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Freshwater pond fish farming in Bangladesh: A micro level land use analysis

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Abstract

Market-oriented farming has been started in Bangladesh over last two decades. As a consequence, diversified agricultural products are now produced which changing the land use pattern. This study conducted in Trishal upazila of Mymensingh district, a major freshwater pond fish farming area of Bangladesh. Secondary data from different relevant government offices (Upazila Agriculture, Fisheries, and Statistical office) were collected to find out how much cropland has been converted to pond fish farming and what will be the future trend of land use in the afore mentioned area. Total land area of Trishal sub-district is 33876 ha and since last three-decade cropland has been converted to commercial freshwater fish farming. As a consequence, the area under commercial fish farming is now 4542 ha (13.41 per cent total area of Trishal upazila); which was only 1920 ha in the year of 2010. The commercial fish farming land area was converted mostly from cropland area and then a little portion came from *Khas* (Government owned fallow land) and fallow land area. Within six years (2010-2016), agricultural cropland area had decreased by 6.68 percent (1.11 per cent per year) and pond fish farming area had increased by 7.74 percent (1.29 percent per year). By 2021, following non-linear (quadratic) trend projection model, about 2000 ha more land will be occupied by pond fish farming.

Introduction

Bangladesh has experienced an average of 6 percent GDP (Gross Domestic Product) growth rate over the last decade. A steady population growth rate and pressure on agricultural land call for devising a strategy that can deal with the new challenges and opportunities to make agriculture more flexible, diversified and efficient (Ahmed *et al.*, 2001, Mahmud *et al.*, 1994). The agriculture sector (combination of crop, fisheries, forestry and livestock) employs the largest share of land holdings and also the major contributor to the country's GDP by 16.77 percent (base year 2005-2006). Individually, crop and fish sector's contributions to national GDP are 7.92 and 3.61 percent, respectively (BER, 2017). In Bangladesh, a country of 161.7 million people (BER, 2017), farmers engage in smallholder subsistence crop (mainly rice) farming. Net cropped area of the country is 7.95 million ha (BBS, 2016).

During the last two decades, the fishery sector has expanded tremendously. According to the Department of Fisheries (DOF) annual reports, the average growth rate of the fishery sector, as a whole, has been above 5 percent during the period of 1984/85 to 2011/12. Moreover, during this period, the aquaculture sub-sector grew very impressively and its growth rate was more than 9 percent (Belton *et al.*, 2011). In some parts of northern Bangladesh, the landscape was once dominated by rice and is now occupied by freshwater ponds for fish to fulfill the protein requirement domestically and to increase the farm income substantially. In 1984-85, the total freshwater fish culture area was 0.125 million hectares. In 2015-16, the total area was increased to 0.795 million hectares (DOF, 2017). Total pond fish production (excluding shrimp) during last decades has increased about three times, from 0.69 million ton in 2001-2002 (DOF, 2002) to 1.72 million ton in 2015-2016 (DOF, 2017).

Cropland is converting to entrepreneurial pond fish farming because of the overall high profitability in fish farming compared to crop production in some areas (Palash, 2015). The increasing price trend of fish, as well as extension work for aquaculture by a number of NGO projects and the government, has contributed positively to the expansion of the area for culture fisheries. As a consequence, this research focused on how much cropland used in pond fish farming as well as what will be future trend of freshwater fish farming land usages.

Land use change – A concern of causes

Adopting new technologies, changing enterprises or farming decisions, taking calculative risk, motivating a certain group and broad aspects of economic development thinking solely depend on level of education, experience in farming, resources availability, access to extension services and market and credit sources of the farmers. Findings from different sources regarding socio-economic status of the farmers of Trishal upazila are summarized here.

