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MORALITY BEFORE KNOWLEDGE

Climate smart disaster risk reduction: Indigenous knowledge practiced for early warning in Coastal Bangladesh

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ABSTRACT

Background: The coastal region of Bangladesh faces severe vulnerability to climate change and climate-induced natural disasters annually. Inhabitants in these areas have developed a wealth of indigenous knowledge over generations, comprising techniques to mitigate the impact of these disasters. This study, conducted in Dashmina Upazila within the Patuakhali District of the southern coastal region of Bangladesh, aimed to identify, evaluate, and scale up existing indigenous knowledge practices for early warning in Climate Smart Disaster Risk Reduction. **Methods:** Information was gathered through various methods such as direct observations, key informant interviews, group discussions, case studies, and a comprehensive literature review. There are 14 Focus Group Discussions (FGD) and communal meetings; 16 Key Informant Interviews (KII) and 5 case histories were conducted. Data were analyzed using Microsoft Excel 2010 for descriptive qualitative analysis, and a SWOT analysis was employed to assess the strengths, weaknesses, opportunities, and threats of these practices. **Findings:** The study revealed several indigenous indicators for early warning, including the observation that ants climbing into houses with stored food signify imminent heavy rainfall, excessive frog barking indicating forthcoming heavy rain, the belief that crows soar high into the sky to summon rain, a combination of heavy clouds with strong wind suggesting little or no rainfall, muddy river waters signaling potential large floods or storm surges, peculiar crowing sounds at night predicting cyclones, and the occurrence of hot winds from specific directions along with black clouds hinting at imminent norwesters. **Conclusion:** The study strongly recommends integrating this indigenous knowledge into decision-making processes for developing disaster risk reduction strategies and incorporating them into future development projects within the region. The study faces recall bias, the study has a single-district scope, and it lacks quantitative validation. **Novelty/Originality of this article:** This research is novel because it systematically documents the indigenous early-warning knowledge of coastal communities in Dashmina Upazila, Bangladesh knowledge that has rarely recorded or scientifically analyzed and invisible to outsiders. It uniquely integrates these traditional cues with modern disaster-risk-reduction perspectives, offering new insights for community-based early warning systems.

KEYWORDS: indigenous knowledge, multi-hazard early warning, cyclone, storm surge, nor'wester.

1. Introduction

Bangladesh has been acknowledged as a country facing high risks of recurring natural

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hazards, affecting an average of 10 million people annually (Biswas et al., 2015b; Saha et al., 2024; Faisal et al., 2024a; Shamsuzzoha et al., 2025). Frequent floods, cyclones, storm surges, flash floods, droughts, tornadoes, riverbank erosion, saline water intrusion, waterlogging, hot and cold waves, landslides, hailstorms, lightning, epidemics, extreme temperatures, and nor'westers significantly disrupt Bangladesh's economy and the lives and livelihoods of its population (Shantana, 2010; Biswas et al., 2015b; Mukherjee et al., 2020; Faisal et al., 2021). Due to its geographical conditions, the people of Bangladesh have long coped with natural calamities (Khan, 2000). The southern region of Bangladesh also frequently suffers from disasters like monsoon floods, cyclones, tidal surges, riverbank erosion, saline intrusion, droughts, nor'westers and extreme temperature fluctuations occurring almost every year with varying intensities (Saha et al., 2019; Mukherjee et al., 2020; Faisal et al., 2021; Faisal et al., 2024a). Over time, the people of Bangladesh have developed various coping strategies and techniques within their local economic and socio-cultural systems through innovation and adaptation (Biswas et al., 2016). Despite some remote rural communities lacking access to modern information systems, they rely on indigenous techniques to face natural disasters and predict changes in the monsoon, preparing against potential dangers (Khan, 2000).

Indigenous knowledge refers to the unique traditional knowledge existing within specific geographic areas, developed by the indigenous population (Grenier, 1998). Although not based on scientific facts, indigenous knowledge is derived from past observations and has often aligned closely with scientific realities, aiding adaptation to harsh environments in many cases (Shrestha, 2011). This knowledge is passed down through oral and behavioral traditions from one generation to the next and is used in various activities like early warning systems, agriculture, construction, natural resource management, fisheries, livestock, and healthcare. Understanding and leveraging indigenous knowledge can help identify crucial practices that can be promoted at the local level. By building upon this knowledge, communities can reduce dependencies on external aid and foster mutual trust, acceptance, common understanding, and self-confidence (Thrupp, 1989). Integrating indigenous knowledge into scientific knowledge and communication strategies can be facilitated by community-based organizations, serving as intermediaries between governmental levels and communities, ensuring messages are understandable and trusted (Mutton & Haque, 2004). Although indigenous knowledge has gained more attention in recent years and studies on it are increasing, research on indigenous early warning systems is still limited. Moreover, these traditional systems are often not connected with scientific knowledge or official early warning systems. The climate change community now recognizes the value of indigenous knowledge for early warnings, and efforts are being made to include and integrate it with scientific systems to improve disaster risk reduction, especially in rural areas (Haokip, 2022).

