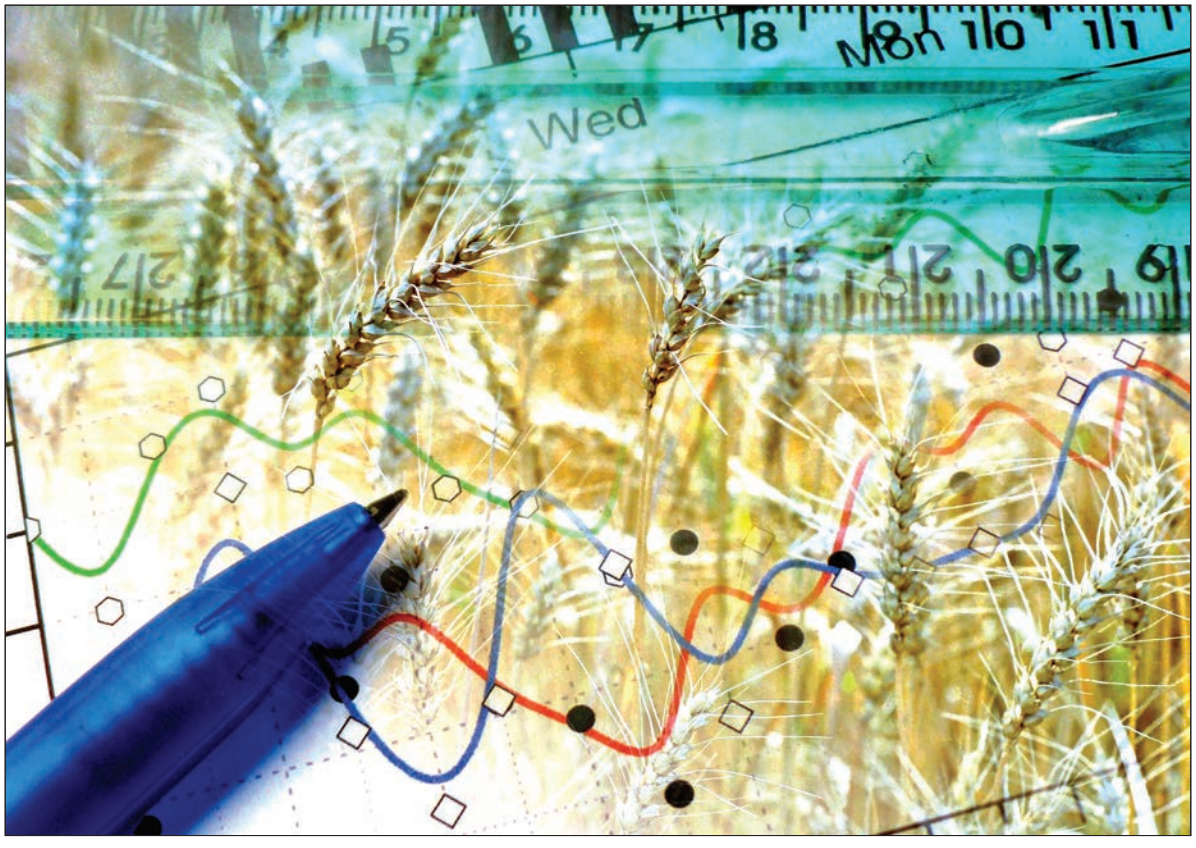


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# Economics of Thai *Koi* (Climbing Perch, Anabas Testudineus) Farming in Pond in Bangladesh

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## ABSTRACT

With the high growth and productivity, Thai *koi* has opened up a new horizon of pond culture in Bangladesh. However, its growth varied widely year to year causing fluctuations in production. This study was undertaken to explore the farm insight practices in an economic viewpoint by framing a total of 149 farmers from Mymensingh district in Bangladesh. The study analyzed the farm profitability and other farming practices based on a per hectare basis for the three feed categories and determine the feed contribution to production. Among variables, feed alone experienced 73% of the gross production costs, implies a greater influence of feed on production. Though, the gross cost was higher, hence, the cost of producing per kg fish was the lowest for the floating feed. The farm income also varied with the variation of input costs among the feed brands and the performance of floating feed was found to be outstanding. Furthermore, floating feed yielded the best performances in terms of feed conversion ratio or daily mean weight gain of fish. Although, the initial investment is higher with the floating, feed farmers can earn much additional returns from the extra investment compared to other feed technologies. Generally, with an average revenue of fish was US$ 1.59 $kg^{-1}$ and cost of US$ 1.38 $kg^{-1}$, Thai *koi* production is considered to be a profitable agri-business. Finally, the outlook for the Thai *koi* farming could be very optimistic in filling the upcoming demand of fish, thus greatly improved human nutrition and food security by removing the problems and constraints are identified.

**Key words:** Bangladesh, cost, feed, floating feed, production, return, Thai *koi*

## INTRODUCTION

Fisheries is now the second most valuable agricultural activities in Bangladesh, playing a substantial role in nutrition, food security, employment and income generation, trade, source of foreign exchange earnings and above all poverty reduction in the economy. Presently, it contributes 4.4% of national GDP, 22.6% to the agricultural GDP and 2.5% to the country's export earnings. Moreover, fish alone is supplementing about 60% of animal protein/capita in the

daily dietary requirement. Fisheries are clearly the most important employer in the economy and about 16.5 million people are directly/indirectly dependent on fisheries related activities for their livelihood (Ministry of Finance, 2013; DoFB, 2011, 2013).

