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Farmers' knowledge of using flood forecast information in fish farming: A case of rural Bangladesh

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A B S T R A C T

The effects of global climate change and extreme weather events are threatening Bangladesh's fish and aquaculture productivity. Given the negative consequences of climate change, both the national and international societies concur that mitigating the effects of climatic unpredictability and change requires the development of weather and climate services. Additionally, if forecasting data is expertly adapted to fish farmers' requirements, they may be better able to handle and adjust to climatic and climatic-induced stressors. The primary goal of the study was to determine how much fish farmers knew about using flood forecast information regarding fish farming. Three villages in the Union Islampur upazila, which is part of the Jamalpur district, were the sites of the study: Kulkandi, Chinaduli, and North-Bamna. A sample of 95 randomly chosen fish farmers (about 25% of the total population) out of 380 fish farmers provided the data. Focus groups, matrix ranking, and key informant interviews were among the qualitative and quantitative techniques used in the study's research methodology. In order to collect both quantitative and qualitative data, formal and semi-structured questionnaires were created. The majority of farmers (53.90%) had a medium level of knowledge, followed by high knowledge (31.57%), and poor knowledge (14.74%) about the use of forecast information in fish farming. Therefore, through a variety of interventions, including training, group discussions, demonstrations, and the distribution of printed materials, concerned authorities like the Department of Fisheries (DOF) should provide chances to increase the knowledge of fish farmers. Regression study revealed that farmers' knowledge regarding using forecast information in fish farming is positively impacted by their level of education, annual earnings from fish farming, organizational participation, and sources of flood forecast information. Therefore, while creating programs and making decisions, legislators, development practitioners, extension specialists, and others should consider these aspects.

Keywords: Knowledge, Flood, Forecast information, Fish farming

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Introduction

Bangladesh is regarded as one of the best places in the world to produce aquatic fish because of its abundance of water bodies, which include both coastal and inland freshwater (45,000 km^2), including rivers, ponds, beels, lakes, floodplains, etc. (Ghose, 2014; Shamsuzzaman *et al.*, 2017). Bangladesh is ranked 11th in the world for producing marine fish, 5th for aquaculture, and 3rd for inland fisheries (FAO, 2018; Sarder, 2020). About 57.10 percent of all fish are produced by aquaculture, making it a promising industry to ensure food security for the world's and Bangladesh's growing populations (Alam *et al.*, 2019; Haque *et al.*, 2019; Mondal and Bhat, 2020). Over 10% of the country's workforce is employed in fishing, aquaculture, handling, and processing, and fish, a common aquatic meal, accounts for 60% of our daily animal protein consumption. They also provide about 5% of the country's GDP (Belton and Thilsted, 2014; Bogard *et al.*, 2015; BFTI, 2016; MoF, 2020; Hossain *et al.*, 2021). However, climate change (CC), the most pressing and quickly developing worldwide environmental challenge, threatens the sustainability of aquaculture and the output of fish (Dutta *et al.*, 2021; Hossain *et al.*, 2021).

Global climate change is expected to increase climate variability and the frequency of extreme weather events, making fish producers in developing countries like Bangladesh that have the least capacity to adapt to generating brackish water especially exposed to major climate risks (Hossain *et al.*, 2021). Aquatic food production systems face a number of challenges, including high water temperatures that surpass fish species' physiological tolerance level, rapid temperature changes that result in fish mortality, and unusual or intense rainfall events that cause harvest losses. These events pose a serious threat to livelihoods, food supplies, and aquatic food production in several ways (FAO, 2018). Reports indicate that between 2003 and 2013, around 25% of the loss and damage that transpired in the agriculture, fisheries, and aquaculture sectors in developing countries can be attributed to climate-related consequences (Hossain *et al.*, 2021). Aquatic farming and food production are negatively impacted by these severe rainfalls and seasonal floods. Therefore, to lower the hazards of intense rainfall, seasonal floods, and climate-induced natural disasters, aquatic or fish farming requires adjusted/adaptive management decisions (Hossain *et* al., 2021). Both the national and international communities agree that, given the negative consequences of climate change, developing weather and climate services is essential to lessening the effects of climatic unpredictability and change (Vaughan and Dessai, 2014). According to Hossain *et al.* (2021) and World Fish (2020), fish farmers could be better equipped to handle and adjust to climatic and climatic-induced stressors if they had access to high-quality climate data and precise forecasts that were tailored to their requirements. About 194 countries agreed to modify their development through adaptation and mitigation measures in 2015 as part of the Paris Agreement for Nationally Determined Contributions (NDCs), taking into account the negative consequences of climate change (Kalikoski *et al.*, 2018; Hossain *et al.*, 2021). The NDC agreement, however, did not outline strategies that may be used to help the poor and most vulnerable cope with climate extremes, especially in the aquaculture and fisheries sectors. According to earlier research, there is a significant opportunity to mainstream and incorporate climate information services into national plans, policies, and strategies to help improve climate resilience (Hossain *et al.*, 2021). Many nations have started using climate information services for agriculture to manage climate risks and meet adaptation needs, according to other research conducted in other parts of the world (Dayamba *et al.*, 2018; Vaughan *et al.*, 2019). While many international communities are implementing climate information services for the agriculture sector, the aquaculture sector is just beginning to use forecast and climate information services (WorldFish, 2020; Hossain *et al.*, 2021).

