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Research

Assessing Farmers' Knowledge of Weather Forecast Information in Crop Production: Evidence from Rural Bangladesh

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Abstract

This study assessed farmers' knowledge of forecast information in crop production, explored the relationship between knowledge and selected socioeconomic characteristics, and identified key constraints limiting its effective use. Eighty farmers from two villages were chosen at random in Raiganj upazila, Sirajganj district, Bangladesh, and interviewed using a structured questionnaire. Farmers' knowledge was measured across six cognitive levels following Bloom's taxonomy, and data analysis was done through Pearson's correlation and multiple linear regression. The results indicate that most farmers (78.8%) possessed a moderate level of knowledge, with 20.0% demonstrating a high level of understanding. Among the eleven characteristics examined, age, education, farming experience, farm size, and credit received were positively correlated with knowledge, whereas media contact with extension and sources of forecast information showed negative relationships. Regression analysis indicated that education level, annual income, and forecast information sources accounted for 35.3% of the variance in knowledge. Over half (55%) of the farmers faced high constraints in using forecast information, while 45% faced them at a moderate level. The most critical barriers included lack of awareness of forecast information sources, poor access to forecast services for crop production, and insufficient advisory support from agricultural extension agents. These findings underscore the importance of strengthening farmers' capacity to understand and apply forecast information by improving access and providing targeted training programs and extension services. Filling such these gaps can enable farmers to make well-informed decisions about their production, reduce risks associated with climatic variability, and ultimately improve agricultural productivity and rural livelihoods in Bangladesh.

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Statement of sustainability: This study offers a novel examination of how smallholder farmers acquire and apply weather forecast information in crop production, linking knowledge levels with socio-economic factors and field-level constraints. By identifying key determinants and barriers, the research provides evidence-based guidance to improve climate advisory services and farmer training programs. This contributes to SDG 2 (Zero Hunger) and SDG 13 (Climate Action) by promoting informed, resilient, and sustainable agricultural practices in climate-vulnerable rural communities.

1. Introduction

Climate change is a significant global issue that endangers agricultural output, undermines food security, and affects the livelihoods of millions worldwide (Toromade et al., 2024). Farmer in developing countries like Bangladesh are particularly susceptible to extreme climate-related hazards, including floods, sea level rise, cyclonic storm surges, riverbank erosion, saline intrusion, and drought (IPCC, 2014). These climatic events significantly jeopardize the lives, livelihoods, and food security of the country's predominantly inhabitants residing in rural areas, 64% of whom depend on farming for their sustenance (Alam et al., 2020; Uddin et al., 2020). These extreme events can lead to reduced crop yields, damage to electricity distribution systems, and disruptions in water supply services (Curtis et al., 2017; Ife-Adediran and Aboyewa, 2020; IPCC, 2021).

The development of weather and climate services has been recognized as essential by both national and international stakeholders (Nyadzi et al., 2018; Vedeld et al., 2020). Because they make it possible to predict floods and other weather-related occurrences, these services are vital to the planning and control of agricultural activities (Gbangou et al., 2020; Kundu et al., 2020; Paparrizos et al., 2020; Nyadzi et al., 2018; Rahman et al., 2020). The primary sources of hydro-climatic data in the country are the Bangladesh Meteorological Department (BMD) and the Bangladesh Water Development Board (BWDB). However, farmers seldom access or utilize these reports for informed agricultural decision-making (Roy and Alam, 2020).

Research indicates that prompt and precise weather and climate information can assist farmers in effectively responding to climatic variability and enhancing agricultural decision-making (Jones et al., 2000; Templeton et al., 2014; Bruno Soares et al., 2018). Improved forecast services have been found to support climate adaptation and boost agricultural productivity (Bruno Soares et al., 2018; Christel et al., 2018). Several studies have assessed the use of forecast information services in Bangladesh as a means to improve agricultural management choices (Kumar et al., 2021). Research has shown that growers encounter challenges in comprehending, interpreting, and effectively implementing forecast information in their farming operations (Archie et al., 2014; DAE, 2018). Despite the fact that research has been done across various regions of the globe (Bacci et al., 2020; Diouf et al., 2019; Ouedraogo et al., 2021; Tarchiani et al., 2021) and some selected areas of Bangladesh (Kumar, 2021) on dissemination, integration of forecast information with advisory services, and the utilization of weather and climate forecasts in various field managerial choices, limited attention has been given to evaluating the knowledge level of farmers regarding forecast information and their use in different crop production decisions.

