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Climate Smart Disaster Risk Reduction: Indigenous Knowledge Practiced for Housing Technology in Coastal Zone of Bangladesh

Md. Faisal[1,*], A. K. M Abdul Ahad Biswas[2], and Milton Kumar Saha[2]

[1] Department of Disaster Resilience and Engineering, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh.
[2] Department of Disaster Risk Management, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh.
***Corresponding author:** faisal@pstu.ac.bd

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Abstract

The coastal region of Bangladesh is highly vulnerable to climate-induced natural disasters, with the population frequently experiencing various calamities. Over generations, inhabitants have developed indigenous knowledge and techniques to mitigate these impacts. This study examines traditional practices for enhancing housing resilience in Dashmina Upazila, Patuakhali District, a region prone to such disasters. By employing a multi-method approach, the research began with Focus Group Discussions (FGDs) involving 14 groups of 6-10 participants to explore indigenous knowledge on housing adaptation. This was followed by Key Informant Interviews (KIIs) with 16 individuals, including social leaders and NGO workers, to validate and expand on FGDs' findings. Direct Observations through transect walks, Case Studies for in-depth analyses, and a review of secondary data from reports and articles complemented the primary data. Data were analyzed using Microsoft Excel 2010 for both quantitative summaries and descriptive qualitative analysis, with a SWOT analysis employed to assess the strengths, weaknesses, opportunities, and threats of these practices. The study identified effective traditional practices such as Raised Homestead Platforms and Deep-Rooted Pillars, which improved resilience against cyclones and flooding, although challenges such as erosion and material durability were noted. Additionally, Securing Roofs with crossbeams, Heavy Weight Hanging at roof corners, and Planting Disaster-Resistant Trees provided additional protection. Practices like Tying Houses to Trees or Pillars and using Lightweight Materials for riverbank erosion were found to be practical but faced durability issues. Overall, these traditional practices significantly enhance housing resilience, offering cost-effective solutions with actionable improvements. Recommendations include employing more durable materials and enhancing community awareness, highlighting the importance of integrating traditional knowledge with modern strategies for effective disaster risk reduction and climate adaptation. The study suggests that these indigenous practices should be taken into account in decision-making processes for planning any development projects aimed at reducing the risk of disasters.

Keywords: Coastal area, disaster risk reduction, indigenous knowledge, housing technology.

Introduction

Bangladesh is one of the world's most densely populated and poorest countries, making it inherently vulnerable to natural disasters due to its geographical and geological settings (Community Based Disaster Risk Reduction Project, 2010; Saha et al., 2024; Faisal et al., 2024). The country regularly faces major natural hazards and disasters, including floods, cyclones, storm surges, flash floods, droughts, tornadoes, riverbank erosion, saline water intrusion, waterlogging, submergence, hot and cold waves, landslides, hailstorms, lightning, epidemics, extreme temperatures, nor'westers, and high levels of arsenic in groundwater (Disaster Profile, Bangladesh, 2014; Biswas et al., 2015; Mukherjee et al., 2020; Faisal et al., 2021). Widespread poverty, coupled with frequent and devastating natural disasters, low literacy rates, inadequate access to basic healthcare, and high unemployment, hampers Bangladesh's efforts toward national development, poverty alleviation, social justice, and disaster risk reduction (DRR) in a changing climate (Hazards in Bangladesh, 2013). Due to extreme poverty and low GDP and per capita income, the Bangladesh government faces limitations in allocating funds for disaster preparedness and mitigation measures. Consequently, rural communities have traditionally relied on Indigenous Knowledge for disaster risk reduction. Community-based initiatives and Indigenous Knowledge (IK) have been found to be more effective in both developed and developing countries, particularly in empowering local communities to build resilience (Sharma, 2021).

According to Grenier (1998) and Boven (2002), Indigenous Knowledge (IK) refers to the unique, traditional local knowledge existing within and developed around the specific conditions of a community to a particular geographical area. It encompasses all aspects of life, including the management of the natural environment upon which livelihoods and survival depend. IK is a powerful resource for rural populations and plays a pivotal role in combating poverty and social exclusion in rural communities worldwide. The terms 'local,' 'traditional,' and 'indigenous' are sometimes considered separately in disaster management and climate change adaptation strategies, while at other times, they are considered similar or overlapping (Hiwasaki et al., 2014). It is important to recognize that indigenous knowledge transfer is more than simply oral or written information. Knowledge and practices become visible through products and achievements, such as building types and materials, and are therefore one form of civilizing activity (Hodder, 2012). The IPCC (Intergovernmental Panel on Climate Change) has identified Indigenous Knowledge as a crucial basis for developing strategies for adaptation and natural management (Anisimov et al., 2007). Scholars working on indigenous knowledge systems have actively supported the view that the indigenous knowledge of local societies offers significant value in saving people's lives and possessions from the negative impacts of disasters (Hiwasaki et al., 2015; McAdoo et al., 2006). Some studies have shown that approaches incorporating indigenous knowledge from local communities have led to successful disaster management (Iloka, 2016; Rahman et al., 2017; Sethi et al., 2011). Communities have cooperated with actors from science and politics, while indigenous knowledge itself has helped them survive disasters (Meyers & Watson, 2005; Kurnio et al., 2017).

Examples of indigenous knowledge saving lives include the community in Bali, where people organize themselves during an earthquake by running to safe places or hiding under tables while shouting 'linuh, linuh, linuh' (meaning 'alive, alive, alive'). On the Mentawai Island west of Sumatra, locals observe the behavior of squirrels and chickens as signs of upcoming hazards. In Kampung Naga Village, Tasikmalaya Regency, southwest Java, local wisdom for mitigating earthquake and landslide risks involves adapting to the natural environment, such as through earthquake-proof building construction (Yani et al., 2016). Local knowledge is experiential and embodied in everyday practice rather than logically formulated or inscribed as a set of processes or rules (Nazarea, 2006).

On the other hand, disaster risk reduction (DRR) involves reducing the threats, occurrences, or impacts of disasters. Vulnerability reduction and capacity building have the greatest potential for achieving successful disaster risk reduction over the long term (Kelman et al., 2012). Community members have not always benefited from science and technology in relation to disaster risk reduction (Dekens, 2007; Shaw et al., 2009). Several studies argue that science-based DRR could be improved and communicated more effectively by integrating it with local knowledge, as the latter is readily accepted by the community (Shaw et al., 2008; Ikeda et al., 2016). Because of this, indigenous knowledge is important in reducing disaster risk (Kelman, 2010).