Only when the recipients—fish farmers whose primary source of income is fishing—are prepared and ready to integrate flood forecasts and protective measures into their operations will these forecast and customized forecast information services prove to be successful (Kamal *et al.*, 2018). Flood vulnerability and its effects on fisheries resources have been the subject of numerous research conducted in Bangladesh (Islam *et al.*, 2014; Chowdhury, 2010; Barange *et al.*, 2018). Climate change adaptation in fish farming has also been the subject of certain studies (Rahman, 2010). Assessing fish farmers' knowledge of flood forecast data and the related issues with applying this data to fish farming has received little attention. Thus, the purpose of this study is to assess the knowledge of fish farmers of how to use flood forecast data and the associated problems when applying this knowledge to fish farming.

Methodology

Three villages in Chinaduli and Kulkandi union, which are part of the Islampur subdistrict of the Jamalpur district, were the purposeful sites of the study. Due to the upazila's frequent flooding and erosion, farmers are particularly susceptible to flood damage to their crops, livestock, fisheries, and other resources (Uddin *et al.*, 2023). Three villages, Kulkandi, North-bamna, and Chinaduli, were chosen as the specific location for this study because they are located near the bank of the river Jamuna, which experiences regular flooding and farmers are highly vulnerable to flood damage. For further clarity of the locale of the study, a map of Jamalpur district and Islampur Sadar Upazila (sub-district) showing study unions are presented in Figure 1.

