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USE OF TRADITIONAL KNOWLEDGE TO FORECAST FLOOD: EVIDENCE FROM RIVERINE FLOODPLAIN IN BANGLADESH

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Abstract: Traditional knowledge (TK) on disaster provides useful forecasting information for the hazard-prone communities. However, the documentation of TK is inadequate in the context of Bangladesh, putting it at risk of extinction. The goal of the study is to evaluate the ability of the people living near the river to forecast floods using their TK. This study collected data from the people living near the river in Bangladesh in 2019 using a questionnaire survey with 377 respondents and focus group discussions. The data from the questionnaire survey was assessed using descriptive and inferential statistical tests. Data analyses were performed in SPSS version 26. Respondents' awareness of TK to forecast floods in riverine contexts was classified into categories: weather phenomena, cloud formation, rainfall patterns, river behavior, and observing plants and animals' behavior. This study revealed that 97.3% of respondents were aware of at least one cue to forecast flood hazards in their area. The findings suggested that the respondents' gender and profession significantly influenced their awareness of using TK to forecast floods by observing the behaviors of plants and animals. For the people living near the river, TK plays a crucial role as they reside in remote areas with inadequate national-level warning systems. These findings will contribute to the current discourse regarding the integration of TK in disaster management practices.

Keywords: traditional knowledge; knowledge transmission; flood; people living near the river; Bangladesh

1. Introduction

Traditional knowledge (TK) is closely associated with people's perceptions, beliefs, understandings, and skills in a community (Wisner, 2009). This knowledge is a system of experiential knowledge (Huntington, 1998), acquired through interactions between society and nature, community behaviors and institutions, and passed down from generation to generation among the community members (Kniveton et al., 2015). In disaster risk management, TK is valuable as it enables local people to forecast local disasters. However, TK is less documented, often neglected by science, and consequently in danger of being lost due to the rapid urbanization, reliance on modern technology, and generational shifts. The *Sendai Framework for Disaster Risk Reduction 2015–2030* (United Nations International Strategy for Disaster Reduction, 2015) has recognized the value of studying TK for disaster management.

The documentation of TK knowledge is inadequate. Notable earlier studies that documented TK on disaster forecasting include the tribal people of Rajasthan, India (Pareek

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& Trivedi, 2011), the Wujie Indigenous community, Taiwan (Roder et al., 2016), and the urban people of Accra, Ghana (Codjoe et al., 2014). Hiwasaki et al. (2015) documented TK of Timor-Leste, the Philippines, and Indonesia. Researchers also explored meteorological signs and animal behaviors to identify TK (Audefroy & Sánchez, 2017), and then integrated TK with modern technology to forecast disasters (Chisadza et al., 2015; Kagunyu et al., 2016; Masinde, 2014).

There has been little research on TK in Bangladesh. Much of the literature explored agriculture management (Misbahuzzaman, 2016), fisheries management (Mamun, 2010), medical science (Khan & Rashid, 2006), natural resource management (Chowdhury et al., 2009), and so on. There are examples of studies that include TK of disaster management (Mondal, 2021), riverbank erosion (Uddin & Rahman, 2013), disaster preparedness (Irfanullah & Motaleb, 2011), awareness of TK among rural women (Pervez et al., 2015), and adaptation to climate change (Anik & Khan, 2012). While previous studies on TK focused on agriculture, health, or natural resource management, little is known about its use to forecast floods in riverine contexts. Therefore, the aim of this study is to evaluate the ability of the people living near the river to forecast floods using TK.

The results of this study provide valuable data for a comprehensive disaster risk reduction program. The integration of TK in floodplain management can enhance local community resilience.

2. Traditional knowledge on hydro-meteorological hazard forecasting

Traditional knowledge is based on facts that are gained through observation and practice, (Mafongoya & Ajayi, 2017), which are encoded in narratives, language, and artistic media, including dance, music, storytelling, rituals, and crafts (Fernández-Llamazares et al., 2021; Woodward et al., 2020). The evolution of TK stems from its uniqueness within a specific culture or society (Agrawal, 1995; Warren, 1991) and is typically acquired through informal learning from family members, peers, and communities (Pervez et al., 2015). After a series of trials and errors, some of the knowledge gains merits, practices, and eventually becomes established within the community.

