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Market choice behavior of fish farmers in the *haor* regions of Bangladesh

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ABSTRACT

The fish farming sector in *haor* regions of Bangladesh is integral to both local livelihoods and the national economy. This study examined the factors that influence fish farmers' choice of market in this region, offering empirical insights into their decision-making processes. Using a random sampling technique, data were collected from 450 fish farmers across three upazilas in Netrokona, Kishoreganj, and Sunamganj districts. The multinomial logit model was employed to identify these influencing factors. The analysis revealed that factor such as age, education, access to extension services, and labor availability have negative effects on the selection of secondary markets. Total market loss also negatively impacts the choice of both secondary and tertiary markets. Furthermore, transportation facilities and distance to the market decrease the probability of selecting tertiary markets. In contrast, access to credit facilities positively influences the choice of secondary markets and negatively influences the choice of tertiary markets. Infrastructure facilities have a positive impact on the choice of secondary and tertiary markets but reduce the likelihood of selecting primary markets. This study underscores the importance of effective support systems, investments in education and infrastructure, risk management enhancements, and the promotion of sustainable practices in the local fish farming industry. Policymakers and stakeholders should consider these findings when developing strategies for the sustainable growth of the *haor* regions' fish farming sector.

Introduction

Bangladesh, endowed with abundant water resources, is considered one of the most suitable countries for freshwater aquaculture ln the world. In the fiscal year 2020-21, the nation achieved a total fish production of 4.759 million metric tons, with aquaculture contributing a substantial 57.39% (DoF, 2021). Notably, the aquaculture sector has demonstrated remarkable resilience and growth, maintaining an impressive 10% average growth rate over the past decade (DoF, 2021). Bangladesh has achieved self-sufficiency in fish production and

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surpassed the target per capita fish consumption of 60 g/day, with a remarkable per capita consumption of 62.58 g/day (FRSS, 2021).

The economic significance of the aquaculture sector in Bangladesh is profound. It significantly contributes to the national GDP, accounting for 2.08% in the fiscal year 2020-21, and plays a substantial role in the overall agricultural GDP, contributing 21.83% (DoF, 2021). Beyond economic figures, the sector is a lifeline for over 12% of the country's population, serving as a vital source of livelihood. It plays a pivotal role in enhancing food and nutrition security, providing nearly 60% of the country's total animal protein supply (DoF, 2021). Moreover, Bangladesh earns substantial foreign currency through the export of fish, shrimps, and other fishery products, with exports totaling BDT 51917.05 million and almost 74.04 thousand metric tons in the fiscal year 2020-21 (DoF, 2021).

The h*aor* areas in Bangladesh, spanning districts like Sunamganj, Sylhet, Moulvibazar, Habiganj, Netrokona, and Kishoreganj, are ecologically, economically, and socially significant (Chakraborty et al., 2005; Acharjee et al., 2021). These areas, characterized by their unique landscape and annual monsoon flooding, are home to 411 *haors* and have a crucial role in the ecosystem of country. They serve as natural flood reservoirs during monsoons, reducing the impact of seasonal flooding in other regions (Mansur, 2005). Additionally, the nutrient-rich sediments carried by floodwaters enrich the aquatic ecosystem, creating a fertile environment for fish breeding and growth (Getu et al., 2015). The *haor* areas are natural habitats for a diverse range of aquatic species and avian fauna, contributing to the country's biodiversity (FAO, 2020; DoF, 2021).

Economically, *haors* significantly contribute to Bangladesh's fish production, serving as a vital safety net for impoverished households. Seasonal fish harvesting is a traditional practice sustaining local communities, particularly during lean periods when alternative livelihood sources are scarce (Chakraborty et al., 2005). The *haor* areas are deeply intertwined with the social and economic fabric of the region, supporting various livelihoods and acting as a crucial resource for rural communities.

Bangladesh, renowned for its rich aquatic diversity boasting nearly 260 freshwater fish species (Alam, 2011), faces challenges in its inland capture fisheries due to the decline and degradation of wetland resources and a poor market structure (Diei-Ouadi and Mgawe, 2010 and FRSS, 2021). This decline has profound implications for the economic sustainability of *haor*-dependent communities. Addressing these challenges necessitates an exploration of the complex dynamics within the fish market, particularly in the context of the *haor* areas.

The intricate fish market in Bangladesh is delineated into four distinct categories: primary, secondary or assembly, higher secondary or wholesale, and final consuming markets (Alam, 2014). The primary market serves as the point of sale, where fish farmers directly engage with mobile collectors or assemblers (Alam, 2014). Moving through the supply chain, the secondary market involves intermediaries who procure fish products from farmers and distribute them to local retailers, wholesalers, or transporters (Alam, 2014). Tertiary fish markets constitute the concluding stage, facilitating the distribution of fish products to end consumers through supermarkets, retailers, or export channels (Alam, 2014). The major actors that are attached in this marketing system, including *bepari* (small-scale traders), rural and urban *paikar* (retailers), *aratdar* (wholesaler), and retailers (Nowsad, 2010; Barman, 2011; Alam et al., 2012; and Islam et al., 2014). This comprehensive market structure reflects the diverse avenues through which fish products traverse from producers to consumers in Bangladesh.