The ability of taking the risk of transforming land use from one enterprise to another depends on the certain aged group of people. Fish culture efficiency varied with the age and number of having ponds (Kaiya *et al.*, 1987). Zannath (2011) found that most of the farmers (43 percent) in this upazila belong to the age group of 41 to 50 years whereas Rahman (2005) found that 38 percent farmers belong to the age group of 31 to 40 years. These findings confirmed that comparatively aged or experienced people were involved in fish farming in the study area. Ninety-seven percent fish farmers were between the ages of 20 to 60 years in Trishal upazila, indicating economically active population were involved in fish farming (Hossain and Islam, 2014).

Effective management of inbound logistics, operations, outbound logistics and marketing depends on the literacy level of the pond fish farmers. According to the latest data of Bangladesh Bureau of Statistics, the current literacy rate of Bangladesh is 72.3 percent (BBS, 2017). In line with national census, majority of the fish farmer had primary or more education in the study area (Zannath, 2011; Hossain and Islam, 2014). Rahman *et al.* (2011) found that the average year of schooling of the fish farmers was 8.78 years.

Technology helps to accelerate any kinds of agricultural farming in any region. Availability of appropriate technologies and associated input support are necessary to change the land use pattern of a specific area. Bangladesh Agricultural University and Bangladesh Fisheries Research Institute (BFRI) are the major technology innovators and are only 15 kilometer away from the study area. These institutes have a great impact in changing cropland to fish farming in Trishal upazila (Palash, 2015).

Availability of capital and marketing facilities are the two pillars of successful farming. Capital comes from two sources, either from own savings or credit from different sources such as, friends, relatives, informal and formal credit institutions, etc. In the study area, most of the small and medium scale fish farmers were self-financed (71 percent) that means not taking loan from any formal and informal credit institutions but getting supports from friends or relatives (Sheheli *et al.,* 2013). Rest of the farmers gets loan from informal and formal credit institutions. The interest rate is higher for getting loan from informal sources such as money lenders, NGOs and village based credit cooperative societies. In Trishal upazila, most of the farmers sell their fish in the farmyard. Wholesalers *(bepari* or *paiker*) come to the farm house and collect fish from the farmer. A small amount of fish is sold by *arathder* in the market place (Palash, 2015). This marketing system also enhanced the fish farming in the study area.

Land use or cover change needs a big push factor to alter the existing mind set of agricultural farming. Farmers have to be motivated to convert their land use by his own decision or by external sources. External sources could be experienced farmers or inspirational training from government extension services or NGOs and also development project intervention of GO/NGOs. Major sources of getting fish farming knowledge or inspiration of fish farming by converting agricultural cropland are from fish farming experienced friends and neighbors (Zannath, 2011; Rahman, 2003; Saha, 2006). In the study area, fisheries extension services were very strong than any other regions, therefore, fish farming land area was increasing over the year (Palash, 2015).

The functioning level of land cover is always changing all over the world. Land use change can be defined as any kind of permanent or cyclical human intervention to satisfy human needs (Vink, 1975). According to Turner and Meyer (1994), land use change is likely to change the land cover. Accordingly, agricultural land use change can be defined as switching agricultural land area among different agricultural sub-sectors. Agricultural land use is changing all over the world to make an adjustment between human needs and country development process.

In Bangladesh, a particular agricultural sub-sector is growing due to congenial geographical and climatic environment. Most of the agricultural land was occupied by the crop and horticulture sub-sector in the past. But the situation has been changing with the rapid population growth and technological advancement. Since a few decades, the scale of agricultural sub-sector land use change in Bangladesh has been higher than any other time in the history.

Dixon *et al.* (2001) found that households are diverse in terms of resources and operate within heterogeneous biophysical environments and the land use patterns exhibit spatial dynamics. Walker *et al.* (2002) mentioned that household's internal demands for survival and subsistence determine the land use choice. Ali (2011) showed that 50 percent upland, 45 percent lowland rice field and 5 percent fallow land were converted to construct *Pangasius* farms in Dhanikhola village (10.13 percent of total cropland area of that village) of Trishal upazila. He also found that less productive or single crop producing land (especially upland) is mainly used for *Pangasius* farming.

