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Socio-Economic Factors Responsible For Adoption of Alien Fish Species by Fish Farmers in Bangladesh

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Abstract

Adoption of alien fish species for aquaculture has become a common practice in Bangladesh. In this study, the socio-economic factors responsible for alien species adoption by fish farmers in Bogra District of Bangladesh were investigated. Data on adoption and socio-economic factors were collected from randomly selected 110 fish farmers. A multiple regression model was used to determine the factors influencing the adoption of alien fish species. The majority of the respondents (62.7%) belong to the moderate adoption category. The results showed that socio-economic factors such as commercialization, social participation, innovativeness, knowledge significantly affected fish farmers decision to adopt alien species. A stepwise regression analysis reveals that farmers knowledge on aquaculture is the deterministic factor regarding adoption. The trend of adopting alien fish species is not a concern limited to the study area, rather it reflects the general scenario of the aquaculture industry in Bangladesh. Therefore, socio-economic studies on alien fish species adoption could be helpful in forecasting future trends and formulating management strategies.

Keywords: Socio-economic factor; Adoption, alien fish species; Aquaculture; Bangladesh.

1. Introduction

Bangladesh is blessed with extensive and diversified freshwater resources including 265 native fish (Rahman, 2005) and 24 prawn species (Department of Fisheries, 2015). Due to anthropogenic and climate induced effects on aquatic ecosystems, fish diversity and abundance has been negatively affected. Historically, fish production in Bangladesh was depended on open water capture fisheries. As the freshwater resources are declining, aquaculture in Bangladesh has become an important source in terms of food security. Many populations in Bangladesh depend heavily on fish to fulfill their daily requirement of protein. Fish therefore plays an important role in alleviating protein shortage in Bangladesh and inland aquaculture supplies more than 50% of the total requirement (Ghose, 2014).

Due to rapid population growth in Bangladesh, the annual requirement of fish is expected to be over 4 million tons by the year 2020 (Hossain, 2012). To cope with this increasing demand of fish as a prominent protein source, aquaculture in Bangladesh has shifted towards alien fish species farming over the last couple of decades. Until now 16 different alien fish species have been introduced in Bangladesh (Galib and Mohsin, 2011). And the common alien fish species for aquaculture include *Pangasius hypophthalmus* (Thai pangas), *Oreochromis mossambicus* (tilapia), *Anabas testudineus* (Thai koi), *Hypophthalmicthys molitrix* (silver carp), *Oreochromis niloticus* (nilotica) and *Ctenopharyngodon idella* (grass carp). The deliberate and indiscriminate import of alien fish species has brought a wide array of complicacies including extirpations of native fish species (Barua *et al.*, 2001). As a result, a significant number of native fish species (76 species) have been identified as endangered to near threatened (IUCN, 2016). Moreover, they not only compete with native species aggressively for food and space but also have substantial ecological and metamorphic impacts on aquatic ecosystems (Cambray, 2003; Leprieur *et al.*, 2009).

Earlier studies on loss of freshwater resources in Bangladesh, have focused only on biological and technical aspects (Chaki *et al.*, 2014; Galib, 2015; Hossain, 2012). Most of the previous studies do not consider the socio-economic factors. Whereas socio-economic factors are widely accepted as the dominant factor controlling natural

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environment (Foster, 1999), as well as in decision making processes (Dietrich, 2010). Although alien fish species have some deleterious effects on aquatic ecosystems and other native species nevertheless these all alien species are being introduced for commercial profit in modern aquaculture of Bangladesh. Information is needed to understand how socio-economic factors affects the fish farmers decision to adopt alien species for aquaculture. Monitoring relationships between socio-economic factors and alien fish species adoption could be helpful in forecasting future trends and formulating management strategies. This study was therefore aimed to identify the socio-economic factors responsible for alien species adoption by commercial fish farmers in Bangladesh.