The economic significance of this market structure is underscored by the fact that 85% of fish consumption is directed through wholesale and retail markets, emphasizing the pivotal role of fish, constituting 60% of the total animal protein intake (Belton et al., 2011; DoF, 2020; and Sapkota et al., 2012). Recent years have witnessed a substantial trend in which a considerable number of Bangladeshi farmers actively engage in fish marketing, selling directly to wholesalers, driven by the remarkable growth in the commercial aquaculture sector (Faruque, 2007; Alam et al., 2012; and Apu et al., 2014).

Despite these trends, challenges persist in the market dynamics, particularly at the higher-secondary/terminal level where competition is relatively higher than the primary/secondary level (Dey et al., 2010). The majority of inland fish production is marketed internally for domestic consumption (97%), with fish farmers typically receiving 56% of the final consumer price, the rest distributed among various intermediaries (Hasan, 2001; Apu et al., 2014; Lesa, 2020; Alam et al., 2012; Apu et al., 2014; and FAO, 2022). The perishable nature of fish and the disparity between catching and selling times result in narrow profit margins for fish farmers, leading to imperfect market competition acknowledged by policymakers highlighting unequal fish price distribution within the value chain in Bangladesh (Sapkota et al., 2012; Alam, 2012; and Sapkota et al., 2015).

In a market-driven economy, the effective transmission of price signals and information is critical for guiding marketing activities and determining pricing mechanisms (Hossain, 2018). Integrated markets facilitate the transmission of information regarding shortages or surpluses, ensuring a balanced demand and supply situation (Awal et al., 2007). Conversely, disintegrated markets lead to temporary price inflation, negatively impacting both producers' and consumers' economic welfare (Awal et al., 2007). The existing market structure in Bangladesh falls short in addressing the multifaceted challenges faced by fish farmers and market actors, resulting in low marketing efficiency and an inability to transmit price signals accurately (Dey et al., 2010). This study aims to bridge this research gap by exploring strategies to improve market conditions for fish farmers in Bangladesh.

Consumption patterns in Bangladesh favor indigenous carp, shrimp, catfish, and other small fish species, emphasizing the importance of an efficient marketing system (Kohls, 2005). Effective distribution channels are pivotal for successful and sustainable fish culture. In the traditional selling system, farmers have limited control over input costs and revenue, as goods are pushed into the marketplace. Contrastingly, the value chain approach fosters closer links between farmers' and consumers' needs, increasing returns for farmers and enhancing livelihoods. Market choice is thus a vital component of sustainable fish production and the overall welfare of stakeholders in the fish value chain.

Unlocking the potential of fish markets offers an opportunity for fish producers to alleviate poverty by increasing income from fish sales. Despite considerable investments in restructuring and land reform, poverty still persists among many fishermen in Bangladesh (Alam, 1999; Edwards, 2000; and De Graaf and Latif, 2002). Addressing the challenges faced by fish farmers in securing profitable market opportunities is crucial. While several studies have identified factors influencing farmers' market choices in recent years (Ogunleye and Oladeji, 2005; Bongiwe and Masuku, 2012; Hassan et al., 2012; and Moturi et al., 2015), none have examined these factors within the specific context of Bangladesh. This study aims to fill this research gap by exploring the choice of markets among fish farmers in the *haor* areas of Bangladesh, particularly in Netrokona, Kishoreganj, and Sunamganj districts, where significant fisheries resources are found. The study endeavors to shed light on the factors influencing fish market choices in these areas, providing valuable insights for fish farmers, market actors, and policymakers to formulate programs and policies related to fish marketing.

Materials and Methods

Selection of the study Areas

The research was conducted in three distinct geographic regions: i) Mohongong upazila, situated in the Netrokona district in northern Bangladesh; ii) Nikli upazila, located within the Kishoreganj district of Bangladesh; and iii) Derai upazila, situated in the Sunamganj district of the north-eastern region of Bangladesh.

