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Impacts of *Pangasius* aquaculture on land use patterns in Mymensingh district of Bangladesh

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Abstract

Pangasius catfish, *Pangasianodoan hypophthalmus* farming has been evolved to a shape of commercial enterprise over the last two decades in north-central part of Bangladesh, particularly in Mymensingh area but there is a lack of quantitative and qualitative data on the impacts of it on land use pattern. This study was conducted using multiple methodological tools including participatory rural appraisal (PRA) tools and mainly questionnaire based farm survey to assess the impacts of *Pangasius* farming on land use from February to September, 2009. The mean farm size (ha), water area (ha) and dyke area (ha) was 1.36±1.25, 1.06±1.31 and 0.30±0.27, respectively. The *Pangasius* productivity was significantly and positively correlated with water area and dyke area. Around 10.1% area of the study area was converted to *Pangasius* farm which was previously used as rice-field. Farmers expanded their farm area by taking leased lands which contributed to 56.47% of total farm area and the lease value of *Pangasius* pond was doubled compared to agriculture land. Around 48% area of dyke were used to produce agriculture crops and the production was 71.01% lower but profit margin was 76.58% higher than normal land. The discharging wastewater of *Pangasius* pond also increased rice productivity in adjacent agriculture farm by 10% and additionally reduced fertilizer and irrigation cost by 30% and 40%, respectively.

Keyword: *Pangasius* aquaculture, impact on land use pattern, Bangladesh

Introduction

Aquaculture and fisheries together contributes about 5% of total GDP of the country's economy and 6% of the total annual export earning. Contribution of aquaculture and fisheries for animal protein accounting for 63% of the total national intake is still dominating although considerable development was occurred in livestock and poultry sector [Department of Fisheries (DoF), 2009]. Bangladesh's total fish production for the year 2007-2008 was above 2.56 million ton achieving sixth rank among the major aquaculture producing countries in the world (FAO, 2009). Out of total fish production, aquaculture contributes 39% and remaining 42% and 19% was from inland capture fisheries and marine fisheries, respectively [Department of Fisheries (DoF), 2009] indicating aquaculture is the fastest growing food producing sector in Bangladesh.

Regionally, inland aquaculture production is dominated in the north-central region, i.e. the greater Mymensingh district, where *Pangasius* catfish, *Pangasianodoan hypophthalmus* farming was started commercially in 1994 by a private fish farm named Al Falah, Mymensingh (Ali, 2009). The estimated total *Pangasius* production in Bangladesh was about 3, 00,000 tonnes in the year 2008 (Edward and Hossain, 2010 and Munir, 2009). Sarker (2000) reported that amongst exotic fish species, *Pangasius* is one of the best aquaculture species in Bangladesh due to its ease of culture, high market demand and well suited to the weather condition its propagation and culture. In recent years, *Pangasius* has become one of the most popular commercial culturable species due to its high yield, higher response to external feeding, and availability of *Pangasius* seeds to meet up the farmer's demand. Over the last 15 years, *Pangasius* aquaculture evolved to a shape of commercial enterprise having long backward and forward linkages providing livelihoods for a wide range of stakeholders (Haque, 2009). Almost all of the produces are consumed domestically proving year round supply of animal nutrition to low and medium income people in both rural and urban areas.

Total fish production of the country during the last two decades has increased about three times, from 895,935 tonnes in 1990-1991 to 2563,296 tonnes in 2007-2008 [Department of Fisheries (DoF), 2009]. Such expansion has huge positive impacts as discussed above, however a large concern is that aquaculture has some negative environmental impacts. Expansion of aquaculture requires conversion of land related to crop fields, wetlands, seasonal waterbodies, mangrove forests, and other terrestrial and aquatic ecosystems. Land is the basic natural resource that provides habitat and sustenance for living organisms, as well as being a major focus of economic and livelihood activities (PDOICZMP, 2004). The population is increasing and the land is being converted from productive purposes, such as crop

cultivation, to other uses such as housing, roads and urban development, and this trend is expected to continue. This is because there is no such a national policy for any systematic land use strategy that was already implemented by other Asian countries (e.g. Vietnam, Indonesia, etc.) consolidating and distributing the land resources to the appropriate users through the control of the government towards sustainable land use (Griffin *et al.,* 2002). Collectively increasing pressure of aquaculture, agriculture and other non-agricultural activities on land use made the scientists and policy makers concerned about sustainability of food production for future generation.