2. Materials and Methods

2.1. Description of the Study Area

This study was carried out in Bogra District (longitude 88°58' to 89°45'E and latitude 24°32' to 25°07'N) of Bangladesh. Five rivers (Karatoya, Jamuna, Nagar, Bangali and Ichamati) have been flowing within its territory. Economy of Bogra District is largely influenced by agriculture and commercial fish farming is becoming more popular because of its high economic return. Bogra District consists of 12 sub-districts, from which Kahaloo and Sherpur were opted randomly as study area for this study (Fig. 1).

2.2. Sampling Design

This research was a quantitative study which revealed the influence of socio-economic factors on adoption of alien species by fish farmers for aquaculture. During this study, data on socio-economic status of 110 farmers were collected through questionnaire survey. Both open and closed form questions were included in the questionnaire to collect quantitative and qualitative information from the farmers. Sample size was determined using Cochran formula (Cochran, 1977) and reliability of the questionnaire was tested by determining Cronbach's alpha (Cronbach, 1951). The average reliability of the questionnaire was 0.90 which is consistent with the acceptable value, ranging from 0.70 to 0.95 (Nunnally and Bernstein, 1974), (Bland, 1997; DeVellis, 2016).

Socio-economic characteristics including age (X_1), education (X_2), family size (X_3), farm size (X_4), fish farming area (X_5), information sources use (X_6), annual family income (X_7), commercialization (X_8), social participation (X_9), innovativeness (X_{10}), and knowledge (X_{11}) on aquaculture were considered as independent variables. Whereas adoption of three dominant alien fish species such as *Oreochromis mossambicus* (Tilapia), *Pangasius hypophthalmus* (Thai Pangus) and *Anabas testudineus* (Thai Koi) in the study area was selected as dependent variable.

2.3. Adoption Index

In this study, adoption index indicates the extent of adoption of three dominant alien fish species. It was separately calculated for each of the alien species using the following equation:

$$AI = \Sigma \frac{E_j}{P_i} \times 100 \quad (1)$$

where AI indicates adoption index, E_j is the extent of adoption expressed in terms of summation of obtained adoption score, and P_i is the potential adoption expressed in terms of possible maximum obtainable adoption score (Kashem, 2004).

Furthermore, mean adoption index was calculated for the convenience of data analysis and expressed as

$$MAI = \frac{\Sigma(TAI+PAI+KAI)}{3} \times 100 \quad (2)$$

where MAI is the mean adoption index, TAI indicates tilapia adoption index, PAI is the Thai pangus adoption index; KAI is the Thai koi adoption index.

Overall adoption index of individual species was computed to find out the magnitude of adoption among the species and calculated as

$$OAI = P_l \times 1 + P_m \times 2 + P_h \times 3 \quad (3)$$

where OAI indicates overall adoption index, P_l is the percentage of respondents having low adoption, P_m is the percentage of respondents having medium adoption, and P_h indicates the percentage of respondents having high adoption.

2.4. Statistical Analysis

Statistical Package for the Social Sciences (SPSS) version 20.0 was used for data analysis. Pearson correlation analysis and regression model were used to understand the relationship among variables.

2.5. Model Specification

A regression model developed to find out the determinants influencing adoption of alien fish species. The model is based on the relationship between adoption of alien fish species and different socio-economic factors. It was hypothesized that adoption of alien fish species in the study area was influenced by a number of selected predictor variables such as X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, and X_{11}. The specified model is given below:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} \quad (4)$$

where Y is the dependent variable (adoption of alien fish species), a is the intercept and b_1, b_2…… b_{11} are the coefficients of independent variables X_1, X_2…… X_{11}.

3. Results and Discussions

3.1. Extent of Adoption of Alien Fish Species

Adoption of alien fish species among the respondents (n=110) are presented in Table 1. A major (62.7%) portion of respondents were found in medium adoption category, followed by high level of adoption with 24.5 percent. Whereas only 12.7 percent of respondents showed low level of adoption. The mean adoption score was 54.5. In this study the majority of the respondents belong to medium adoption category. Due to high adaptive capacity and productivity, alien fish species have been rapidly adopted by the fish farmers.