Indigenous knowledge preservation can enhance risk literacy, as education can improve the capacity of individuals and communities to reduce disaster risk (Kurnio et al., 2021). Due to long observation and interaction with disasters, indigenous knowledge preserves prevention culture in daily life, especially in facing natural hazards (Zulfadrim et al., 2019). For example, local knowledge emphasizes using flexible materials for building houses, such as bamboo, coconut roots (ijuk), and coconut leaves (kiray), to withstand earthquakes (Kurnio et al., 2021). Preserving local knowledge can be achieved in many ways that do not require significant time or money. Incorporating local knowledge into disaster education materials for children or official government strategies is one example. Documentation and validation also contribute to the transmission of local and indigenous knowledge to the younger generation (Gratani et al., 2011; Green et al., 2010). Knowledge integration and ensuring its transmission is crucial, especially since local and indigenous knowledge faces challenges in being passed down to the younger generation (Hiwasaki et al., 2015). It is important to maintain this knowledge so that future generations can continue to use it and strengthen community resilience. To make the best use of local and indigenous knowledge for increasing community resilience, it is important to understand how it can be integrated with scientific knowledge. Once integrated, communities can develop effective strategies to adapt to climate change and mitigate the impacts of climate-related hazards. Scientists, practitioners, and policymakers can fully incorporate local and indigenous knowledge into their work (Hiwasaki et al., 2015).

The objective of this research is to identify, analyze, improve, and document indigenous knowledge and practices related to housing technology utilized by the people in Dashmina Upazila of the Patuakhali district to mitigate risks associated with storm surges, cyclones, riverbank erosion, and monsoon floods. Additionally, this research aims to scale up the existing valuable Indigenous Knowledge (IK) and practices to enhance climate-smart disaster risk reduction (CSDRR) in coastal Bangladesh. An indirect objective is to raise awareness about indigenous knowledge as an effective tool for reducing risks posed by natural disasters. By enhancing the comprehension of indigenous knowledge and offering concrete examples of its successful application, this research intends to inspire practitioners and policymakers to acknowledge and integrate this 'wealth of knowledge' into future disaster-related interventions.

Methods

Study Area

This study was conducted in Dashmina Upazila, located in the Patuakhali District of Bangladesh (Figure 1). The upazila covers an area of 351.87 square kilometers and is situated between 22º02´ and 22º18´ north latitudes and 90º29´ and 90º40´ east longitudes. Dashmina Upazila is bordered to the north by Bauphal Upazila, to the east by Char Fasson Upazila, and to the south and west by Galachipa Upazila in Patuakhali District (BBS, 2012). Dashmina Upazila consists of six unions: Betagi-Sankipura, Bahrampur, Bansbaria, Alipur, Rangopaldi, and Dashmina. The postal code for the area is 8630. The total population of Dashmina Upazila is 123,388, with a population density of 351 people per square kilometer. There are 28,490 households, with an average household size of 4.3 members. The population is comprised of 49% males and 51% females, with 93% identifying as Muslim and 7% as Hindu. The average literacy rate in the upazila is 29.6%. The main crops grown in the area include paddy, potatoes, pulses, chili peppers, and watermelons, while the primary fruits cultivated are bananas, jackfruit, and papayas (BBS, 2012).

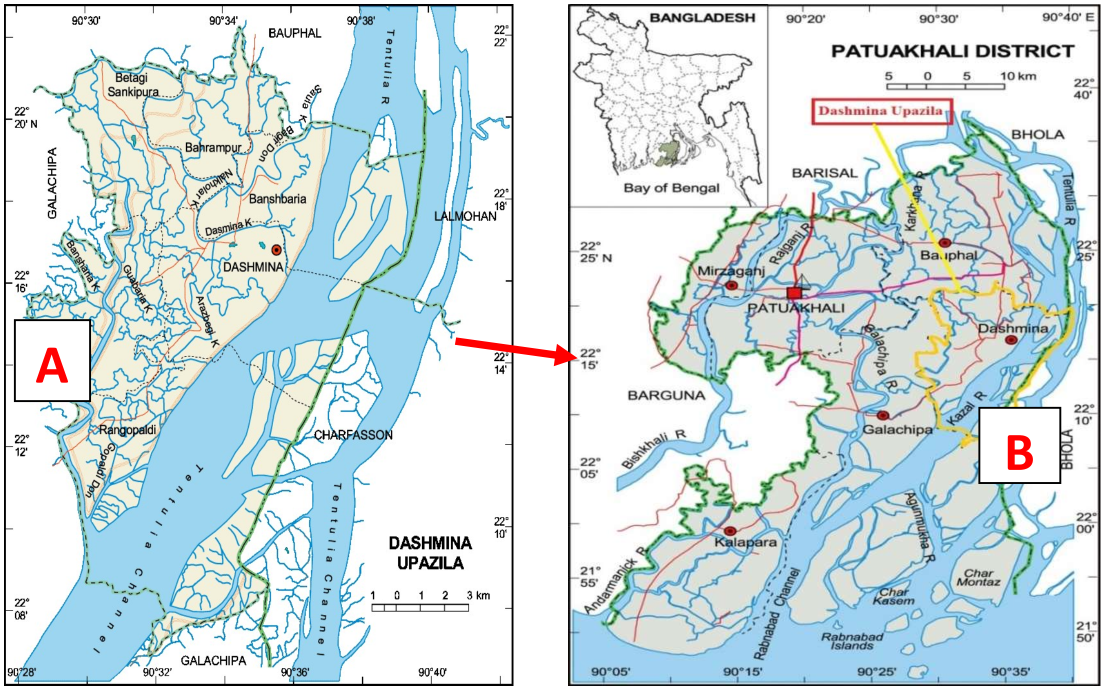

Figure 1. Study area map (A) shows Patuakhali District, the position of it in Bangladesh and position of Dashmina Upazilla in Patuakhali District; map (B) shows the Dashmina Upazila. (Map source: Faisal et al., 2024).

Data Collection on Indigenous Knowledge

To achieve the research objectives, primary data were gathered from the local area using various methods, such as Focus Group Discussions (FGD), Key Informant Interviews (KII), direct observations, and case studies. Additionally, secondary data were obtained from diverse organizations engaged in indigenous knowledge for disaster risk reduction and climate change adaptation. This secondary data also included scientific reports, research articles, and newspaper articles.

The information collected was qualitative, emphasizing subjective insights and perspectives. The target groups for data collection included the general population, members of Community-Based Organizations (CBOs), representatives from Union Parishads, social leaders, NGO workers, school teachers, religious leaders, officials from the Upazila Parishad, individual households, and older community members.

Focus Group Discussion (FGD): For focus group discussions, smaller groups consisting of 6 to 10 individuals were selected based on their specialized knowledge or unique perspectives on a particular issue (Hawkins, 2009). FGDs were the primary method used to obtain detailed descriptive data from respondents. Focus groups gathered information on indigenous knowledge for building houses to adapt to climatic hazards and their impacts. These focus groups were composed of vulnerable community members, including those who were impoverished, landless, elderly, women, and knowledgeable. All FGD members were over 40 years old. Pre-designed discussion guidelines were used to guide these sessions. Discussions were recorded using a mobile phone, and notes were taken in an exercise book. In total, 14 group interviews were conducted to explore indigenous knowledge related to the research objectives.