Building on the above context, this study aimed to examine farmers' knowledge regarding the use of forecast information in crop production and to identify the factors that influence this knowledge. The specific objectives were:

- To evaluate the level of farmers' knowledge in utilizing forecast information for crop production;
- To identify the key factors influencing farmers' knowledge of forecast information use; and
- To determine the severity of problems in applying forecast information.

2. Methodology

2.1. Population, Sampling, and Data Collection

In the flood-prone Dhubil Union of Raiganj sub-district in Sirajganj district, the inquiry was purposefully undertaken. The study followed a two-stage sampling procedure. The union was selected purposively due to its climate vulnerability, while respondents were selected using simple random sampling from an official list of 800 farmers to ensure equal selection probability and representativeness at the study-area level. The findings are therefore generalizable to similar climate-vulnerable rural contexts rather than the entire country. From this population, a 10 percent sample was selected through simple random sampling, resulting in a sample size of 80 farmers. Using a pre-tested structured questionnaire, data was acquired from January to February 2023 through in-person interviews. Prior to finalizing the questionnaire, key informant interviews were conducted with the Upazila Agriculture Officer, two local extension workers, and two model farmers.

2.2. Measurement of Variables

2.2.1. Measurement of Level of Farmers' Knowledge of Weather Forecast Information

Farmers' knowledge of using forecast information in crop production was assessed using six cognitive levels based on Bloom's (1956) taxonomy and its revision by Anderson and Krathwohl (2001). These levels included remembering, understanding, applying, analyzing, creating, and evaluating. Open-ended questions were designed for each level, with score ranges as follows: remembering (0–8), understanding (0–4), applying (0–10), analyzing (0–7), evaluating (0–6), and creating (0–8). Thus, a respondent's total knowledge score across all aspects might be anything from 0 to 43. The participants were classified into three categories according to their total score: poor knowledge (up to 14), moderate knowledge (15-28), and fair knowledge (above 28). A similar method was followed by Kabir et al. (2022). The cut-off points were determined through proportionate division of the total possible score range (0–43) into three ordered categories to ensure conceptual clarity and comparability with previous extension research, rather than being arbitrarily assigned.

Furthermore, a Knowledge Index was computed to assess the relative knowledge levels across farmers. Separate indices were computed for each of the six cognitive levels, as the questions varied across these levels, leading to differences in the resulting scores. The Standardized Knowledge Index (SKI) was then determined using the following Eq. 1 (Farouque et al., 2025):

$$SKI = \frac{TCS}{TPS} \times 100 \tag{1}$$

Where, SKI= Standardized Knowledge Index for a component; TCS= Total computed score for a level of knowledge obtained by all the respondents; and TPS= Total possible score for that level of knowledge of all the respondents

The potential SKI for a knowledge level may vary from 0 to 100%, where 0 signifies no knowledge and 100% represents the maximum degree of information. Although the raw score ranges differed across cognitive levels, the use of the Standardized Knowledge Index (SKI) ensured comparability by converting each domain-specific score into a percentage of its respective total possible score. This normalization procedure removes scale differences and allows valid cross-domain comparison of knowledge levels.