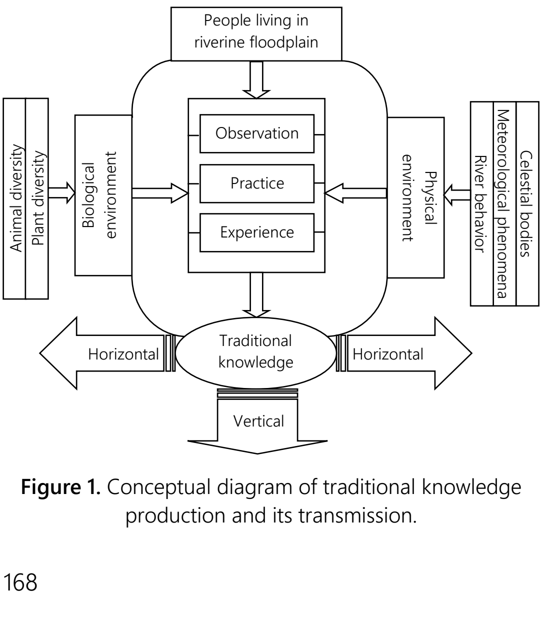

Figure 1. Conceptual diagram of traditional knowledge production and its transmission.

Local people transmitted their experiences orally through art, songs, narratives, and laws (Kaje & Thomas, 2023). There are two pathways for this knowledge transmission that take into account both spatial and temporal aspects: i) vertical transmission from one generation to another (temporal dimension), and ii) horizontal transmission from one community to another (spatial dimension; Figure 1). Elders play a vital role in the transmission of TK, thereby enabling its transfer across generations (Fernández-Llamazares et al., 2021). The current study refers to the intergenerational transmission of TK as vertical knowledge transmission. Traditional knowledge spreads uniformly within a local community, with little or no influence on other communities, and is practiced within a defined territory.

People who are living in hazard-prone regions have developed their own ways of surviving with disaster (Pareek & Trivedi, 2011). Communities use localized knowledge as a natural warning sign (McAdoo et al., 2009) and are understood by local people, which gives them favorable lead times for disaster preparation (Howell, 2003).

The people living near the river have developed TK for survival in riverine environments. The development and application of TK for survival in riverine contexts include three main aspects: inundation, bank erosion, and drought (Tran et al., 2009). People living near the river have a close relationship with the river and its bio-physical environment. By reading the behavior of the river and its surrounding environment, the local communities can perceive their risks and develop strategies to avoid disasters. The conceptual model of this study qualifies knowledge of flora and fauna behavior as biological environments and the knowledge of celestial bodies, meteorological phenomena, and river behavior as physical environments. In this study TK is defined as the cumulative knowledge developed by the long-settled people living near the river, who have a strong bond with the natural environment, local climatic patterns, and hydrological systems.

3. Methods and materials

3.1. Study area and sampling

The Teesta floodplain in Bangladesh, which spans the majority of Rangpur and its surrounding regions, was the site of this study (Figure 2). It lies between the old Himalaya piedmont plain on the west and the right bank of the Brahmaputra River on the east (Ahmed, 2014). The Teesta floodplain is located in the northwest of the country. The Teesta floodplain encompasses 10,298 km^2, or almost 14% of the nation's total arable land (Mondal & Islam, 2017).

The idea for this study arose during PhD fieldwork conducted in Bangladesh between 2018 and 2019. This initial research formed the basis for further research. In order to collect new data and continue further research, fieldwork in the Rangpur and Gaibanda river basins was carried out in June and December 2024. During these visits, informal interviews were conducted with local people to gather their insights into TK. These fresh perspectives are integrated into the findings and discussion sections of the paper, illustrating how the research has evolved over time.

To collect quantitative data, this study used a multi-stage sample approach. The people living in the Teesta floodplain were purposefully selected for this study. The Teesta River, Dudhkumar River, and Dharla River cut through the Teesta floodplain. The right bank of the Teesta River was purposely selected to conduct the survey. This river is the fourth largest transboundary river in Bangladesh, which passes through five northern districts: Nilphamari, Lalmonirhat, Kurigram, Rangpur, and Gaibandha. The river spans roughly 121 km in Bangladesh out of its total length of 414 km. Bangladesh constructed Teesta Barrage (situated 16 km downstream of the Bangladesh border) across this river.

This study encompassed three distinct locations along the Teesta River—upstream, midstream, and downstream—to gain a deeper understanding of the similarities and differences in the practices and beliefs of TKs among communities that have faced similar types of disasters. The researcher purposefully selected three districts, namely Nilphamari, Rangpur, and Gaibandha, from the upstream, midstream, and downstream regions, respectively. Three unions were selected randomly: Purbachhatnai union from Nilphamari district, Gajaghanta union from Rangpur district, and Belka union from Gaibandha district. Situated on the right bank of the Teesta River, these three unions face floods, riverbank erosion, and drought. Floods cause the most damage to the people living near the river.