Aquaculture production has been increasing every year continually as opposed to marine and capture fisheries. The production of farmed fish has increased from 0.039 million tons (mt) in the early 1960s to 1.72 mt at the moment is inspiring. It accounts for nearly 53% of the country's total production and the growth is credited largely from pond fisheries (Ali *et al*., 2010; DoFB, 2013). Pond aquaculture in Bangladesh has flourished commercially on a small-scale all over the country and created a great potential for farmers to earn higher income as well as self-employment generation. Freshwater aquaculture consists of mostly ponds and ditches. Bangladesh's total pond area is currently 371,309 ha which is about 55% of culture total or 7.89% of total inland water. Pond aquaculture presently contributes 1.34 mt with a growth rate of about 8% per annum. Though, the water area is small compared to open waters but it represents 50% of total inland fish production and 41% to the nation's total fish catch (DoFB, 2013). Pond culture has become a vital industry to food security, thus nations hope lies with it. Unfortunately, the challenge in the pond aquaculture is productivity gains. The annual fish production per hectare is still low in Bangladesh, 3615 kg $ha^{-1}$ for ponds which is the lowest in the world even far lower than Asian countries (Dey *et al*., 2005; Karim *et al*., 2006). Another concern is that the existing rate of increase in fish production is lesser than that of population boom in Bangladesh. Therefore, it is strongly felt that all sorts of efforts need to be employed to increase the domestic production to ensure the food and nutritional security of the growing population.

## FOOD SECURITY

Government has recognized food security as a prime factor in contributing to socio-economic development of Bangladesh. It is also country's constitutional mandate of its article 15 (a) is to secure to the basic necessities of life including food. Bangladesh is an agro-based developing country for the citizen. Hence, food security is totally depending on the performance of agriculture sector. Hence, fish provides food for millions of poor people in Bangladesh. Thilsted *et al*. (1997) reported that fish is also an important source of vitamins and micronutrients for the poor in Bangladesh.

Though, Bangladesh has been blessed naturally with vast water resources and fish production increased tremendously but fish consumption is still below the recommended dietary allowance. Recommended protein intake of a healthy person is 45 g $capita^{-1}$ $day^{-1}$ of which 15 g is prescribed from animal protein as against the 11 g we are enjoying (Mustafa *et al*., 2010). Moreover, the availability of protein intake from fish gradually decreased from 73-60% during 1991-2012 (DoFB, 2013). Many studies claimed that the protein intake is not equal among the all sorts of people in the society. It is, because, fish remains a critical component of food and nutritional security in Bangladesh. Children and women are generally susceptible to the deficiencies of vitamin and micronutrients as they have comparatively higher requirements for growth and reproductive functions. Moreover, the demand for fish is constantly increasing in Bangladesh with about three million people being added every year to the population (Chowdhury, 2009).

With this scenario, small exotic fish species of Climbing perch (*Anabas testiduneus*) was imported from Thailand into Bangladesh in 2002 and it locally bears the name of Thai *koi*. It contains very high amount of physiologically available iron and copper essentially needed for hemoglobin synthesis, besides, it possesses easily digestible fat of very low melting point and good many essential amino acids (Saha, 1971). Therefore, climbing perch is considered as a valuable

item of diet for sick and convalescent (BFRI, 2006). Fish, particularly small fish, are rich in micronutrients and vitamins (Larsen *et al*., 2000; Roos *et al*., 2003). Furthermore, small fish also has specific importance for the diets of children and lactating mothers to avoid child blindness and lessen infant mortality (Roos *et al*., 2007). Thai *koi* can play an important role to meet the growing demand of fish thus human nutrition, food security can be greatly improved due to the following reasons; the growth and productivity of Thai *koi* is much higher than other fish species cultured in Bangladesh, it is cultured twice in a year and reaches 80-100 g in size within 90-120 days, the medicinal and nutritional value has been recognized (Chandi, 1970) and finally, it can be stocked in ponds with high densities.

Thai *koi* is now one of the high commercial valued farm fishes and is getting more popular among farmers due to its taste and high market demand both at home and abroad. It is very much esteemed for its prolonged freshness. The production of Thai *koi* was 3,871 tons in 1999-2000 while the production increased to 31,143 t in 2011-12, with an annual growth rate of 54%. Most of this growth is credited due to introduction of Thai *koi* in pond culture. The share of *koi* fish in total pond culture has increased from 0.69-2.32% during this period. The production trend shows that the highest production experienced in 2011-12 with the annual growth rate of 132% while, the lowest production was documented in 2008-09 with a growth rate of -72% (Table 1). Although, the overall growth performance is impressive but growth fluctuates widely from one year to another indicating that there might be some problems in Thai *koi* culture in the study area causing fluctuations in production.