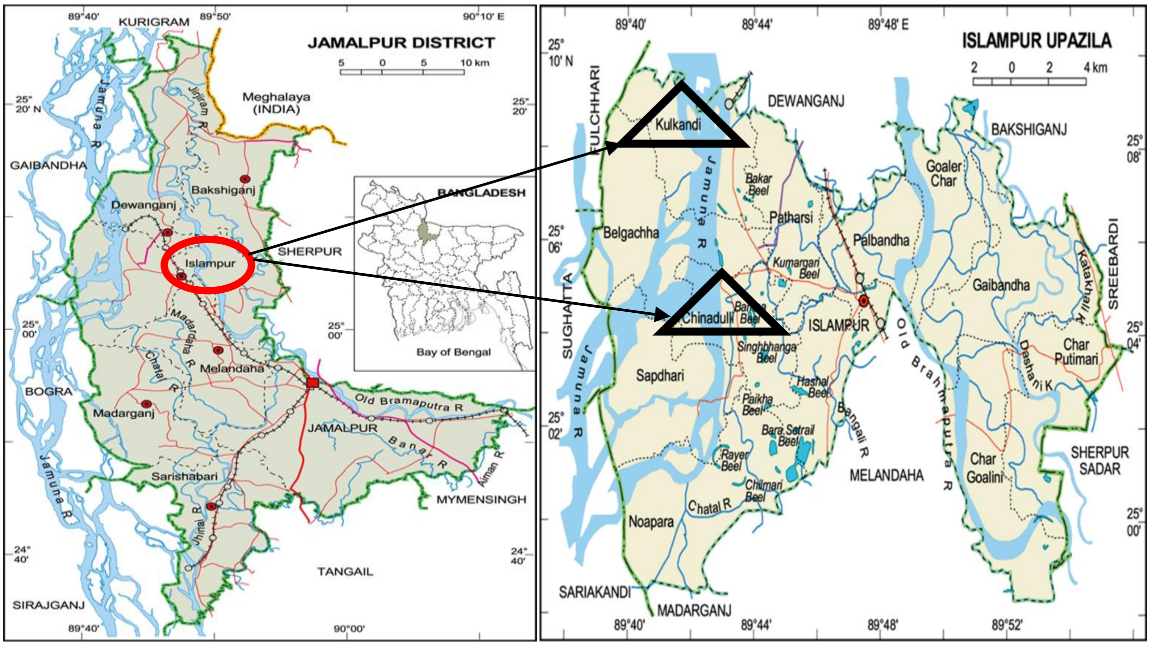

Fig. 1. Map of Jamalpur district and Islampur upazila (sub-district) showing the study areas.

The study's respondents were fish farmers in the study area who experienced flooding annually while engaged in fish farming. Instead of gathering data from the entire population, a sample was used. Out of the 380 total inhabitants, 95 people, or 25% of the population, were chosen at random from these three villages and are displayed in Table 1. To choose the sample from the population for this study, a random sampling procedure was employed.

Table 1. Distribution of sampled fish farmers in the selected study areas.

Name of the upazila (sub-district)	Name of the unions	Name of the villages	Population	Sample size
Islampur	Kulkandi	Kulkandi	188	47
	Chinaduli	Char kulkandi	192	48
Total			380	95 (25%)

Thirteen characteristics of the fish farmers were chosen as explanatory variables of the study. They are age, level of education, household size, earning members, fish farming experience, farm size, the area under fish farming, annual income from fish farming, organizational participation, training received, credit received, extension media contact and sources of forecast information. On the other hand, knowledge of fish farmers on using flood forecast information was considered as the focus variable of the study. A set of sixteen questions was used to gauge a respondent's knowledge of using flood forecast information. The fish farmers' knowledge was assessed using sixteen selected questions encompassing three broad aspects: i) forecast-related knowledge, ii) knowledge of using flood forecasts in fish cultivation, and iii) knowledge of using heavy rainfall forecasts/warnings in fish cultivation.

Consequently, the sum of a respondent's scores on each question was used to determine their overall knowledge score. Every right response resulted in a score for every question. However, a question with a partially accurate response received a partial score and a question with an incorrect answer received a '0'. A respondent's score could vary from 0 to 36, with 36 denoting the highest level of knowledge in fish farming activities.

Twelve statements were chosen to gauge the problem farmers faced when applying flood forecast information to fish farming. Farmers' problems using flood forecast information for fish farming were measured using a four-point rating system. The scores were 3, 2, 1, and 0 based on how much of a problem they faced—high, medium, low, and not at all, respectively. Shajahan *et al.* (2019) followed a similar process. The problem confrontation scores for each of the 12 statements were added to determine each respondent's overall problem-faced score. As a result, the conceivable score may range from 0 to 36, where 0 denoted no problem and 36 the most serious level of problem. The following formula will be used to calculate the problem-faced index:

$$PFI = (P_h \times 3) + (P_m \times 2) + (P_l \times 1) + (P_n \times 0)$$

Where,

P_h= Percentage of respondents with "high problem"
P_m= Percentage of respondents with "medium problem"
P_l= Percentage of respondents with "low problem"
P_n= Percentage of respondents with "not at all"

The total score obtained by 95 respondents for each problem issue might be between 0 and 285 (95×0 to 95×3), where 285 denotes the most problematic issue in each issue and 0 denotes no problems at all. The problems' problem-facing index (PFI) value was then used to rank them in order (RO). To measure the relevant variables, appropriate scales were created and put into use. Data was gathered through in-person interviews between October 17 and November 16, 2021. The gathered data was analyzed using both statistical and inferential techniques. To evaluate the data and test the hypothesis, Pearson's Product Moment Correlation Coefficient (r) was used. The association between fish farmers' knowledge and their chosen characteristics was examined in order to test the null hypothesis and produce a variety of charts and graphs. Multiple regression analysis, including both, enter and stepwise approaches, was used to determine the factors impacting fish farmers' knowledge of how to use flood forecast information. The stepwise regression technique helps quantify the individual contribution of factor variables once irrelevant variables are removed from the model (Quddus and Kropp, 2020). The equation is as follows (Eq. (1).

$$y_i = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + \epsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, y_i =knowledge of fish farmers, β_0 = constant, X_1= age, X_2= level of education, X_3 = household size, X_4 = earning member, X_5= fish farming experience, X_6= farm size, X_7= area under fish farming, X_8= annual income from fish farming, X_9= organizational participation, X_{10}= training received, X_{11}= credit received, X_{10}= extension media contact, X_{10}= sources of flood forecast information and ϵi= Error term

The data was analyzed using a computer application called SPSS (Statistical Package for Social Science).