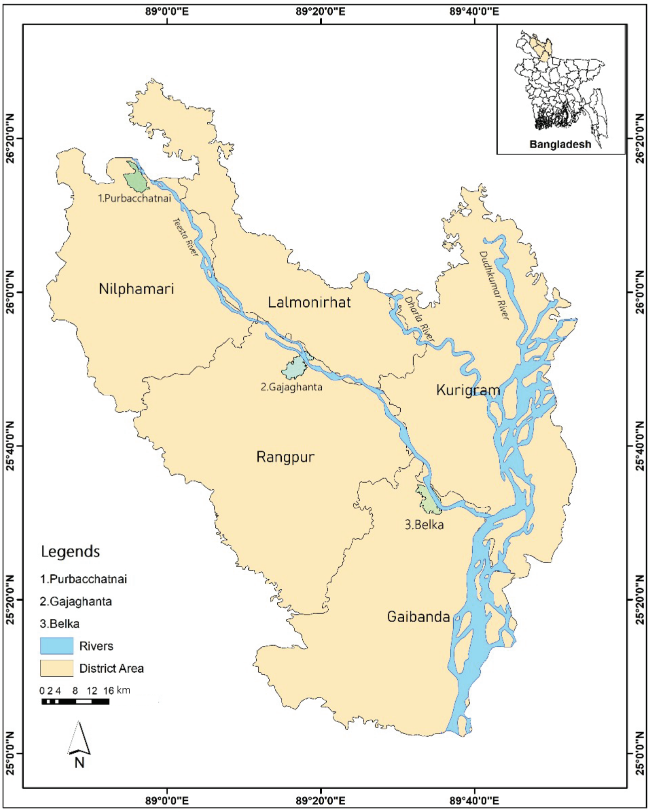

Figure 2. Study area map.

According to Bangladesh Bureau of Statistics (2013), the total number of households in the targeted unions was 3,435 in Purbachhatnai, 7,929 in Gajaghanta, and 7,608 in Belka. With a confidence level of 95% and a margin of error of 5%, the calculated sample size of this study was 377. Using the proportional allocation technique, the sample sizes for these three unions were 68 for Purbachhatnai, 158 for Gajaghanta, and 151 for Belka, respectively. The quantitative data were collected from April to May 2019 through a face-to-face survey.

A systematic random sampling technique was used to select households for the survey. This study recruited ten data collectors and trained them on the data collection procedures. Every fifth or sixth house along the river served as the starting point for a data collector. Each data collector conducted surveys with every third or fourth house on the vertical paths, aiming to interview a maximum of 10 households on each path. The survey questionnaire included questions about flood hazard characteristics, exposure to floods, vulnerability and capacity to flood, risk perception, and knowledge and awareness of flood early warning. The questionnaire had twelve sections: (1) demographic information, (2) occupation, (3) dwelling information, (4) water and sanitation, (5) means of transportation and communication, (6) health status, (7) energy sources, (8) land ownership, (9) food availability, (10) social network, (11) coping strategies during floods, and (12) household preparedness and perception on flood risk. The questionnaire was designed with both closed and open questions. There were 54 questions in the questionnaire. The author conducted a pretest of the questionnaire before the final survey. The sample unit was the household; each household had just one interviewee.

Furthermore, qualitative data were collected using three focus group discussions (FGDs) with local people in 2018 to explore in depth a variety of information, including, but not limited to, flood characteristics, flood vulnerability, and TK about flood risk reduction. The author selected respondents for FGD using a snowball sampling technique. A total of 31 respondents participated in the three FGD sessions. The ages of the FGD respondents were between 30 and 90 years.

For the quantitative data, descriptive and bivariate analyses were performed using SPSS (version 26). SPSS has been used for data analysis to assess indigenous knowledge in several studies (Kagunyu et al., 2016; Lauer & Matera, 2016; Pervez et al., 2015; Šiljeg et al., 2022). To evaluate the relationship between TK and socio-demographic variables, this study used a chi-squared test (χ^2). On the other hand, FGDs were analyzed using a content analysis approach, and the respondents' perceptions about the TK to forecast floods were used for this study. The combination of a questionnaire survey, FGDs, and informal interviews ensured a robust understanding about the use of TK to forecast floods by the people living near the river.

3.2. Respondents' profile

The sample included responses from 377 respondents from the Teesta River floodplain (Table 1). Before the interview, the respondents were informed about the study's objectives and disclosures (such as the confidentiality of their personal data, their willingness to provide information, and the length of the conversation). The sample overrepresents males (58.9%). The mean age of the respondents was 43.91 years (±14.26 years), and around 38.2% of respondents were in the age group between 36 and 50 years. Regarding education, two-thirds of the individuals did not have any formal education. A majority of respondents (96.6%) experienced inundation of their homes in the last five years. Agriculture was the primary occupation of around 41.1% of respondents, followed by housewives (37.1%). Around one-third of the respondents have been living in their current residence since birth.