Unfortunately, Bangladesh is losing much of its rich heritage of indigenous knowledge on disaster management due to insufficient documentation (Khan, 2000). Among the coastal districts, Patuakhali-especially the Dashmina and Bauphal sub-districts-faces persistent threats from floods, riverbank erosion, salinity intrusion, nor'westers, tidal surges and cyclones (Biswas et al., 2015a; Iva et al., 2017; Rahim et al., 2019 Faisal et al., 2024a, 2024b). Howell (2003) noted that poor people often live in marginal, low-lying areas that are most at risk of natural disaster. They are also the least likely to hear radio warnings or understand different warning signals. Howell pointed out that uneducated people often feel disconnected from scientific warning systems, and women are even more affected because of they stay in house. In such situations, indigenous early warning systems are crucial for taking timely action. This study aims to explore, analyze, and document indigenous knowledge used for early warning in Dashmina Upazila, Patuakhali district. Additionally, it seeks to scale up valuable indigenous knowledge and practices to enhance Climate Smart Disaster Risk Reduction in Bangladesh. An indirect objective is to raise awareness about indigenous knowledge as an effective tool for reducing risks from natural disasters. By improving understanding and providing concrete examples of successful applications, this

research hopes to inspire practitioners and policymakers to integrate this 'knowledge wealth' from local communities into future disaster-related interventions.

2. Methods

2.1 Ecology of the study area

The study was conducted in Dashmina Upazila, situated in the Patuakhali District of Bangladesh (Fig. 1). Covering an area of 351.87 square kilometers, it lies between 22º02′ and 22º18′ north latitudes and 90º29′ and 90º40′ east longitudes. The upazila shares its borders with Bauphal upazila to the north, Char Fasson upazila of Bhola zila to the east, and Galachipa upazila to the south and west within the Patuakhali District (Bangladesh Bureau of Statistics, 2012). Dashmina consists of 6 unions, with notable places including Betagi-Sankipura, Bahrampur, Bansbaria, Alipur, and Rangopaldi, and its postal code is 8630.

The total population of Dashmina Upazila is 123,388, with a population density of 351 individuals per square kilometer. The upazila comprises 28,490 households, with an average household size of 4.3 people (Bangladesh Bureau of Statistics, 2012). The gender distribution shows 49% male and 51% female residents, with 93% identifying as Muslim and 7% as Hindu. The average literacy rate stands at 29.6%. The primary crops cultivated in this area include paddy, potato, pulses, chili, and watermelon, while prominent fruits grown are banana, jackfruit, and papaya (Bangladesh Bureau of Statistics, 2012).

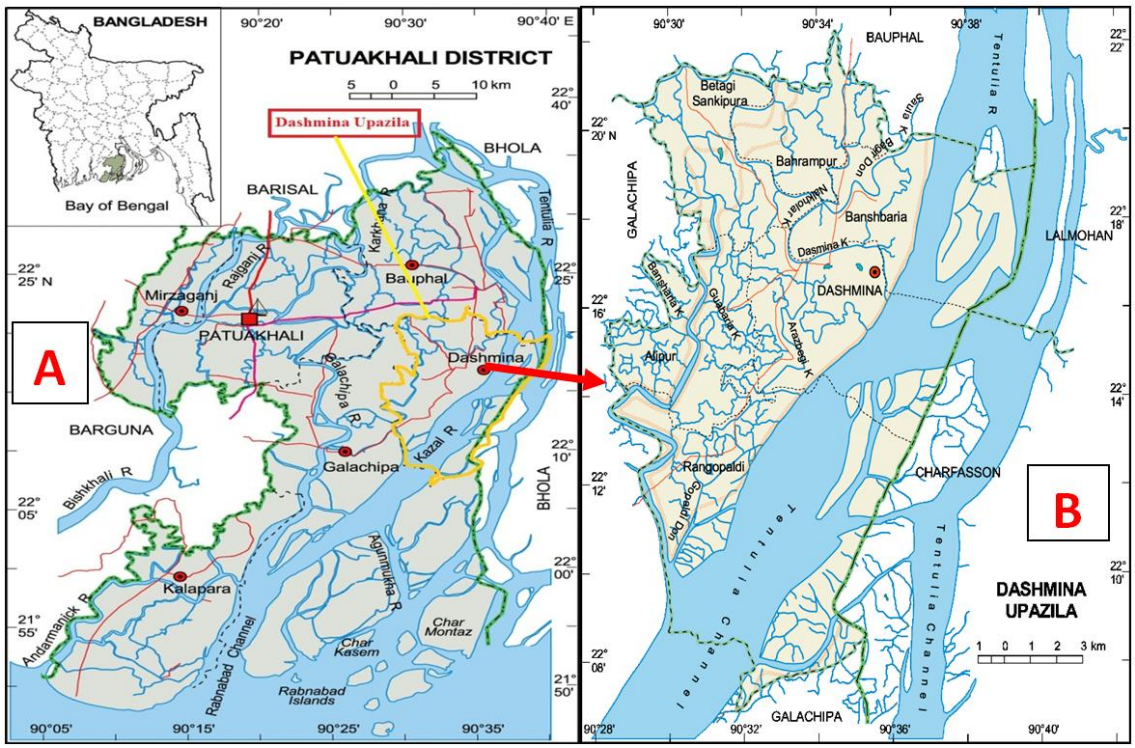

Fig. 1. Map (a) shows Patuakhali District within Bangladesh and highlights Dashmina Upazila; Map (b) provides a closer look at Dashmina Upazila
(Faisal et al., 2024b)

2.2 Data collection on indigenous knowledge

To fulfill the objectives of this research, primary data was collected from the locality through key informant interview, focus group discussion, case studies and local history. The secondary data was collected through various organizations working in indigenous knowledge for disaster risk reduction and climate change adaptation and from different scientific report, research articles, newspaper articles, journal papers etc. The qualitative nature of the information was collect. The target people for data collection was general

people, community based organization members, Union Parisad representatives, social leaders, Non-Governmental Organization (NGO) workers, school teachers, religious leader, respective officials of Upazila Parishad, individual households and older.