Results and Discussion

Socio-economic and personal profile of the fish farmers

According to the data in Table 2, most respondents (57.89%) fell into the medium age group, while 22.10% were young and 20.00% were old. Adoption of technology generally has a favorable correlation with farmer experience. Because they are more open to new ideas and technology, younger and middle-aged farmers are more likely to implement new techniques and practices, according to a study (Li *et al.*, 2020; Das *et al.*, 2019). In terms of education, the majority (50.53%) are at the secondary level, whilst 27.37% of fish farmers had just primary education, 3.15% were illiterate, and 18.95% had higher education. Similar results were found in the investigation of Rahman *et al.* (2020). Additionally, Table 2 shows that 13.68% of the respondents were from small families, whereas the majorities (86.32%) were from medium-to-large families. Uddin *et al.* (2022) and Wossen *et al.* (2017) used similar classifications. The data showed that 41.06% of fish farmers had members who earned a moderate amount, 3.15% had members who earned more, and 55.79% of fish farmers had members who earned few. (Ali, 2012) also reported similar results. The average experience of the fish farmers was 9.94 years, with a standard deviation of 5.01. The majority of fish farmers (47.37%) had only been farming for up to seven years, followed by those with eight to fifteen years (34.74%) and those with more than fifteen years (17.89%). A mean of 0.935 hectares and a standard deviation of 0.541 were found for the farm size. The research showed that 54.74 percent of fish farmers had a small-sized farm, with 43.16% having a medium farm and 2.10% having a large-sized farm. The average farm size of the farmers surveyed was 0.620 hectares. According to Uddin *et al.* (2017), it was larger than the nation's average farm size of 0.6 hectares.

Table 2. Findings of the socio-economic characteristics of the fish farmers (*n*=95).

Characteristics (Measuring units)	Range		Categories	Respondents (n=95)		Mean	SD*
	Possible	Observed		Number	Percent		
Age (years)	-	20-67	Young (up to 35)	21	22.10	45.08	11.23
			Middle age (36-55)	55	57.89		
			Old (above 55)	19	20.00		
Level of education (years of schooling)	-	0-16	Illiterate (0)	3	3.15	7.63	3.49
			Primary (1-5)	26	27.37		
			Secondary (6-10)	48	50.53		
			Above secondary (>10)	18	18.95		
Household size (no. of members)	-	2-9	Small (1-4)	13	13.68	6.17	1.70
			Medium (5-6)	41	43.16		
			Large (above 6)	41	43.16		
Earning member (no. of members)		1-3	Fewer (up to 1)	53	55.79	1.47	0.562
			Moderate (2 to 3)	39	41.06		
			More (>3)	3	3.15		

Fish farming experience (years)	-	4-23	up to 7	45	47.37	9.94	5.01
			8-15	33	34.74		
			above 15	17	17.89		
Farm size (hectare)	-	0.12-3.24	Small farm (0.21- 0.99)	52	54.74	0.935	0.541
			Medium farm (1.0-2.99)	41	43.16		
			Large farm (above 3.00)	2	2.10		
Area under fish farming (hectare)	-	0.12-2.5	Marginal (0.02-0.20)	3	3.15	0.781	0.418
			Small farm (0.21-1.0)	51	53.69		
			Medium farm (1.01-3.0)	41	43.16		
Annual income from fish farming ('000' BDT)	-	180-700	Low (180-354)	30	31.57	432.42	124.94
			Medium (355-527)	41	43.16		
			High (> 528)	24	25.27		
Organizational participation (score)	0-12	0-3	No participation (0)	9	9.50	1.66	0.918
			Low (1-3)	86	90.50		
Training received (days)	-	0-3	No training (0)	5	5.26	1.75	0.825
			Up to 2 days	71	74.73		
			Above 2 days	19	20.00		
Credit received ('000' BDT)	-	0-500	No credit (0)	8	8.43	202.6	107.1
			1-165	26	27.37		
			166-330	50	52.63		
			above 330	11	11.57		
Extension media contact (score)	0-27	16-26	Low (1 to 9)	0	0.00	21.15	2.50
			Medium (10 to18)	82	86.30		
			High (above 18)	13	13.70		
Source of flood forecast information	0-33	4-26	Low (1-11)	36	37.90	15.21	6.67
			Medium (12-22)	43	45.26		
			High (above 23)	16	16.84		

