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A study on hydro-meteorological disaster risk reduction strategies of Rakhine ethnic minorities of Bangladesh

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ABSTRACT

This study investigates the disaster risk reduction (DRR) strategies of the Rakhine ethnic minority in coastal Bangladesh, highlighting the role of indigenous knowledge and culturally specific practices in enhancing community resilience to hydro-meteorological hazards. Despite their vulnerability to frequent cyclones, tidal surges, and flooding, the Rakhine community has developed adaptive strategies rooted in traditional knowledge, communal governance, and resilient infrastructure. Utilizing Scopus AI, this study identified four key themes—local knowledge, community engagement, dynamic adaptation, and governance—to structure data collection and analysis, providing a targeted exploration of the Rakhine's DRR practices. Data from key informant interviews, focus group discussions, and field observations reveal that Rakhine resilience is bolstered by indigenous forecasting methods, temple-centered disaster preparedness, and adaptive housing designs. Comparative analysis with national and international DRR frameworks suggests that incorporating such localized strategies into formal policies could enhance the inclusivity and effectiveness of disaster management systems. This research underscores the importance of culturally embedded DRR practices, advocating for a policy shift towards models that recognize and integrate the adaptive capacities of marginalized communities.

1. Introduction

Bangladesh is highly vulnerable to hydro-meteorological hazards, with its unique geographic and climatic conditions exacerbating the impacts of climate change. Increasingly frequent and severe events such as cyclones, floods, and rising sea levels threaten the country's coastal regions, which account for a significant proportion of disaster-related losses worldwide (Azad & Pritchard, 2023; Sony et al., 2023; Yu et al., 2024). These hazards pose particular risks to rural and ethnic communities (Ryan et al., 2020; Sony et al., 2025), who often rely on natural resources and traditional knowledge practices for their livelihoods. According to Medeiros (2021), traditional knowledge is a dynamic, community-based system of cultural and environmental understanding passed down orally through generations. At this point, DRR strategies have become essential in addressing these vulnerabilities (Shiroshita et al., 2024), with frameworks such as the Sendai Framework for

Disaster Risk Reduction (SFDRR) (2015–2030), advocating for a comprehensive, community-centered approach (Khan & Mishra, 2022; Roy et al., 2023).

The SFDRR underscores the value of indigenous knowledge systems in DRR, which refers to the locally developed skills, practices, and technologies used to manage natural resources and maintain the health of humans and animals (Mistry, 2009), calling for their integration to enhance resilience and support sustainable development goals, particularly in vulnerable and marginalized communities (Nohrstedt et al., 2022). Despite this, the integration of indigenous DRR strategies within national frameworks in Bangladesh remains limited (Khan & Mishra, 2022; Rashid et al., 2023), particularly for ethnic minorities like the Rakhine. Thus, studying the Rakhine community's DRR practices not only addresses a critical gap in DRR research but also aligns with global DRR priorities (Khan & Mishra, 2022), offering insights that could strengthen resilience policies for marginalized communities.

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Moreover, indigenous knowledge plays a critical role in DRR (Roy et al., 2022), particularly among communities that have historically faced environmental hazards. Embedded within the cultural practices, social structures, and adaptive behaviors of ethnic minorities, this knowledge provides valuable strategies for risk management that often complement scientific approaches (Roy et al., 2022; Sony et al., 2025). Globally, indigenous communities have developed unique coping mechanisms involving environmental cues, resource management, and communal support systems (Wang et al., 2019). DRR research in Bangladesh, however, has predominantly focused on mainstream communities (Sony et al., 2023), overlooking the unique contributions of ethnic minorities like the Rakhine people, a Buddhist group residing along the coastal areas of Patuakhali and Cox's Bazar (Islam et al., 2020).