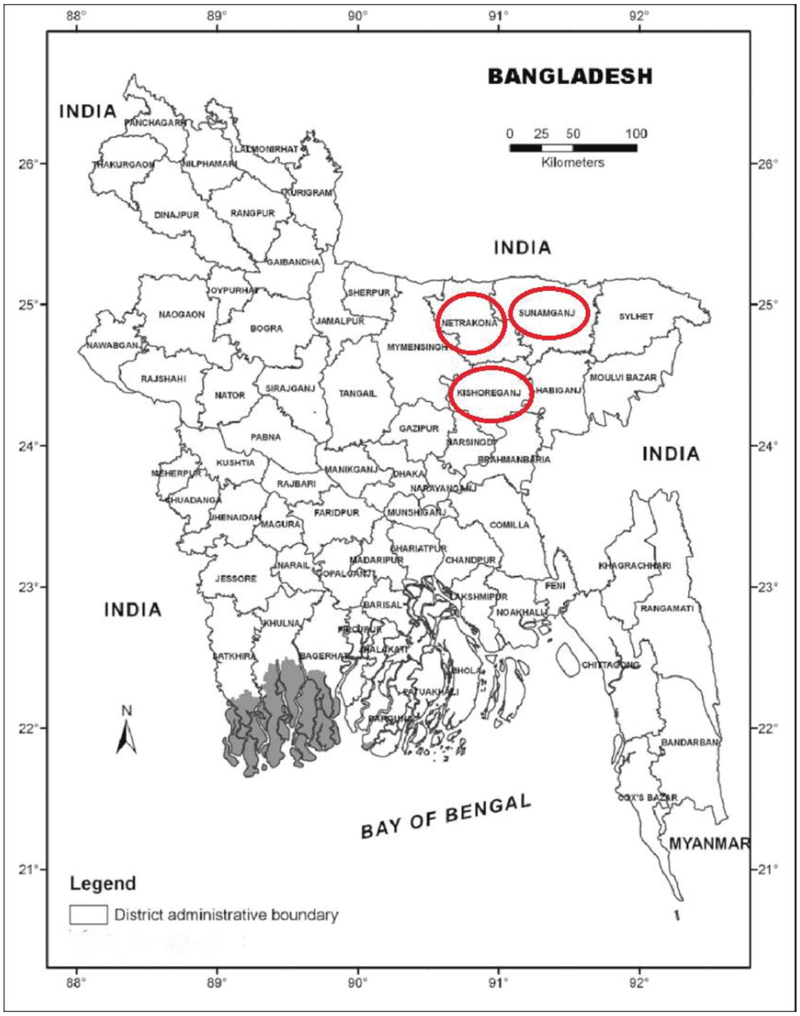

Fig. 1: Map of the study area

In terms of inland open water capture and culture fish production, all these three districts have distinct position (Shamsuzzaman et al., 2017; and DoF, 2022). Thus, insight from the fish farmers of these regions will illustrate an appropriate result. A comprehensive research approach was adopted, involving a blend of participatory, qualitative, and quantitative methods for the primary data collection. Interview schedule was deployed as instrument tool to obtain data from targeted sources. The study incorporated a substantial sample size, comprising a total of 450 fish farmers.

Sampling Procedure and Sample Size

The sample sizes were determined using a list provided by the upazila fisheries office. The following formula, as outlined by Olsson (2011), was employed to calculate the sample size stability,

$$n = \frac{N \times n_0}{N + n_0} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$n = \frac{N \times n_0}{N + n_0} = \frac{9882 \times 384}{9882 + 384} \approx 370 \quad where\ n_0 = \frac{z^2pq}{e^2} = \frac{(1.96^2 \times 0.9 \times 0.10)}{0.05^2} \approx 384$$

Where, n is the sample size, z is the value of the normal curve, p is the estimated population proportion, q is 1-p, and e is the error term (5%). In the study area, according to the list of upazila fisheries office, a total of 9882 fish farmer exists.

Thus, a total of 450 fish farmers were included in the sample for primary data collection, with 150 farmers selected from each of the following districts: Netrokona, Kishoreganj, and Sunamganj throughout the August 2022 to January 2023.

Econometric Modelling – Factors influencing farmers' choice of market option

Following the compilation of data, a statistical analysis was conducted using the STATA software. To test the integrity of dataset, the study also assessed multicollinearity among the variables through the variance inflation factor (VIF) test. Acceptability is determined if the VIF values are below 10 (Table 1).

Table 1. Determination of multicollinearity among variables (test of variance inflating factor, VIF)

	VIF	1/VIF
Age (in years) (Continuous)	1.721	.581
Years of schooling (Continuous)	1.552	.645
Access to training (Categorical)	1.457	.686
Extension contacts (Categorical)	2.527	.396
Transportation facilities (Categorical)	1.845	.542
Distance to market (Continuous)	1.665	.6
Access to credit facilities (Categorical)	1.557	.642
Infrastructure facilities (Categorical)	1.055	.948
Annual Income of Household (Continuous)	1.124	.889
Family size (Continuous)	1.135	.881
Labor availability (Categorical)	1.861	.537
Selling point (base: primary market) Secondary market	2.168	.461
Secondary market	1.603	.624
Mean VIF	1.636	.

The objective of the analysis was to elucidate the impact of independent variables, including socio-economic and marketing characteristics, on the fish farmers' choice of market within the fish's value chain. This decision is inherently multivariate, as it entails choosing between different market categories, denoted as j + 1 alternative, in relation to the dependent variable Y, representing the choice of the market in the value chain, where j can be 1, 2, or 3.

To model this nominal outcome with unordered categori-es, we employed the Multinomial Logistic Model (MNL) (Gujarati, 2003). The MNL model is particularly suited for estimating such categorical outcomes and provides independence across choices, thereby minimizing the likelihood of correlation or substitution between them, as discussed by Wooldridge (2008, 2012).

Furthermore, the MNL model can be applied to analyze the market choice behavior of various actors within the examined value chain (Edoge, 2014). In a broader context, the decision to select or reject a market can be framed within the framework of utility and profit maximization, as proposed by Norris and Batie (1987). While utility itself remains unobservable, the choices made by economic agents are manifest through their actions. Greene (2000) outlines the specification of the linear utility model as follows.

$$U_j = \beta'_j X_i + \varepsilon_j \text{ and } U_k = \beta'_k X_i + \varepsilon_k \quad \ldots\ldots (2)$$

Where

Y_j and Y_k = the producer's two market choices and their derived utility, denoted by U_j and U_k, respectively;

X_i = a vector of explanatory variables influencing perceived desirability of involving market choice;

β_j and β_k = market choice parameters;

ε_j and ε_k = error terms assumed to be independently and identically distributed.