2.2.2. Measurement of Severity of Problems in Using Weather Forecast Information

A 4-point rating system was utilized to evaluate the severity of issues experienced in utilizing forecast information at the research site. A total of nine problems were identified and participants evaluated problem as high, medium, low, or not at all, with scores of 3, 2, 1, and 0, respectively. The overall problem score for each responder might vary from 0 to 27, with 0 signifying no issues and 27 being the maximum severity level. A problem-facing score (PFS) was employed to identify the primary challenges in utilizing forecast information (Eq. 2). Other researchers (Uddin et al., 2020; Uddin et al., 2025) employed a comparable methodology.

$$PFS = (Ph \times 3) + (Pm \times 2) + (Pl \times 1) + (Pn \times 0) \quad (2)$$

Where, PFS = Problem Facing Score, Ph = Number of responses indicating severe problems; Pm = Number of responses indicating medium problems; Pl = number of responses indicating low problems; and Pn = number of responses indicating no problem.

The PFS of a certain issue may fluctuate from 0 to 240, with 0 signifying no difficulty and 240 denoting highest problem in using forecast information.

2.3. Data Analysis

A total of eleven characteristics of the farmers were considered as independent variables: age, level of education, household size, farming experience, farm size, annual income, organizational participation, training exposure, credit received, extension media contact, and Access to forecast information sources. These variables were assessed using descriptive statistical tools such as rank order, frequency, mean, and percentage (Podder et al., 2022). To identify the factors influencing farmers' knowledge, a multiple linear regression analysis was conducted. To identify the factors influencing farmers' knowledge, a multiple linear regression analysis was conducted. Annual income was rescaled (expressed in BDT 10,000 units) prior to regression analysis to improve coefficient interpretability. The statistical package for the social sciences (SPSS, version 25) was used for both descriptive and inferential statistical studies. The statistical package for the social sciences (SPSS, version 25) was used for both descriptive and inferential statistical studies.

3. Result and Discussion

3.1. Farmers' Socioeconomic Characteristics

The largest percentage of farmers (76.2%) were in the middle age group (Table 1). Over half of the respondents (51.2%) had completed only primary education. A significant portion (57.5%) came from medium-sized families, and most farmers (67.5%) had between 21 and 40 years of farming experience. Nearly half of the respondents (48.8%) operated small farms. A large percentage of farmers (53.8%) made little money each year, and most also demonstrated low levels of organizational involvement. In terms of training, a notable portion (52.6%) of respondents had attended sessions lasting between 2 and 5 days. The data further indicated that 53.7% of farmers had not received any credit. Additionally, 70% had medium-level contact with extension media, and all farmers (100.0%) had a low to medium range (16–30) of sources for obtaining forecast information.

3.2. Farmers' Knowledge of Weather Forecast Information in Crop Production

The findings indicate that the largest proportion of farmers (78.8%) demonstrated a moderate level of knowledge in weather forecast information for crop production, followed by 20% who showed a high level of knowledge (Table 2). This predominance of moderate knowledge among farmers may be attributed to their partial exposure to weather forecast information through informal sources such as television, mobile phones, and peer networks, combined with limited formal training on interpretation and application of forecast data. Although forecast access has improved, many farmers find the available information unspecific and of limited use in agricultural decision-making, and formal extension services often do not adequately bridge this gap in technical understanding and practical application, which may constrain higher levels of forecast knowledge (Kumar et al., 2020).

Table 3 showed respondents' knowledge score based on Standardized knowledge index (SKI). Farmers demonstrated a relatively high level of understanding (SKI = 66.56%) and moderate ability in remembering (SKI = 57.97%) and creating (SKI = 53.44%) information. However, their capacity to apply (SKI = 35.42%), analyze (SKI = 45.28%), and evaluate (SKI = 29.48%) weather forecast information was considerably lower.

Table 1. Socio-economic background of the farmers.