**SD=Standard deviation*

Only 3% of fish farmers had marginal farming areas under fish farming, according to the data, while 53.69% ran small farms and 43.16% ran medium-sized farms which are under fish farming. The average farm size of the farmers who took part in the survey was 0.781 hectares. It was bigger than the average farm size in the country, which is 0.6 hectares (Uddin *et al.*, 2017; Uddin *et al.*, 2022). The farmers earned between 180 and 700 thousand BDT a year, with a mean of 432.42 and a standard deviation of 124.94. A total of 95 fish farmers were classified as low-income (31.57%), medium-income (43.16%), and high-income (25.27%). The largest percentage of respondents (90.50%) had limited organizational participation among fish farmers, while the remaining respondents (9.50%) had no organizational participation at all. The average duration of the farmers' training was 1.75 days, with a standard deviation of 0.825, and the range was 0 to 3 days. Of the fish farmers who were the subject of the inquiry, only 5.26% had no prior training experience, while 74.73% received training for no more than two days and 20% had training for more than two days. Averaging 202.6 and with a standard deviation of 107.11, the farmers' credit ranged from 0 to 500 thousand BDT. Fish farmers who received 166-330 thousand BDT were the largest percentage (52.63%), followed by those who received 1-165 thousand BDT (27.37%), above 330 thousand BDT (11.57%), and "no credit" for fish farming (8.43%). An average of 21.15 and a standard deviation of 2.5 were found for farmers' interactions with extension media, which varied from 16 to 26. Fish farmers who had medium exposure were the majority (86.30%), whereas 13.70% had strong media contact. Scores for flood forecast information sources varied from 4 to 26, with a standard deviation of 6.67 and an average of 15.21. Eighty-three percent of fish farmers employed low to medium sources of flood forecast information, whereas 16.84% had high sources, according to Table 2.

Knowledge of farmers on using flood forecast information towards fish farming

The study's main focus variable was the fish farmers' knowledge of how to use flood forecast information for fish farming. The fish farmers' knowledge was assessed using sixteen selected questions encompassing three broad aspects: i. forecast-related knowledge, ii. knowledge of using flood forecasts in fish cultivation, and iii. knowledge of using heavy rainfall forecasts/warnings in fish cultivation.

Table 3. Farmers' allocation according to their knowledge by using flood forecasting information for fish farming (n=95).

Category	Fish Farmer (n=95)		Mean	Standard deviation
	Number	Percent		
Poor knowledge (up to 12)	14	14.74	18.96	7.11
Moderate knowledge (12-24)	51	53.69		
High knowledge (above 24)	30	31.57		
Total	95	100		

Table 3 shows that around 53.69 percent of farmers had moderate knowledge, 14.674 percent had poor knowledge, and 31.57 percent had high levels of knowledge. The majority of respondents had a medium level of knowledge because the majority of fish farmers ran a small fish farm, had just seven years of farming experience, and were involved in a few organizations. A similar conclusion was reached by Kabir (2015), who discovered that farmers have a moderate level of knowledge regarding ICT-based farming.

Factors affecting farmers' knowledge of using flood forecast information in fish farming

The next section discusses the findings of a few statistical techniques that were employed to investigate the factors affecting fish farmers' knowledge regarding applying flood forecast information for fish farming.