If a producer decides to use option j on i_{th} market chain, it follows the perceived utility or benefits from option j compared to the option, k:

$$u_{ij}(\beta'_j x_i + \varepsilon_j) > (\beta'_k x_i + \varepsilon_k), k \# j \text{ .... (3)}$$

The probability of a household, when adopting option j among the set of market choice options, can be defined as:

$$p\left(y = \frac{1}{x}\right) = p\left(u_{ij} > u_{ik}\right) \text{................. (4)}$$

$$= p\left(\beta'_j + \varepsilon_j - \beta'_k x_i - \varepsilon_k > \frac{0}{x}\right)$$

$$= p\left(\beta'_j x_i - \beta'_k x_i + \varepsilon_j - -\varepsilon_k > \frac{0}{x}\right)$$

$$= p\left(\beta^* x_i + \varepsilon^* > \frac{0}{x} = F(\beta^* x_i)\right)$$

Where,

p = probability function, u_{ij}, u_{jk} and x_i;

$\varepsilon^* = \varepsilon_j - \varepsilon_k$ is a random disturbance term;

$\beta^* = (\beta'_j - \beta'_k)$ is a vector of unknown parameters, which can be interpreted as the net influence of the vector of independent variables influencing factors;

F ($\beta^* X_i$) = is the cumulative distribution function of ε^* evaluated at $\beta^* X_i$. The exact distribution of F depends on the distribution of the random disturbance term ε^*(Greene, 2000).

Let M_{ij} be the j_{th} market that an actor chooses, in i_{th} market Mij could then take the value of 1 if the j_{th} market is chosen on i_{th} market and 0 otherwise. The probability that an actor with characteristics X chooses market j on the i_{th} market is specified as:

In this study, the market choices made by farmers were classified into three distinct options, denoted as Yi. These categories were developed based on observed market linkages and the prevailing patterns of market choices between producers and buyers, as documented in studies by Chowdhury (2004), Ahmed and Rahman (2005), Sen (2013), Ali et al. (2015), Amentae (2016), and Haldar et al. (2020). It is crucial to note that Yi is a categorical variable encompassing discrete values ranging from 0 to 2, representing the available options to farmers. It is worth mentioning that a small subset of farmers who engage in selling their fish through more than one or multiple markets has been excluded from the analysis, as their numbers are minimal and do not significantly impact the findings.

1. Farmgate ($Y_{0,}$ supply their produce to farmgate, Primary market),
2. Upazila market ($Y_{1,}$ supply their produce to upazila market, Secondary market),
3. District market ($Y_{2,}$ supply their produce to district market, Tertiary market).

To find the influential factors related to market choice options, the multinomial logistic regression model is;

$$\eta_{ij} = \log\frac{\pi_{ij}}{\pi_{ij}} = \beta_0 + \beta_1 X_1 + \beta_2 X_{12} + \cdots \text{.........} + \beta_K X_K + \varepsilon_i \text{ ....(7)}$$

Where,

$j=1,\ldots\ldots j\text{-}1$, $\sum_j \pi_{ij} = 1$, β_0= Constant, π_{ij}=P (Y_i= j)

β_K = regression coefficient, $\frac{\exp(\eta_{ij})}{\sum_{k=1}^{k=J} \exp(\eta_K)}$

$\frac{\pi_{ij}}{\pi_{ij}}$ = odds of success, ε_i = Error term

The selection of independent variables in the specified model was informed by an extensive literature review and insights gained from field survey. These variables are presumed to exert an influence on the dependent variables, as summarized in Table 2.

Table 2. Independent variables that influence farmer's choice in selecting the fish market in the study areas.

Variables	Definition of variables	Source
Y=Market choice	Dependent variable	Current survey data
	Explanatory variables	
Age (X_1)	Age of farmers in years	Field survey, 2022, Sigei *et al*. (2014), Kawala*et al*. (2018)
Years of schooling (X_2)	Education (years of schooling) (0= illiterate or having ability to signature, 1= primary, 2= secondary, 3= higher secondary to above)	Tola (2014), Chaweza, and Nagoli (2018); Malit et al. (2021)
Access to training (X_3)	1= if participate any training program; 0= otherwise)	Lapar *et al.* (2002)
Extension contact (X_4)	1= if farmer has extension contact; 0= otherwise	Tefera (2014), Tshiunza *et al.* (2001)
Transportation facilities (X_5)	1= if the study area has good transportation facilities, 0= otherwise	Hoq *et al*. (2021)
Distance to the market (X_6)	1= Farmer location less than 5 km to the nearest market in kilometers; 0= Farmer location more than 5 km to the nearest market in kilometers)	Tola (2014), Kawala *et al*. (2018)
Access to Credit facilities (X_7)	1= if good access to credit facilities; 0 = otherwise	Nyaga J *et al.* (2016), Adu, 2018, Acharjee *et al.* (2023)
Infrastructure facilities (X_8)	1= if study area has good infrastructure facility, 0= otherwise	Hoq et al. (2021)
Annual income in Taka/ha/ years (X_9)	1= Very low "up to 50000", 2= Low "50001- 150000", 3 = Medium "150001- 250000", 4 = High "250001- above 350000"	Nyaga J *et al.* (2016)
Family size of the farmer (X_{10})	1= small "1-3 members", 2= Medium "4-5 members", 3= Large "6 to above members"	Hoq *et al.* (2021), Adu, 2018, Kawala *et al*. (2018)
Labor availability (X_{11})	1= if good availability of human labour facilities; 0= otherwise	Field survey, 2022
Total market loss (X_{12})		Field survey, 2022

It's important to note that, out of the three market choice options mentioned earlier, the 'farmgate market' is designated as the base category or reference market for the analysis. Subsequently, this study compared the estimated marginal effects or coefficients for the upazila and district markets with the reference market to understand the extent of deviation between them. It is crucial to emphasize that the estimated parameters provide insights into the direction and magnitude of the influence of independent variables on the dependent variable.