Akhter *et al.* (2014) conducted a study to quantify land transformations and evaluate how land cover has changed in the time interval. An amount of about 3544.9 ha agricultural land was transformed into non-agricultural land in Trishal upazila within a period of 17 years from 1983 to 2000. It accounts 10.55 percent of total land area of this upazila. The transformation/conversion rate of agricultural land to non-agricultural land in Trisal upazila was 0.621 percent/annum or 208.5 ha/annum. Similar result has

been reported by Quasem (2011) who estimated an annual conversion of farm land to non-agricultural land to be 0.56 percent from a field survey conducted since 2001 to 2008 covering 24 villages of six divisions of the country. There could be different rate of land use change however, it is clear that the agricultural land has been converting to non-agricultural land over time.

Different sources of water bodies are available in Trishal upazila such as ponds, beels, rivers and khals. The availability of large volume of water bodies enhances fish culture activity rapidly in this area. Hashem (2013) found that lots of small-scale fish farms have already been established and many farmers have been shifted to fish culture converting their existing rice fields. There are 20,065 ponds in this upazila that cover the land area of 6340.39 acres (Hashem, 2013).

Materials and Methods

The study used secondary data which were obtained from different upazila level offices of Trishal upazila in Mymensingh district. The data set covers the period of 2000-2016. The data set contains year-wise variable of commercial and domestic pond fish land area, land used for housing, roads, markets, social institutions, gov. offices, khas land, educational institutions, religious institutions, industries, brick fields and forest areas. The researcher or enumerator personally visited the upazila agricultural and fisheries offices and LGED (Local government and engineering department) office to get the necessary information. Moreover, other required information was collected from different issues of BBS (Bangladesh Bureau of Statistics), WorldFish and other published sources.

Since pond fish farming area is increasing over the year without showing any upward and downward picks or seasonality in the study areas, the trend projection model is appropriate for analyzing future trend of pond fish farming area. In addition, lack of adequate time series data of pond fish farming area restricts the use of other forecasting tools in this case. When a time series reflects a shift from a stationary pattern to real growth or decline in the time series variable of interest (pond fish farming area), that time series is demonstrating the trend component. The trend projection method of time series forecasting is based on the simple linear regression model. The trend projection model is:

$PFA_t = b_0 + b_1 t + e$ .....(1)

Where,

PFA_t = Trend value of pond fish farming area in period t;
b_0 = Intercept of the trend projection line;
b_1 = Slope, or rate of change, for the trend projection line;
t = Time period; and
e = Error term.

Along with linear trend, quadratic trend (a nonlinear trend projection method) was also used to see if the future scenario of time series forecasting trend is not moving in linear way. The following quadratic projection model is used:

$PFA_t = b_0 + b_1 t + b_2 t^2 + e$ …….(2)

Results and Discussion

Land utilization of Trishal upazila

Table 1 shows the land use pattern of Trishal upazila over the time. In the year of 2010, major area of Trishal upazila was occupied by agricultural land (78 percent). After 6 years, though agricultural land (other than fisheries) stood the first position in using of land area but the amount of agricultural land decreased by about 7 percent. On the other hand, fish culture land area was increasing notably (about 8 percent) which is evident from Table 1 and Figure 1. Inevitably, increased fish farming land area comes from four sources such as agricultural, *khas*, fallow and forest land area, accordingly (Fig. 1).