In terms of inland aquaculture, particularly of *Pangasius* aquaculture in Bangladesh, as there is no any legal aquaculture legislation in place for land use, consequences could be the same as the of shrimp farming in coastal areas (Primavera, 2006). Therefore, the overall environmental impact due to land use for Pangasius farming became an important issue deserves to be addressed thoroughly. Considering the above fact, the present research work was carried out to assess the impacts of *Pangasius* aquaculture on land use patterns in selected areas in Bangladesh.

Materials and Methods

This study was conducted in Dhanikhola of Trishal *upazila* under Mymensingh district (Fig. 1) from February to September, 2009. Ali (2010) reported that *Pangasius* farming first started by private enterprise in Trishal which was very close of the study village. The authors also reported that the number of *Pangasius* farms higher in Dhanikhola compared to other areas of Trishal *upazila*. This village was a typical *Pangasius* producing area in terms of early development, having large number of farms, higher production level and better access to the markets. There were 135 farms in the study area and out of which, 60 farms were randomly sampled for this study. The information of this study was collected based on questionnaire interview and in addition, key informant interview and focus group discussion. Draft questionnaire were tested with few farmers before preparing final questionnaire. During the testing period, attention was given to include any new information and based on the feedback the final questionnaire was prepared.

Fig. 1. Map of Trishal *upazila* showing the study area

The collected information were entered into the data-base software MS-Excel and analyzed by SPSS (version 11.5). The findings were presented in textual, tabular and graphical forms to explicit impacts of *Pangasius* aquaculture on land use pattern.

Results and Discussion

Pangasius farming system

Farming trends: Total aquaculture production was 1,064,801 tonnes for the year 2008-2009, of which *Pangasius* production was 59,477 tonnes, accounting for 6.5% of the country's recorded aquaculture production (DoF, 2010). This data was a substantial increase compared to the year 2007-2008, when the Pangasius accounted for just 3.77% of reported production. The number of *Pangasius* farm development over the years shows increasing trend however, it has got a static position during 2007 and 2008 (Fig. 2). In 2009, new farmers have again started farming due to high market price of *Pangasius*. This figure also suggests that the production of *Pangasius* aquaculture has significantly increased over the last decade.

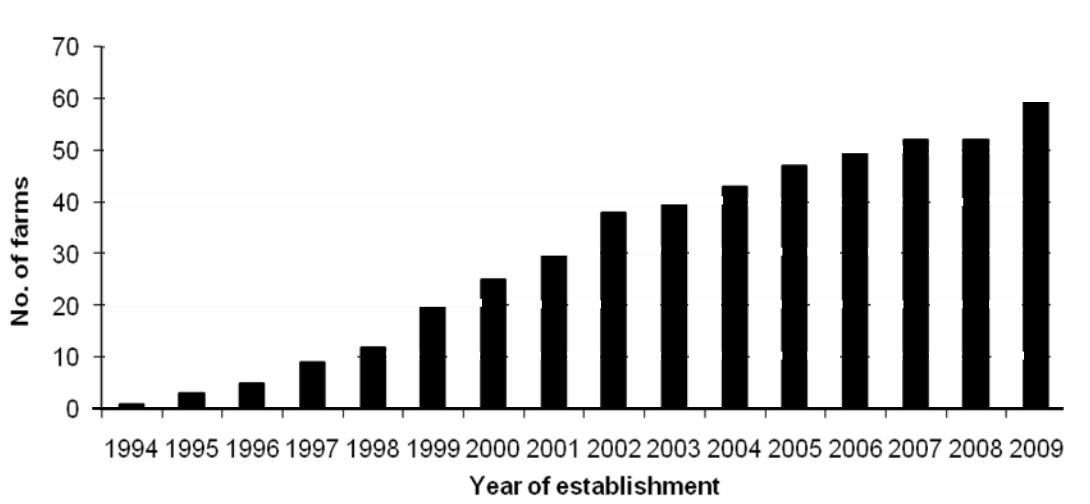

Fig. 2. Cumulative annual growth of *Pangasius* farms in the study area (source of data: farm survey)

Farm productivity: Most of the farms (66.7%) in the study area have their own nursery pond and farmer stocked fry in nursery pond before transferring to the grow-out ponds. The remaining farmers (33.3%) who have no nursery pond purchased fingerling from nursery farmers or traders. Almost all farmers (95%) purchased carp fingerling from the local fry trader.