Thai *koi* has opened up a new horizon of pond culture in Bangladesh. The private sector is the key actors in its culture with a good strategy, application of better management and handling technology correctly, the outlook for the aquaculture can be very positive. However, intensive culture of this strain is relatively a new activity among Bangladesh's farmers. Little or no information on Thai *koi* production in the economic arena is available in the literature. Hence, there is a need to find out details to develop and grow this farming system in an economically viable and sustainable fashion. Considering the importance of this fish for aquaculture, the objective of this study is to carry out the farm insights like production performance, contribution of inputs, costs and returns and problems faced by the farmers during production. The study considers a total of 149 sampled farmers randomly selected from the northern three sub-district

Table 1: Thai *koi* production from pond during 1999-2000 to 2011-12

| Year | Total production (tons) | Pond total (%) | Annual growth (%) |
|---|---|---|---|
| 1999-2000 | 3871.25 | 0.69 | |
| 2000-2001 | 4495.52 | 0.73 | 16.13 |
| 2001-2002 | 4864.26 | 0.71 | 8.20 |
| 2002-2003 | 5264.38 | 0.70 | 8.23 |
| 2003-2004 | 6127.74 | 0.77 | 16.40 |
| 2004-2005 | 1892.48 | 0.25 | -69.12 |
| 2005-2006 | 8887.65 | 1.17 | 369.63 |
| 2006-2007 | 2354.67 | 0.29 | -73.51 |
| 2007-2008 | 6495.37 | 0.75 | 175.85 |
| 2008-2009 | 1824.00 | 0.20 | -71.92 |
| 2009-2010 | 7056.00 | 0.62 | 286.84 |
| 2010-2011 | 13406.00 | 1.10 | 89.99 |
| 2011-2012 | 31143.00 | 2.32 | 132.31 |

DoFB (2000, 2012)

of Mymensingh region in Bangladesh. The estimation is done on tabular form to find out the crude association or differences among different feed categories to achieve the objective of the study.

## METHODOLOGY

Mymenshing district in the North-central Bangladesh was selected purposively for the study area due to the following reasons: Thai *koi* culture was introduced first in this region; secondly, many farmers in this region have adapted in Thai *koi* farming in their ponds as it yields higher returns (Sarker, 2011; DoFB, 2006) and a number of fish hatcheries have been established in the area to meet the increasing demand for fish fries (Ahmed and Garnett, 2011). All these result the expansion of Thai *koi* farms in the district. There are three upazilas (sub-district) under this district, namely; Muktagachha, Gauripur and Mymensingh sadar, selected as Thai *koi* farmers were concentrated in these areas. Around 35% of farm populations from each upazila totaling 150 Thai *koi* farms were selected to accomplish this study. The sample size for each upazila stands at; 71 for Muktagachha, 49 for Gauripur and 30 for Mymensingh sadar. Finally, the selection of farms was based on random sampling procedure. During compiling the data, one farm was found to be an outlier that ultimately dropped from the analysis. Hence, a total of 149 sample farms are retained and analyzed for the present study. Thai *koi* are harvested twice a year. This study considers first production cycle (February-July) in 2013 production period. The data set covers the period during August 2013.

In modern fish culture, commercial feed alone covers 60-80% of total production cost. There are three different categories of industrial pellet feed used by the farmers; floating; sinking and mixed feed. Therefore, we analyzed the farm profitability and other farming practices based on a per hectare basis for the three feed categories and determine the feed contribution to Thai *koi* production. The intensity of inputs used varies across the three feed technologies and it varied production variability in the study area. The collected information were compiled, tabulated and analyzed in accordance with the objectives of the research. The tabular technique of analysis was used based on arithmetic means, percentages and ratios. Moreover, the data was generally used to find out the crude association or differences among the different feed brands. The costs and

Table 2: Equations in estimating the production costs and return of Thai *koi* farming

| Particulars | Equations |
|---|---|
| Variable costs | Cost of labor, feed, fingerling, chemical fertilizer (lime, salt, zeolite and pesticide), equipment (non-durable), interest on borrowed, harvesting and marketing and miscellaneous (energy, carrying and mobile) |
| Fixed costs | Leased value of ponds+excavation of ponds+equipment (durable) +farm structure +operating capital (Int) |
| Leased value of ponds | Valuation of pond at its rental price |
| Excavation of ponds | Actual cost incurred |
| Equipment (durable) | Depreciation+interest on average value+repairing cost +interest on repair |
| Depreciation | [(Purchase price-salvage value)/economic life] |
| Farm structure | Depreciation+interest on average value +repairing cost +interest on repair |
| Gross costs | Total variable costs+total fixed costs |
| Gross revenue | Total production×prevailing per unit market price |
| Net return | Gross revenue-gross costs |
| Income above variable costs | Gross revenue-variable costs |
| BCR | Gross revenue/gross costs |

returns incurred in the farming process were calculated for one production cycle (six months). Finally, output and input variables used for this study are accounted for on a per hectare basis for the three different feed types. Table 2 equips the equations used in estimating the production costs and returns of Thai *koi* production.

## RESULTS AND DISCUSSION

**Technology practices in Thai *koi* farming:** Thai *koi* is totally a feed intensive species and intensive culture is relatively a new production technology in Bangladesh. As noted earlier that there are three kinds of pellet feeds used by the sampled farmers which are floating, sinking and mixed feed. Farmers make a combination of floating and sinking feeds and it is branded as mixed feed in the study. The ingredients of both types of feeds are more or less the same. However, floating pellet technology needs hi-tech, high-pressure and temperature and hence is more expensive than sinking feeds. Generally, the floating feed floats 10-12 h in the water. Thus, waste of floating feed is low hence, environment friendly. On the contrary, sinking feed gets dissolved into water and pollutes water. Though, sinking feed is less expensive, however, the waste of sinking feed is higher than the floating pellet. The most common feeding frequency is thrice a day for all feed categories. Use of feed is largely influenced by its market prices and economic condition of the farmers. Basically, an intensive farming system is characterized by a relatively high stocking density of fish population. However, farmers do not follow any specific rates in stocking fingerlings. The average size of fingerlings also varied between 0.13 and 2 g. Fish growers collect fingerlings from three sources; private hatcheries, nurseries or produce it themselves. Fish fingerlings are stocked in mid-February to early-March and are harvested primarily from May to July, a culture period of around 90-180 days. Aeration is an important process to maintain oxygen and water quality and farmers do it manually. The farm owner changes water during culture periods to improve water quality and they use water from underground sources. In general, farmers harvest fish using commercial harvesters. They harvest fish by using cast, push and seine nets.