Table 1. Land use status of Trishal upazila over time

Uses of land	2010		2016	
	Amount (ha)	Percentages	Amount (ha)	Percentages
Agricultural land	26412	77.97	24150	71.29
Fish pond area	1920	5.67	4542	13.41
Housing	2094	6.18	2200	6.49
Roads and Highway	626	1.85	633.5	1.87
Market and commercial area	71	0.21	72	0.21
Social institution	70	0.21	71	0.21
Govt. offices	24	0.07	24	0.07
Khas land	2021	5.97	1584	4.68
Educational institution	130	0.38	131	0.39
Religious institution	81	0.24	82	0.24
Play ground	120	0.35	120	0.35
Industries	28	0.08	48	0.14
Brick fields	81	0.24	110	0.32
Forest land	65	0.19	63.5	0.19
Fallow land	133	0.39	45	0.13
Total area	33876	100.00	33876	100.00

Source: Author's calculation, 2016

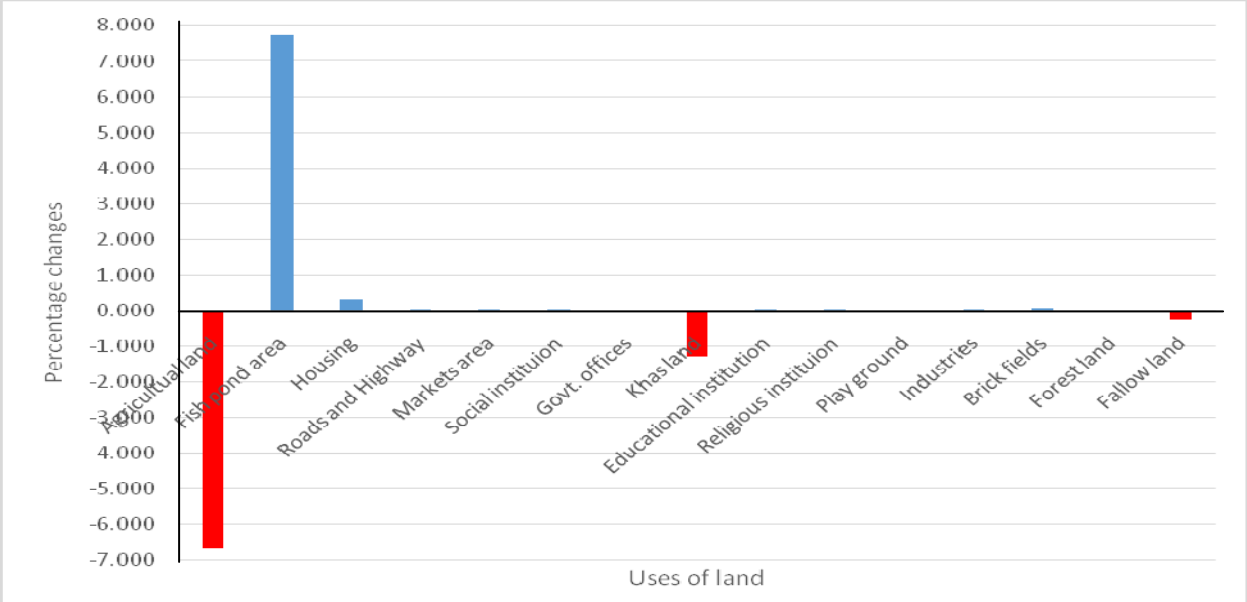

Fig. 1. Conversion of land uses in Trishal upazila between 2010 and 2016

Trend of converting cropland to fish farming

Total return is the capital gain/loss of an investment and the amount of each farming alternative received by the farmer, expressed as monetary values. In the production process, all raw materials, services and efforts are converted to output and rewarded by capital gain/loss of those investments. Agriculture is a highly risky enterprise, so total return could be gained or lost. In case of crop farming, even in fish farming, some farmers are facing the loss of capital investment. Comparatively, smaller farmers are facing this issue because of three main reasons namely, increased production cost, disruption in the production of commodities and lower market price. To overcome the loss of capital investment, farmers are more diversifying the use of agricultural land.

Fig. 2 shows the total pond and culture fish area of Bangladesh over the time. Total fish culture area was increasing sharply up to the year of 2011-12, after that the increasing rate became slower since the country obtained almost self-dependency in fish production. The rate of increasing pond area was also in line with the total culture fish area in Bangladesh. Figure 3 shows that homestead pond fish farming area was decreasing over the time but commercial fish farming area was increasing continuously. These two figures show the national and local level pond fish farming area over the time. Having comparative advantages of fish farming in Trishal upazila, the increasing rate of pond fish farming in local level area was much higher compared to the increasing rate of national level pond fish farming area (WorldFish, 2012).