The grow-out farming system of *Pangasius* in Bangladesh is polyculture with carps. The stocking density of *Pangasius* varied from 1.5 to 9.5/m^2 (mean: 4.56±1.93) depending on fingerling size. The mean stocking density was not significantly different ($p>0.05$) among three study communities. Moreover, farmer also stocked carps fingerling and the stocking density varied from 0.375 to 5/m^2 (mean: 1.98±1.31). Ali *et al.* (2011) reported a similar trend of *Pangasius* farming in Mymensingh district.

The mean productivity of *Pangasius* farms was 33.09±8.65 tonnes/ha (ranging from 14.82 to 45.43 tonnes/ha) of which *Pangasius* production varied from 12.84 to 40.56 tonnes /ha (mean: 30.90±8.54) and carps production 2.20±1.62 tonnes/ha (ranging from 0.48 to 5.78 tonnes/ha). No statistically significant difference ($p>0.05$) was found among three communities in terms of average production. Ahmed *et al.* (2010) reported that the *Pangasius* productivity in Mymensingh district varied from 8.34 to 13.95 tonnes/ha which was significantly lowered compared to the present study. Recently, a study has been conducted by Ali *et al.* (2011) who reported that the average productivity of *Pangasius* aquaculture was 40.20 tonnes/ha in Mymensingh district.

Most of the farmers (60%) used commercial pelleted feed purchased from local market, 30% of farmers used farm-made feed and remaining 10% used both commercial pellet and farm-made feed. Farmer purchased feed ingredients from local market but the quality of the ingredient was not satisfactory. Normally, 6-7 types of ingredients including rice bran or polish, maize meal, wheat flour or wheat bran, dry fish, mustard oil cake, soybean meal, meat and bone meal were used to prepare farm-made feed. In addition, mussels, vitamins, calcium and feed binders were also used.

Impacts on land use pattern

The present study area covers 2000 ha of which 202.5 ha, that is 10.13% of total area, was converted from agriculture to *Pangasius* farm (Source: Trishal Land Office). The sample farmers of the present study used 47.56% of their land for *Pangasius* aquaculture and remaining 52.44% used as rice-field, vegetables etc. (Fig. 3). The results indicated that most of the farmers land is used to generate income by means of *Pangasius* aquaculture. Similar situation is observed in the coastal area of Bangladesh. More than 80% of the land in Rampal *upazila* was under rice cultivation in 1975, whereas in 1999 it decreased to less than 20%. Over that period, most of the rice fields was replaced by rice–shrimp farming as well as only shrimp cultivation indicating sharp decrease of land resources for rice farming (Karim, 2006). Hossain and Lin (2001) also found that most of the suitable areas for mangrove afforestation are currently being used for shrimp and salt production in Bangladesh.

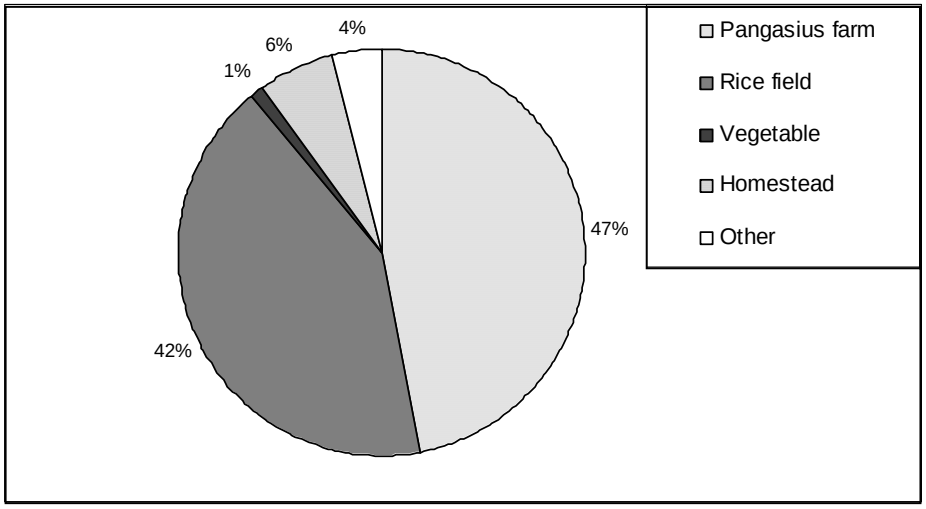

Fig. 3. Land use pattern of *Pangasius* farmers in the study area (source of data: farm survey)