**Descriptive statistics:** The mean statistics of the variables used in the production process based on the three feed brands are shown in Table 3. The results revealed that considerable variation exists among the farm in terms of production practices and socio-economic attainments. Both hired and family labor used by the farmers which is measured in man-days (1 man-day equals 8 h of work). There was no large difference in the case of using labor among the feed users with an average of 393 man-days per hectare. The average number of fingerlings released in ponds was 1,814 pieces per decimal and it fluctuated broadly among the feed users ranging from 2,210 for the sinking feed to 1,537 pieces in the floating feed users. The average usage of feed ranged from 31,794 kg $ha^{-1}$ for sinking feed to 29,578 kg for the mixed feed. Both feed and stocking density seemed to be fairly high. The recommended stocking density of Thai *koi* is 300-400 pieces/decimal (Kohinoor *et al*., 2010). The average quantity of lime, salt and zeolite were roughly 293, 243 and 226 kg $ha^{-1}$, respectively. The average cost of pesticides was approximately US$ 11.89 $ha^{-1}$. The production of Thai *koi* for the sampled farms varied among the three feed brands. It was the highest (17,761 kg $ha^{-1}$) for floating feed users followed by 15,972 and 15,695 kg $ha^{-1}$ for mixed and sinking feed users groups, respectively with an average of 16,551 kg $ha^{-1}$. Remarkably, the

Table 3: Summary of statistics of the variables by feed categories

| | Feed types | | | |
|---|---|---|---|---|
| Variables | Floating | Sinking | Mixed | All farms |
| Fish production (kg ha$^{-1}$) | 17761.45 | 15694.66 | 15971.50 | 16551.33 |
| **Productive variables** | | | | |
| Labor (man-day ha$^{-1}$) | 388.89 | 390.06 | 402.35 | 393.20 |
| Fingerlings (No./decimal) | 1537.00 | 2210.00 | 1732.00 | 1814.00 |
| Feed (kg ha$^{-1}$) | 31732.70 | 31793.68 | 29577.63 | 31131.21 |
| Lime (kg ha$^{-1}$) | 297.90 | 270.48 | 312.74 | 292.98 |
| Salt (kg ha$^{-1}$) | 217.80 | 261.46 | 255.00 | 243.21 |
| Zeolite (kg ha$^{-1}$) | 196.60 | 229.16 | 262.23 | 226.49 |
| Pesticide (US$ ha$^{-1}$) | 11.78 | 13.00 | 10.75 | 11.89 |
| **Farm characteristics** | | | | |
| Farm size (ha) | 0.60 | 0.42 | 0.39 | 0.48 |
| Water depth (m) | 1.43 | 1.35 | 1.39 | 1.39 |
| Frequency of water change | 14.77 | 13.62 | 14.48 | 14.30 |
| Farm distance (m) | 172.45 | 233.70 | 202.90 | 201.79 |
| Farm visit/day (m) | 5.21 | 4.90 | 4.67 | 4.95 |
| Culture length (days) | 118.90 | 127.20 | 127.00 | 124.06 |
| **Socioe-conomic characteristics** | | | | |
| Farmers age (years) | 38.68 | 37.20 | 38.95 | 38.26 |
| Education (years of schooling) | 9.34 | 9.58 | 8.00 | 9.03 |
| Training on *koi* (days) | 0.13 | 0.06 | 0.07 | 0.09 |
| Farming experience on *koi* (years) | 4.82 | 4.56 | 4.41 | 4.61 |
| Involvement of family members | 1.20 | 1.16 | 1.02 | 1.13 |
| Sample size | 56.00 | 50.00 | 43.00 | 149.00 |

Field survey, 2013

application of feed ha$^{-1}$ between the two main feed brands (floating and sinking) in Thai *koi* culture does not vary widely, however, the floating feed produced 2,067 kg ha$^{-1}$ and 1,790 kg ha$^{-1}$ more fish than the sinking feed and mixed feed, respectively. Hence, Sarker (2011) studied on small-scale *koi* fish farming and found productivity to be 22,179 kg ha$^{-1}$ while, Khan (2012) found it to be 19,995 kg ha$^{-1}$ based on pangas culture in Bangladesh.

Along with productive variables, farm characteristics are also explored to get a clear idea about the culture practices of this strain. All farms in the study area practiced the intensive technology in Thai *koi* farming. The average area of pond was 0.48 ha ranging from 0.39-0.60 ha. Ideally, the depth of water in the ponds during culture ranged from 1.52-2.13 m, as it would support the maintenance of oxygen and temperature. It is also useful for quick digestion of the feed that results in better growth of fish. The average depth of water was 1.4 m which was more or less identical for all farms.