The study also conducted a test to assess the Independence of Irrelevant Alternatives (IIA) in MNL model using the Hausman test. The non-rejection of the null hypothesis in this test indicates that the market options specified in the MNL model are appropriate. This further validates the suitability of the MNL specification for the dataset. Additionally, the study employed the Kruskal-Wallis (K-W) test to make comparisons between two or more independent samples of equal or varying sizes. The Wald test was also employed as a part of the analytical approach. All these analyses were performed using the STATA software. For a comprehensive view of the independent variables employed in the model, please refer to Table 2.

Results and Discussion

Socio-demographic profile of fish farmers in study area

A comprehensive overview of the socioeconomic characteristics of fish farmers across three distinct regions: Netrokona, Kishoreganj, and Sunamganj, along with the results of one-way ANOVA tests, each accompanied by their respective significance levels were illustrated in Table 3. Notable findings emerge from this analysis.

Table 3. Socioeconomic characteristics of fish farmer in the study areas.

Particulars	Netrokona		Kishoreganj		Sunamganj		ANOVA (one-way) test	
	No	(%)	No	(%)	No	(%)	F- value	p-value
Age (Years)								
≤ 24	0	0.00	2	1.50	4	3.00		
25- 34	21	13.83	36	23.83	30	20.00		
35-44	72	48.00	79	53.00	78	52.00	6.41***	0.002
45-59	54	36.17	31	20.67	38	25.00		
≥ 60	3	2	2	1	0	0		
Total	150	100	150	100	150	100		
Years of schooling status								
Illiterate or having the ability to signature (<1)	27	18	22	15	19	13		
Primary (level 1-5)	60	40	65	43	53	35	0.187	0.829
Secondary (level 6-10)	35	23.5	33	22	49	33		
Higher Secondary to above (level 11-16)	28	18.5	30	20	29	19		
Total	150	100	150	100	150	100		
Access to training								
Yes	20	13.33	63	42.33	102	68.30		
No	130	86.67	87	57.67	48	31.70	57.949***	4.19492E-23
Total	150	100	150	100	150	100		
Extension contact								
Yes	28	18.50	49	33	57	38		
No	122	81.50	101	67	93	62	7.338***	0.001
Total	150	100	150	100	150	100		
Transportation facilities								
Yes	67	44.57	58	38.60	81	54.00		
No	83	55.43	92	61.40	69	46.00	3.642**	0.027
Total	150	100	150	100	150	100		
Distance to the market								
Less than 5 km	55	36.70	94	62.50	68	45.50		
More than 5 km	95	63.30	56	37.50	82	54.50	1.707	0.183
Total	150	100	150	100	150	100		
Access to credit facilities								
Yes	64	42.50	27	18.00	93	62.15		
No	86	57.50	123	82.00	57	37.85	33.320***	3.24746E-14
Total	150	100	150	100	150	100		
Infrastructure facilities								

Particulars	Netrokona		Kishoreganj		Sunamganj		ANOVA (one-way) test	
	No	(%)	No	(%)	No	(%)	F- value	p-value
Yes	37	24.70	51	34.10	29	19.50		
No	113	75.30	99	65.90	121	80.50	4.351**	0.013
Total	150	100	150	100	150	100		
Annual income (Taka/ha/year)								
Very low (up to 50000)	75	50	31	21.00	8	5.32		
Low (50001-150000)	29	19	51	34.00	18	11.70	41.110***	4.08393E-17
Medium (150001- 250000)	16	11	47	31.00	83	55.50		
High (250001- above 350000)	30	20	21	14.00	41	27.48		
Total 150 100	150	100	150			100		
Family size of the farmer								
Small (1-3 members)	27	18.00	22	15.00	34	23.00		
Medium (4-5 members)	59	39.00	71	47.00	84	56.00	5.872***	0.003
Large (6 members and above)	64	43.50	57	38.00	32	21.00.		
Total	150	100	150	100	150	100		
Labor availability								
Yes	80	53.33	15	10	17	11.33		
No	70	46.67	135	90	133	88.67	43.995***	3.61915E-18
Total	150	100	150	100	150	100		
Total market loss (in Kg)								
Area	Kg	(% of total)	Kg	(% of total)	Kg	(% of total)		
Physical loss	2.32	48%	1.24	26%	1.24	26%		
Quality loss	2.27	41%	1.62	29%	1.61	29%	873.960***	3.4409E-155
Market loss	2.19	27%	2.85	36%	2.85	36%		
Total								

Source: Field survey, 2022. Note: *, ** and *** indicates significant at 10%, 5% and 1% level.