Table 1. Characteristics of respondents

Variables	All sample (*N* = 377)	Purbachhatnai (*n* = 68)	Gajaghanta (*n* = 158)	Belka (*n* = 151)
Gender of respondents				
Male	222 (58.9%)	42 (61.8%)	83 (52.5%)	97 (64.2%)
Female	155 (41.1%)	26 (38.2%)	75 (47.5%)	54 (35.8%)
Age of respondents				
18 to 35 years	135 (35.8%)	19 (27.9%)	48 (30.4%)	68 (45.0%)
36 to 50 years	144 (38.2%)	22 (32.4%)	67 (42.4%)	55 (36.4%)
≥ 51 years	98 (26.0%)	27 (39.7%)	43 (27.2%)	28 (18.5%)

Table 1. Characteristics of respondents (*continued*)

Variables	All sample (*N* = 377)	Purbachhatnai (*n* = 68)	Gajaghanta (*n* = 158)	Belka (*n* = 151)
Education of respondents				
No formal education	247 (65.5%)	48 (70.6%)	97 (61.4%)	102 (67.5%)
Primary	70 (18.6%)	10 (14.7%)	34 (21.5%)	26 (17.2%)
Secondary or more	60 (15.9%)	10 (14.7%)	27 (17.1%)	23 (15.2%)
Occupation of respondents				
Agriculture	155 (41.1%)	32 (47.1%)	58 (36.7%)	65 (43.0%)
Housewife	140 (37.1%)	19 (27.9%)	69 (43.7%)	52 (34.4%)
Daily labor/ Rickshaw/ Driver	51 (13.5%)	15 (22.1%)	15 (9.5%)	21 (13.9%)
Service/ Business	26 (6.9%)	1 (1.5%)	13 (8.2%)	12 (7.9%)
Unemployed	5 (1.3%)	1 (1.5%)	3 (1.9%)	1 (0.7%)
Stayed in the current residence since birth				
Yes	122 (32.4%)	26 (38.2%)	75 (47.5%)	21 (13.9%)
No	255 (67.6%)	42 (61.8%)	83 (52.5%)	130 (86.1%)
Homestead inundation in the last five years				
Yes	364 (96.6%)	58 (85.3%)	157 (99.4%)	149 (98.7%)
No	13 (3.4%)	10 (14.7%)	1 (0.6%)	2 (1.3%)

3.3. Variables used to assess TK for flood forecasting

The conceptual framework of this study guided the selection of the indicators to assess TK for forecasting floods (Figure 1). Based on the study's objective and the conceptual framework shown in Figure 1, the current study classified the TK for forecasting floods in riverine contexts into five categories: weather phenomena, cloud formation, rainfall patterns, river behavior, and observing plants and animals' behavior. Each category posed a question to the respondents (Table 2). Positive responses to category questions were marked "yes"; negative responses were marked "no". Socio-demographic characteristics, including the respondent's gender, age, education, and profession, were obtained for bivariate analysis.

Table 2. Variables for analysis

Category	Question: How could you forecast a flood in your locality?
Weather phenomena	(a) I could forecast floods by observing weather phenomena, such as wind direction, appearance of fog, and temperature variations.
Cloud formation	(b) I could forecast floods by observing the color and shape of clouds, the appearance of rainbows and stars, and the color of the sun and moon.
Rainfall patterns	(c) I could forecast floods by observing the rainfall patterns and the seasons of rainfall.
River behavior	(d) I could forecast floods by observing the roaring, color, smell, and floating objects in the river water.
Observing plants and animals' behavior	(e) I could forecast floods by observing plants and animals' behavior using local proverbs.
	(f) I have no idea.

4. Results and discussions

4.1. Use of traditional knowledge by the respondents

This section assesses and presents the respondents' awareness of TK to forecast hydro-meteorological hazards. As shown in Figure 3, a majority of the respondents from the whole study area (97.3%) were aware of at least one TK cue to forecast flood hazards. Forty percent of the respondents knew at least two TK cues (within the category) to forecast flood disasters. Only 4% of the respondents claimed to be able to forecast floods using all the available cues. However, 2.7% of the respondents informed the researchers that they had no idea how to use TK to forecast floods. Almost 50% of respondents in Gajaghanta were aware of two TK cues for flood forecasting, representing the highest number across all areas. In contrast, a significantly higher proportion of respondents from Purbachhatnai were aware of four or more TK cues (χ^2 = 45.78, p < .001).