Key Informant Interview (KII): After conducting FGDs, the researcher identified indigenous knowledge, its history, and possible improvements for housing technology. KII was then conducted for validation and advanced analysis of the identified knowledge. KII gathered qualitative information from individuals with substantial experience in the pertinent issues aligned with the study objectives. These interviews targeted individuals representing various interest groups and diverse perspectives related to the study theme (Hawkins, 2009). All key informants were current or former social leaders, school teachers, representatives from Union Parishads, members of Community-Based Organizations (CBOs), NGO workers, and religious leaders, and tended to be 40-70 years old. Exceptions were women members of Union Parishads and several school teachers. These respondents were chosen for their knowledge of local issues. A pre-designed interview questionnaire was used to guide the sessions, and the discussions and responses were recorded in an exercise book. In total, 16 Key Informant Interviews were conducted to explore indigenous knowledge pertaining to the study's objectives.

Direct Observations: After collecting a detailed overview of climate-induced risks and indigenous knowledge of housing technology in the study area from FGD and KII, direct observations were conducted to gather detailed information and for final validation of collected data. Data collections through direct observation involved transect walks across areas of interest. These walks allowed for observing, listening, and identifying various conditions of indigenous knowledge practiced at both individual and community levels. The observations were guided by questions such as: What? When? Where? Who? Why? How? (Louise, 1998) to comprehensively understand the nuances and aspects of the indigenous practices related to disaster risk reduction and climate adaptation. Through structured observation, the researcher was able to witness indigenous housing patterns and construction technology. Researchers also took photographs of housing technology during these direct observation sessions.

Case Studies: Case studies involve conducting detailed investigations into a small number of sampled units, which are selected as representatives of the larger population (Hawkins, 2009). These studies delve into individual life experiences and provide in-depth insights into the benefits of indigenous housing technology in various disastrous conditions. Local histories also provide detailed accounts of changes that have occurred or are occurring within a specific area (Cavestro, 2003). These histories can encompass various aspects, such as the evolution of housing patterns in the study area. They offer a comprehensive perspective on the transformations and developments within a local context across different facets of life and the environment. Four case studies were conducted for this research.

Secondary Data Review: The secondary data review involved examining a range of pertinent sources, including reports, books, articles, maps, journals, research papers, websites, thesis papers, and baseline reports from various Non-Governmental Organizations (NGOs). This process aimed to gather existing information and insights relevant to the research objectives from previously published or documented sources.

Assessment of Indigenous Knowledge

Attributes Assessment:

The assessment focused on how communities have adapted to coexist with disasters such as cyclones, tidal floods, riverbank erosion, and waterlogging. It examined traditional coping mechanisms, particularly traditional technologies used in housing to mitigate disaster risks. The analysis highlighted how various elements contribute to the communities' ability to withstand and manage the impacts of disasters, emphasizing the strengths and effectiveness of these traditional approaches in building resilience and addressing the challenges posed by natural calamities.

SWOT (Strength, Weakness, Opportunity, and Threat) Analysis

A SWOT analysis is a systematic tool commonly used by evaluation specialists in any field of study (Chang & Huang, 2006; Gurl, 2017). The data and information gathered on indigenous knowledge and practices were analyzed from the perspective of strengths, weaknesses, opportunities, and threats to disaster risk reduction (SAARC Disaster Management Centre, 2009). Various strategies can follow from a SWOT analysis, including those that link Strengths and Opportunities (SO Strategies), link Weaknesses and Opportunities (WO Strategies), focus on Strengths and Threats (ST Strategies), and arise from assessing Weaknesses and Threats (WT Strategies). For example, SO strategies utilize the fact that strengths may help capitalize on external opportunities, whereas WO strategies focus on pursuing external opportunities to lessen weaknesses. Similarly, ST strategies focus on using existing internal strengths to mitigate external threats, while WT strategies consist of actions intended to reduce both internal weaknesses and external threats simultaneously (Sevkli et al., 2012).

The SWOT analysis of this research has two dimensions: internal elements of Strengths and Weaknesses, and external aspects of Opportunities and Threats. The process for conducting a SWOT analysis includes: (1) conducting a SWOT analysis session, (2) providing a meeting overview and explanation of the work, (3) identifying strengths and weaknesses, as well as opportunities and threats, using brainstorming techniques, (4) determining the necessary steps to move from strategy action and its consequences, (5) developing the SWOT matrix, (6) comparing with other internal and external factors and SO, WO, ST, WT strategies, (7) determining the necessary steps to move from strategy action and its consequences, and (8) updating the SWOT matrix at appropriate intervals.

Improvement of Indigenous Knowledge

After collecting the Indigenous Knowledge, efforts were made to scale up or improve these valuable Indigenous Knowledge (IK) and practices through discussions with community people and brainstorming for Climate-Smart Disaster Risk Reduction (CSDRR) in Bangladesh.

Data Analysis

Since data was collected from multiple sources, several tools were employed to analyze it and assist with theme development. Writing notes in a fieldwork diary helped to prevent the loss of relevant impressions, spontaneous ideas, evaluations, solutions, and thoughts during data collection. Following each day of fieldwork, a reflective journal was updated to include opinions on the day's progress, the quality of the data collected, impressions of how the research is progressing, and the potential for personal biases in the research process. The collected data was analyzed using Microsoft Excel 2010 software, which enabled the creation of various tables for representation. Qualitative data were depicted descriptively. All data underwent thorough rechecking, and the research findings were summarized and concluded using Microsoft Office Word 2010 for report preparation.

Results and Discussion

Indigenous Knowledge for Housing Technology

Raised homestead platform

The local community in the study area bases their construction of homestead platforms on past experiences with cyclones like Sidr and Aila. According to their observations, during these cyclones, the water level outside the embankment was approximately two feet higher than inside the area. They have noted that the average storm surge height ranged from seven to nine feet.

Prior to Cyclones Sidr and Aila, most houses had platforms that were lower than these water levels. Consequently, this led to substantial losses in terms of lives, livestock, and property. However, houses with higher platforms were able to protect their assets more effectively. Learning from this experience, many damaged houses were rebuilt with raised platforms following the cyclones. Even today, when constructing new houses, locals consider this knowledge and elevate their house platforms above normal flood levels (Figure 2).

However, due to financial constraints, many economically disadvantaged individuals are still unable to adopt this technology. Moreover, the community suggests that employing a two-layer homestead platform proves more effective in safeguarding the house's basement from water damage.

Figure 2. Raised homestead platform.

Assessment of the knowledge

a. Attributes: It is a technological indigenous knowledge. This indigenous knowledge represents a traditional technological approach.

b. Resource needs: The resources required for this traditional technology include soil, labor, a khonta (a traditional cutting tool), a spade, bamboo baskets, and rope.

c. Why this technology? This technology is utilized to safeguard houses from various water-related natural phenomena such as tidal surges, high tides, storm surges, and floods.

d. SWOT analysis:

Strength	Weakness	Opportunity	Threat
▪ Lowcost requirement, making it financially feasible for all. ▪ Cost-effective approach. ▪ Soil, the main resource, is abundantly available in the area. ▪ Simple and easy-to-understand	▪ Poor soil quality, especially sandy soil, making the platform susceptible to damage or erosion from the force of water during storm surges. ▪ Vulnerability to high-speed tidal surges that can wash away	▪ Community collaboration can significantly reduce labor costs and enhance the effectiveness of the technology.	▪ The risk of erosion or damage due to poor soil quality could compromise the stability of the platform. ▪ The possibility of complete destruction by high-speed tidal surges poses a significant threat.