Multiple linear regression analysis

Multiple linear regression analysis was used to determine the factors and their significance in predicting the main variable. Regression analysis took into account the following explanatory variables, age (X_1), level of education, (X_2), household size (X_3), earning member (X_4), fish farming experience (X_5), farm size (X_6), area under fish farming (X_7), annual income from fish farming (X_8), organizational participation (X_9), training received (X_{10}), credit received (X_{11}), extension media contact (X_{12}) and source of flood forecast information (X_{13}). Table 4 displays the findings of the regression analysis of the variables influencing fish farmers' knowledge of applying flood forecast information to fish farming. The Variance Inflation Factor (VIF), displayed in Table 4, was used to analyze the multicollinearity of the variables in the model. High tolerance levels were also present in the variables, and multicollinearity was not a problem, as demonstrated by the highest VIF score of 3.765. As per the regression analysis results presented in Table 4, the R^2 value of the multiple regressions was 0.964, and the corresponding F-value of 163.881 was also significant at the 0.001 level. Multiple regression analysis revealed that the factors that most strongly predicted the change in the fish farmers' knowledge regarding the use of flood forecast information towards fish farming were education level, source of flood forecast information, annual family income from fish farming, and organizational participation.

Table 4. Multiple linear regression analysis explaining the dependent variable.

Explanatory variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	5.301	2.130	-	2.489	0.015	-	-
Age (X_1)	-0.035	0.022	-0.054	-1.592	0.115	0.388	2.578
Level of education (X_2)	1.749	0.083	0.859	21.010	0.000	0.271	3.691
Household size (X_3)	0.131	0.164	0.029	0.800	0.426	0.339	2.950
Earning member (X_4)	-0.696	0.415	-0.055	-1.678	0.097	0.423	2.366
Fish farming experience (X_5)	0.094	0.053	0.066	1.774	0.080	0.330	3.029
Farm size (X_6)	0.674	0.853	0.051	0.790	0.432	0.108	2.270
Area under fish farming (X_7)	-0.831	1.286	-0.049	-0.646	0.520	0.080	2.535
Annual income from fish farming (X_8)	0.007	0.003	0.115	2.317	0.023	0.184	3.422
Organizational participation (X_9)	0.702	0.315	-0.090	-2.232	0.028	0.279	3.589
Training received (X_{10})	0.414	0.226	0.048	1.833	0.071	0.673	1.486
Credit received (X_{11})	-0.002	0.002	-0.029	-0.778	0.439	0.335	2.982
Extension media contact (X_{12})	-0.138	0.117	-0.049	-1.187	0.239	0.266	3.765
Sources of flood forecast information (X_{13})	0.139	0.043	0.129	3.250	0.002	0.285	3.505
N= 95, R^2 = 0.964, Adjusted R^2 = 0.958, F value= 163.881							

The results showed that the degree of education of farmers greatly enhanced their knowledge of how to use flood forecast information in fish farming; that is, if a farmer's educational attainment increases by one unit (one number), their knowledge of how to use flood forecast information in fish farming increases by 1.749 units. Education is seen to be crucial for maintaining a catfish farm, including feed management (Mbokane *et al*., 2022). The findings of Sumon (2014) and Yeasmin *et al.* (2014) were comparable. Perhaps the most evident element influencing the adoption of flood forecasting in fish farming is that farmers with higher levels of education are more accustomed to information technology. People's viewpoints are widened and their ability to solve problems creatively is stimulated by education. Therefore, compared to fish farmers with lower levels of education, those with greater levels of education are better aware of the use of flood forecast information in fish farming. According to Yeasmin *et al.* (2014), the educational attainment of the respondent encourages the exploration of innovative problem-solving techniques. According to Chowhan and Ghosh (2020), respondents' use of ICT in fish farming is influenced by their educational attainment.

Table 4 also makes it clear that the respondents' annual family income from fish farming and their level of knowledge were significantly positively correlated, meaning that if the respondents' annual family income from fish farming changes by one unit (one number), their knowledge level changes by 0.007. This means that fish farmers with a high annual family income have a better understanding of how to use flood forecast information in fish farming. This may be because fish farmers who earn more money each year might choose to invest in a variety of ICT-related media and equipment, including smartphones, televisions, and internet activities, to access flood, and forecast data via these platforms. Fish farmers who earned more money each year from fishing therefore knew more than those who made less. Rahman *et al.* (2018) found that farmers with greater incomes are more knowledgeable about using ICTs to obtain agricultural information, which is consistent with this finding. The findings also showed that farmers who participate in more organizations have a higher level of knowledge about applying flood forecast information to fish farming; a change of one unit (one number) in the organizational participation score corresponds to a change of 0.702. Results indicated that employing flood forecast information in fish farming was significantly improved by farmers' greater organizational participation. Flood forecasts and their applications in fish farming may have been somewhat familiar to farmers who took part in other organizational activities, perhaps because of their active involvement in these groups. This finding is comparable to that of Sultana *et al.* (2018), who found that farmers with higher levels of organizational participation receive the most up-to-date information about mango business and production.