Characteristics	Scoring system	Score range	Categories	Respondent		Mean	SD*
		Observed (possible)		Number (n=80)	Percent (%)		
Age	Actual years	30-75(unknown)	Young (18- 35)	4	5.0	48.66	8.33
			Middle age (36-55)	61	76.2		
			Old (above 55)	15	18.8		
Level of education	Years of schooling	0-15(unknown)	Illiterate (0)	18	22.5	2.24	2.94
			Sign only (0.5)	16	20.5		
			Primary (1-5)	41	51.2		
			Secondary (6-10)	2	2.5		
			Above secondary (above 10)	3	3.3		
Household size	No. of members	2-12(unknown)	Small (up to 4)	22	27.5	5.74	2.19
			Medium (5-7)	46	57.5		
			Large (above 7)	12	15.0		
Farming experience	Years of farming	15-55(unknown)	Up to 20 years	18	22.5	28.45	8.59
			21-40 years	54	67.5		
			Above 40 years	8	10.0		
Farm size	Hectares	0.03-6.77(unknown)	Landless and marginal (0.02-0.2)	4	5.0	1.02	0.91
			Small (0.21-0.99)	39	48.8		
			Marginal (1.0-2.99)	35	43.7		
			Large (3 and above)	2	2.5		
Annual income	‘000	20-655(unknown)	Low (up to 150)	43	53.8	200.75	171.99
			Medium (151-300)	17	21.2		
			High (above 300)	20	25.0		
Organizational participation	Score	0-4(0-12)	Low (up to 4)	80	100	0.74	1.06
			Medium (5-8)	0	0		
			High (above 8)	0	0		
Training exposure	Days	0-5(unknown)	No training (0)	38	47.4	1.40	1.51
			Up to 2 days	21	26.3		
			3-5 days	21	26.3		
Credit received	‘000	0-70(unknown)	No received (0)	43	53.7	14.83	19.36
			Up to 25	16	20.0		
			26-50	16	20.0		
			Above 50	5	6.3		
Extension media contact	Score	7-19(0-30)	Low (up to 10)	24	30.0	11.90	2.41
			Medium (11-20)	56	70.0		
			High (above 20)	0	0		
Access to Forecast Information Sources	Score	9-28(0-45)	Low (up to 15)	30	37.5	17.46	4.34
			Medium (16-30)	50	62.5		
			High (above 30)	0	0		

Table 2. Distribution of the farmers according to their knowledge level of using forecast information in crop production (n=80).

Category	Farmer		Mean	Standard deviation
	Number	Percent		
Poor knowledge (up to 14)	1	1.2	23.46	5.25
Moderate knowledge (15-28)	63	78.8		
Fair knowledge (above 28)	16	20.0		
Total	80	100		

These findings indicate that while farmers are able to comprehend and recall weather forecasts, they face challenges in effectively using, interpreting, and critically assessing such information for practical crop management decisions. The barriers might include technical language, probabilistic terms, format of the information, timing, trust, and relevance to their local context (Antwi-Agyei et al., 2021; Chisadza et al., 2020; Ebhuoma, 2022; Mitheu et al., 2022).

Table 3. Standardized Knowledge Index (SKI) scores across six cognitive domains of forecast information use in crop production (n = 80).

Level of knowledge	The sum of possible scores for a level of knowledge	Sum of computed scores for a level of knowledge	Standardized Knowledge Indices (SKIs) (%)
Remembering	640	371	57.97
Understanding	320	213	66.56
Applying	960	340	35.42
Analyzing	720	326	45.28
Evaluating	960	283	29.48
Creating	640	342	53.44

Note: SKI values are expressed as percentages of the total possible score for each domain to ensure cross-domain comparability.

3.3. Correlation Between Socioeconomic Factors and Their Knowledge of Weather Forecast Information in Crop Production

Table 4 displays the correlation analysis's findings. Among the 11 individual characteristics of farmers, seven showed significant correlations with their knowledge. Age, level of education, farming experience, farm size, and credit received were positively associated, whereas extension media contact and sources of forecast information exhibited negative relationships.

Table 4. Summary of the correlation analysis (n=80).