Strength	Weakness	Opportunity	Threat
technology, accessible to everyone. ▪ Serves as an essential measure for protection on both sides of the embankment. ▪ Community cohesion through mutual labor sharing reduces labor costs associated with the technology.	the entire soil platform. ▪ Potential security threat as thieves could easily cut down the platform to gain access to houses.		▪ Security risks where thieves may exploit the vulnerability of the platform for unauthorized access to houses.

Improve the knowledge

- To enhance the resilience of the platform, it is recommended to use a mixture of materials for the outer part of the base platform. This mixture may include mud, wood dust, rice chaff dust, and cow dung, which collectively strengthen the platform and protect it from excessive water pressure.
- If feasible, constructing the outer part of the base platform using bricks, sand, and cement can significantly bolster its durability and resistance to water pressure.

Implementation of Deep-Rooted Pillars at the House Base

During discussions, residents of the study area highlighted that typical house constructions lack deeply rooted pillars at the base (Figure 3). Traditional houses in this region typically have rectangular structures built on elevated homestead platforms. In the case of typical houses, the wooden pillars (khuti) supporting the structure are placed directly on a concrete block, brick, or even directly on the soil just above the homestead platform.

According to the discussions, the absence of deeply rooted pillars is identified as a primary reason for the extensive damage experienced by houses during cyclones, nor'westers, or tidal surges. This vulnerability is due to the lack of strong foundational support, making the structure unstable during these extreme weather events. This vulnerability became evident during the impact of cyclones SIDR and AILA, resulting in the significant damage or destruction of the majority of traditional houses. However, a few traditional houses equipped with deeply rooted pillars were able to withstand the forces of cyclones SIDR and AILA.

As a result of this learning, most residents in the area have incorporated this knowledge into their rebuilding efforts after cyclone SIDR. They have started to reinforce their house structures by incorporating deep-rooted pillars to enhance resilience against such natural disasters.

Figure 3. Deep rooted pillar use at the base of the house.

Case study 01:

Sahera Khatun, aged 55, residing in Dokkhin Daspara village within Basbaria union, shared an account of her house being one of the rare examples that entirely withstood the cyclone Sidr without sustaining any damage. The key factor attributing to this resilience was the construction of her house's pillars, predominantly made from Loha wood, which were rooted five feet deep beneath the house's platform. Additionally, her house had a tin shed roof that was firmly screwed in place. The basement of her house was elevated six feet above the courtyard level.

She noted that in her village, the majority of house pillars were shallow-rooted or lacked proper rooting altogether. As a result, these houses were completely overturned by the cyclone Sidr. Only a few houses in the village, including Sahera Khatun's deeply rooted house, remained standing after both Sidr and Aila. Post the cyclones, her house emerged as one of the few standing structures in the village. More than 100 people sought shelter there, earning her house the reputation of being a mini cyclone shelter for the village.

Source: Sahera Khatun; Age: 55; Village: South (Dokkhin) Daspara; Union: Basbaria, Dashmina, Patuakhali.

Assessment of the knowledge

a. Attributes: This knowledge represents a technological indigenous practice and is considered a traditional technology.

b. Resource needs: The resource requirements include an additional 4-5 feet wooden pillar and two bricks.

c. Why this technology?

This technology is employed to prevent the house from being overturned and to maintain its structural integrity during cyclones, nor'westers, strong winds, storm surges, and floods.

d. SWOT analysis:

Strength	Weakness	Opportunity	Threat
▪ Easy-to-understand and implement technology. ▪ Cost-effective.	▪ Lack of awareness about the technology.	▪ Use of durable materials like "Loha," "Sundory," or "Kerosin" (local	▪ Deterioration of low-quality wooden pillars and susceptibility to

Strength	Weakness	Opportunity	Threat
▪ Utilizes locally available resources. ▪ Applicability on both sides of the embankment.	▪ Difficulty in acquiring large, straight wooden pillars. ▪ Vulnerability due to weak junctions when joining two pillars together.	names) as straight wooden pillars. ▪ Possibility of reinforcing with concrete pillars, especially in the basement.	damage from the soil over a few years. ▪ Vulnerability of the house to cyclones, norwesters, and storm surges if the underground part of the pillar becomes damaged.

Improve the knowledge

Improvements to the existing knowledge involve implementing several modifications:

- Utilizing six to eight base concrete pillars, each approximately 5 feet in length, to reinforce the bottom layer of the base platform.
- If wooden pillars are used, covering their bottom part with polythene to shield them from soil. The wood of Loha and Sundori trees is recommended for constructing these wooden pillars due to their durability.
- Considering bricks and cement pillars as more resilient alternatives, although this may incur additional costs compared to wooden pillars.
- Incorporating a four-side veranda as an effective mechanism to alleviate the pressure exerted by cyclonic winds.

These modifications aim to enhance the structural strength and resilience of the houses against cyclones and other adverse weather conditions.

Securing House Roof by Tying with Crossbeam (Arra), Wooden Pillar (Khuti), or Fixed Wooden Pegs to Ground

The people in the study area utilize a particular technology for houses constructed with wood and tin. They secure the roof using a method involving an "Arra" (crossbeam), which is fastened using either plastic ropes or iron wires. At times, they also fasten the roof to the lower part of wooden pillars ("khuti") that are embedded into the soil, again using plastic ropes or iron wires (Figure 4).

Another technique involves using wooden or bamboo pegs fixed into the ground near the plinth at the house corners. The roofs of two sides are then fastened to these pegs, functioning similarly to a crossbeam, using iron wires or nylon ropes. It's a customary practice to inspect and repair these fixtures during the Bengali month of Chaitro. This knowledge has been passed down through generations, with the locals learning these techniques from their ancestors.

Assessment of the knowledge

a. Attributes: This knowledge represents a technological indigenous practice and is considered a traditional technology.

b. Resource needs: The resources required for this technology include wooden pegs, iron wire, nylon rope, and knowledge regarding the application of these materials.

c. Why this technology? This technology is employed to prevent the roof from being blown away by cyclones, norwesters, or strong storm winds.

d. SWOT analysis:

Strength	Weakness	Opportunity	Threat
▪ Anchors the house roof effectively by tying it down. ▪ Well-defined and easily applicable technology. ▪ Utilizes locally available materials. ▪ Can be implemented by anyone.	▪ Occasional breakdown of nylon ropes and iron wires. ▪ Incurs very little additional expense but may cost approximately a day's wage for labor. ▪ Possibility of pegs breaking down.	▪ Successful track record in preventing the roof from being blown away during storms.	▪ Potential breakdown of pegs, ropes, or wires, affecting the technology's effectiveness.