The introduction of shrimp farming has gradually changed the land-use patterns of the surrounding farms, transforming agriculture and mangrove areas into shrimp-farming areas (Karim, 2006). In the present study, 50% upland, 45% low land rice-field and 5% fellow land were converted to construct *Pangasius* farms which suggests that upland rice-field was less productive or single crop producing land is mainly used for *Pangasius* farming. Karim (2006) also reported that about 3.5% of forest and 2.4% of pasture land was converted into shrimp ponds. In the present study, the farm size varied from 0.16 to 7.69 ha (mean: 1.36±1.25). Most of the farmer (66.66%) extended their farm by taking leased lands and it contributed 56.47% of the total farms. This result implies that *Pangasius* aquaculture is a profitable business and farmers had tried to extend their farm area which increased the lease value of local agricultural area. The present study revealed that the lease value of *Pangasius* pond varied from US$ 705.71 to 1085.71/ha (mean: 935.07±65.23). It was around double compared to agricultural land (571.42±58.78). This trend is significalty higher comapared to shrimp farming in Bagerhat district (Karim, 2006). The average lease value of agriculture land was 314.28±17.35/ha before starting *Pangasius* aquaculture in Bangladesh. As such, it can be concluded that *Pangasius* aquaculture provided an opportunity for more economic use of land although it is responsible for creating inequity in the society because poorer agricultural farmer were not able to introduce *Pangasius* farming and ultimately they were not benefited.

The mean farm sizes (ha), surface/water area (ha) and dyke area (ha) was 1.36±1.25, 1.06±1.31 and 0.30±0.27, respectively. The water area mainly used as grow-out (82.45%) ponds and remaining (17.55%) used as nursery ponds. Most of the farmers (70%) used their farm dyke in different extent and remainder (30%) did not use dyke. The total *Pangasius* farm production was significantly and positively raised with increasing total surface as well as dyke of area of *Pangasius* farm (Fig. 4). This again reflects strong message of keeping a large potential area of dyke completely unused that could be used for other agricultural production adopting integrated aquaculture approach (IAA) towards maximizing land productivity and profit margin of farms.