Dependent variable	Selected characteristics (Independent variables)	Correlation coefficient (r) with 78 df
Farmers' knowledge of using forecast information in crop production	Age	0.282*
	Level of education	0.366**
	Household size	0.047NS
	Farming experience	0.324**
	Farm size	0.253*
	Annual income	-0.089NS
	Organizational participation	-0.087NS
	Training exposure	-0.054NS
	Credit received	0.228*
	Extension media contact	-0.372**
	Sources of getting forecast information	-0.490**

**The correlation is significant at the 0.01 probability level (table value 0.287) with 78 degrees of freedom; *The correlation is significant at the 0.05 probability level (table value 0.220) with 78 degrees of freedom; NS= Not Significant

The positive significant correlation between age and knowledge of using forecast information in crop production (r = 0.282) indicates that with age, farmers are more likely to have encountered various climate-related challenges such as floods, droughts, or storms. These experiences may have increased their appreciation for the value of forecast information and improved their ability to interpret and apply it (Cliffe et al., 2016).

The respondents' educational attainment demonstrated a strong and favorable correlation (r = 0.366). Producers possessing advanced education are probably better conscious of the significance of utilizing forecast data to lower production risks. Hu et al. (2006) found analogous findings. Higher education often enhances farmers' ability to access and utilize various sources of forecast information, such as newspapers, mobile applications, television, and internet platforms, which may not be easily navigable for less educated individuals (Mapiye et al., 2023).

The farming experience demonstrated a substantial favorable correlation (r = 0.324) with knowledge of using forecast information in crop production, as experienced farmers had more knowledge of farming activities. Experienced farmers who are repeatedly exposed to their past achievements and setbacks develop an adaptable mindset (Cocks, 2021). This allows them to recognize the value of scientific information, including weather and climate forecasts, which may not be as readily understood or trusted by less experienced farmers. In many cases, farmers with longer experience have also had more opportunities to participate in agricultural extension programs or local farmer groups, where forecast information is often disseminated and explained (Norton and Alwang, 2020).

Farmers' comprehension of forecast information had a positive correlation with their farm size. In other words**,** larger farm owners are more likely to be knowledgeable about using weather or climate forecasts (e.g., rainfall predictions, temperature outlooks, drought warnings) to guide crop-related decisions (Singh et al., 2023), like when to plant, irrigate, apply fertilizers or pesticides, or harvest. Larger farm owners typically have more financial resources, better access to extension services, and may own smartphones, radios, or internet-connected devices which make it easier to access forecast information (Chisama, 2016). Das et al. (2019) also observed similar results.

The knowledge of utilizing forecast information in crop production was significantly positively correlated with the credit received. Credit enables growers to invest in mobile phones, radios, or internet access—tools that help receive real-time weather updates and forecasts (Kamal and Bablu, 2023).

The significant negative relationship between extension media contact and farmers' knowledge of using forecast information appears theoretically unexpected, as information exposure is generally assumed to enhance learning. However, extension media contact in this study primarily captured frequency of exposure rather than the quality, localization, or interpretive depth of the content. According to communication effectiveness frameworks, knowledge improvement depends not only on information access but also on message clarity, contextual relevance, and feedback mechanisms. Furthermore, Cognitive Load Theory suggests that when information is complex, fragmented, or delivered without practical interpretation, increased exposure may overwhelm individuals' processing capacity, reducing effective learning. In the study context, forecast information disseminated through mass media may lack localized advisory support, leading to confusion rather than enhanced application-level understanding. Similar findings have been reported where information quantity alone did not improve farmers' knowledge due to technical language, probabilistic uncertainty, or inconsistent messaging (Fabregas et al., 2022; Sarku et al., 2025). These results indicate that the effectiveness of extension media depends more on content design and advisory integration than on mere contact frequency.