Improve the knowledge

Improvements to the existing knowledge entail the following modifications:

- Utilizing concrete pillars instead of wooden or bamboo pegs for greater durability.
- Opting for thick iron wire instead of rope to enhance strength and reliability.
- Enhancing awareness about the technology through courtyard sessions, utilizing flip charts as supportive materials for better comprehension.

- Tying the top four corners of the house to the basement pillars. This would require a maximum of 4 kg of rope (priced at 250 BDT/kg of nylon rope).

These adjustments aim to strengthen the resilience of the technology by employing more durable materials and enhancing community understanding through awareness campaigns.

Heavy Weight Hanging in the Four Corners of the Roof during Cyclone Season

A method employed involves tying a bundle of four, six, or eight bricks using either iron wire or thick plastic rope. One end of the wire or rope is used to secure the bundle, while the other end is fastened to one corner of the roof. The wire or rope is adjusted in length so that the brick bundle hangs approximately one to two feet from the roof's edge. This arrangement ensures that heavy brick bundles are secured at each of the four corners of the roof.

The purpose of adding this extra weight is to mitigate the risk of the roof being blown away during norwesters or cyclones. This practice is typically carried out in the month of Chaitro (March) according to the Bengali calendar. This timing is strategic as most wind-related hazards begin occurring from Baishak (April) in the coastal zones of Bangladesh.

Case study 02:

Harun Mridha, aged 40 and residing in Hazir Hat within Dashmina Union, faces a unique challenge as his house is situated at the edge of a pond. Due to the soft soil and the proximity of the pond, there is no viable method to anchor his house to the ground. To safeguard his corrugated iron sheet roof house from the seasonal storms, he adopts a preventive measure by hanging brick bundles (each containing 4 to 8 bricks) in all corners of the roof.

He executes this technique annually at the end of the Bengali month Chaitra (March). This practice, passed down from his father, serves as a means to add weight and stability to the roof, aiming to prevent potential damage caused by seasonal storms.

Source: Harun Mridha; Age: 40; Village: Hazir Hat; Dashmina; Patuakhali, Bangladesh

Assessment of the knowledge

a. Attributes: This practice represents a technological indigenous knowledge and is considered a traditional technology. It involves adding weight to the roof structure to enhance its stability and security.

b. Resource needs: The resources required for this technique include bricks, iron wire, and plastic rope.

c. Why this technology? The purpose of employing this method is to prevent the roof from being blown away during storms. Adding weight to the roof structure serves as a preventive measure to reinforce it and mitigate the risk of damage caused by strong storms.

d. SWOT analysis:

Strength	Weakness	Opportunity	Threat
▪ Easy to apply. ▪ Applicable by anyone. ▪ Low-cost solution.	▪ Susceptibility of iron wire to breakage. ▪ Vulnerability of plastic rope to breakage.	▪ Most suitable in situations where other options are not feasible. ▪ Economic cost is insignificant,	▪ Possibility of being inadequate against very high wind speeds, potentially leading to the roof being blown away

Strength	Weakness	Opportunity	Threat
▪ All required materials are readily available.		equivalent to about one-third of a single day's wage for a local day laborer.	and posing a danger to human or other lives.

Improve the knowledge

Enhancements to the existing knowledge could involve the following improvements:

- Attaching the brick bundle with a mixture of sand and cement to ensure a stronger and more secure attachment, thereby reducing the labor required for implementation.
- Increasing awareness among community members about this effective local technology through courtyard sessions. Utilizing flip charts as supportive materials during these sessions can aid in better understanding and dissemination of information regarding the technique.

These enhancements aim to strengthen the application of the technology by improving its structural integrity and spreading awareness among the community for better adoption and utilization.

Planting Disaster-Resistant Trees around the Home

The community in the study area has emphasized the vulnerability of certain trees during cyclones, norwesters, or strong winds. They have pointed out that specific trees like the chambul tree, Rain tree, Akashmoni tree, Shisu tree, Amrul tree, and Amra tree are prone to breaking and falling, posing a threat to nearby houses and causing potential harm to individuals in the vicinity.

Conversely, local community members have identified certain trees that demonstrate resilience against cyclones and strong winds. These include the betelnut tree, coconut tree, date tree, palm tree, and loha tree. Drawing from their extensive experience, these trees have been recommended for planting around houses as they are less susceptible to damage during severe weather conditions.

The community has shared their observations that planting these resilient trees around houses serves as a protective barrier, helping to mitigate the impact of strong winds by intercepting and reducing wind speed before it reaches the homes. Moreover, during the Sidr cyclone event, it was noted that houses surrounded by date, palm, and coconut trees demonstrated increased resistance. Some individuals even sought refuge in these trees when unable to reach designated cyclone shelters, and those who remained in their houses found additional protection due to these resilient trees.

In essence, the community advocates for the planting of sturdy trees such as betelnut, coconut, date, palm, and loha trees around households as a proactive measure to enhance resilience against natural disasters like cyclones and strong winds, based on their historical experiences and observations.

Assessment of the knowledge

a. Attributes: This knowledge represents traditional indigenous technology and holds economic value as well. The trees recommended for cyclone protection can be sold, providing an opportunity for owners to generate income.

b. Resource needs:

   - Exclusively cyclone-resistant trees like date trees, palm trees, betelnut trees, loha trees, coconut trees, etc., maintaining a minimum distance of 15 to 20 feet.
   - Avoid planting weak trees within a radius of at least 30 feet around the house.

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c. Why this technology? This technology is implemented to shield the house from cyclonic winds, thereby safeguarding lives.

d. SWOT analysis:

Strength	Weakness	Opportunity	Threat
▪ The measure proves to be cost-effective in yielding long-term benefits. ▪ It effectively protects houses from cyclonic winds. ▪ It aids in securing houses by enabling them to be tied and reinforced.	▪ The ropes used to secure houses to trees may break, compromising the efficacy of the method. ▪ A significant amount of time is required for trees to grow, making immediate implementation unfeasible.	▪ It meets the demand for fruits such as palm, date, betelnut, and coconut.	▪ Trees like palm, coconut, etc., susceptible to extreme storm winds, may break and fall onto houses, causing damage. ▪ Ripe fruits from palm and coconut trees pose a risk to individuals as they can fall unpredictably at any time, potentially causing harm.

Improve the knowledge

To enhance the protective measures around the house:

- Create a garden comprising betelnut, palm, coconut, and shal trees, especially on the southern side of the house, maintaining a minimum distance of 30 feet between the garden and the house. These trees are specifically chosen for their resilience against disasters.
- Beyond the disaster-resilient tree garden, establish an additional layer of trees such as mehogoni, Raintree, chambool, etc. These trees form a secondary barrier that helps mitigate the impact of cyclonic winds. The combined effect of these two layers of trees acts as an initial buffer, reducing the velocity of the wind before it reaches the house.
- Intensify tree planting in a tiered arrangement around the house. This strategic placement forms a protective wall during cyclones, providing an added layer of defense against strong winds.