The findings also showed that fish farmers who have access to more flood forecast information sources are highly educated about using that information in fish farming; a change of one unit (one number) in the sources results in a 0.139 change in knowledge. This implies that farmers are more likely to use their knowledge of flood forecast information to fish farming if they are exposed to more flood forecast sources. Similarities were also discovered by Hobday *et al.* (2016) and Okeleye *et al.* (2016).

Results of Stepwise multiple regression analysis

To find out how much each important variable contributed to the variation in fish farmers' knowledge about using flood forecast information for fish farming, a stepwise multiple regression analysis was conducted. The findings are displayed in Table 5.

Table 5. Summary of the stepwise multiple regression analysis.

Models	Multiple R	Multiple R^2	Variation explained (percent)	Significance level
Constant + X_2	0.974	0.948	94.8	0.000
Constant + X_2 + X_{13}	0.976	0.953	0.5	0.000

The stepwise regression analysis's findings are shown in Table 5. The results demonstrated that the model had two explanatory variables that were discovered through the entry approach of multiple linear regression analysis. According to the results, the first variable to be included in the model was the level of education (X_2), which also contributed the most (94.8%) to the explanation of the variation in farmers' knowledge regarding the use of flood forecast information in fish farming. The sources of flood forecast information (X_{13}), which accounted for 5% of the variation in farmers' knowledge of the use of flood forecast information for fish farming, was the second variable added to the model. Given that 50.53% of the farmers in the sample had only completed secondary school, this variable became one of the most significant determinants of their knowledge of how to use flood forecast information in fish farming. Sakib and Afrad (2014) discovered that farmers' educational attainment significantly contributed to the explanation of the dependent variable in the instance of their understanding of aquaculture operations in the Bogra region of Bangladesh. Their findings are consistent with this one.

Problems faced by the fish farmers in using flood forecast information in fish farming

The extent of problems faced by the fish farmers

Twelve specific items of problems with a four-point scoring system were used to gauge problems that fish farmers faced while using flood forecast information for fish farming. In contrast to the likely range of 0 to 36, their observed ratings on the problems they faced ranged from 13 to 35, with a mean and standard deviation of 25.59 and 4.83, respectively. When employing flood forecast information for fish farming, fish farmers encountered a variety of problems. The extent of problems that farmers encountered when utilizing flood forecast information for fish farming is depicted in Figure 2. The findings showed that 50.53% of respondents had high-level problems, 48.42% had medium-level problems, and 1.05% had low-level problems.

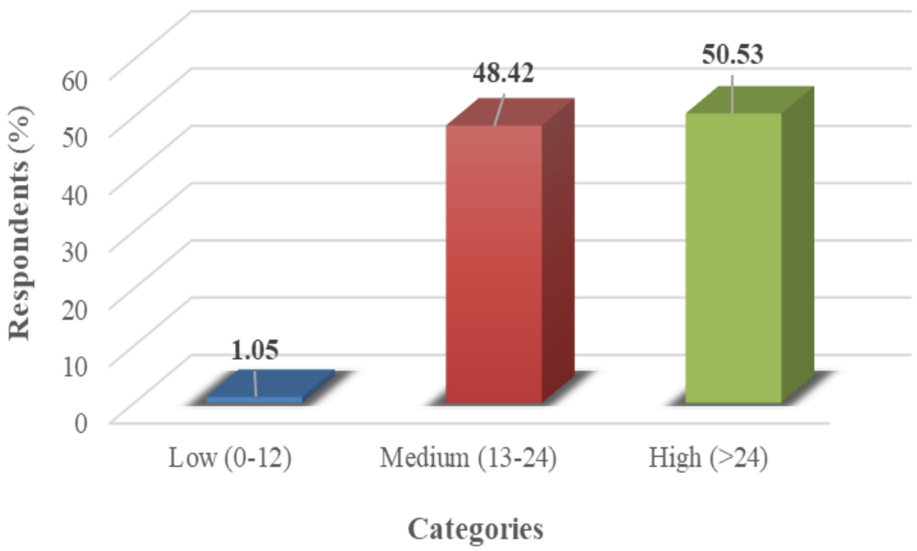

Fig. 2. Categorization of the selected fish farmers based on the extent of problems faced.