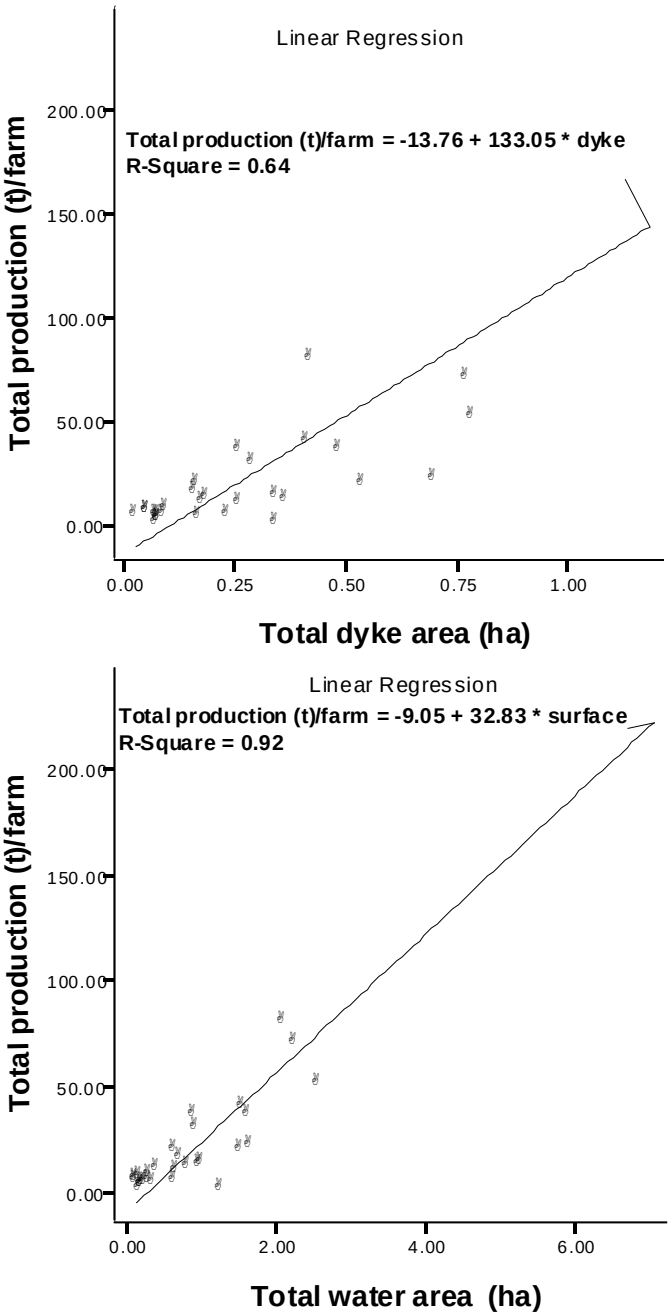

Fig. 4. The relationship between productivity with (a) dyke area and (b) water area (source of data: farm survey)

The study also revealed that the number of dyke users was high but the amount of land used to produce crops was very low (only 13%). Out of 13% of dyke, 48% of area was used for producing vegetables and remaining area for other purposes (Fig. 5). The vegetable production cost per unit area for dyke cropping was 70.01% lowered compared to other agricultural farm however, profit margin was 76.58% higher. The result indicated that major proportion of the dyke was empty although there was a potential scope for producing other crops on the dyke area. In Bangladesh, the well-off farmers mostly developed *Pangasius* aquaculture using commercial feed regularly and farmers could have 5 farm components (fish, crop, vegetable, livestock and poultry), but the size of the components was small (Verdegem, 2005). The re-use of pond-mud and the polyculture was well appreciated by farmers and extension services. Applying a high level of both feed and fertilizer gave high positive nutrient balances for the pond. Farmer used 74.69 tonnes feed per hectare of pond (Ali *et al*., 2011) assuming that 30% of the nitrogen in the feed is converted into fish flesh and the reminder are deposited as bottom sediments in the pond (Rahman, 2004). The bottom sediment is enriched with organic matter, nitrogen, phosphorous, and macro and micronutrients (Rahman *et al.,* 2004) and the value of these nutrients for crop production is potentially high (Voss *et al.,* 1999). The bottom sediments are usually removed in 1 to 4 years intervals (2.27±0.81) and placed on the dyke for repairing. Using pond sediments on the dikes resulted in higher plant yields and improved some of the soil fertility characteristics (Verdegem, 2005). Thus, the gross margins of the entire pond-dyke systems could be maximized to a greater extent through further research on the potential use of *Pangasius* pond sediments for diversified productive agricultural practices. Ideally, the Integrated Agriculture Aquaculture (IAA) approach results in increased income diversification and intensification, improved natural resource efficiency, increased productivity (Lightfoot *et al*., 1992) and the IAA approach, is considered a sustainable farming model for small-holder farming households (Prein, 2002).

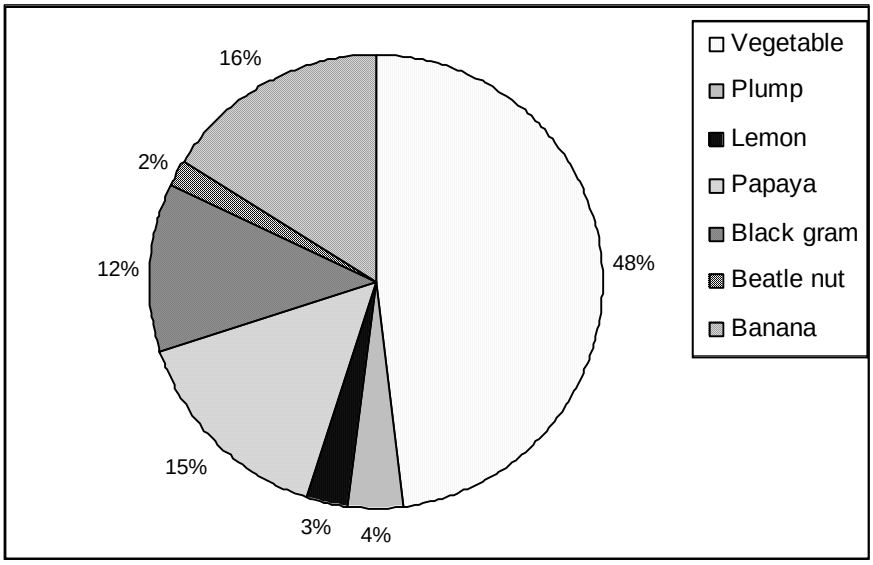

Fig. 5. Use of *Pangasius* pond dykes for producing different crops (source of data: farm survey)