Frequent change of water during culture period increases water quality. The analysis shows that farmers using floating feed change water frequently than other feed users. There is a relationship between distance of farms and farm visits day$^{-1}$. A larger distance results fewer visits/day to the farm. Nearer farms upsurge the visits day$^{-1}$ and help improve the management of the ponds. Although, the visits per day did not differ much, however, the distance of ponds from the house-hold area varied widely among the feed users. The culture duration was found to be the highest in the case of the sinking and mixed feed technologies, on an average, it was 124 days per

production cycle. However, the mean table weight of fish was lower in the sinking feed of around 66 g, in opposition, it was 76 g in the case of floating feed with a lower (119 days) culture days. Hence, studies found that this fish attains 80-100 g in size within 3-4 months and becomes ready for market (Saha *et al*., 2009; Hasan *et al*., 2010).

Correspondingly, we have farmer demographic statistics that is shown in the lower part of Table 3. Apparently, younger people with an average age of 38 years are engaged in this industry and it varied slightly among the three feed user groups. The average years of schooling of the farm managers was in general moderate in the context of Bangladesh and level of education of the farmers were class 9. This result is consistent with the study by Khan (2012). However, a total of 10% of the farmers were illiterate. A total of 13 out of the 149 sample farmers received training on Thai *koi* farming. Experience is generally hypothesized to have a positive influence on production. Thai *koi* culture is a new agribusiness venture in Bangladesh with an average farming experience of below 5 years. Involvement of family members in fish farming did not vary widely among the feed brands.

To receive more income from any enterprise, costs of production is the influential factors. Hence, the present study put importance to explore the structure of production costs and its impact on farm income. Thai *koi* culture follows intensive technology and uses various modern inputs such as industrial pellet feed, fingerlings, labor, chemical fertilizers, non-durable equipment and other management costs like interest on borrowed capital, harvesting and marketing and miscellaneous cost. The fixed costs incurred in the production are leased value of ponds, excavation of ponds, durable equipment (feeding tray, cast and blue nets, motor/shallow tube well, etc.), farm structure and interest on operating capital. All-inclusive sample farmers in the research area follow Thai koi monoculture. In determining the gross return, revenue from selling of fish is accounted. Before starting the cost-benefit analysis, the study look at the physical contribution of feed classes by calculating Feed Conversion Ratio (FCR) and Mean Weight Gain (MWG) of fish.

**FCR and daily MWG fish:** FCR or daily MWG of fish are important calculations of costs and returns for the farmers which are calculated using the equation by Phuong *et al*. (2005). The equations are as follows:

$$\text{MWG} = \frac{\text{Present weight (g)} - \text{Initial weight (g)}}{\text{Culture length}}$$

and

$$\text{FCR} = \frac{\text{Fd}}{W_f - W_i}$$

where, $F_d$ is feed used, $W_f$ is final weight, $W_i$ is initial weight. The estimated results showed that the daily MWG of fish ranged from 0.53-0.65 g (Table 4). Weight per day gain of fish was slower for sinking or mixed feed than the floating feed users. Ray and Patra (1989) revealed that Thai *koi* can achieve a rate of growth from 0.5-0.9 g day$^{-1}$ while Van and Hoan (2009) found the rate ranged from 0.129-0.222 g day$^{-1}$. The mean FCR value of different feed categories ranged

Table 4: Feed conversion ratio and mean weight gain of fish by feed types

| | Feed categories | | | |
|---|---|---|---|---|
| Items | Floating | Sinking | Mixed | All kinds |
| FCR for Thai *koi* | 1.77 | 2.03 | 1.89 | 1.87 |
| Daily MWG of fish (g day$^{-1}$) | 0.65 | 0.53 | 0.60 | 0.59 |

Field survey, 2013

Table 5: Per hectare production costs of Thai *koi* farming among feed types (US$)

| | Feed types | | | | |
|---|---|---|---|---|---|
| Cost items | Floating | Sinking | Mixed | All types | Total cost (%) |
| **Variable cost total** | 22,168.00 | 20,046.96 | 20,401.00 | 20,946.30 | 91.58 |
| Labor | 1,315.01 | 1,344.19 | 1,368.84 | 1,340.34 | 5.86 |
| Feed | 17,933.68 | 15,705.43 | 16,180.30 | 16,679.90 | 72.93 |
| Fingerlings | 1,423.35 | 1,837.51 | 1,612.98 | 1,617.06 | 7.07 |
| Chemical fertilizer | 185.12 | 208.94 | 234.15 | 207.27 | 0.91 |
| Equipment (non-durable) | 148.75 | 119.81 | 144.14 | 137.70 | 0.60 |
| Interest on borrow | 257.75 | 95.047 | 85.57 | 153.46 | 0.67 |
| Harvesting and marketing | 479.79 | 258.56 | 327.30 | 361.55 | 1.58 |
| Miscellaneous cost | 424.55 | 477.47 | 447.70 | 448.99 | 11.96 |
| **Fixed cost total** | 2,031.15 | 1,799.61 | 1,931.84 | 1,924.79 | 8.42 |
| Rented value of ponds | 321.04 | 309.76 | 323.11 | 317.85 | 1.39 |
| Cost for Excavation of ponds | 451.81 | 355.25 | 393.50 | 402.58 | 1.76 |
| Equipment (durable) | 309.89 | 271.02 | 325.98 | 301.49 | 1.32 |
| Farm structure | 98.03 | 90.88 | 100.55 | 96.35 | 0.42 |
| Interest on operating capital | 850.38 | 772.70 | 788.70 | 806.52 | 3.53 |
| **Gross cost (I+II)** | 24,199.15 | 21,846.57 | 22,332.80 | 22,871.10 | 100.00 |
| **Cost kg$^{-1}$ of fish** | 1.36 | 1.39 | 1.40 | 1.38 | |