Firstly, significant age variations exist among the regions, particularly in the 35-44 age group, where the differences are statistically significant (p-value = 0.002), indicating a notable divergence in this age demographic among the regions which is different from national average age variances (HIES, 2022). Although there is no pronounced divergence in educational levels among the regions (p-value = 0.829), it is noteworthy that a substantial portion of individuals in all areas have primary-level education whereas, in Bangladesh more than 77% of the people have primary education which supports the result (BBS, 2020). Access to training programs significantly differs, with Sunamganj having notably higher access (p-value < 0.001), as does extension service availability (p-value = 0.001), favoring Sunamganj and Kishoreganj. Again, Netrokona stands out with significantly better transportation facilities (p-value = 0.027) compared to the other regions, potentially influencing market access and mobility. Access to credit facilities displays significant regional variation (p-value<0.001), with Sunamganj having notably greater access, potentially impacting investment and business expansion. Kishoreganj has a higher proportion of infrastructure facilities (p-value=0.013), which can impact overall farm productivity. Substantial income disparities are evident among the regions (p-value<0.001), with Netrokona reporting significantly higher annual incomes, highlighting variations in economic well-being. Family size always differs significantly (Islam, 2023), here in this study Kishoreganj had more medium-sized families (p-value = 0.003) similar to national average family size of 4.026 member (HIES, 2022). Labor availability is significantly lower in Kishoreganj and Sunamganj and significantly varies among the regions (p-value < 0.001), which can potentially impact farm operations. Importantly, an extremely significant difference in total market loss is observed among the regions (p-value < 0.001), with Netrokona experiencing significantly lower losses, indicating variations in market efficiency and management practices. These findings underscore the diverse challenges and opportunities within each region's fish farming sector, providing valuable insights for policymakers and researchers aiming to tailor interventions and policies to address the specific needs of these communities.

Estimation of market choice behavior

The factors governing fish farmers' choice of market in the study area were comprehensively assessed through the application of a multinomial logit (MNL) model. This analytical approach allowed us to consider a diverse set of twelve variables, each selected with careful consideration to capture both socio-economic and marketing characteristics. These variables included age (measured in years) and years of schooling, both treated as continuous variables. The analysis also accounted for access to training and extension contacts, represented as categorical variables that denote specific conditions. Additionally, the influence of transportation facilities and access to credit facilities, both expressed as categorical variables, was scrutinized. Continuous variables, such as distance to the market, annual household income, family size, and total market loss, were included to provide a comprehensive perspective on the market choice determinants.

In examining market choice, the "Primary market" served as the designated base category or reference point. This reference market enabled us to calculate average marginal effect estimates, elucidating the probabilities of fish farmers choosing secondary or tertiary markets over the primary market. The result of analysis thus centred on assessing how the explanatory variables influenced the decision to sell fish in secondary and tertiary markets concerning the primary market, revealing the nuanced dynamics at play in this choice.

To ensure the robustness and accuracy of our analytical model, the study rigorously examined the Independence of Irrelevant Alternatives (IIA) assumption by applying the Hausman test. The test's failure to reject the null hypothesis emphasized that the MNL model was appropriately specified for the data set. This underscores the suitability of the model and provides a sound basis for subsequent analyses.

Table 4. Factors controlling market choice option of fish farmers

Selling Point (Base outcome = primary market)	Coef.	St.Err.	p-value	Sig
	Secondary Market			
Age (in years) (Continuous)	-.056***	.022	.01	***
Years of schooling (Continuous)	-.108***	.038	.005	***
Access to training (Categorical)	-.669	.438	.127	
Extension contacts (Categorical)	-6.191***	.696	0	***
Transportation facilities (Categorical)	.035	.406	.932	
Distance to market (Continuous)	.017	.085	.846	
Access to credit facilities (Categorical)	1.631***	.456	0	***
Infrastructure facilities (Categorical)	.779**	.381	.041	**
Annual income of household (Continuous)	-.004*	.002	.051	*
Family size (Continuous)	.322***	.112	.004	***

Selling Point (Base outcome = primary market)	Coef.	St.Err.	p-value	Sig
	Secondary Market			
Labor availability (Categorical)	-2.092***	.587	0	***
Total market loss (Continuous)	-1.339***	.348	0	***
Constant	11.196***	2.384	0	***
	Tertiary Market			
Age (in years) (Continuous)	.042	.036	.252	
Years of schooling (Continuous)	-.06	.061	.323	
Access to training (Categorical)	-.531	.573	.354	
Extension contacts (Categorical)	-1.914***	.689	.005	***
Transportation facilities (Categorical)	-3.677***	.927	0	***
Distance to market (Continuous)	-.258**	.113	.023	**
Access to credit facilities (Categorical)	-1.961	1.214	.106	
Infrastructure facilities (Categorical)	1.59***	.586	.007	***
Annual Income of Household (Continuous)	.005	.003	.12	
Family size (Continuous)	-.226	.198	.254	
Labor availability (Categorical)	-15.518	1234.291	.99	
Total market loss (Continuous)	-2.361***	.577	0	***
Constant	14.47***	4.009	0	***

Source: Field Data, 2022

[Notes: Mean dependent variable = 0.644, SD dependent variable 0.663, Pseudo r-squared = 0.525, Chi-square = 451.051, Akaike crit. (AIC) = 460.592, Number of observations = 450, Prob> chi2 = 0.000, Bayesian crit. (BIC)= 567.432, *** p<.01, ** p<.05, * p<.1]

The results obtained from MNL model (Table 4) estimations were statistically significant in explicating the diverse determinants that shape farmers' choices among different fish markets. The chi-square ($\chi 2$) value of 451.051, significant at the 1% level, reinforced the statistical strength of the model. Furthermore, the simulated result of the coefficient of determination (r) demonstrated that the model effectively explained approximately 52.5% of the variation in market choice among fish farmers in the study areas. The rejection of the null hypothesis, based on the Wald test, pertaining to the coefficients (except the constant) being zero at the 1% level, validated the robustness and meaningfulness of the findings.