While several studies (i.e., Roy et al. (2022); Shiroshita et al. (2024); Wang et al. (2019)) highlight the effectiveness of community-based DRR approaches, the specific practices of ethnic minorities remain underexplored in both national research and policy. The Rakhine's locally embedded DRR strategies offer a culturally grounded approach to disaster resilience (Rahman et al., 2021, 2022), yet they remain understudied despite the community's growing vulnerability to hydro-meteorological hazards. Addressing this gap, the current study examines the DRR strategies of the Rakhine to enhance understanding of how these culturally specific practices can inform and strengthen broader resilience frameworks.

Furthermore, in line with the SFDRR's call to incorporate indigenous knowledge into formal DRR policies (Khan & Mishra, 2022), this study aims to document and analyze the Rakhine's unique DRR practices (Rahman et al., 2022), thereby providing valuable insights for more inclusive national and international frameworks. Specifically, following earlier studies (e.g., Rahman et al. (2021); Rashid et al. (2023); Roy et al. (2022); Sony et al. (2023); Yu et al. (2024)) this research seeks to examine how cultural organizations, communal leadership, and traditional coping mechanisms contribute to the Rakhine community's resilience. By investigating these strategies, the study also seeks to address broader DRR objectives, including the Sustainable Development Goals (SDGs) that prioritize inclusive resilience and social equity (Khan & Mishra, 2022). This approach supports the view that understanding and valuing indigenous knowledge was essential for building sustainable resilience within vulnerable populations (Islam et al., 2020; Rahman et al., 2021; Wang et al., 2019).

This study contributes to the literature on DRR by positioning the Rakhine community's practices as a model for culturally integrated disaster management strategies. Using qualitative methods—such as key informant interviews, focus group discussions, and direct observations—this research have shed light on a comprehensive overview of the Rakhine's adaptive behaviors and risk management practices. In doing so, it not only addresses the current gap in DRR literature concerning ethnic minorities but also offers a framework for future comparative studies on indigenous resilience strategies. The findings have the potential to inform DRR policies in Bangladesh and similar regions, where cultural considerations and community-driven approaches have increasingly recognized as critical components of effective disaster management (Wang et al., 2019).

2. Literature review

Research on DRR increasingly recognizes the value of indigenous knowledge and community-based practices as essential components of resilience frameworks. Indigenous communities worldwide rely on culturally specific methods to manage environmental risks, incorporating unique early-warning systems, resource management practices, and communal support networks (Rahman et al., 2021). For example, indigenous groups in the Philippines (Lawangen & Roberts, 2023) and sub-Saharan Africa (Guodaar et al., 2023) use environmental cues, such as animal behaviors and seasonal changes, as natural early-warning indicators for hazards like typhoons and droughts. In Zimbabwe, for

instance, local communities interpret cloud formations and changes in bird migration patterns as warnings of impending droughts (Nyahunda et al., 2024), while similar practices in the Pacific Islands involve using ocean currents and wind shifts to anticipate storms (Weir & Kumar, 2020). Although these localized practices enhance preparedness and are often highly effective, formal DRR frameworks in many regions tend to prioritize technological solutions, often marginalizing the role of culturally embedded knowledge systems (Shaw et al., 2021; Shiroshita et al., 2024).

In Bangladesh, DRR efforts have primarily concentrated on mainstream communities in coastal and flood-prone areas, focusing on technology-driven approaches such as early-warning systems, cyclone shelters, and community training initiatives (Khan & Mishra, 2022; Sony et al., 2023). These strategies have contributed to reducing disaster impacts in highly vulnerable regions (Khan & Mishra, 2022), but the adaptation of such practices often overlooks the unique needs and contributions of ethnic minorities, such as the Rakhine people (Islam et al., 2020; Rahman et al., 2022). The Rakhine, a Buddhist ethnic minority with distinct cultural practices, rely on traditional approaches to disaster preparedness, including temple-based governance and indigenous architectural adaptations (Islam et al., 2020). Similar to flood-adapted housing in Cambodia (Yang et al., 2024) and elevated stilt houses in Vietnam (Taki & Doan, 2022), the Rakhine construct “Tong houses” that are raised on stilts to mitigate flood damage, a practice rooted in both cultural significance and practical disaster resilience (Rahman et al., 2021, 2022). However, the DRR strategies of the Rakhine community are seldom incorporated into national policies (Rahman et al., 2022), underscoring a significant gap in recognizing the contributions of ethnic minorities to Bangladesh's overall resilience framework.