Pangasius farms influenced positively the production of rice in the surrounding agricultural land other than dyke. Individually, a farm increased rice production of 93% surrounding agriculture farms and decreased of 7% farms. The findings indicated that most of the farms developed in less productive upland rice field they enhanced crop production in its surrounding areas. However, Karim (2006) provided contradictory statement and he also found that the yields of most of the field crops had declined following the start of shrimp cultivation which might be due to the negative affects of saline water on the surrounding crop land. Production of wheat, jute and sugarcane has been affected seriously, and now it is not possible to grow these crops due to soil salinization. This clearly indicates that land based freshwater aquaculture has potential scope to increase agricultural production in a sustainable way.

Inland aquaculture relies on the use of freshwater that mainly produces fish and crustaceans (Verdegem *et al*., 2006). Underground water mainly used in *Pangasius* aquaculture as well as a minimal level of surface water from river and *beel* (Fig. 6). The water exchange rate varied from 20% to 70% (mean: 47.23±5.34) of *Pangasius* pond water for 1-6 (mean: 2.17±0.45) times during a production cycle of 6-8 months. Such level of water exchange is very minimal compared to daily water exchange in *Pangasius* farms in Vietnam (Phan *et al*., 2009) that might have several water quality implications demanding further research attention.

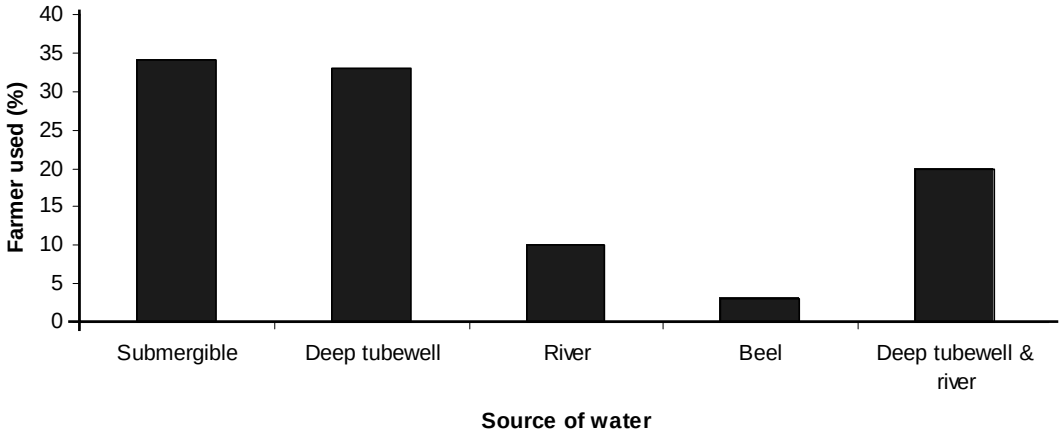

Fig. 6**.** Sources of water for *Pangasius* farming in the study area area (source of data: farm survey)

Pangasius farms discharge pond water into rice fields without being treated, which led to negative impacts on the environment. Prein (2002) reported that the water and nutrients lost through drainage from aquaculture ponds can also be used to irrigate or to fertilize crops, either on the dyke or in adjacent rice-fields. Nearby agriculture farmer can reduce 30% fertilizer cost and 40% irrigation cost by using discharging wastewater of *Pangasius* farm. Thus, the use of discharge water enhanced productivity of rice fields in the adjacent farms by 10%. A similar trend also reported for pangasius farming in Mymensingh area (Khan, 2009).