3.4. Factors Influencing Farmers' Knowledge of Using Forecast Information in Crop Production

The regression model was statistically significant ($F = 4.926$, $p < 0.001$), with an R^2 of 0.443 and an adjusted R^2 of 0.353 (Table 5), indicating that approximately 35.3% of the variation in farmers' knowledge of forecast information is explained by the included predictors. Multicollinearity diagnostics indicated that the VIF values for age (9.979) and farming experience (9.457) were close to the conventional threshold of 10, reflecting their conceptual overlap. However, since all VIF values remained below 10 and tolerance values exceeded 0.10, multicollinearity was not considered severe enough to compromise the stability of the regression estimates (Shrestha, 2020).Given their conceptual relatedness, future studies may consider alternative model specifications excluding one of these variables to further examine robustness. Among the predictors, level of education, annual income, and sources of forecast information were statistically significant. Education was positively and significantly associated with knowledge ($B = 0.620$, $p = 0.001$), indicating that each additional year of schooling was associated with an increase of 0.620 units in the knowledge score, holding other variables constant. This finding highlights the importance of formal education in strengthening farmers' cognitive capacity to interpret and apply forecast information. Similar findings were reported by Roy (2017) and Ghosh et al. (2020).

Annual income exhibited a statistically significant negative association with knowledge ($B = -8.553E-6$, $p = 0.036$). The very small unstandardized coefficient reflects the large monetary scale (BDT) in which income was measured. While the magnitude per unit increase is minimal, the standardized coefficient indicates a moderate relative negative effect. This suggests that relatively higher-income farmers may rely less on forecast information for operational decision-making or may adopt alternative risk-management strategies.

The number of forecast information sources also showed a significant negative influence ($B = -0.679$, $p = 0.003$), indicating that each additional source was associated with a decrease of 0.679 units in knowledge score. The number of forecast information sources was significantly negatively associated with knowledge score. The negative association indicates that receiving forecast information from a greater number of sources was statistically linked with lower knowledge scores. However, the present study did not directly assess the quality, consistency, or clarity of information across sources; therefore, the underlying mechanism cannot be conclusively determined from the dataset. Prior research suggests that the effectiveness of climate information services depends not merely on the number of information channels but on content relevance, usability, and advisory integration (Nyadzi et al., 2018; Vedeld et al., 2020; Fabregas et al., 2022). The result therefore suggests that simply increasing the number of information sources may not automatically improve farmers' understanding. Future research should examine whether differences in content quality, message coherence, or extension support explain this relationship (Kumar et al., 2021; Muema et al., 2018). Although several variables—including age, farming experience, farm size, household size, organizational participation, training exposure, credit received, and extension media contact—were not statistically significant in the multivariate model, their lack of significance does not necessarily indicate irrelevance. Some of these factors were significantly correlated with knowledge in the bivariate analysis (Table 4), suggesting that their influence may operate indirectly or overlap with stronger predictors such as education. In addition, multicollinearity between age and farming experience may have reduced their independent effects in the regression model. Therefore, these findings should be interpreted cautiously, and future studies may further explore potential mediation or interaction effects among these variables. It is important to note that the present study is based on cross-sectional data, which allows identification of statistical associations but does not permit causal inference. Therefore, the relationships observed between socioeconomic characteristics and knowledge of forecast information should be interpreted as correlational rather than causal. Longitudinal or experimental research designs would be required to establish causality more definitively.

Table 5. Summaries of the multiple linear regression analysis.

Explanatory variables	Unstandardized Co-efficient		Standardized Co-efficient	t value	Sig. B	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	21.762	5.718		3.806	0.000		
Age	-0.013	0.180	-0.021	-0.073	0.942	0.100	9.979
Level of education	0.620	0.186	0.346	3.329	0.001	0.756	1.323
Household size	0.053	0.243	0.022	0.216	0.829	0.795	1.258
Farming experience	0.162	0.170	0.264	0.951	0.345	0.106	9.457
Farm size	1.043	0.846	0.181	1.233	0.222	0.379	2.639
Annual income	-8.553E-6	0.000	-0.280	-2.137	0.036	0.476	2.103
Organizational participation	-0.483	0.474	-0.098	-1.018	0.312	0.886	1.129
Training exposure	0.277	0.345	0.080	0.803	0.425	0.825	1.212
Credit received	7.962E-6	0.000	0.029	0.304	0.762	0.878	1.139
Extension media contact	0.708	0.402	0.325	1.760	0.083	0.240	4.168
Sources of getting forecast information	-0.679	0.223	-0.562	-3.047	0.003	0.241	4.150