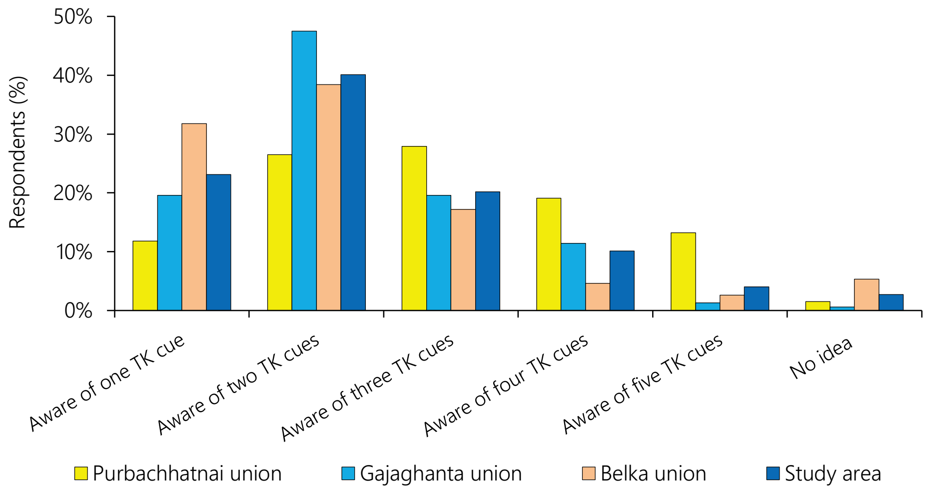

Figure 3. Awareness of TK to predict floods among the unions and in the whole study area.

The study found that 21.8% of the respondents could forecast floods by observing weather phenomena, 44.3% by observing cloud formation, 44.3% by observing rainfall patterns, 82.8% by observing river behavior, and 30.8% by observing plants and animals' behavior. This indicates that most people in the study area had a good understanding of how to forecast floods by observing the river's behavior.

4.2. Association between socio-demographic factors and awareness of TK

This section explores the associations between different socio-demographic factors and five TK cues. The Gajaghanta union had a higher percentage of respondents than the other two unions who could forecast flood hazards using the five cues provided (Table 3). In contrast, a lower proportion of respondents from Purbachhatnai were able to forecast flood hazards using given cues except for cloud formation (Table 3). The FGD participants from Purbachhatnai said, "We are living in the extreme northern zone of Bangladesh. We are unable to receive a timely early warning. Therefore, the national-level warning system does not function properly in this area. We believe that our acquired knowledge consistently aids us in forecasting rainfall, floods, and even riverbank erosion." These spatial variations suggested that the horizontal transmission of TK is not uniform because it varies according to the locality (Pervez et al., 2015; Warren & Meeh, 1980).

The association between the geographical distribution of respondents and cloud formation was found to be significant ($p < .001$; Table 3). The findings revealed that among the respondents who were able to predict floods using cloud formation, a significantly higher proportion were from Purbachhatnai Union as compared to Belka Union (Table 3). This study did not find any significant association between geographical distribution of the respondents with the weather phenomena ($p = .75$), rainfall patterns ($p = .053$), river behavior ($p = .058$), and observing plants and animals' behavior ($p = .328$).

Of the five cues, it is noteworthy that more than 80% of the respondents from the whole study area (89.7% from Purbachhatnai, 84.8% from Gajaghanta, and 77.5% from Belka) were able to forecast floods based on river behavior. This could be because people who live in riverine areas have a long-standing familiarity with the behavior of rivers (Mondal, 2021; Uddin & Rahman, 2013), including the roaring, color, smell, and floating objects in the water. The 2024 field investigation revealed similar findings, showing people still rely on river behavior to forecast floods.

On the other hand, the findings revealed a contrasting scenario regarding the forecasting of floods by examining weather phenomena and observing plants and animals' behavior, with less than one third of the respondents from the whole study area demonstrating this capability. This may be because local people are uncertain about flood forecasting using their TK due to upstream river flow control. Furthermore, the FGD participants informed the researchers that the biological diversity in their areas is diminishing, leading to the extinction of many species. As a result, people cannot solely rely on the ecological signs to forecast floods. The field investigation in 2024 corroborated these findings, as community members reported a decline in biological diversity, making it difficult to predict floods by observing the behavior of plants and animals.

Table 3. Geographical variations of the TK in the study area

Category	Purbachhatnai	Gajaghanta	Belka	Total	*p* value
Weather phenomena					
Yes	21 (25.6%)	35 (42.7%)	26 (31.7%)	82 (100.0%)	.075
No	47 (15.9%)	123 (41.7%)	125 (42.4%)	295 (100.0%)	
Cloud formation					
Yes	54 (32.3%)	65 (38.9%)	48 (28.7%)	167 (100.0%)	< .001
No	14 (6.7%)	93 (44.3%)	103 (49.0%)	210 (100.0%)	
Rainfall patterns					
Yes	36 (21.6%)	75 (44.9%)	56 (33.5%)	167 (100.0%)	.053
No	32 (15.2%)	83 (39.5%)	95 (45.2%)	210 (100.0%)	
River behavior					
Yes	61 (19.6%)	134 (42.9%)	117 (37.5%)	312 (100.0%)	.058
No	7 (10.8%)	24 (36.9%)	34 (52.3%)	65 (100.0%)	
Observing plants and animals' behavior					
Yes	26 (22.4%)	47 (40.5%)	43 (37.1%)	116 (100.0%)	.328
No	42 (16.1%)	111 (42.5%)	108 (41.4%)	261 (100.0%)	