The multinomial logit regression result was illustrated on market choice options by fish farmers in the study area and in Table 5, the crucial marginal effects derived from the multinomial logit regression.

Table 5. Marginal Effect calculation using delta method

	dy/dx	Std.Err.	z	P>z
Age (in years) (Continuous)				
Primary market	0.004	0.002	1.74	0.081
Secondary market	-0.007	0.002	-3.25	0.001
Tertiary market	0.003	0.002	2.01	0.044
Years of schooling (Continuous)				
Primary market	0.011	0.004	2.74	0.006
Secondary market	-0.011	0.004	-2.79	0.005
Tertiary market	-0.001	0.003	-0.2	0.84
Access to training (Categorical)				

	dy/dx	Std.Err.	z	P>z
Primary market	0.075	0.048	1.57	0.117
Secondary market	-0.064	0.047	-1.37	0.172
Tertiary market	-0.011	0.025	-0.44	0.66
Extension contacts (Categorical)				
Primary market	0.662	0.036	18.6	0
Secondary market	-0.638	0.026	-24.11	0
Tertiary market	-0.024	0.028	-0.87	0.385
Transportation facilities (Categorical)				
Primary market	0.077	0.045	1.73	0.083
Secondary market	0.079	0.046	1.71	0.086
Tertiary market	-0.156	0.027	-5.72	0
Distance to market (Continuous)				
Primary market	0.005	0.009	0.59	0.558
Secondary market	0.007	0.009	0.83	0.408
Tertiary market	-0.012	0.005	-2.65	0.008
Access to credit facilities (Categorical)				
Primary market	-0.112	0.038	-2.97	0.003
Secondary market	0.21	0.04	5.25	0
Tertiary market	-0.098	0.023	-4.34	0
Infrastructure facilities (Categorical)				
Primary market	-0.107	0.037	-2.92	0.003
Secondary market	0.045	0.038	1.21	0.228
Tertiary market	0.062	0.029	2.16	0.031
Annual income of household (Continuous)				
Primary market	0	0	0.91	0.365
Secondary market	0	0	-2.65	0.008
Tertiary market	0	0	2.19	0.029
Family size (Continuous)				
Primary market	-0.023	0.012	-1.9	0.058
Secondary market	0.04	0.011	3.68	0
Tertiary market	-0.017	0.008	-2.06	0.039
Labor availability (Categorical)				
Primary market	0.301	0.06	5.02	0
Secondary market	-0.194	0.06	-3.23	0.001
Tertiary market	-0.107	0.011	-9.79	0
Total market loss (Continuous)				
Primary market	0.18	0.034	5.29	0
Secondary market	-0.098	0.034	-2.9	0.004
Tertiary market	-0.082	0.023	-3.63	0

[Note: *** p<.01, ** p<.05, * p<.1]

This information vividly depicts the impact of various independent variables on the choice of alternative markets relative to the primary market. The analysis shows that specific variables, including age (in years), years of schooling, extension contacts, access to credit facilities, infrastructure facilities, annual household income, family size, labor availability, and total market loss, exhibited statistical significance in influencing the decision to sell fish in secondary and tertiary markets. In contrast, the remaining variables did not demonstrate statistical significance, highlighting the differential influence of each variable on the market choice decision.

Explanation of the significant variable

The multinomial logit model employed in the study provides valuable insights into the factors influencing fish farmers' choice of markets. Notably, farmer's age emerged as a significant determinant in this decision-making process. The findings indicate a significant negative relationship between age and the likelihood of selecting the secondary market as the selling point, with a 0.7% decrease for every additional year of age, holding other variables constant. In contrast, the farmer's age increases the probability of selling fish in the primary market. This outcome is consistent with prior research (Edoge, 2014), who similarly identified age as a significant factor positively related to farmers' choice of marketing channels. However, some other research findings were diverged (Sigei et al., 2014 and Kawala et al., 2018), as they found a statistically non-significant effect of age on farmers' market choice decisions in their respective studies.

Years of schooling exhibited an intriguing negative impact on farmers' market choices. An additional year of schooling was associated with a 1.1% decrease in the probability of choosing the secondary market as the selling point compared to farmers without formal education, a statistically significant result ($p < 0.01$). This implies that educated farmers tend to prefer selling their fish in the primary market. These findings align with Tola (2014), who observed that farmers with higher levels of education favored direct sales to the farmgate market due to the perishable nature of fish and the need for prompt value-added processes. Furthermore, Malit et al. (2021) reported similar results regarding the significant influence of education levels on the choice of marketing channels.

In the context of the secondary market, having extension contacts exhibited a substantial negative marginal effect of -0.638, indicating a highly significant impact at the 1% level. The presence of extension contacts significantly decreased the probability of selecting the secondary market, underlining the critical role of extension services in shaping farmers' market choices. In the tertiary market, the effect of extension contacts was relatively smaller but still negative, with a marginal effect of -0.024. This implies that farmers with access to extension services may receive valuable guidance, knowledge, or support that encourages them to explore alternative market options or adopt different marketing strategies. However, this result diverges from some previous studies such as Tefera (2014) and Tshiunza et al. (2001), which found that direct contact with extension services increased the probability of adopting better market options.