Focus group discussion was the main instrument used to collect in-depth descriptive data from the informants. Where a smaller group (6-10) of people is selected for their specialized knowledge or perspective on an issue (Hawkins, 2009). FGDs served as the primary method for obtaining detailed descriptive data from informants. The discussions gathered information on indigenous knowledge related to early warning sign of climatic hazards. Participants included vulnerable community members such as the poor, landless, elderly, women, and other knowledgeable individuals. Howell's (2003) study found out that older people have "knowledge of local warning indicators based on animal behaviour or natural phenomena" and largely not transmitted to younger generations and regarded as unscientific. All FGD participants were over 40 years of age. Using a pre-designed discussion guideline for facilitating the sessions, the discussions were recorded by mobile phone and write down in exercise book. There are 14 FGDs was conducted for indigenous knowledge.

Key informant interviews were conducted in order to obtain qualitative information, the interview was conducted from the persons who have sufficient experience on the relevant issues of the study objectives and people who represent the different interest groups and different perspectives of the theme being studied (Hawkins, 2009). Key informant interview was conduct from the social leader, school teacher, Union Parishad representatives, community based organization members, NGO workers, religious leader, and respective officials of Upazila Parishad. Using a pre-designed interview questioner for facilitating the session and the discussions were writing down in exercise book there are. There are 16 key informants interview was conducted for indigenous knowledge.

Case studies consist of a more in-depth study of a small number of sampled units, selected as representative of the population. It was from the part of individual life experience (Hawkins, 2009). This study explore individual life experiences and provide in-depth insights of indigenous signs and signals of various hazards as early warning. A total of five case studies were conducted for this research. The secondary data review consisted of reviewing various relevant reports, different relevant books, articles, maps, journals, research paper, website, thesis paper, baseline reports from different NGOs.

2.3 Assessment of indigenous knowledge

Assess how the communities have learnt to live with disasters (cyclone, tidal floods, riverbank erosion, water logging etc.) and their traditional early warning mechanisms. The data and the information gathered on indigenous knowledge and practices will analyze from strengths, weaknesses, opportunities and threats to disaster risk reduction point of view (South Asian Association for Regional Cooperation Disaster Management Centre, 2009). A SWOT analysis is a simple tool used to understand a situation by examining its Strengths, Weaknesses, Opportunities, and Threats (Chang & Huang, 2006; Gurl, 2017). In this study, information on indigenous knowledge and practices was analyzed using these four categories to see how they support or limit disaster risk reduction. The SWOT analysis helps create different strategies, such as using strengths to take advantage of opportunities (SO), using opportunities to reduce weaknesses (WO), using strengths to address threats (ST), and reducing both weaknesses and threats at the same time (WT) (Sevkli et al., 2012). The SWOT analysis in this research comprises two key dimensions: internal factors (strengths and weaknesses) and external factors (opportunities and threats). The process included holding a SWOT session, explaining the purpose, brainstorming to identify all four elements, deciding on actions and expected results, preparing the SWOT matrix, comparing internal and external factors to form strategies, planning how to carry out these strategies, and updating the matrix when necessary.

2.4 Improvement of indigenous knowledge and data analysis

After collecting the Indigenous Knowledge, try to scaling up or improvement these valuable indigenous knowledge and practices with the discussion of community people and own brain storming for Climate Smart Disaster Risk Reduction in Bangladesh. Data was collected from different sources (FGD, KII, case study) and develop key themes. Notes were written in a fieldwork diary to make sure no important impressions, ideas, evaluations, or thoughts were forgotten during data collection. After each day of fieldwork, a reflective journal was updated to record opinions about the day's progress, the quality of the data collected, how the research was going overall, and any possible personal biases in the process. The collected qualitative data was described in words. All data was carefully checked again, and the research findings were summarized and written in Microsoft Word 2010 to prepare the final report.

3. Results and Discussion

3.1 Indigenous knowledge for early warning

3.1.1 Predicting cyclones and storm surges based on wind direction and cloud conditions

During specific lunar phases like full moon or dark moon, if there's a persistent east to east-south wind flow accompanied by dark, black clouds over an extended period, locals perceive it as an indication of an approaching cyclone. However, when the wind direction shifts, their perception changes, and they consider it a normal phenomenon, understanding that cyclones might not manifest in such instances. In the pre, during, and post-monsoon periods, if the weather remains sunny and clear with elevated temperatures for 10 to 15 consecutive days, people anticipate the likelihood of a cyclone or storm surge. This observed pattern leads them to associate such weather conditions with the potential onset of cyclones and storm surges. During the full moon or black moon period, if there's a strong wind indicating an approaching cyclone from the south, southeast, or east, people anticipate a storm surge. However, they acknowledge that the occurrence of a storm surge is contingent upon the wind direction. If the wind changes to a west or north direction, locals do not anticipate a storm surge. In the event of a cyclone, if strong winds blow from the south or east, causing rapid water elevation and powerful waves, the sudden change in wind direction, such as from north to south or west to east, can halt the rising water levels. The geography of the study area, with the Bay of Bengal and large rivers situated in the south and east, significantly influences these observations. High tides also contribute to the potential impact of strong storm surges.