In summary, by strategically planting these trees in different layers and intensities around the house, a multi-tiered defense system is created. This approach aims to reduce the impact of cyclonic winds and enhance protection for the house and its inhabitants.

The Practice of Tying Houses for Protection

In the study area, traditional houses lack the necessary strength to withstand cyclonic winds. For instance, during Cyclone Sidr, only a few families took the initiative to secure their homes by tying the four corners of their houses with ropes, connecting them to the nearest date tree or palm tree (Figure 5). In cases where date or palm trees were unavailable, if the house was built on pillars, individuals tied the top four corners to the base of these pillars. Following Cyclone Sidr, it was observed that those who had implemented these measures, although their roofs were stripped away by the force of the wind, the structural integrity of their houses remained intact.

Case study 03:

Hosneara Begum, a 40-year-old woman residing in Rong Gopaldi village, Dashmina Upazila, Bangladesh, is a mother of two daughters and one son. Her family faced a critical situation on November 15, 2007, as her mother-in-law was severely ill. Hosneara's husband earns a living as a fisherman.

Before Cyclone Sidr struck, they received information about the approaching cyclone from their neighbors, but initially did not consider it a serious threat. As the wind intensified, they realized the gravity of the situation. By evening, it became evident that a significant cyclone was imminent. However, due to the high wind speed and the considerable distance of the cyclone shelter from their house, they were unable to seek refuge there. Consequently, they made the decision to stay in their home.

Given her husband's profession as a fisherman, they had a sufficient supply of rope at their disposal. They took immediate action and secured their house by tying it to nearby date, coconut, and betelnut trees. As a result, their house remained upright and protected, although there was some partial damage, such as the tin shed roof being blown away and the house tilting. Despite this, they were safe within the shelter of their house.

Hosneara Begum acknowledged that the resilience of their house during Cyclone Sidr was due to the swift action of tying the house securely to cyclone-resistant trees, demonstrating the effectiveness of this measure in safeguarding their home during the cyclone.

Source: Hosneara Begum; Age: 40; Village: Rong gopaldi; Dashmina Upazila, Bangladesh

Figure 5. Tying the house.

Assessment of the knowledge

a. Attributes: This represents indigenous technological knowledge.

b. Resource needs:

- Presence of protective trees situated within a distance of 10-15 feet from the houses.
- Nylon or plastic rope for tying the top four corners of the house, requiring approximately 5 kg per house.

c. Why this technology? This technology is employed to shield the house from cyclonic winds or, at the very least, to maintain the structural integrity of the house and prevent it from overturning.

d. SWOT analysis:

Strength	Weakness	Opportunity	Threat
▪ This measure is highly cost-effective yet remarkably efficient. ▪ It proves to be an effective defense against cyclonic winds. ▪ The structure of the house remains intact without causing destruction to the homestead platform.	▪ In some cases, the roofs may be dislodged by the pressure of cyclonic winds, but the structure itself remains undamaged. ▪ Concrete pillars are recommended over trees for tying the house. ▪ There's a potential alternative of using iron wire instead of plastic rope for tying the house.	▪ The implementation of concrete pillars as a more reliable alternative to trees for tying the house. ▪ Considering iron wire as an alternative to plastic rope for securing the house.	▪ The trees used for tying the house may break during severe cyclonic winds. ▪ Plastic ropes used for tying the house may break. ▪ There's a risk of roofs being blown away due to the force of the cyclonic winds.

Improve the knowledge

To enhance the protective measures for houses:

- Utilize iron wire instead of plastic rope when tying the house to trees. This substitution mitigates the risk of the rope breaking and ensures a stronger and more secure tie between the house and the trees.
- Install concrete pillars at the four corners of the house, positioned 5-10 feet away from such disaster-resilient trees. This precautionary measure is taken because these trees, while effective in many ways, have limitations. During heavy storm winds, these trees may be susceptible to breakage, potentially falling onto the house. Additionally, the ripe fruits of these trees pose a risk to individuals, making it safer to maintain a distance between the house and these trees by using concrete pillars for reinforcement.

Utilizing Lightweight Materials in House Construction to Mitigate Riverbank Erosion Damage

In the Basbaria, Dashmina, and Gopaldi unions situated alongside the river, the swifter occurrence of riverbank erosion has led to the frequent relocation of houses, sometimes up to 3-4 times due to the impact of erosion. Those who construct their houses with concrete face a significant challenge in relocating as these structures are permanent settlements, causing substantial losses when damaged by erosion. Conversely, individuals opting for brick or cement houses along the riverbank encounter severe losses when their houses are fully destroyed by erosion. Those using semi-permanent materials like tin and wood endure moderate losses due to the higher cost involved in transporting these heavier materials and resettling in new locations.

Therefore, individuals affected by riverbank erosion tend to opt for lighter construction materials when building their homes. Lighter materials such as bamboo, wood, hogol leaf, date palm leaf, straw, low-cost tin, golpata, jute stalks, jute rope, and plastic rope are preferred. These materials facilitate easy relocation at a lower cost with less damage. While houses made from these lightweight materials are inexpensive and easy to construct, they lack durability and are prone to collapse during storms, necessitating reconstruction every two to three years.

Moreover, these housing materials can be recycled as cooking fuel, reducing economic costs. This practice, observed in Basbaria, Dashmina, and Gopaldi unions within Dashmina upazila, has been passed down through generations among the local community.

Assessment of the knowledge

a. *Attributes:* This constitutes a traditional technology, representing indigenous knowledge passed down through generations.

b. *Resource needs:*

- Bamboo and wood for structural framework.
- Hogol leaf, Golpata, date leaf, and jute stalks for walls.
- Golpata, palm tree leaf, straw, and low-cost tin for roofing.
- Jute rope and plastic rope for tying components together.

c. *Why this technology?*

This technology aims to mitigate economic losses induced by riverbank erosion through the utilization of cost-effective and flexible housing materials.

d. *SWOT analysis:*

Strength	Weakness	Opportunity	Threat
▪ Minimizes economic or asset loss triggered by riverbank erosion. ▪ Simple and easy to implement. ▪ Well-defined and straightforward technology. ▪ Utilizes locally available materials. ▪ Represents a low-cost approach.	▪ May lead to a lower standard of living perception. ▪ Some individuals might perceive it as a symbol of poverty.	▪ Potential alternative uses for available materials. ▪ Applicability in other localities.	▪ Vulnerability to collapse during cyclones, storm surges, and nor'westers due to the lightweight nature of these houses.

Improve the knowledge

- Suspending weights from the four corners of the roof during the cyclone season serves as a preventive measure, minimizing the risk of the roof being blown away by cyclonic winds.
- Securing the roof of the house by tying it with wooden pegs firmly fixed to the ground aids in preventing the roof from being dislodged or blown away during cyclonic winds.
- Tying the entire house to disaster-resilient trees such as date trees or palm trees using ropes acts as a safeguard, preventing the structure from overturning due to cyclonic winds.