Table-1. Distribution of the respondents according to their overall mean adoption of alien species

Adoption categories (scores)	Fish farmer		Mean adoption index (MAI)
	Number	Percent	
Low adoption (up to 33)	14	12.7	
Medium adoption (33-67)	69	62.7	58.4
High adoption (above 67)	27	24.5	
Total	110	100.0	

Figure 2 shows the Overall adoption index (OAI) among the respondents. The highest OAI was observed for tilapia. Tilapia is well-suited to aquaculture as their ability to cope with a range of environmental conditions and high production potential. Earlier studies reported that per hectare production of tilapia can be ranged from 18,500 to 23,500 kg (Sarker, 2013; Toma *et al.*, 2015). Tilapia is therefore also known as the 'aquatic chicken' (Canonico *et al.*, 2005). As shown in Figure 2, the OAI of Thai pangus was 226.3 and stood second in terms of adoption in the study area. The average Thai pangus production in Bangladesh found to be 19,995 kg/ha (Khan, 2012). Due to its high production rate, this species is mainly cultivated for making more financial profits. Among the three adopted alien species, Thai koi production was the lowest 9,400 to 9,500 kg/ha (Kohinoor *et al.*, 2016). And placed in the third place regarding adoption (Fig. 2). Compare to per hectare production of native fish species, its production is still considerably high. Therefore, Thai koi has been also opted by the fish farmers despite many challenges. Although this is a small study, the trend of adopting alien fish species is not limited only to the study area rather it reflects the general scenario of inland aquaculture of Bangladesh.

3.2. Socio-Economic Factors Responsible For Adoption of Alien Species

Table 2 shows the correlation coefficients between selected socio-economic factors of the respondents and their adoption of alien species. All the factors except 'family size' of the respondents demonstrated positive and significant relationship with adoption of alien species.

Table-2. Correlation coefficients between the selected socio-economic factors of fish farmers and their adoption of alien species for aquaculture

Socio-economic factors	Correlation coefficient (r)
Age	0.213*
Education	0.473**
Family size	0.068
Use of information sources	0.540**
Farm size	0.291**
Fish farming area	0.293**
Annual family income	0.476**
Commercialization	0.241**
Social participation	0.214*
Innovativeness	0.298**
Knowledge	0.623**

*p < 0.01; **p < 0.05

To find out the significant factors influencing adoption of alien fish species a multiple regression analysis was carried out. The results of multiple regression analysis are shown in Table 3. Results indicated that four socio-economic factors such as commercialization, social participation, innovativeness, and knowledge had significant contribution on alien fish species adoption for aquaculture in the study area.

Table-3. Regression coefficients of adoption of alien species for aquaculture by fish farmers with selected socio-economic factors

Socio-economic factors	Coefficients		t-value	Level of significance
	Unstandardized	Standardized		
Constant	-38.622		-1.675	0.097
Age	0.179	0.084	0.719	0.474
Education	-0.442	-0.095	-0.582	0.562
Family size	-0.507	-0.037	-0.381	0.704
Information sources	0.429	0.181	1.161	0.249
Agricultural farm size	-12.874	-0.518	-1.629	0.106
Fish farming area	13.059	0.520	1.723	0.088
Annual family income	-0.00001	-0.067	-0.332	0.741
Commercialization	0.544	0.199	2.070	0.041
Social participation	-2.972	-0.225	-2.454	0.016
Innovativeness	0.620	0.171	2.018	0.046
Knowledge	2.365	0.605	3.371	0.001

R2 = 0.47 Adjusted R2 = 0.41 F-value = 7.77 $p < 0.01$

A stepwise regression was further performed to determine the specific factor responsible for adoption of alien species, and findings are presented in Table 4. It was observed that among the four significant socio-economic factors, knowledge is the particular deterministic factor influencing adoption of alien fish species. The significance of knowledge in adopting technologies has been well documented, (Davenport and Prusak, 1998; Dawoe *et al.*, 2012; Isaac *et al.*, 2009; Sakib *et al.*, 2014; Samah and Kamaruddin, 2015). Farmers usually obtained knowledge from their previous experiences and therefore find it easy to adopt. The belief and perception originated from the farmers past knowledge affects the decision of adopting or rejecting a new technology which is hard to systemize (Boven and Morohashi, 2002).