Transportation facilities demonstrated a significant impact on market choice, with a marginal effect of -0.156 in the tertiary market, indicating a 15.6% decrease in the probability of choosing the tertiary market as the selling point compared to not having transportation facilities, while holding other variables constant. This result underscores the pivotal role of transportation infrastructure in shaping farmers' market preferences.

Furthermore, the distance to the market significantly influenced market choice. An increase in distance from the farming location resulted in a 0.012 decrease in the probability of selecting the tertiary market, holding other factors constant. This aligns with the findings of previous studies (Hoq et al., 2021; Malit et al., 2021; Kawale et al., 2018; Nyaga et al., 2016; Edoge, 2014; and Jari, 2009) all of which highlighted the significant influence of distance to the market on farmers' market choice and that of fish traders.

The availability of credit facilities had varying effects on market choice. It increased the probability of selling fish to the secondary market by 21%, indicating that farmers prefer the secondary market as they gain access to fish financing, which eases financial constraints and promotes input purchase and fish production. However, despite this access to credit, farmers in the *haor* area still preferred selling in the primary market. This preferential result is supported with prior studies (Acharjee et al., 2023 and Hoq et al., 2021) and is in line with the notion that credit access directly affects market choice options in fish marketing. The result of credit facilities in market choice is also reinforced by prior research findings (Malit et al., 2021 and Rembold et al., 2011).

Infrastructure facilities exhibited positive marginal effects of 0.045 and 0.062 in the secondary and tertiary markets, respectively. These results indicate that infrastructure facilities increase the probability of farmers selling fish in the secondary and tertiary markets by 3.8% and 6.2%, respectively while reducing the likelihood of selling in the primary market. Earlier studies also found similar positive effects of infrastructure facilities on fish farmers' market choice (Hoq et al., 2021).

Family size showed varying effects on market choice, with a positive marginal effect of 0.04 in the secondary market and a negative marginal effect of -0.017 in the tertiary market, both significant at the 1% and 5% levels, respectively. These results imply that a larger family size increases the probability of choosing the secondary market, possibly due to higher production output, while decreasing the probability of selecting the tertiary market. This aligns with some of the prior findings (Malit et al., 2021) but contrasts with the results of others (Kawala et al., 2018).

Finally, labor availability had a significant negative effect on the probability of choosing the secondary market, decreasing the likelihood by 19.4% compared to the primary market. This underscores the impact of labor availability on farmers' market choices. Total market loss had significant negative marginal effects on both the secondary and tertiary markets, indicating that an increase in total market loss decreased the probability of choosing these markets as the selling point. This suggests that farmers are responsive to market losses and tend to avoid markets where they anticipate greater losses. This result emphasizes the importance of managing market losses to promote engagement in secondary and tertiary markets.

Conclusion and Recommendations

In this study, a comprehensive analysis was conducted on the socio-demographic profile of fish farmers in three distinct regions—Netrokona, Kishoreganj, and Sunamganj—followed by an in-depth examination of the factors influencing fish farmers' market choices using a Multinomial Logit (MNL) model. Findings of this study provide valuable insights into the nuanced dynamics of the fish farming sector in the *haor* districts of Bangladesh, contributing essential knowledge for policymakers, researchers, and stakeholders.

The socio-demographic analysis revealed significant variations among regions, emphasizing the diverse challenges and opportunities within each community. Age, education, access to training and extension services, transportation facilities, credit availability, infrastructure, income, family size, labor availability, and total market loss exhibited substantial variations, underscoring the need for tailored interventions. Notably, Netrokona emerged as distinct in several aspects, presenting higher incomes and lower total market losses.

The MNL model results shed light on the intricate determinants of fish farmers' market choices. Farmer's age, education, extension contacts, access to credit, infrastructure facilities, family size, labor availability, and total market loss were identified as significant factors influencing the decision to sell fish in secondary and tertiary markets. The negative impact of age on the likelihood of choosing the secondary market, the role of education in favoring the primary market, and the significance of extension services underscored the complexity of these decisions. Based on the above noted findings, the potential recommendations are noted below:

1. Market Literacy Programs: Implement targeted programs for skill development and education to enhance fish farmers' market literacy, empowering them to make informed decisions in secondary and tertiary markets.

2. Risk Management Strategies: Develop strategies to manage market risks and enhance transportation alternatives, essential for promoting increased farmer involvement in secondary and tertiary markets, contributing to a more resilient and diversified fish supply chain.

3. Collaboration for Infrastructure Improvement: Encourage collaboration between governmental and non-governmental organizations to improve infrastructure facilities, positively impacting market choices through enhanced access to financing, better transportation options, and increased production capabilities.

4. Government Support Services: Strengthen financial assistance, awareness programs, extension services, and labor availability to expand market alternatives, fostering economic prosperity in the region.

5. Promotion of Market Diversity: Organize seminars, workshops, and market exposure trips to broaden farmers' perspectives, encouraging exploration of new markets and contributing to the overall growth of the regional fish farming sector.

In conclusion, integrating these recommendations into policy and practice can significantly contribute to the long-term development of the fish farming sector in the *haor* districts. Addressing identified challenges and leveraging opportunities will facilitate a more sustainable and prosperous future for fish farmers, benefiting both local communities and the broader economy.

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Conflict of Interest

All authors declare that they have no conflict of interest.

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