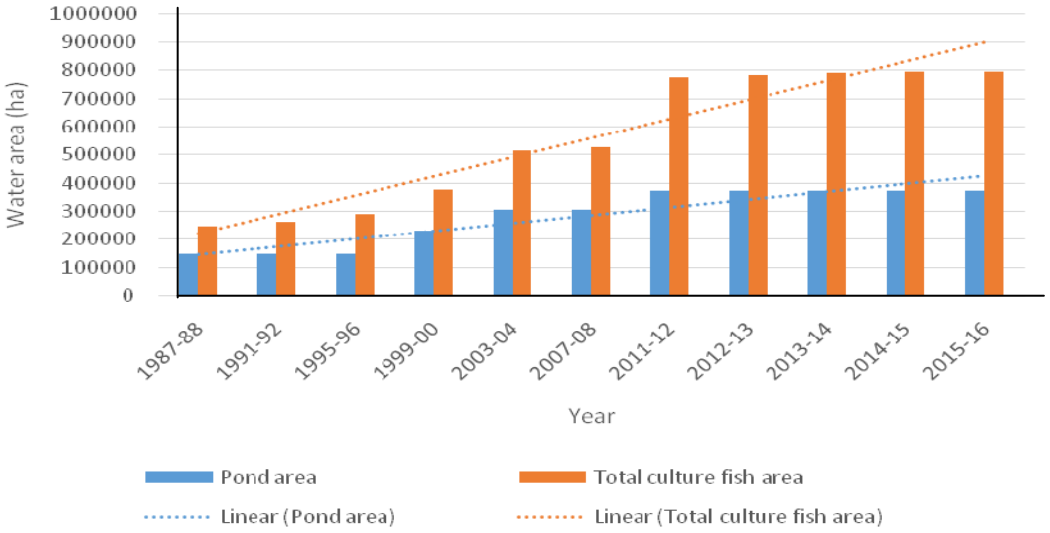

Fig. 2. Trend of increasing pond and total cultured fish area in Bangladesh

Since three decades, the cropland is converting to fish farming in the study areas. One of the main reasons of changing land use pattern is capital gain from alternative farming. The facts from the study area prove the statement significantly. The lowest annual income of fish farmer from one-hectare area was Tk. 192,930 and the highest income was Tk. 348,650 per year with the mean Tk. 228,300 (Sheheli *et al.*, 2013). Rahman *et al.* (2011) conducted a study in Trishal upazila to see the fish farmers' household income from various sources and found that fish farming provides the highest percentage of household income (38.72 percent) followed by crop farming (17.29 percent) and business (16.53 percent). Undiscounted Benefit-Cost Ratio (Undiscounted was calculated by dividing gross return by gross cost) for fish farming was 1.21 which indicates that production of fish was profitable in the study area. Thus, we may conclude that fish production is a profitable enterprise (Hossain and Islam, 2014).