Field survey, 2013

between 1.77 and 2.03. The best FCR value was also gained for the floating feed (1.77) while sinking feed resulted in the lowers (Table 4). However, the FCR values of this study were relatively lower than lab-based FCR values. Hossain *et al.* (2012) found the FCR of dissimilar experimental diets ranged between 1.95 and 5.73, while Mustafa *et al.* (2010) found it to be 2.88-4.63. Doolgindachabaporn (1994) showed that the FCR value of climbing perch ranged from 1.8-3.0.

**Farm costs:** Table 5 shows that a wide variation in input costs and accordingly both item-wise and total costs vary broadly. The gross cost of fish farms consists of variable and fixed costs, of which, variable costs itself represents about 92% of total costs in the case of all types of feed. Among the all cost components, feed alone represents 73% of the total production cost and about 80% of the variable costs implies the greater influence of feeds on Thai *koi* culture. Sarker (2011) found that feed costs constituted 69.4% of total costs in small-scale *koi* production, while Khan (2012) reported it to be 71% of variable cost for *pangas* fish farming in Bangladesh. However, feed cost varies extensively among the feed types and it is the highest at US$ 17,934 ha$^{-1}$ for floating feed followed by US$ 16,180 and US$ 15,705 for mixed and sinking feed, respectively. The second highest cost was 7% for fingerlings followed by labor was 5.86% for all categories. Sarker (2011) found costs to be 7.4 and 15% for fingerling and labor, respectively. Cost of fingerlings varies among feed

categories. It is the highest at US$ 1,838 for the sinking feed and the lowest at US$ 1,423 for the floating feed. There were no large variations in labor costs among the feed types, it was US$ 1,340 $ha^{-1}$ for all samples. In the context of fixed costs, the highest cost was experienced by interest on operating capital followed by excavation of ponds. Per hectare gross production costs in Thai *koi* farming was US$ 24,199, 21,847 and 22,333 for the floating, sinking and mixed feed, respectively, with an average of US$ 22,871 for all brands of feed. Finally, the study revealed that the average production cost of producing per kg Thai *koi* was US$ 1.38 for all farms and the cost was lower for floating feed compared to other feed technologies.

**Farm return:** Farm income is an important indicator that shows economic viability of the enterprise. Farm income was measured in terms of yield, gross return, gross margin and net return which are interconnected. The value of fish products was calculated at prevailing market rate and it varied among feed classes, with an average of US$ 1.59 $kg^{-1}$. It appears from Table 6 that gross and net returns per hacter were both highest in the floating feed category with values of US$ 28,757 and US$ 4,558, respectively. It was US$ 25,608 and 3,275 for the mixed feed and US$ 24,200 and 2,353 for the sinking feed, respectively. However, 12 sampled farmers (8% of total) in the study area experienced losses. Considering all kinds of feed, both gross and net returns were found to be US$ 26,319 $ha^{-1}$ and US$ 3,448 $ha^{-1}$, respectively. Kohinoor *et al.* (2010) reported that the profits of *koi* culture was US$ 4,519 $ha^{-1}$ while, Sarker (2011) found net returns of small-scale *koi* culture to be US$ 7,601 $ha^{-1}$. Gross margin $ha^{-1}$ also varied among the three feed types but on average was US$ 5,373 for all feed types. The empirical results further showed that the estimated BCR was 1.15 for all sampled farms and the highest BCR was found to be 1.19 with the floating feed. Sarker (2011) found BCR to be 1.28 in *koi* farming. Finally, the average revenue from selling per kg of fish was US$ 1.59 and the best revenue was ensued by the floating feed users.

If we assume that all input quantities and costs are constant except feed, the estimated results showed that application of feed $ha^{-1}$ between two main feed types did not differ largely. However, per hectare cost varied widely among the feed categories. Per hectare cost of the floating feed was higher by US$ 2,228 and 1,753 compared to the sinking and mixed feed brands, respectively. Though, the initial investment was higher in using floating feed, however, the gross returns were much higher compared to the sinking and mixed feeds. With an average market price of fish at US$ 1.59 $kg^{-1}$ and a production cost of US$ 1.38 $kg^{-1}$, Thai *koi* culture in ponds can be considered a profitable agri-business in Bangladesh.

Table 6: Benefits per hectare of Thai *koi* production among different feed categories (US$)

| | Feed categories | | | |
|---|---|---|---|---|
| Items | Floating | Sinking | Mixed | All categories |
| Gross cost | 24,199.15 | 21,846.58 | 22,332.86 | 22,871.10 |
| Gross return | 28,756.79 | 24,200.04 | 25,607.52 | 26,318.83 |
| Net benefit (B-A) | 4,557.64 | 2,353.47 | 3,274.66 | 3,447.73 |
| Gross margin | 6,588.79 | 4,153.08 | 5,206.50 | 5,372.52 |
| BCR (B/A) | 1.19 | 1.11 | 1.15 | 1.15 |
| Average return/kg of fish | 1.62 | 1.54 | 1.60 | 1.59 |

Field survey, 2013

The overall analysis suggests that productivity of Thai *koi* is quite high compared to other fish species cultured in Bangladesh. Thai *koi* for its high growth and productivity could be a good candidate for aquaculture industry in Bangladesh. However, further development of this enterprise would need a reduction in major variable costs specially feed cost. The development of low-cost feeds would help to reduce production cost thus, increases farmer's profit margins in the study area. Furthermore, in the short-run, farmers are suggested to use floating feed due to its high productivity and better profit margin.