- Raising public awareness through community meetings serves as an effective strategy to disseminate knowledge and encourage the adoption of these protective measures against cyclonic winds and related damages.

Constructing Attached Homes to Enhance Resilience against Cyclones and Storm Surges

In the observed area, certain individuals have chosen to construct their homes in an attached format. Notably, two houses are constructed adjoining each other, sharing a single wall between them (Figure 6). A significant feature of these attached houses is the use of large crossbeams that span across both houses simultaneously, essentially covering two houses with one crossbeam. This construction method results in exceptionally sturdy attached houses that exhibit a high resistance to intense cyclonic winds.

The integration of these two houses through a shared structure contributes to their strength against various natural calamities, including cyclones, nor'westers, storm surges, and floods. This unified structure acts as mutual support, where one house reinforces and lends support to the other, effectively safeguarding both against the impact of strong winds and other environmental hazards. The joint construction creates a robust defense mechanism, enhancing the overall resilience of these attached houses against adverse weather conditions and potential natural disasters.

Figure 6. Attached house for increase the strength against cyclone and storm surge.

Case study 04:

Dulal Howladar and Jafor Howladar, two brothers residing in Bashbaria village near the launch station, chose to construct their homes in a unique manner by building two houses on a single large platform in an attached format. These houses are separated by only a tin wall, and they utilized a total of six crossbeams, shared between the two houses, effectively joining them. The integration of these crossbeams into the entire pillar structure of both houses strengthened the attachment significantly, essentially functioning as one large, interconnected dwelling.

Although each house has separate upper roofs distinguishing them as individual units, the verandahs of both houses share a single roof. During Dulal Howladar's account of Cyclone SIDR's history, he highlighted that their attached house structure successfully withstood the cyclone's impact. He mentioned that within their compound, there were a total of seven houses - their two attached houses and five separate ones. Interestingly, while all the individual houses, whether fully or partially, suffered damage due to the strong cyclonic winds and storm surge, their attached house remained remarkably resilient. Only a few roof screws were found to be loose; otherwise, the structure remained intact.

Dulal Howladar expressed confidence in their house's ability to withstand any cyclone similar to SIDR. This success story has inspired others in the village to consider constructing such attached houses. Consequently, some villagers who built new houses after Cyclone SIDR opted for similar attached house constructions, influenced by the resilience displayed by Dulal and Jafor Howladar's innovative approach to their dwelling.

Assessment of the knowledge

a. *Attributes:* This represents indigenous technological knowledge, manifesting as a traditional house design conceptualized by local people. It aims to withstand strong winds, secure land, and foster stronger relationships between two families.

b. *Resource needs:*

- Wood, tin, bamboo, screws, nails, and rope are essential materials for constructing these houses.
- These houses require fewer resources compared to building two separate houses.

c. *Why this technology?*

This technology is effective in protecting against strong cyclonic winds and storm surges. Additionally, it conserves land and promotes closer relationships between two families residing in the attached houses.

d. *SWOT analysis:*

Strength	Weakness	Opportunity	Threat
▪ Cost-effective: Requires less expenditure compared to building two separate houses. ▪ Creates a substantial structure effective in resisting strong winds. ▪ Requires less land than constructing separate houses.	▪ Potential reduction in privacy for the two families due to the shared structure. ▪ Possibility of creating conflicts or disagreements among the two families. ▪ In the event of a fire, if one house catches fire, the adjacent house may also be affected.	▪ Enhances family relationships and fosters social cohesion between the two households. ▪ Particularly advantageous considering the decreasing availability of homestead land.	▪ Risks associated with diminished privacy and potential conflicts between the families. ▪ Increased vulnerability to fire hazards where one house's mishap may affect the other due to their shared structure.

Improve the knowledge

- Install deeply rooted pillars at the foundation of the house to significantly bolster its strength and stability.
- Construct the house on a high-raised homestead platform to elevate it from ground level, adding an extra layer of protection against flooding and enhancing its resilience.

- Secure the house by tying it to disaster-resilient trees or concrete pillars, providing additional support and fortification against strong winds and natural disasters.
- Raise awareness among the community about the advantages of attached houses, encouraging them to adopt this architectural pattern for their new houses. Highlight the benefits and positive outcomes to inspire individuals to follow this construction model, emphasizing its strength, durability, and suitability in mitigating various environmental risks.

Conclusions

The study delves into indigenous knowledge and practices related to housing technology prevalent in Bangladesh, particularly in the vulnerable coastal regions susceptible to frequent natural disasters and climate change effects. These indigenous practices encompass various techniques such as raised homestead platforms, deep-rooted pillars supporting the house, employing heavy weights at roof corners during cyclone seasons, securing roofs with crossbeams, wooden pillars, or pegs, planting disaster-resilient trees around houses, utilizing lightweight materials for houses to mitigate riverbank erosion, and constructing attached houses for increased resilience against cyclones and storm surges. However, despite their effectiveness, these local practices often remain unknown outside their respective communities, emphasizing the need to uncover and disseminate these techniques widely. The primary obstacle lies in the lack of proper documentation, necessitating immediate efforts to comprehensively document these practices across technical, cultural, social, and economic dimensions for effective integration into disaster risk reduction strategies.

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References

Anisimov, O. A., Vaughan, D. G., Callaghan, T. V., Furgal, C., Marchant, H., Prowse, T. D., ... & Walsh, J. E. (2007). Polar regions (arctic and antarctic). *Climate change*, 15, 653-685.

BBS (Bangladesh Bureau of Statistics) (2012) *Community Report Patuakhali Zila*. Statistics and Informatics Division Ministry of Planning.

Biswas, A. K. M. A. A., Sattar, M. A., Hossain, M. A., Faisal, M., & Islam, M. R. (2015). An internal environmental displacement and livelihood security in Uttar Bedkashi Union of Bangladesh. *Science and Education*, 3(6), 163-175.

Boven, K., & Morohashi, J. (2002). *Best practices using indigenous knowledge* (pp. 12-13). The Hague: Nuffic.

Cavestro, L. (2003). *PRA-participatory rural appraisal concepts methodologies and techniques.* Padova University. Padova PD. Italia.

Chang, H. H., & Huang, W. C. (2006). Application of a quantification SWOT analytical method. *Mathematical and computer modelling,* 43(1-2), 158-169.

Community Based Disaster Risk Reduction Project (DIPECHO-V) (2010). *Indigenous Knowledge and Practices on Mitigation in the Upazilas of Mirzagonj and Pathargata*.

Dekens, J. (2007). *Local knowledge for disaster preparedness: A literature review.*

Disaster Profile, Bangladesh (2014). Centre for Research on the Epidemiology of Disasters (CRED). Emergency Events Database EM-DAT. Available: http://www.emdat.be/result-country-profile. (28 May, 2014).