Farming communities

The farming communities are relatively young, with the age of farm owners ranging from 23-60 years old (mean: 38.4±9.90). More than 20.0% farmers completed primary education, 30.0% Secondary School Certificate (SSC), 23.3% Higher Secondary certificate (HSC) and 26.7% Bachelor degree, which were higher than national literacy level of 65% (BBS, 2002). This suggested that mainly educated generations are engaged in *Pangasius* farming and showing behavioral characteristics of aquaculture entrepreneurship. The household size of the farmer family was usually consisted 5.17±1.42 members (ranging from 3 to 10) while the national average family size of Bangladesh was 4.89 in 2004 [Bangladesh Bureau of Statistics (BBS), 2004]. In the present study, the primary occupation was considered the occupation from which most of the income was earned and it was found that 56.7% and 43.3% of farmers took farming as their primary and secondary occupation, respectively. Table 1 suggests that 13.3% farmers have no secondary occupation and only *Pangasius* farming contributed to their household income.

Table 1. Primary and secondary of *Pangasius* farmer in the study area (source of data: farm survey)

Activities	Primary occupation		Secondary occupation	
	No. of farmer (n)	% of farmer	No. of farmer (n)	% of farmer
Pangasius farming	34	56.7	26	43.3
Aqua-feed business	4	6.7	6	10
Business	10	16.7	6	10
Agriculture	6	10	14	23.3
Service	6	10	0	0
None	0	0	8	13.3

The average annual household income of the farmer indicated that a significant amount of income derived from the *Pangasius* farming (Fig. 7) followed by business which also related to *Pangasius* aquaculture support services (e.g. feed business). The annual income of the *Pangasius* pond varied from US$ 1362.11 to 3952.56/ha (mean: 2451.19±978.38) whereas agricultural lands varied from US$ 285.71 to 428.57/ha (mean: 355.27±45.76) that is about 7 times higher than agricultural land. As a result, people were engaged in *Pangasius* aquaculture for getting higher and quick economic return. A similar trend has also been reported for the shrimp farming system in Rampal *upazila* of Bagerhat district (Karim, 2006).

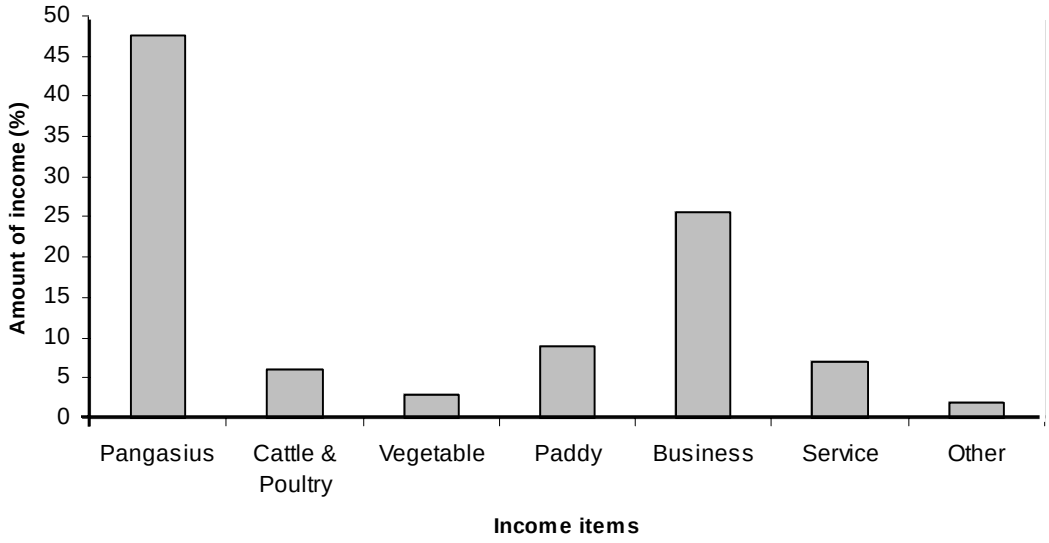

Fig. 7. Annual household income of *Pangasius* farmer (source of data: farm survey).

Conclusion

Mainly middle aged and educated people were involved in *Pangasius* aquaculture, predicting further entrepreneurial growth of *Pangasius* farming in Mymensingh region of Bangladesh. *Pangasius* farming added lease value to upland rice fields as well as increased rice productivity of the surrounding upland rice-field. The dyke of *Pangasius* farm was not efficiently used which predicts that there is a potential of integrated aquaculture farming in aquaculture dominating area. Thus, on-farm action research and development initiatives could be taken in this regard through the collaborative efforts of government and non-government organizations.

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