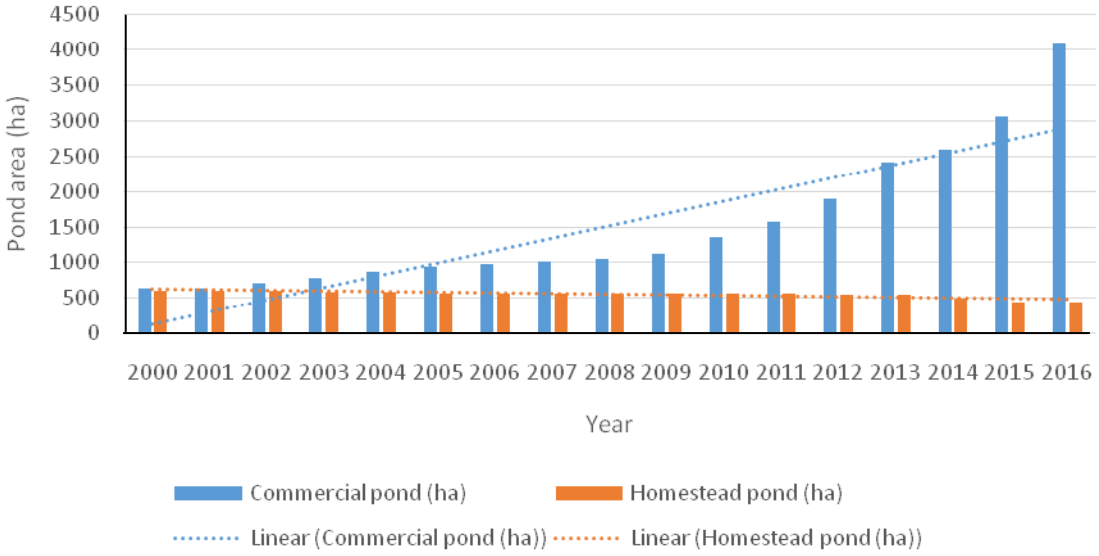

Fig. 3. Land use trend of commercial and homestead pond farming in Trishal upazila

Resource fixity and secureness of home consumption cereal food limit the fish land area extension of small-scale farmers. All croplands are not suitable for fish farming and most of the farmers are not interested in converting their entire land. Palash (2015) conducted a research study in Trishal, Bhaluka, Mucktagaca and Fulbaria upazila of Mymensingh district and found that only seven percent of farmers showed interest in converting the whole land to fish farming, if possible. If the small farmer wants to increase the availability of cropland by one decimal, then they have to sacrifice 0.09 percent of fish land from the farming.

Future trend of pond fish farming

Though homestead pond fish farming area is decreasing but overall fish farming area is increasing in the study area. Fig. 2 shows that nationwide total cultured fish area and pond fish farming area were increasing in slow growth rate; the growth rate was very sharp at the beginning but later on, it became very slow. On the contrary, local level (Trishal upazila) pond fish farming area was increasing very sharply from the year of 2010 to 2016 but before that, growth rate was slow (Fig. 3). Table 2 and Figure 4 show the next five years' trend of pond fish farming in two methods.

Table 2. Future trend of pond fish farming in the study area

Year	Pond fish farming area in ha (Linear trend method)	Pond fish farming area in ha (Nonlinear trend method)
2017	3553.54	4570.13
2018	3718.40	5073.85
2019	3883.26	5613.24
2020	4048.12	6188.30
2021	4212.98	6799.03

Source: Author's calculation

In linear trend projection (multiple linear regression model), pond fish farming land area will be reduced in the following years and the model is not best fitted with the previous data (Fig. 4). After analyzing several forecasting methods, quadratic trend forecasting method provides the best results or best fitted to the previous and following results. The R^2 values of quadratic trend model also explained the variation significantly. However, according to the nonlinear forecasting method, freshwater pond fish sector will occupy about 2000 ha more land in the upcoming years which is an alarming finding for the policy maker for rethinking about land use policy. Since from the Fig. 1, we notice that majority of the pond fish farming land came from the conversion of cropland in the study area.