Gratani, M., Butler, J. R., Royee, F., Valentine, P., Burrows, D., Canendo, W. I., & Anderson, A. S. (2011). Is validation of indigenous ecological knowledge a disrespectful process? A case study of traditional fishing poisons and invasive fish management from the Wet Tropics, Australia. *Ecology and Society,* 16(3).

Green, D., Billy, J., & Tapim, A. (2010). Indigenous Australians' knowledge of weather and climate. *Climatic change*, 100(2), 337-354.

Grenier, L. (1998). *Working with indigenous knowledge: A guide for researchers*. idrc.

Gurl, E. (2017). *SWOT analysis: A theoretical review*.

Hawkins, R. (2009) Rural Appraisal Methods- Approaches. ICRA Learning Materials (www.icra-edu.org)

Hazards in Bangladesh (2009). *National Plan for Disaster Management, 2010-2015.* Disaster Management Bureau, Disaster Management and Relief Division, Ministry of Food and Disaster Management, Bangladesh Disaster. p.15.

Faisal, M., Saha, M. K., & Biswas, A. M. A. A. (2024). Risk Analysis of Climate Induced Disaster in Coastal Bangladesh: Study on Dashmina Upazila in Patuakhali District. *International Journal of Disaster Management*, 6(3), 355-368.

Faisal, M., Saha, M. K., Sattar, M. A., Biswas, A. M. A. A., & Hossain, M. A. (2021). Evaluation of climate induced hazards risk for coastal Bangladesh: a participatory approach-based assessment. *Geomatics, Natural Hazards and Risk*, 12(1), 2477-2499.

Hiwasaki, L., Luna, E., & Shaw, R. (2014). Process for integrating local and indigenous knowledge with science for hydro-meteorological disaster risk reduction and climate change adaptation in coastal and small island communities. *International journal of disaster risk reduction,* 10, 15-27.

Hiwasaki, L., Luna, E., Syamsidik, & Marçal, J. A. (2015). *Local and indigenous knowledge on climate-related hazards of coastal and small island communities in Southeast Asia. Climatic Change*, 128, 35-56.

Hodder, I. (2012). The Present Past: An Introduction to Anthropology for Archeologists. Pen and Sword.

Ikeda, N., Narama, C., & Gyalson, S. (2016). Knowledge sharing for disaster risk reduction: Insights from a glacier lake workshop in the Ladakh region, Indian Himalayas. *Mountain Research and Development,* 36(1), 31-40.

Iloka, N. G. (2016). Indigenous knowledge for disaster risk reduction: An African perspective. *Jàmbá: Journal of Disaster Risk Studies*, 8(1), 1-7.

Kelman, I. (2010). Hearing local voices from small island developing states for climate change. *Local Environment*, 15(7), 605-619.

Kelman, I., Mercer, J., & Gaillard, J. C. (2012). Indigenous knowledge and disaster risk reduction. *Geography*, 97(1), 12-21.

Kurnio, H., Fekete, A., & Garschagen, M. (2017). Tribal indigenous knowledge of tsunamic hazard prone areas in disaster reducing risk with particular study on Simeuleu Island Aceh and other islands offshore west of Sumatra.

Kurnio, H., Fekete, A., Naz, F., Norf, C., & Jüpner, R. (2021). Resilience learning and indigenous knowledge of earthquake risk in Indonesia. *International Journal of Disaster Risk Reduction*, 62, 102423.

Kurnio, H., Fekete, A., Naz, F., Norf, C., & Jüpner, R. (2021). Resilience learning and indigenous knowledge of earthquake risk in Indonesia. *International Journal of Disaster Risk Reduction*, 62, 102423.

McAdoo, B. G., Dengler, L., Prasetya, G., & Titov, V. (2006). Smong: How an oral history saved thousands on Indonesia's Simeulue Island during the December 2004 and March 2005 tsunamis. *Earthquake Spectra, 22(3_suppl), 661-669.*

Meyers, K., & Watson, P. (2005). Legend, ritual and architecture on the ring of fire. Indigenous Knowledge for Disaster Risk Reduction, 17.

Mukherjee, A., Faisal, M., & Saha, M. K. (2020). Measuring Resilience of Urban Slum to Climate Induced Disasters: A Study on Barishal City Corporation, Bangladesh. *International Journal of Disaster Management*, 3(2), 34-47

Nazarea, V. D. (2006). Local knowledge and memory in biodiversity conservation. Annu. Rev. Anthropol., 35(1), 317-335.

Poudyal Chhetri, M. B. (2001). A Practitioner's view of disaster management in Nepal: organisation, system, problems and prospects. *Risk Management*, 3, 63-72.

Rahman, A., Sakurai, A., & Munadi, K. (2017, February). Indigenous knowledge management to enhance community resilience to tsunami risk: lessons learned fromSmongtraditions in Simeulue island, Indonesia. *In IOP Conference Series: Earth and Environmental Science* (Vol. 56, p. 012018). iop Publishing.

SAARC Disaster Management Centre (2009). Indigenous Knowledge for Disaster risk Reduction in South Asia. New Delhi.

Saha, M. K., Biswas, A. A. A., & Faisal, M. (2024). Livelihood vulnerability of coastal communities in context of the climate change: A index-based assessment. *World Development Sustainability*, 4, 100152.

Sethi, S. N., Sundaray, J. K., Panigrahi, A., & Chand, S. (2011). Prediction and management of natural disasters through indigenous technical knowledge, with special reference to fisheries.

Sevkli, M., Oztekin, A., Uysal, O., Torlak, G., Turkyilmaz, A., & Delen, D. (2012). Development of a fuzzy ANP based SWOT analysis for the airline industry in Turkey. *Expert systems with Applications*, 39(1), 14-24.

Sharma, R. (2021). Community Based Flood Risk Management: Local Knowledge and Actor's Involvement Approach from Lower Karnali River Basin of Nepal. *Journal of Geoscience and Environment Protection*, 9(6), 35-65.

Shaw, R., Sharma, A., & Takeuchi, Y. (2009). *Indigenous knowledge and disaster risk reduction: From practice to policy*. Nova Science Publishers, Inc..

Shaw, R., Uy, N., & Baumwoll, J. (Eds.). (2008). *Indigenous knowledge for disaster risk reduction: Good practices and lessons learned from experiences in the Asia-Pacific Region*. United Nations, International Strategy for Disaster Reduction.

Smith, P. J., Brown, S., & Dugar, S. (2017). Community-based early warning systems for flood risk mitigation in Nepal. *Natural Hazards and Earth System Sciences*, 17(3), 423-437.

Yani, A., Widaningsih, L., & Rosita, R. (2016). Rumah Panggung in Kampung Naga, West Java, Indonesia and Minka Gassho Zukuri in Shirakawa-go, Japan: The Local Wisdom of Traditional Houses in Mitigating Earthquake. *TAWARIKH*, 7(2).

Zulfadrim, Z., Toyoda, Y., & Kanegae, H. (2019). The integration of indigenous knowledge for disaster risk reduction practices through scientific knowledge: cases from Mentawai islands, Indonesia. *International Journal of Disaster Management*, 2(1), 1-12.