n=80, R square= 0.443, Adjusted R square= 0.353, F-value= 4.926

3.5 Farmers` Problems While Utilizing Weather Forecast Data

A majority (55%) reported experiencing a high level of constraints, while the remaining 45% faced a moderate level (Table 6). Significantly, none of the participants indicated a minimal level of limitations. Our results correspond with those of Guido et al. (2020), who discovered that most farmers faced difficulties in anticipating seasonal rainfall, affecting their decisions on crop diversification and the adoption of drought-tolerant cultivars. The Problems Facing Score (PFS) was calculated and is provided in Table 7.

Table 6. Farmers' extent of problems in using forecast information (n=80).

Categories (Score range)	No. of farmer	Percentage	Mean	Standard deviation
Low (up to 9)	0	0	18.65	2.38
Moderate (10-18)	36	45.0		
High (above 18)	44	55.0		

Table 7. Rank order of the problems.

Problems	The extent of the problems (n=80)				PFS	Rank order
	High (3)	Moderate (2)	Low (1)	Not at all (0)		
Lack of knowledge of different forecast information sources	46	32	0	2	202	1
Poor access to forecast information in crop production from different sources	39	34	7	0	192	2
Poor access to a forecast-related advisory from the local level of agriculture extension agent	38	30	12	0	186	3
Lack of training on accessing and using forecast information	37	29	14	0	183	4
Lack of knowledge of forecast information	28	39	13	0	175	5
Insufficient technical proficiency in utilizing media (IT, Facebook, mobile SMS, website) for obtaining prediction information	24	25	31	0	153	6
The limited scope of applying forecast information in crop production due to lack of credit	8	52	20	0	148	7
Incapable of comprehending the forecast information	12	41	27	0	145	8
Limited scope of using forecast information for flood management due to scarcity of land	9	23	37	11	110	9

The findings show that the lack of knowledge of different forecast information sources, with a PFS of 202, was the most critical problems in using forecast information. A lack of knowledge about where or how to access timely and reliable forecasts prevents farmers from effectively incorporating forecast data into agricultural decision-making. Several interrelated factors contribute to this challenge. The farmers interviewed in the research region predominantly possessed a primary level of education (Table 1). Farmers with low educational attainment are less exposed to technological platforms such as mobile apps, radio bulletins, TV updates, and internet services, which are the primary channels for forecast dissemination. Moreover, limited outreach from government or NGO extension services further restricts farmers' opportunities to become familiar with forecast sources (Norton and Alwang, 2020). Language and accessibility barriers also exacerbate the problem, as information is often shared in formats or languages that rural farmers find difficult to understand or access (Kumar et al., 2021). Consequently, many farmers in the study area remain uninformed about forecast services, reducing their ability to use such information for crop planning and risk reduction.

Poor access to forecast information in crop production from different sources, with a PFS of 192, ranked as the second major constraint (Table 7). This issue is strongly linked with the first-ranked constraint, lack of knowledge of forecast information sources. Farmers in the study area, mostly smallholders with low income (Table 1), not only lacked awareness of where to obtain forecasts but also faced infrastructural barriers such as weak mobile networks, irregular electricity supply, and limited internet services. As a result, even when forecasts were available, accessibility remained poor, reducing their usefulness for crop planning, irrigation, and pest control. Together, these two leading constraints created a reinforcing barrier that limited farmers' effective utilization of forecast services, a challenge also noted by Kumar et al. (2021).