Table 4 presents a crosstabs analysis between the gender of respondents and TK data. This study confirmed a correlation between the respondents' gender and their knowledge to forecast floods by observing plants and animals' behavior. The findings indicated that a significantly higher proportion of male respondents were familiar with the plants and animals' behavior for flood forecasting compared to female respondents ($p < .001$) (Table 4). Although the associations were not statistically significant, the proportion of female respondents' awareness about flood prediction using weather phenomena ($p = .612$), cloud formation ($p = .206$), rainfall patterns ($p = .833$), and river behavior ($p = .490$) was remarkably higher. The findings of this study are inconsistent with the previous study (Pervez et al., 2015), which reported rural women were truly unaware of environmental issues in many cases. The current study findings highlighted the invisible but active engagement of women in flood disaster risk management, including preparedness, response, rehabilitation, and recovery (Azad & Pritchard, 2023; Rakib et al., 2017).

Table 4. Relationships between gender of respondents and TK

Category	Male	Female	Total	*p* value
Weather phenomena				
Yes	46 (56.1%)	36 (43.9%)	82 (100.0%)	.612
No	176 (59.7%)	119 (40.3%)	295 (100.0%)	
Cloud formation				
Yes	92 (55.1%)	75 (44.9%)	167 (100.0%)	.206
No	130 (61.9%)	80 (38.1%)	210 (100.0%)	
Rainfall patterns				
Yes	97 (58.1%)	70 (41.9%)	167 (100.0%)	.833
No	125 (59.5%)	85 (40.5%)	210 (100.0%)	
River behavior				
Yes	181 (58.0%)	131 (42.0%)	312 (100.0%)	.490
No	41 (63.1%)	24 (36.9%)	65 (100.0%)	
Observing plants and animals' behavior				
Yes	84 (72.4%)	32 (27.6%)	116 (100.0%)	< .001
No	138 (52.9%)	123 (47.1%)	261 (100.0%)	

Traditional knowledge is the sum of observations and experiences (Orlove et al., 2010). Over three quarters of the respondents across all age groups in the whole study area possessed sufficient knowledge of river behavior to accurately forecast floods. This is because people living near the river for a long time have been acquainted with the river's behavior (Mondal, 2021; Uddin & Rahman, 2013).

Table 5 presents a crosstab analysis between the ages of respondents and TK. None of the TK cues were found to be significant with the age of the respondents. The results showed that the higher percentage of the respondents of the 35–44 years age group were able to forecast floods by observing weather phenomena ($p = .266$), cloud formation ($p = .09$), rainfall patterns ($p = .327$), river behavior ($p = .632$), and plants and animals' behavior ($p = .403$; Table 5). The unexpected findings of this study were the higher proportion of respondents of 35–44 years age groups than the seniors (65 years and above) were aware of weather phenomena (25.6% vs. 13.4%), cloud formation (28.1% vs. 13.8%), rainfall patterns (27.5% vs. 10.8%), river behavior (33.0% vs. 12.8%), and plants and animals' behavior (30.2% vs. 18.1%; Table 5). One possibility for these unexpected findings is that the elderly might be incapable of furnishing the information with proper language during the short-duration interview (Pervez et al., 2015).

Table 5. Awareness of TK to forecast flood based on age of respondents

Category	18–24 years	25–34 years	35–44 years	45–54 years	55–64 years	65 years Senior	Total	*p* value
Weather phenomena								
Yes	7 (8.5%)	14 (17.1%)	21 (25.6%)	20 (24.4%)	9 (11.0%)	11 (13.4%)	82 (100.0%)	.266
No	10 (3.4%)	60 (20.3%)	98 (33.2%)	55 (18.6%)	35 (11.9%)	37 (12.5%)	295 (100.0%)	
Cloud formation								
Yes	10 (6.0%)	32 (19.2%)	47 (28.1%)	28 (16.8%)	27 (16.2%)	23 (13.8%)	167 (100.0%)	.09
No	7 (3.3%)	42 (20.0%)	72 (34.3%)	47 (22.4%)	17 (8.1%)	25 (11.9%)	210 (100.0%)	
Rainfall patterns								
Yes	10 (6.0%)	33 (19.8%)	46 (27.5%)	37 (22.2%)	23 (13.8%)	18 (10.8%)	167 (100.0%)	.327
No	7 (3.3%)	41 (19.5%)	73 (34.8%)	38 (18.1%)	21 (10.0%)	30 (14.3%)	210 (100.0%)	
River behavior								
Yes	13 (4.2%)	57 (18.3%)	103 (33.0%)	62 (19.9%)	37 (11.9%)	40 (12.8%)	312 (100.0%)	.632
No	4 (6.2%)	17 (26.2%)	16 (24.6%)	13 (20.0%)	7 (10.8%)	8 (12.3%)	65 (100.0%)	
Observing plants and animals' behavior								
Yes	4 (3.4%)	20 (17.2%)	35 (30.2%)	24 (20.7%)	12 (10.3%)	21 (18.1%)	116 (100.0%)	.403
No	13 (5.0%)	54 (20.7%)	84 (32.2%)	51 (19.5%)	32 (12.3%)	27 (10.3%)	261 (100.0%)	