Similarly different studies have found that drizzling, gloomy skies, abnormal wind circulation, strong winds from the south or southeast, unusually hot weather followed by rain, and a muddy smell in the air are major indicators of cyclones and storm surges (Paul & Routray, 2012; Howell, 2003). Strong winds blowing from the south or southeast often signal the approach of a cyclone (Howell, 2003). Coastal people believe that winds blowing from the Agni-con (southeast) direction are more likely to cause a storm, while winds from the Ishan-con (northeast) direction may generate cyclones, though usually less severe in nature (Haque, 2018). In case of 1970 cyclone in Bangladesh, Muhammad Nurul Islam narrated: "I know there are Disaster Signals ranging from Signal No. 1 to 10, but I have no idea what they mean. I can predict any disaster coming when the sky turns gloomy, bees move around in clusters, the cattle become restless and the wind blows from the south" (Howell, 2003). The people's understanding of these weather patterns and their relationship to cyclones and storm surges reflects their indigenous knowledge, which is deeply rooted in their observations and experiences. These insights contribute to their ability to anticipate and interpret impending natural calamities in their region.

3.1.1.1 Case study 01

H. S, a fisherman residing by the Tatulia River, often fishes alongside his brother near their home. One day, while they were fishing in the river's midsection, they noticed the gradual emergence of black clouds from the west and southwest. Coupled with winds blowing in from the south, they became certain that a storm surge would likely occur that night, especially considering it was the time of the dark moon. Their residence lies beyond the embankment, situated very close to the river, merely 100 feet away, intensifying their concern for their safety. As the hours passed, the wind speed escalated, and the water waves transformed from strong to increasingly powerful. Sensing the escalating danger, they decided to abandon their fishing expedition and hurried back home. Eventually, the wind shifted directions, first from the south to the east, and later from the east to the northeast. Surprisingly, despite the persistent high wind speed, they felt a sense of relief. Their understanding of local weather patterns reassured them, as they knew that if the wind veered from the north or northeast, the risk of a severe storm surge subduing their house diminished significantly. Their anticipatory understanding was affirmed that night when, despite the relentless wind speed, the water did not inundate their home as the wind had shifted away from the north or northeast direction. This incident showcased the significance of their indigenous knowledge, enabling them to interpret subtle weather cues and take timely precautions to safeguard themselves and their property from the imminent threat of a storm surge (H. S., 55).

3.1.1.2 Case study 02

A. M. H, aged 65, primarily works as a farmer, with fishing as his secondary occupation. He is a highly experienced individual known for his keen observations of nature. He recounted the story of SIDR, a cyclone that struck the region. According to his narrative, during the midnight hours of SIDR, a powerful wind blew in from the southeast. This wind direction had persisted since the previous afternoon. As the tide rose in the middle of the night, the water surged rapidly due to the strong winds, rising to a level 12 to 15 feet higher than the normal tide. Abdul Mozid Hawlader, equipped with a torch, walked along the embankment, closely monitoring the water conditions. Upon observing the water reaching the top level of the embankment, he promptly instructed his family members and neighbors to seek refuge on the roof of their house, anticipating that the village would soon be inundated. However, within half an hour, as the water barely breached the embankment, the wind direction shifted from the south to the west and then to the east. This change in wind direction eased Abdul Mozid's concerns, and the water gradually subsided. They sought shelter back inside their house (A. M. H., 65).

3.1.2 Observed wind speed, wave size and water bubble for predicting storm

The technology employed for safe return from the river before a storm strikes involves the astute observations made by local fishermen in Dashmina Upazila. During the months of September to November and May to July, these fishermen keenly observe the wind speed and wave sizes both before embarking on a fishing trip and while they are already in the middle of the river. They have noted that if the wind intensifies and blows from the north, north-east, or north-west while black clouds gather, and if the waves grow larger, particularly coming from the south, these are indicative signs of an approaching severe storm with high-speed winds. In response to these observations, they avoid venturing out for fishing altogether. If they happen to be in the middle of the river when these signs manifest, they swiftly return to the safety of their locality.

This knowledge has been passed down through generations among the people of Dashmina Upazila, particularly among fishermen, learned inherently from their elders over many years. Additionally, they have noticed that before a significant storm surge, numerous water bubbles appear scattered across the river, serving as another warning sign of an

impending danger. The careful observation of wind patterns, cloud formations, wave behavior, and the presence of water bubbles serves as a practical and indigenous method for these local fishermen to predict and preemptively respond to potential storms, ensuring their safety while navigating the river. Research find that the roaring sound of the sea or river, along with bubbling water and gigantic waves, were the most commonly reported water-related indicators of an approaching cyclone or storm surge (Paul & Routray, 2012).

3.1.2.1 Case study 03

A. D., approximately 50 years old and hailing from Bashbaria village, has been a fisherman for about 35 years. He followed in the footsteps of his father, learning the art of fishing from him. In 2007, a day before the devastating cyclone SIDR struck, Alomgir was out fishing in the deep river. During his time on the river, he noticed some abnormal occurrences: there were unusual waves coming from the south while the wind speed seemed strangely high from the north. Moreover, he observed large water bubbles floating in the river. Recognizing these signs as indicators of an impending severe storm, he made the decision to swiftly return to his locality to seek safety. Upon reaching the locality, he heard the broadcast indicating a single-digit number nine, which might have been a signal or warning related to the approaching cyclone SIDR. Alomgir Dorji's astute observations of the irregular wave patterns, conflicting wind directions, and the presence of large water bubbles served as crucial cues prompting him to predict the imminent danger and take proactive measures to safeguard himself and return to safety before the cyclone struck. His experience and knowledge, honed over decades spent on the river, enabled him to interpret the subtle signs of nature, facilitating his timely retreat to the safety of the locality, potentially sparing him and others from the brunt of the devastating cyclone (A. D., 50).