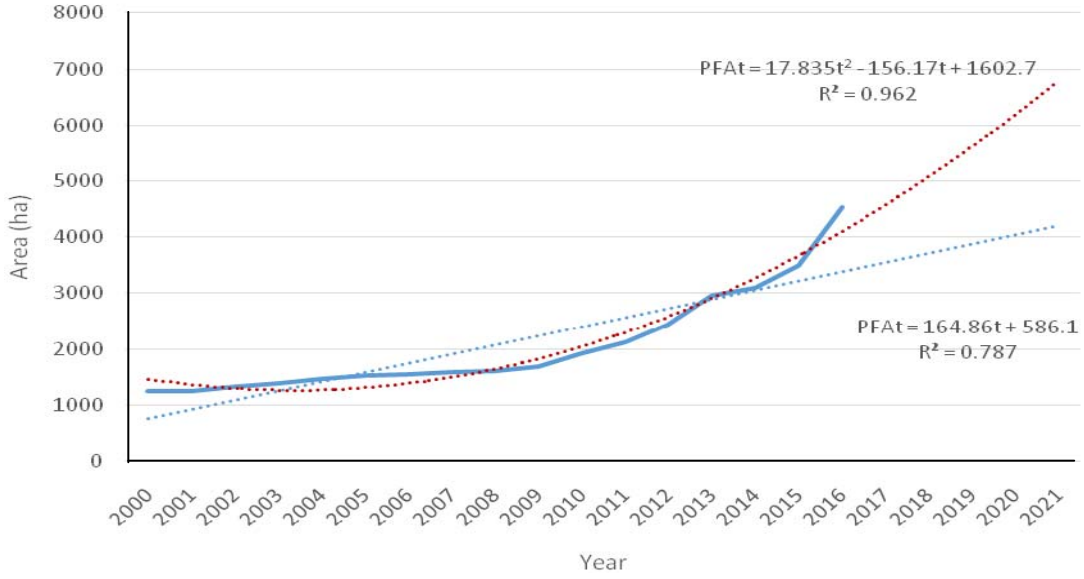

Fig. 4. Trend projection of pond fish farming land use

Conclusion

Agricultural farming decisions and crop selections depend on comparative advantages of resource usages of a specific region. Trihsal upazila is suitable for pond fish farming and the logistic supports are available for the development of aquaculture in this area. Results show that overall agricultural land was decreasing over the year but pond fish farming area was increased by about 137 percent (In the year of 2010, pond fish farming area was 1920 ha, but it was increased to 4542 ha in the year of 2016) within 6 years. The increased freshwater fish farming area was come from cropland, *Khas* land, fallow land and forest land, according to their contribution to additional pond fish farming area respectively. National cultured fish area and pond fish farming area were increasing but in slow growth rate whereas pond fish farming area was increasing very sharply in the study area, if we look at the recent land usages by pond fish farming area. The forecasting also showed that it will increase in the upcoming years.

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References

Ahmed, A., Rajan, K.S., and Shibasaki, R. (2001). Modeling Agricultural Land use Change in Bangladesh: Farmer as an Agent of Change. Paper Presented at the 22nd Asian Conference on Remote Sensing, 5-9 November, Singapore.

Akhter, J., Kader, M. A., Rahman, M., and Shawkhatuzzaman, M. (2014) Changes of land use in Fulbaria and Trishal upazila of Mymensingh district of Bangladesh. Journal of Bangladesh Agricultural University, 12(1): 13–18.

Ali, H., and Haque, M.M. (2011). Impacts of Pangasius Aquaculture on Land Use Patterns in Mymensingh District of Bangladesh. Journal of Bangladesh Agricultural University, 9(1): 169–178.

Badmus, M.A., and Ariyo, O.S. (2011). Forecasting Cultivated Areas and Production of Maize in Nigerian using ARIMA Model, Asian Journal of Agricultural Sciences, 3(3): 171–176.

BBS (2016). Yearbook of Agricultural Statistics. Bangladesh Bureau of Statistics, Dhaka, Bangladesh.

BBS (2017). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics, Dhaka, Bangladesh.

Belton, B. et al. (2011). Review of Aquaculture and Fish Consumption in Bangladesh. The WorldFish Center, Studies and Reviews 2011–53.

BER (2017). Bangladesh Economic Review. Ministry of Finance, Government of the People's Republic of Bangladesh.

Dixon, J., Gulliver, A., and Gibbon, D. (2001). Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World. FAO and World Bank, Rome and Washington.

DOF (2002). Fisheries Statistical Year Book of Bangladesh. Fisheries Resource Survey System, Department of Fisheries, Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh.

