia farming (1,020 x 10 =10,200 kg/year). This was because in the ten-pond production model there was an additional labour who worked full time to the farm resulting in increased production rate compared to the one pond production model.

However, in Mozambique, Salia (2008) estimated that yields of one pond of 500 m^2 was 834 kg or 1.7 kg per m^2, which is more than the finding in this thesis which is 1.3 kg per m^2 (1.4 kg per m^2 in a ten-pond production model). This may be due to more favourable temperature of Africa round the year and improved management system of each pond. Herrara (2014) found in Cuba that yields of tilapia from nine different ponds were lowest 9.47 tons/ha/year to highest 12.65 tons/ha/year which is almost the same as our results show.

So, according to the estimated EBITDA and yields, tilapia aquaculture is more profitable and more yield-oriented aquaculture farming than carp and a comparatively large farm of tilapia aquaculture is also more profitable and more yield-oriented aquaculture farming than small farm of tilapia aquaculture.

6 CONCLUSIONS

The result of this evaluation showed that both tilapia and carp culture practices evaluated were viable although there were differences in EBITDA. Productivity could be increased by use of better yielding fish breeds and efficient production techniques. This would possibly have an effect of lowering production costs and increasing production volumes. These would be reflected in terms of higher viability as well as the EBITDA of the culture systems.

The success of the development of sustainable aquaculture in Bangladesh lies in the promotion of aquaculture as a viable investment opportunity where potential investors see opportunities to make attractive economic gains. The Department of Fisheries of Bangladesh must back this promotion by spearheading the development of higher yielding, market-oriented aquaculture species and efficient aquaculture production technologies.

However, farmers and investors in aquaculture will invest more when they perceive that they can make more profits. They, therefore, need economic comparisons among different aquaculture to assist them in making their decisions. For this reason, the Department of Fisheries of Bangladesh needs to have such information. The information could include:

a. Aquaculture profits by species
b. Aquaculture production by species
c. Aquaculture productivity by culture systems
d. Available fish markets, estimated demand, supply, and corresponding prices offered
e. Sources and costs of aquaculture inputs

The Department of Fisheries of Bangladesh will therefore need to impress on all those who are involved in aquaculture, the need for proper record keeping, and must devise efficient means of collecting, storing, and analysing this information.

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