3.1.3 Predict nor'wester by observing extreme hot weather

The residents, particularly the elders, of Dashmina Upazila have a unique belief regarding the weather. They firmly assert that if an intense heatwave persists for a week or longer, it serves as an indicator of an imminent nor'wester or cyclone. This weather forecasting technique is specifically applied during the months of May to June and October to November. Based on their observations and traditional knowledge passed down through generations, the community prepares itself for the likelihood of an extreme weather event during these periods. The prolonged and extreme heatwave triggers their preparedness, prompting them to ready themselves for the potential impact of a nor'wester or cyclone.

This indigenous understanding of weather patterns and their proactive approach in response to prolonged hot weather demonstrates their reliance on traditional wisdom to forecast and brace for potential natural calamities during specific periods of the year. By acknowledging these signs, the community aims to mitigate risks and minimize the impact of these anticipated weather phenomena on their lives and livelihoods. Research find that persistently high temperatures accompanied by strong winds are indicators of severe rainfall and windstorms (Motsumi & Nemakonde, 2025).

3.1.4 Heavy rainfall prediction by observing frog croaking (field frog, local name: Kola Bang) and crow purr indicates imminent heavy rainfall

The residents of Dashmina Upazila claim that when there is an extensive chorus of frog croaking throughout the night, it is believed to foretell an imminent heavy rainfall. According to local beliefs, this natural phenomenon of intense frog barking is considered a potential indicator or precursor of impending significant rainfall in the area. While there is no scientific evidence to support this claim, it is a prevalent folk belief deeply rooted in the community's traditional understanding of nature's signals. The correlation between frog activity and heavy rainfall, as perceived by the people of Dashmina Upazila, remains a part of their cultural folklore and traditional knowledge passed down through generations.

Several study find that the sight and sound of numerous croaking frogs indicate the likelihood of imminent heavy rainfall (Enock, 2013; Howell, 2003). Frogs making a lot of noise by their calls are the indicators of rain within a week (Khetran et al., 2012).

The local belief among people is that if a crow makes a particular purring sound, it signifies an imminent heavy rainfall. According to this belief, when a crow caws in a specific manner, locals interpret it as the crow "over-topping" or flying upwards towards the sky, thereby signaling the onset of immediate heavy rain. This notion is deeply rooted in the traditional folklore of the community, where the behavior of crows is seen as a harbinger of impending weather changes, specifically indicating the swift arrival of intense rainfall. While this belief lacks scientific evidence, it is an integral part of the cultural heritage and oral traditions passed down through generations among the inhabitants of the area.

3.1.5 Moth flying indicates heavy rainfall

Local observations suggest that when a substantial number of moths gather and start flying around light sources suddenly, it is interpreted as a sign indicating the imminent occurrence of heavy rainfall. According to this belief, the sudden increase in moth activity around artificial lights serves as a natural indicator or predictor of forthcoming heavy rain. This traditional understanding is rooted in the perception that certain insect behaviors, such as the gathering of moths around light sources, can foretell changes in weather patterns, specifically anticipating significant rainfall. While lacking empirical evidence, this belief is deeply ingrained in the cultural traditions and shared knowledge of the community, passed down through generations as an element of their folklore.

Studies have found that the appearance of black butterflies in a particular area indicates the early onset of rainfall and a good rainy season for that region. The presence of red ants suggests imminent rainfall, while the appearance of many flying ants during the rainy season is considered a sign of higher-than-usual rainfall for the year (Enock, 2013). Research also shows that heavy rains are often predicted when ants emerge from their holes in large numbers to collect food from homes and fields, a behavior associated with an impending long wet spell. The ants typically disappear less than twenty-four hours before the storm (Enock, 2013). Another study found that bees or locusts moving in clusters in the sky, an increase in the number of flies and mosquitoes, and birds flying aimlessly are indicators of approaching cyclones and storm surges (Paul & Routray, 2012). Similarly, Howell (2003) reported that bees moving in clusters, Kurpals (a type of gull) flying high and crying, birds flying without a clear direction, an increase in flies and mosquitoes, and insects attacking cattle all signal that a cyclone is approaching soon.

3.1.6 Ant climbing in house with food anticipate rain

Local observations suggest that when ants are seen carrying reserved food in their mouths and transporting it to secure locations within houses, it is interpreted as a sign foretelling impending rainfall. According to this belief, the behavior of ants safeguarding their food reserves by moving them to protected areas indoors indicates an anticipation of rain. This traditional understanding is rooted in the perception that ants, known for their industrious nature and forward-thinking behaviors, sense changes in weather conditions and take preemptive measures to protect their food supplies and habitat from potential rain-related disturbances. Despite lacking scientific evidence, this belief forms a part of the cultural folklore and shared knowledge passed down through generations within the community, highlighting the interconnectedness between nature's cues and animal behaviors in predicting weather patterns.

Enock (2013) revealed that when black and brown ants collect food inside houses in large numbers, it indicates impending rainfall and a prolonged wet spell. Similarly, when these ants bring out dead insects or damp food after a rainy period, it signals a short dry weather after which the rains will resume. Another study found that ants climbing toward the roofs of houses indicate an approaching cyclone or storm surge (Paul & Routray, 2012).