Table 6 shows association between the education of the respondents and their awareness of TK to forecast floods. The only TK that significantly correlated with respondents' education was weather phenomena (p = .016). In this study, it was discovered that compared to individuals with a secondary education or higher, those without a formal education were more likely to be able to predict when floods would occur based on weather phenomena, cloud formation, rainfall patterns, river behavior, and the behavior of plants and animals. This could be because educated people have access to mass media and technology, which allows them to learn about scientific warnings. These results are in line with those of previous research (Pervez et al., 2015) that indicated a negative correlation between education and TK awareness (Pervez et al., 2015). The strongest justification to support these findings came from the FGD participants. As the respondents informed:

> "Our forefathers taught us TK through the sharing of poems, proverbs, and jingles. But nowadays, educated adults do not want to listen to us. Everything is getting digitized. They do not believe in our inherited knowledge. Even when we try to share our knowledge with them, they do not want to hear us. They criticize us as backdated. We are frustrated by the possibility of our TK disappearing from our community upon our passing." (Summarized from the FGDs)

Table 6. Awareness of TK to forecast flood based on education of respondents

Category	No formal education	Primary school	Secondary and above	Total	*p* value
Weather phenomena					
Yes	57 (69.5%)	7 (8.5%)	18 (22.0%)	82 (100.0%)	.016
No	190 (64.4%)	63 (21.4%)	42 (14.2%)	295 (100.0%)	
Cloud formation					
Yes	111 (66.5%)	29 (17.4%)	27 (16.2%)	167 (100.0%)	.866
No	136 (64.8%)	41 (19.5%)	33 (15.7%)	210 (100.0%)	
Rainfall patterns					
Yes	104 (62.3%)	35 (21.0%)	28 (16.8%)	167 (100.0%)	.463
No	143 (68.1%)	35 (16.7%)	32 (15.2%)	210 (100.0%)	
River behavior					
Yes	201 (64.4%)	61 (19.6%)	50 (16.0%)	312 (100.0%)	.525
No	46 (70.8%)	9 (13.8%)	10 (15.4%)	65 (100.0%)	
Observing plants and animals' behavior					
Yes	75 (64.7%)	23 (19.8%)	18 (15.5%)	116 (100.0%)	.914
No	172 (65.9%)	47 (18.0%)	42 (16.1%)	261 (100.0%)	

The association between the occupation of the respondents and TK cues is shown in Table 7. The findings revealed a significant association between the occupation of respondents and observing plants and animals' behavior to forecast floods (p = .001). Compared to housewives (23.3%), a significantly higher proportion of respondents who engaged in agricultural activities (52.6%) were able to forecast flood by observing plants and animals' behavior (p = .001). Although the difference was not so high, interestingly, a higher proportion of housewives (39.0%) were aware of weather phenomena than those who engaged in agricultural activities (36.6%; p = .619). The findings revealed that among the respondents who were able to predict floods using cloud formation (42.5% vs. 41.3%), rainfall patterns (41.3% vs. 37.7%), and river behavior (41.3% vs. 37.8%), the difference between farmers and housewives was very small. The research explored the reasons behind these unexpected findings and it was found that among the 140 housewives, 79 respondents (56.4%) had been living in the community since birth. These findings suggest that TK is a matter of long experience, which the housewives learn as a way of life (Pervez et al., 2015). These findings again confirmed the role of housewives in flood disaster risk management (Azad & Pritchard, 2023; Rakib et al., 2017) and the custodians of TK (Pervez et al., 2015).