## PROBLEMS AND CONSTRAINTS

Thai *koi* production technology is relatively a new practice in Bangladesh. As it is a new technology, the farmers are facing many problems and constraints. It was found that the problems and constraints mentioned by the farmers were location specific. Hence, the major problems in the form of percentages are depicted in Table 7.

Thai *koi* farmers use industrial pellet feeds. It was evident that a high percentage of about 79% farmers claimed that the price of fish feed was very high. This problem was acute in Gauripur area followed by Muktagacha. Sometimes, it is beyond affordable price which impairs production seriously. This problem is particularly crucial at the final stage when they start to use the grower feed. At this stage, the feed agents are alleged to create an artificial crisis by hoarding the feed and releasing then when prices are high. High feed cost causes the production costs to be high. A study by Sarker (2011) found that high prices of fish feed was a major problem of *koi* farming in Bangladesh. Tihn (2003) also reported that more than 50% of Thai *koi* farmers were lost due to high feed costs. Feed is the most important item in intensive *koi* culture as it determines the economic viability of the farm. Fish feed alone represents 60-80% of total production costs. Therefore, feed input may alone dictate the profitability/loss of a farm. However, 69% of farmers in the study area reported that the feed lacks quality. A total as about 78% of respondents in Gauripur stated this compared to 64% in Muktagacha. The farmers voiced that there was no mechanism to check the quality of feed.

Success of fish culture depends mostly on the availability of quality fingerlings on time and its management is also an important aspect in modern fish culture. Quality fingerlings produce healthy and high-quality fish and about 64% of the pond owners reported that the availability of quality fingerlings was a major constraint for fish production. This problem was severe in

Table 7: Overall problems and constraints faced by the Thai *koi* growers

| | Responded farmers by locations (%) | | | |
|---|---|---|---|---|
| Attribute of problems | Gauripur | Muktagacha | Sadar | All |
| High price of feed | 81.63 | 78.57 | 73.33 | 78.52 |
| Lack of quality feed | 77.55 | 64.29 | 66.67 | 69.13 |
| Non availability of quality fingerlings | 63.27 | 68.57 | 56.67 | 64.43 |
| Lack of access of technical support | 65.31 | 64.29 | 60.00 | 63.76 |
| Lack of training | 59.18 | 62.86 | 66.67 | 62.42 |
| Lack of access to fund | 65.31 | 55.71 | 63.33 | 60.40 |
| Control and identification of fish disease | 51.02 | 57.14 | 46.67 | 53.02 |
| Problem of selling fish at fair prices | 48.98 | 45.71 | 43.33 | 46.31 |
| Sample size | 49.00 | 70.00 | 30.00 | 149.00 |

Field survey, 2013

Muktagacha (about 69%) compared to others two areas. The study found that there were three sources of fingerlings; a total 46% of respondents reported that fingerlings were collected from private hatcheries followed by 35% from nursery and for the rest 19% of farmer's fingerlings were produced by the farmers themselves. The success of induced breeding depends on sufficient number of mature and healthy brood fish stock. However, it was learnt at field level that they used brood fish from their current stock. This could result in inbreeding which results in a reduction of fish growth rate. Outbreak of fish diseases is a knotty problem for the development of farm operation. The study showed that about 53% of the respondents stated that attack of virus and diseases hampered the Thai *koi* farming. This problem was severe in Muktagacha followed by Gauripur. The farmers also claimed that sometimes they face some new diseases which are not easily identifiable. They also reported that they do not receive support from the extension agents or study stations to identify the diseases and/or get any preventive measures.

Intensive aquaculture essentially follows scientific techniques and methods. Therefore, farmers need to be trained on the proper use of the modern techniques of fish culture. However, about 62% of the farmers listed lack of training on *koi* culture, ranging from a minimum of 59% in Gauripur to a maximum of about 67% in Sadar upazila. This problem was found to be severe in Muktagacha followed by Sadar upazila. It was also evident that only around 9% of the total farmers received instruction on modern methods of *koi* farming, however they also claimed that the training was insufficient. The delivery of extension services at farm level during the production period was found to be problematic. Only 3% of respondents received extension services from study and fisheries extension offices. Sarker (2011) also reported insufficient cooperation of concerned agencies. The farmers in the study area started *koi* farm by self-endeavor, of which 47% growers were motivated by seeing others and the remaining were inspired by friends/relatives/neighbors. About 64% farmer in the study area informed that lack of technical know-how hinders the production process. Sarker (2011) reported that about 42% of *koi* farmers voiced this issue.