Rank order of the problems faced by the fish farmers

Table 6 shows the degree of problem that fish farmers encounter while using flood forecasting information for fish farming along with their rank order values. When employing flood forecast information, the respondent identified "pond location in low land" as the main issue (Score=242). In a study on the aquaculture of striped catfish (*Pangasianodon hypophthalmus*) in Bangladesh, Ali *et al.* (2012) found that fish farmers were concerned about some ponds' low-lying locations. As the second most significant problem, "lack of knowledge on flood forecast information" (Score=228) was listed. This is in line with research from Ghana, which discovered that applying successful adaptation techniques in fish farming is challenging due to a lack of understanding of flood forecast data (Asiedu *et al.*, 2017).

The third-ranked issue was "unable to understand the flood forecast information/content" (Score=213). One of the reasons adaptive procedures are not implemented on time is the incapacity to comprehend scientific prediction information and language. Limpo *et al.* (2022) and Sarku (2022) likewise came to similar conclusions. Using flood forecast information for fish farming also presented a number of issues, including the restricted ability to sell fish caught during floods, periods of high rainfall, and advanced floods. Lack of supplies and equipment for managing ponds before, during, and after heavy rains; lack of funds for managing ponds (raising embankments, purchasing nets) prior to floods; lack of technical expertise in using media (IT, Facebook, mobile SMS, IVR, website) to access flood forecasts; and limited availability of flood forecast-related advice for fish farming from local fisheries extension agents.

Table 6. Rank order of the problems faced by the fish farmers in using flood forecast information in fish farming.

Problem faced by the fish farmers	Level of the problem				Score	Rank
	High (3)	Medium (2)	Low(1)	Not at all (0)		
Pond location in low land	53	41	1	0	242	1
Lack of knowledge on flood forecast information	51	33	9	2	228	2
Unable to understand the flood forecast information/content	32	55	7	1	213	3
Limited scope of selling captured fish during flood	34	49	12	0	212	4
Limited scope of selling captured fish during, heavy rainfall	57	30	8	0	211	5
Limited scope of selling captured fish before flood	31	56	5	3	210	6
Lack of materials/equipment regarding pond management before heavy rainfall	27	47	20	1	195	7
Lack of materials/equipment regarding pond management before flood	27	45	23	0	194	8
Lack of materials /equipment regarding pond management during heavy rainfall	25	43	26	1	187	9
Insufficient money for Pond management (buying net, raising embankment) before flood	20	51	23	1	185	10
Lack of technical knowledge on using media (IT, Facebook, mobile SMS, IVR, website) for accessing flood forecast	32	30	25	8	181	11
Poor access of flood forecast related advice in fish farming from local level fisheries extension agent	1	47	47	0	142	12

Conclusion

Today, one of Bangladesh's main economic sectors is fishing. The demand for fish is constantly rising due to Bangladesh's expanding population. Understanding farmers' awareness of forecasting information and its use in fish farming is essential to boosting adaptive capacity for brackish water production in climate-vulnerable nations like Bangladesh. According to the study's analysis, the majority of fish farmers (53.69) knew only a little bit about applying flood forecast data for fish farming. There seems to be a lack of knowledge among fish producers. Therefore, through a variety of interventions, including training, group discussions, demonstrations, and the distribution of printed materials, concerned authorities like the Department of Fisheries (DOF) should provide chances to increase the knowledge of fish farmers. Influential elements influencing farmers' knowledge were found to include educational level, annual income from fish farming, organizational participation, and sources of information on flood forecasts. Therefore, while creating programs and making decisions, legislators, development practitioners, extension specialists, and others should consider these aspects. Furthermore, the Department of Fisheries, the Bangladesh Meteorological Department, and pertinent local-level NGOs should address the serious problems that fish farmers confront as a result of their ignorance and inability to comprehend forecast information. It is advised that these organizations offer farmers effective assistance and thorough educational programs.

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