Likewise, Howell (2003) reported that ants climbing trees while carrying eggs on their backs are a sign of an approaching cyclone.

3.1.7 Heavy rain in Bhadra Ashwin (autumn) (August-September) indicates flood

Local observations in Dashmina Upazila suggest a correlation between heavy rains during the Bhadro and Ashwin months and the prediction of impending floods. The occurrence of floods in this area is predominantly linked to high tides and the inability of the rivers to adequately discharge excessive rainfall. When heavy rains coincide with the Bhadro and Ashwin months, it often leads to a significant increase in river levels. If the rivers become overloaded with water and are unable to efficiently drain the surplus rainfall, flooding becomes a looming concern for the locality.

Dashmina Upazila experiences flood durations typically lasting between 3 to 5 days due to the presence of numerous canals that aid in draining the excess rainwater from the area. These canals play a crucial role in facilitating drainage and mitigating the impact of floods by providing an outlet for the accumulated water. The community has recognized the significance of these canals as an essential part of their flood management strategy, allowing for better water dispersal and reducing the duration and severity of flooding events. The understanding of flood occurrence in Dashmina Upazila involves a complex interplay of weather patterns, river levels, high tides, and the local drainage infrastructure. These observations and insights have been accumulated over time, forming an integral part of the community's knowledge and practices in managing and adapting to the recurrent flood challenges in the region.

3.1.8 Heavy formation of cloud in the south and cloud moving south to north indicates rain

According to local observations, the formation of dark, heavy black clouds in the southern sky, gradually moving from south to north, is often interpreted as a precursor to imminent heavy rainfall. This weather pattern, observed by people in the area, serves as a traditional indicator signaling the likelihood of intense rain. The visual cues of these dark clouds progressing in a northward direction suggest an impending weather system that may bring substantial precipitation to the region. This natural phenomenon, where the movement and appearance of the clouds in a particular direction are associated with forthcoming rain, is a part of the community's traditional understanding of weather forecasting. Despite the lack of scientific evidence supporting this belief, it holds significance within the local folklore and cultural heritage, shaping the way inhabitants anticipate and interpret changes in weather patterns. Such observations of cloud movements and formations have been passed down through generations and play a role in the community's weather-related decision-making processes.

The appearance and movement of dark, dense clouds often signal imminent rainfall, likely to occur within a few hours or days. However, exceptionally dark clouds are a cause for concern, as they indicate the possibility of an approaching hailstorm (Motsumi & Nemakonde, 2025). A westward wind is considered a warning sign, often indicating that heavy rainfall is approaching and may bring hazardous conditions (Motsumi & Nemakonde, 2025).

3.1.9 Heavy cloud with strong wind indicates low rainfall

The local proverb "Joto gorje toto borse na" reflects a common belief among the people that when heavy clouds gather accompanied by lightning, and strong winds, there will be minimal rainfall. According to this belief, the occurrence of intense weather phenomena, such as lightning, thunder, and strong winds, disrupts the likelihood of substantial rain. The proverb implies that despite the ominous appearance of heavy clouds, the combination of these elemental forces prevents or hinders significant precipitation. The reasoning behind this belief is attributed to the belief that the forceful winds accompanying the stormy

conditions disperse or push away the gathered clouds, preventing them from releasing substantial rain over the area.

The perception is that the wind's movement disrupts the cloud formations, causing them to dissipate or relocate to other regions, thereby reducing the chances of significant rainfall in the specific area where these weather events are observed. While this belief is deeply ingrained in local folklore and traditional knowledge, it lacks scientific validation. Nonetheless, it serves as a part of the community's cultural heritage, influencing their interpretations of weather patterns and aiding in their predictions regarding rainfall based on observed meteorological phenomena. Research find that the occurrence of strong winds is a sign of poor rainfall (Barry & Chorley, 2009). Heavy and stormy winds blowing from the direction where rain is forming suggest that the rain will disperse (Motsumi & Nemakonde, 2025).

3.1.9.1 Case study 04

P. B., a 50-year-old resident of Dhondonia village in the Bashbaria union, has spent her entire life in this locality. During a focus group discussion conducted in her yard, the sky was heavily clouded with lightning, thunder, and strong winds. Despite the ominous weather, when the heavy rain commenced, Parvenu Begum calmly remarked, "joto gorje toto borse na," implying her belief that when there is an abundance of lightning and thunder, with strong wind it indicates minimal rainfall. She further explained that if accompanied by wind, the clouds would likely be dispersed, resulting in very little rainfall. As the discussion progressed, the participants witnessed the tremors of heavy rain, yet Parvenu Begum's insight regarding the weather conditions remained firm. Following some time, the observation was validated when the clouds gradually began to move away. Within an hour, the weather reverted to normalcy, with only a minimal amount of rain having fallen. Parvenu Begum's understanding, rooted in local beliefs and traditional knowledge, emphasized the correlation between specific meteorological events and their implications for rainfall. Her assessment of the weather conditions, despite the initial intensity of the storm, ultimately proved accurate as the clouds dispersed, resulting in limited rainfall and a return to typical weather patterns. This instance highlights the valuable insights derived from the community's indigenous wisdom and their ability to interpret and predict weather patterns based on their observations and cultural understanding (P. B., 50).