Poor access to a forecast-related advisory from the local level of agricultural extension agents, with a PFS of 186, listed as the third most significant limitation encountered by farmers. (Table 7). While lack of knowledge of different forecast information sources ranked 1st, and poor access to forecast information in crop production from different sources ranked 2nd, the weak advisory support from extension agents highlights a further barrier in effectively using forecasts for agricultural decision-making. Agricultural extension workers are expected to serve as an essential bridge between scientific forecast providers and rural farmers. However, the findings revealed that this linkage remains weak in the study area. Farmers reported that extension workers rarely provided timely or forecast-related guidance, leaving them without professional support to interpret weather information for crop management. In many cases, extension agents are overburdened with administrative responsibilities or lack specialized training in climate information services, which limits their ability to deliver such advisories effectively (Norton and Alwang, 2020). The majority of respondents in the research region were classified within the low- and medium-knowledge categories of forecast use (Table 3), their dependence on localized advisory services is relatively high. Without the necessary guidance, forecast information accessed through mass media or informal channels often remains underutilized (Muema et al., 2018) This constraint further reinforces the knowledge gap and increases farmers' vulnerability to climate variability, as they cannot confidently translate forecast data into practical decisions such as sowing, input application, or harvest scheduling.

Lack of training on accessing and using forecast information, with a PFS of 183, ranked as the fourth most important constraint faced by farmers (Table 7). Without adequate training, many farmers are unable to navigate the available platforms or interpret the technical content of forecasts for practical decision-making in crop production. Training programs not only build farmers' skills in understanding weather data but also strengthen their confidence to apply such information in activities like crop selection, irrigation planning, and pest management. In the research area, however, nearly half of the participants reported never receiving any training (Table 1), which reflects the limited efforts of extension agencies and NGOs to build local capacity. Similar to the findings of Cliffe et al. (2016) and Norton and Alwang (2020), the lack of systematic and continuous training reduces farmers' ability to integrate forecasts into routine agricultural practices.

4. Conclusion

This study assessed farmers' knowledge of using weather forecast information in crop production within a climate-vulnerable rural context of Bangladesh. The findings indicate that most farmers possess a moderate level of knowledge, with relatively stronger performance in understanding and remembering forecast information but comparatively weaker capacity in applying, analyzing, and evaluating it for practical decision-making. These patterns suggest that while forecast exposure exists, deeper interpretive and application-oriented competencies remain limited.

Among the eleven socioeconomic characteristics examined, education, annual income, and sources of forecast information were statistically associated with variations in knowledge levels in the multivariate analysis. Education showed a positive association, whereas annual income and the number of forecast information sources were negatively associated with knowledge. These relationships highlight the complex interplay between socioeconomic capacity, information access, and effective utilization of climate services. However, given the cross-sectional nature of the study, these findings should be interpreted as associations rather than evidence of causal effects.

Farmers reported substantial constraints in utilizing forecast information, particularly limited awareness of forecast sources, inadequate access to reliable services, and insufficient advisory support from local extension agents. These structural and informational barriers may restrict the effective translation of forecast information into agricultural practice.

Overall, the study suggests the importance of strengthening communication strategies, improving the clarity and contextual relevance of forecast messages, and enhancing extension-based advisory support tailored to farmers' literacy levels and local realities. Efforts aimed at improving accessibility, interpretability, and institutional coordination may contribute to more effective use of weather forecast information in agricultural planning. Such improvements are likely to support more informed decision-making and resilience-building in climate-sensitive farming systems.

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Authors' contributions

Sharmin Akter: Conceptualization, methodology, interpretation, writing – review and supervision; Swarnasree Sarker: Investigation, literature review, formal analysis, writing – original draft; Mohammed Nasir Uddin: Methodology, review and editing, co-supervision; Solaiman Saad: Methodology, interpretation, writing – review and editing; Mohammad Maruf Hasan: Data analysis, review, editing, formatting; Saifur Rahman: Methodology, formal analysis; Md. Rayhan Sojib: Methodology, writing– review and editing. All authors read and approved the final manuscript.

Declarations

Ethics approval and consent to participate: The study was reviewed and approved by the Departmental Academic and Research Committee (DARC), Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh, Bangladesh. All participants provided informed consent voluntarily prior to data collection. Participation was entirely voluntary, and respondents were informed about the purpose of the study before interviews were conducted. No minors were included in the study. Personal data were handled with strict adherence to anonymity and confidentiality protocols.

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