DOF (2017). Fisheries Statistical Year Book of Bangladesh. Fisheries Resource Survey System, Department of Fisheries, Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh.

Hashem, S. (2013). Land use Change Detection for Better Aquaculture Planning through Remote Sensing Image and GIS Tools in Trishal upazila, Mymensingh. Unpublished MS Thesis. Department of Aquaculture. Bangladesh Agricultural University, Mymensingh.

Hashem, S., Akter, T., Salam, M.A., and Hasan, M.T. (2014). Aquaculture planning through Remote Sensing Image analysis and GIS tools in Northeast region, Bangladesh, International Journal of Fisheries and Aquatic Studies; 1(5): 134–143.

Hossain, M. T., and Islam, M. N. (2014). Profitability Analysis of Small and Large Farms of Fisheries Sub-Sectors: A Case Study at Trishal Upazila in Mymensingh. Journal of Economics and Sustainable Development, Vol.5, No.22.

Kaiya, M.K.U, Mollah, M.F.A., and Islam, M.S. (1987). Survey of pond fishery resources in Mirzapur Upazila under Tangail district, Food and Agriculture Organization of the United Nations, (http://agris.fao.org/agris-search/search.do? record ID=BD882511688).

Mahmud, W., Rahman, S.H., and Zohir, S. (1994). Agricultural Growth through Crop Diversification in Bangladesh. Working Paper No. 7, International Food Policy Research Institute, Washington, D.C.

Palash, M. S. (2015). Land use Change from Crop to Fish Farming in Bangladesh: Determinants and Impacts on farm Profitability, Margrafh Publishers, Germany.

Quasem, M. (2011). Conversion of Agricultural Land to Non-agricultural Uses in Bangladesh: Extent and Determinants. Bangladesh. Development Studies, XXXIV (1): 59–85.

Rahman, A. R. (2005). Profit Efficiency of Tilapia Monoculture in Trishal Upazila of Mymensingh District. Unpublished MS Thesis. Department of Agricultural Economics, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur.

Rahman, M.M. (2003). Socio-economic aspects of carp culture development in Gazipur, Bangladesh. Unpublished M.S. Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh.

Rahman, S. M. A., Haque, A., and Rahman, S. M. A. (2011). Impact of Fish Farming on Household Income: A Case Study from Mymensingh District. Journal of Social Sciences, 7 (2): 127–131.

Saha, S.R. (2006). Status of pangas catfish (*Pangasius hypophthalmus*) farming in Mymensingh region. Unpublished MS Thesis. Department of Fisheries Management, BAU, Mymensingh.

Sheheli, S., Fatema, K., and Haque, S. M. (2013). Existing Status and Practices of Fish Farming in Trishal Upazila of Mymensingh District. Progressive Agriculture, 24(1 & 2): 191–201.

Turner II, B.L., and Meyer, W.B. (1994). Global Land Use and Land Cover Change: An Overview. Page 3-10 in W. B. Meyer AND B.L. Turner II (eds.). Changes in Land Use and Land Cover: A Global Perspective. Cambridge University Press, Cambridge, UK.

UAO (2016). Upazila Agricultural Office, Trishal Sadar Upazila, Trishal, Mymensingh.

Vink, A.P.A. (1975). Land Use in Advancing Agriculture. Advance series in Agricultural Sciences 1, Springer, Berlin.

Walker, R., Perz, S., Caldas, M., and L.G.T. Silva (2002). Land use and Land Cover Change in Forest Frontiers: The Role of Household Life Cycles. International Regional Science Review, 25: 169–199.

Worldfish (2012). The WorldFish Center. Bangladesh and South Asia Office. Dhaka, Bangladesh.

Zannath, M. (2011). Current Status of Traditional Aquaculture at Trishal Upazila in Mymensingh District. Unpublished MS Thesis. Department of Aquaculture, Bangladesh Agricultural University, Mymensingh.