3.1.10 River water color turning muddy indicates large floods or storm surges

The local community has developed a predictive understanding based on their observations of river water conditions. They believe that if the river's water becomes unusually muddy, surpassing its normal turbidity levels, it could signal an impending natural calamity. This observation stems from their collective experience, wherein they have noticed instances of excessive muddiness in the river water. According to their traditional knowledge, an unexpected increase in turbidity, marked by excess mud or sediment in the river, often precedes significant natural events such as large floods or storm surges. This observation serves as a key indicator prompting them to anticipate the imminent occurrence of such calamities. Their ability to discern changes in the river's water clarity and connect it to potential weather-related disasters highlights their reliance on local environmental cues and experiences. This indigenous knowledge, though lacking scientific validation, plays a crucial role in their readiness and preparedness for possible natural disasters, allowing them to take precautionary measures in advance of such events.

Study find that abnormally warm river water, dark or smoky or cloudy color of water, and a sudden rise in water levels are indicators of an approaching cyclone or storm surge (Paul & Routray, 2012). In the case of the 1970 cyclone, the natural disaster occurred at the middle of the night, and some local indicators such as weather and sea or river patterns would not be visible few hours beforehand (Haokip, 2022).

3.1.11 Warm wind blowing with black cloud indicates nor'wester

The residents of Dashmina Upazila have noted a recurring weather pattern during the months of Baishak to Jhoistho. They have observed instances when a mild day is interrupted by the occurrence of hot winds blowing from the west, north west, or north side. Concurrently, they notice the formation of dark, black clouds in the western sky. Based on their extensive lifelong experiences, these particular weather conditions serve as a significant indicator for them. Their accumulated knowledge suggests that when these specific atmospheric elements align-a combination of hot winds from the west, North West, or north direction, along with the presence of ominous black clouds in the western sky-it is a reliable signal that a weather phenomenon known locally as "nor'wester" is imminent. This understanding is deeply ingrained in their cultural and experiential learning.

The term "nor'wester" typically refers to a severe thunderstorm or squall line that moves across the region, often accompanied by heavy rain, thunder, lightning, and strong winds. The residents' ability to recognize the precursor elements, such as the hot winds and the formation of black clouds in the west, helps them anticipate the impending arrival of these intense weather events. Their reliance on these specific atmospheric cues derived from their long-standing observations and experiences aids in their preparedness for potential weather disturbances, allowing them to take necessary precautions in advance of the approaching nor'wester. This traditional knowledge forms a crucial part of their ability to adapt and respond to the varying weather patterns in their region. Studies find that the unusually hot and humid weather is an indicator of an approaching cyclone (Howell, 2003). Clouds shaped like an elephant's trunk are considered a sign of an impending tidal surge (Hassan, 2000).

3.1.12 Crows crowing in the night indicates cyclone

The residents of Dashmina Upazila have a distinct observation regarding the behavior of crows, particularly their vocalizations during specific times of the day. Typically, crows are known to crow in the evening upon returning to their nests and during the early morning hours when they depart. However, the locals have noticed that crows rarely vocalize during the night. According to their observations and beliefs, if crows are heard crowing in the night with unusual or atypical sounds, it is considered an unusual occurrence and holds significant meaning for them. They interpret this behavior as a potential indication or omen suggesting the imminent arrival of a cyclone. The abnormal crowing of these birds during nighttime, a departure from their usual behavioral pattern, is regarded as a precursor to an upcoming cyclonic weather system. This traditional understanding, although lacking scientific substantiation, is deeply embedded in the local folklore and cultural beliefs of the community. Their ability to associate this unusual behavior of crows with the possibility of a cyclone's approach aids the residents in their preparedness for potential natural disasters. This indigenous knowledge, passed down through generations, serves as a valuable early warning sign for them to take necessary precautions and brace themselves for the incoming cyclonic weather event.

Howell (2003) revealed that crows or cockerels calling or flying at night indicate an impending cyclone. Khetran et al. (2012) explain that before the onset of a storm, animals can sense it and begin making distinctive sounds. In the case of the 1970 cyclone, Muhammad Abdul Ali Majhi said: "We take notice of continuous crying of the dogs, increase of flies and mosquitoes, movement of ants, crying of kurpals, hot and humid weather and so on. These signs occur about 5-7 days earlier" (Haokip, 2022). Bibi Sahera Khatun also confirmed this when she said: "The dogs had been howling for four days before the flood hit in 1970" (Haokip, 2022).

3.1.12.1 Case study 05

M. B., a 65-year-old resident of Bagura Village in Boharumpur union, possesses a deep understanding of the behavior of crows and its perceived connection to impending cyclones. According to her, the presence and vocalization of crows at unusual times, specifically during the night, serves as a significant indicator of an impending cyclone, known locally as "Jhor." Living adjacent to a pond where numerous crows inhabit the trees, Morjina Begum has become intimately familiar with the typical habits of these birds. She recalls instances from her family's history where the abnormal crowing during the night preceded major cyclones. Her observations, based on her family's experiences, have reinforced her belief in the correlation between crow behavior and cyclonic weather events. She vividly remembers the night before Cyclone Sidr struck in 2007, when the crows were crowing unusually. Sensing the significance of this behavior, Morjina Begum warned her household members about the imminent cyclone, which indeed struck the following night. This incident reaffirmed her belief in the predictive power of the crows' behavior, a knowledge she inherited from her grandparents.Morjina Begum also recalls a similar occurrence in 1970 before the devastating Bhola cyclone. At that time, the abnormal crowing during the night led to discussions among her grandparents about the likelihood of a cyclone with storm surge. True to their apprehensions, the Bhola cyclone hit the area the next day. Her reliance on this traditional knowledge, passed down through generations, demonstrates the valuable role of indigenous wisdom in predicting and preparing for natural disasters such as cyclones. Despite lacking scientific validation, Morjina Begum's observations and experiences highlight the importance of local folklore and ancestral wisdom in anticipating weather-related calamities, allowing communities to take precautionary measures in the face (M. B., 65).