Intensive fish farming is an expensive agri-business that needs high investment. The farmers reported that they faced shortage of working capital in particular to purchase supplementary inputs like feed during the production period. In general, about 60% of respondents recognized that the access to credit was one of the major constraints in fish culture. This problem was as high in Gauripur to as low in Muktagacha. Only a few of 15% farmers received fishery credit from banks and NGOs. However, the borrowed amount was claimed to be quite insufficient to meet the needs of fish farming. However, in most cases, farmers do not get bank loan in time due to cumbersome banking practices. Moreover, the cost of borrowing is very high and it lies between 15-20% as reported by the farmers. The fish culturist also reported that due to lack of capital, they had to buy the inputs (specially feed) in credit. For this, the sellers charge an extra price and this also makes the production process costly. Lack of operating capital, credit restrictions and high interest rates in Bangladesh was also reported by Sarker (2011).

Fish marketing in Bangladesh is largely at the hands of the private sector (Dey *et al*., 2001). The farmers of the study area sell fish to the *beparies/paikers* (wholesalers) at their landing centers as reported by 65% of the respondents, 22% to *aratdars* (commission agents) at the wholesale market and the remaining 13% farmers sell their fish at the market directly by their own arrangement. The farmers also identified some basic problems in marketing of their products. About 89% of sampled farms mentioned that they always suffered price uncertainty of their products. A total of 82% of growers reported that they had low bargaining power in getting a fair price for their

fish crops. Bulk selling of fish was another problem mentioned by 56% of the farmers. About 13% of farmers reported that they had to sell their fish products on credit and sometimes, the credits were not settled. Overall, 46% of farmers (Sarker, 2011 noted it 53%) reported that they did not get a fair price of their fish crops.

## CONCLUSIONS

Exotic fish species of Thai *koi* offer tremendous potential in fresh water fish production in Bangladesh. Thai *koi* is completely feed intensive fish species and intensive culture is comparatively a new activity among Bangladesh's farmers. Considering the importance of this fish for aquaculture, this study was undertaken to scan the farm insight practices in an economic viewpoint. Feed Conversion Ratio (FCR) or daily Mean Weight Gain (MWG) of fish is important calculation of costs and returns for the farmers. In both cases, the performance of floating feed was found to be outstanding compared to other feed brands.

Based on the empirical results, it was found that considerable variation existed among the farm in terms of production practices, input use intensity and logically, it caused output variability in the study area. Among variables, feed alone insurances the highest 73% of the total production cost, implied a greater influence of feed on Thai *koi* culture. However, feed cost varied widely by the feed types. Per hectare application of feed between floating and sinking did not differ largely, however, per hectare cost of feed varied widely. Consequently, the gross cost per hacter also fluctuated broadly among the feed kinds. Though, the gross cost was higher, hence, the cost of producing per kg fish was found to be lower in floating feed compared to other two feed categories. As cost varied, farm income differed accordingly. The highest production and revenue was received with the use of the floating feed in terms of BCR, gross and net returns. Finally, with an average income of fish US$ 1.59 $kg^{-1}$ and cost of US$ 1.38 $kg^{-1}$, Thai *koi* culture in ponds are considered to be a profitable agri-business in Bangladesh. Although, the primary investment that is high in floating feed, can earn much better return from extra investment compared to other feed technologies.

The overall findings suggest that productivity of Thai *koi* is quite high compared to the other fish species cultured in Bangladesh. Therefore, due to its high growth and productivity, Thai *koi* farming could be a solution to mitigate the growing demand for fish, hence, needs to promote all over Bangladesh. However, further development of this agri-business would need a reduction in major variable costs specially feed cost. The development of low-cost feeds would help to reduce production cost thus, increases farmer's profit margins. For short-run, farmers are suggested to use floating feed due to its high productivity and better profit margin. It may be finally concluded that the outlook for the Thai *koi* culture could be very positive in meeting the future demand of fish thus, greatly improve human nutrition and food security by removing the problems and constraints were identified.

**Policy remarks:** Thai *koi* culture can play an important role to cover nutritional deficits for the growing population, as well as economic development of our country. However, this study identifies some problems that obstruct the prospects of this agri-business in Bangladesh. The policy recommendations emerging from the results of this study are highlighted below:

- Importance should be given for study to develop low cost feed formulations. The Department of Fisheries can provide technical support at the farm level to prepare it. In the short-run, farmers are recommended to use floating feed to achieve higher production and productivity

- Government should fix up the prices of fisheries inputs in coordination with the traders/manufacturers and farmers and, or government can provide subsidies on fish inputs for the betterment of this sector. An effective mechanism needs to be developed to maintain and ensure the quality of fish inputs at the farm level and special emphasis should be given to fish feed
- Government can develop a modality between hatchery and pond owners to produce and supply quality fingerlings and make it available at the right time and place
- Credit supply is one of the vital issues of the resource poor farmers in Bangladesh. Institutional credit facilities with low interest, quick disbursement and a soft repayment system should be made available. This would support resource poor farmers' access into Thai *koi* production. Government can implement this policy through commercial and specialized banks
- Government as well as related NGOs should provide a holistic training program for the farmers to improve their technical knowledge on modern fish culture. Farmers training are relatively low-cost method of attaining increases in productive efficiency reported by Ellis (1993). Furthermore, technical support and extension services during production would help to improve the farmer's managerial efficiency thus, increase productivity
- Low bargaining power for agricultural products is a common phenomenon for Bangladesh's farmers. Hence, the farmers usually do not get fair prices for their products. Government should establish a 'price commission' for aquaculture products to ensure fair prices for the farmers
- A proper coordination among researchers, extension agents, traders and pond managers for the exchange of knowledge and information is finally recommended

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