Table 7. Awareness of TK to forecast flood based on respondents' profession

Category	Agriculture	Housewife	Others[a]	Total	*p* value
Weather phenomena					
Yes	30 (36.6%)	32 (39.0%)	20 (24.4%)	82 (100.0%)	.619
No	125 (42.4%)	108 (36.6%)	62 (21.0%)	295 (100.0%)	
Cloud formation					
Yes	71 (42.5%)	69 (41.3%)	27 (16.2%)	167 (100.0%)	.054
No	84 (40.0%)	71 (33.8%)	55 (26.2%)	210 (100.0%)	
Rainfall patterns					
Yes	69 (41.3%)	63 (37.7%)	35 (21.0%)	167 (100.0%)	.943
No	86 (41.0%)	77 (36.7%)	47 (22.4%)	210 (100.0%)	
River behavior					
Yes	129 (41.3%)	118 (37.8%)	65 (20.8%)	312 (100.0%)	.621
No	26 (40.0%)	22 (33.8%)	17 (26.2%)	65 (100.0%)	
Observing plants and animals' behavior					
Yes	61 (52.6%)	27 (23.3%)	28 (24.1%)	116 (100.0%)	.001
No	94 (36.0%)	113 (43.3%)	54 (20.7%)	261 (100.0%)	

Note. [a]Others include daily labor, rickshaw puller, driver, service holder, businessman, unemployed.

The study found that Gajaghanta union had a higher percentage of respondents who could forecast flood hazards using five cues, while Purbachhatnai had a lower proportion except for cloud formation. However, the geographical distribution of the respondents did not significantly correlate with weather phenomena, rainfall patterns, river behavior, or the observation of plant and animal behavior. The study found that male respondents were more familiar with plant and animal behavior to predict floods, while farmers were more adept. Those without formal education were more aware of TK cues.

5. Conclusion

Forecasting an upcoming hazard would help the people living near the river with disaster preparedness and responses to avoid or minimize losses. This study examined the use of TK to forecast floods among the people living near the river in three unions: Purbachhatnai, Gajaghanta, and Belka of the Teesta floodplain.

The people living near the river employed weather phenomena, cloud formation, rainfall patterns, river behavior, and observing plants and animals' behavior to forecast floods. The findings suggested that male respondents were more familiar with the behavior of plants and animals to predict floods compared to females. Similarly, a significantly higher proportion of farmers were able to forecast floods by observing plants and animals' behavior as compared with housewives. Respondents with no formal education were more aware of TK cues to predict floods than those with secondary education and above. The ages of respondents were found to be insignificant with all TK cues. Interestingly, awareness of TK cues was pretty high among the housewives.

Studying and documenting TK in a natural disaster context can be beneficial for a disaster-prone country like Bangladesh, as it can serve as an alternative (Briggs, 2013). Additionally, TK is cost-effective, participatory, and easier for communities to adopt. Therefore, TK can be a "window of opportunity" because it has the side benefit of promoting context-specific local cultural practices and conservation of local biodiversity.

However, due to poor documentation and the growing reliance of younger people on technology, TK is at risk of extinction. Traditional knowledge not only helps the local people to anticipate future hazards by observing and interpreting natural signs, but also to take long-term preparedness and mitigation measures. Therefore, we should rigorously evaluate the impact of TK on natural disaster forecasting, preparedness, and rehabilitation (Thaman et al., 2002).

Many international development agencies are increasingly recognizing the importance of TK at the project level, primarily due to its cost-effectiveness (Warren, 1991). However, interventions and promotional activities by some development organizations or business groups at the project level related to agriculture, disaster management, and natural resource management are often driven by the capitalist market economy. Such a capitalist market economy may foster dependency on global markets for local communities. For example, farmers are more involved in the market economy, perhaps substituting the production of more hazard-tolerant traditional crops with cash crops. Because of the market-driven economic development approach, local communities can no longer rely on the TK that has developed over several generations. The breakdown of traditional coping mechanisms may reduce households' ability to respond to temporary shocks (Kreimer & Arnold, 2000). In addition, researchers noted that an excessive influx of foreign donations can undermine the local community's spirit of self-respect and self-reliance (Islam et al., 2013).

Traditional knowledge is learned informally from family and community members, but it is not recognized as a disaster risk management tool. Policymakers and practitioners should encourage research and documentation on TK and promote a culture to maintain and transmit it to future generations. The inclusion of TK in educational curricula will ensure the transmission of TK across the community and over the generations. This approach promotes a society that is more inclusive and equitable, meaning a fair society where everyone, regardless of their socio-economic background, has equal access to opportunities, resources, and rights toward achieving sustainable development. The government should also come forward to respect and value TK for the sustainable benefit of disaster management; otherwise, if market-driven economic development fails and the community forgets their TK, the community might have fewer options to manage the adverse consequences. If we lose this localized knowledge, it will lead to a "cultural disaster" (Thaman et al., 2002).

This study aims to assess the ability of the local communities to forecast floods using their TK, which is based on the self-reported data and may produce bias. This is a cross-sectional study, and the data were collected from the right bank of the Teesta River in Bangladesh. Therefore, we cannot generalize the findings to the entire Teesta floodplain or the northern regions. The bivariate analysis does not provide a causal relationship between two variables; further study may apply multivariate analysis to identify the potential factors that influence the ability of local communities' understanding about TK. Nevertheless, these findings will contribute to the current discourse regarding the integration of TK in disaster management practices.

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