3.2 Analysis of the knowledge

The attributes of these technologies are traditional in nature and primarily rely on local knowledge and experience. They are used to monitor key environmental signs in order to predict and anticipate upcoming natural disasters.

Table 1. SWOT analysis

SWOT	Description
Strength	Long-standing, generational knowledge of local weather and natural phenomena. Practical, real-time observations of wind direction, cloud formation, water behavior, animal activities, and lunar phases. Proven effectiveness in early warning, allowing timely precautions and life-saving decisions (e.g., Hasem Sikder, Abdul Mozid, Alomgir Dorji). Community-based and low-cost method not requiring advanced technology. Integrates multiple environmental cues for more reliable predictions.
Weakness	Lacks scientific validation and quantitative measurement; largely qualitative. Predictions can be subjective and vary with individual interpretation. Limited geographic applicability; region-specific. Cannot provide precise timing or intensity of disasters. Overreliance may delay response if cues are misinterpreted. Need Long time experience.
Opportunity	Integration with modern meteorological forecasting to enhance early warning systems. Simple tools can be used for observe weather correctly Basis for community-based disaster risk reduction programs. Documentation and dissemination could enhance resilience in similar coastal and riverine areas. Development of low-cost community training programs.

	Inform policy-making and climate-smart disaster management strategies.
Threat	Climate change may alter local weather patterns, reducing reliability of traditional cues. Environmental changes (river siltation, urbanization) may affect effectiveness. Younger generations may lose interest, leading to knowledge erosion. Extreme or unprecedented events may exceed predictive capacity. Potential conflicts with scientific early warning systems if not integrated properly.

3.3 Improve the knowledge

It is essential to integrate traditional knowledge of weather patterns and cyclone indicators into modern knowledge and practices. This incorporation can be facilitated through local NGOs, government training programs, and disaster monitoring systems. These organizations should work collaboratively to bridge the gap between traditional wisdom and contemporary scientific forecasting methods. Utilizing simple tools for analyzing observable weather conditions can serve as an effective method for detecting potential signs of an impending cyclone. These tools may include observing changes in animal behavior, such as the unusual crowing of birds, or noting alterations in wind direction and cloud patterns. Raising awareness within the community is crucial for a better understanding of formal weather forecasts and cyclone warnings. Conducting community meetings with interactive sessions can facilitate this process. Educational posters, designed to simplify complex meteorological information, should be employed during these sessions to aid comprehension and enhance awareness among community members.

The involvement of elderly individuals, who possess valuable insights based on their experiences and inherited knowledge, is vital in forming village disaster preparedness teams. Their involvement ensures that traditional warning signs are considered and integrated into the community's disaster preparedness plans. Documentation of traditional warning knowledge regarding cyclones and weather forecasting methods should be prioritized. This documentation will preserve valuable insights and aid in passing down this knowledge to future generations. Developing effective dissemination strategies is essential to widely share early warning knowledge within the community. These strategies should employ various mediums such as workshops, educational campaigns, local media, and social platforms to reach a broader audience. Establishing well-coordinated mechanisms among villagers, local authorities, NGOs, and relevant agencies is crucial. This coordination ensures that information regarding cyclone warnings and disaster preparedness measures is efficiently communicated, understood, and implemented across the community.

4. Conclusions

In Bangladesh, a considerable portion of the population faces recurrent natural disasters and the adverse impacts of climate change on an almost annual basis. Among the most vulnerable are those residing in the coastal regions, where the susceptibility to climate-induced natural disasters is notably high. This study conducted an analysis focusing on the documentation of indigenous knowledge and practices employed for early warning systems aimed at disaster risk reduction. The findings of this study reveal various indigenous practices utilized by local communities for early warning and disaster preparedness. These practices include observing natural indicators such as wind speed, wave size, and the appearance of water bubbles to predict storm surges. Additionally, cues like extreme hot weather are associated with the possibility of cyclones and nor'westers. Other observations include frog croaking indicating heavy rainfall, the purring of crows signaling impending heavy rainfall, moth activity foretelling heavy rainfall, ants climbing with reserved food predicting heavy rainfall and floods, and the occurrence of heavy rain in the months of Bhadra and Ashwin hinting at monsoon floods. Moreover, specific cloud

formations, wind patterns, and river water color changes serve as warning signs for potential floods or storm surges. For instance, the movement of clouds from south to north, cloudy weather with lightning, thunder, and wind indicating reduced rainfall, and warm winds accompanied by black clouds signaling nor'westers. Notably, crows crowing during the night are believed to indicate the onset of cyclones and storm surges. However, despite the wealth of knowledge and practices existing within these communities, much of this indigenous wisdom remains invisible to outsiders and is confined within specific localities. Consequently, there is a critical need to unearth and disseminate these practices beyond their communities. A major obstacle in integrating Indigenous Knowledge into disaster risk reduction efforts is the lack of comprehensive documentation. Therefore, the primary imperative is to systematically document these invaluable practices across technical, cultural, social, and economic dimensions to ensure their preservation and integration into broader disaster management strategies.

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