Table-4. Regression coefficients of adoption of alien species between fish farmers and the deterministic socio-economic factor responsible for adoption

Socio-economic factors	Coefficients		t-value	Level of significance
	Unstandardized	Standardized		
Constant	16.280		3.019	0.003
Knowledge	2.435	.623	8.278	0.000
$R^2 = 0.39$	Adjusted $R^2 = 0.38$	F-value= 68.5	$p < 0.01$	

Despite having sharp knowledge on aquaculture, farmers in Bangladesh may not acquaintance with the antagonistic effect of alien species on native ecology and biodiversity. Perhaps they focus on only production and cost-benefit consistency so that they can make more profit. Activities such as training, awareness raising, and skill development programs should be carried out for the farmers to make them understand about the complicacies associated with alien fish farming. Besides, farmers must be subsidized to turn back in indigenous species culture for betterment of ever-growing aquaculture industry in Bangladesh.

4. Conclusion

In this study, three dominant alien fish species i.e. *Oreochromis mossambicus* (Tilapia), *Pangasius hypophthalmus* (Thai Pangus), and *Anabas testudineus* (Thai Koi) were taken into consideration to understand their extent of adoption. The results showed that 62.7% of the respondents were found in the medium level of alien fish adoption and OAI of tilapia was the highest followed by Thai pangus and Thai koi. Stepwise regression analysis revealed that adoption was mainly influenced by the farmers knowledge on production rate of alien fish species. Apparently, fish farmers in Bangladesh culture alien fishes only for their financial sustainability. This ongoing situation may create a provision for alien species to spread all over the rivers across the country and will make the status more critical for the environment and biodiversity in near future. The results of the research represent the general scenario of overall aquaculture industry in Bangladesh and also provide useful insights for the policymakers. By addressing all findings, it can be recommended that application of strategies such as skill improvement training, awareness raising activities, subsidy as compensation, code of good aquaculture practices and research to discover new native species profitable for aquaculture may require to tackle this prevailing situation.

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Figure-1. Location of the study area in Bangladesh

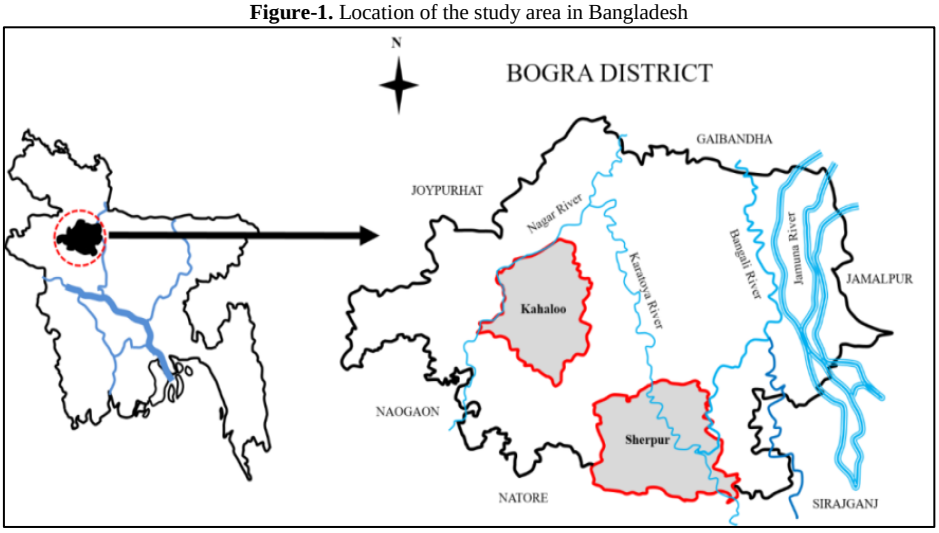

Figure-2. Overall Adoption Index (OAI) of the investigated alien fish species