To address this gap, the present study utilized Scopus AI technologies, a novel methodological approach, to analyze existing literature and identify thematic connections relevant to the Rakhine's DRR strategies. Scopus AI helped to isolate four core themes—local knowledge, community engagement, dynamic adaptation, and governance—which structured the investigation and guided the data collection and analysis (Fig. 1). This AI-assisted thematic identification underscores the study's innovative approach, as it enhances the rigor of the conceptual framework by aligning it with established gaps in DRR literature. Each theme reflects a distinct aspect of the Rakhine's adaptive practices and informs the study's exploration of their unique resilience strategies.

The first theme, local knowledge, refers to the unique understanding, skills, and beliefs that a community develops over time through direct experience and interaction with its environment (Roy et al., 2022), captures the Rakhine community's reliance on traditional forecasting methods, indigenous technology, and intergenerational wisdom as foundations for disaster preparedness. Similar practices have observed among indigenous communities in regions like the Pacific Islands (Hiwasaki et al., 2014), where local knowledge of ocean patterns



Powered by Scopus AI, Mon Mar 25 2024

Fig. 1. Conceptual mapping on disaster risk reduction strategies (Source: Author produces from Scopus AI).

informs evacuation plans, and in Guatemala, where volcanic activity has monitored through locally developed indicators (Lohse et al., 2018). This reliance on locally embedded knowledge offers low-cost, accessible methods for early warning, contrasting with technology reliant DRR systems in wealthier nations (Rahman et al., 2021; Roy et al., 2018).

Community engagement, the second theme, reflects the collective resilience mechanisms within the Rakhine community, including temple-centered gatherings and collaborative disaster planning (Islam et al., 2020). These culturally embedded structures are not unique to the Rakhine; similar approaches are seen in Nepal and India, where religious and cultural gatherings play a vital role in organizing community support during natural hazards (Karki et al., 2022; Wani et al., 2022). In the Rakhine context, temples serve as central spaces for both spiritual and practical mobilization, facilitating information sharing and resource distribution (Tun, 2015). This contrasts with the more secular, government-led DRR frameworks that lack the social cohesion found in community-centered models (Albris et al., 2020; Roy et al., 2023).

Dynamic adaptation captures the Rakhine's flexible responses to changing environmental conditions, from adaptive housing designs to migration practices during severe cyclones (Roy et al., 2022; Sony et al., 2023). Studies on disaster-prone regions, such as the Pacific Islands and Indonesia, have shown that communities employ architectural adaptations—such as elevating homes on stilts or building with flood-resistant materials—to mitigate the impact of frequent flooding (Azad & Pritchard, 2023; Hiwasaki et al., 2014; Timperio et al., 2020). This theme in the Rakhine context highlights how indigenous infrastructure serves both functional and cultural roles (Roy et al., 2022), offering valuable insights for DRR frameworks aiming to integrate traditional and contemporary resilience strategies (Islam et al., 2020).

Finally, governance within the Rakhine community is facilitated through both religious and secular leaders, who coordinate disaster preparedness and recovery efforts (Islam et al., 2020; Tun, 2015). This decentralized governance structure promotes rapid response, adaptability, and collective trust (Sony et al., 2023), aligning with governance models observed among indigenous communities in places like Canada, where tribal leaders play central roles in DRR efforts (Albris et al., 2020; Foster-Sanchez & McGee, 2024; Heim & Charles, 2024). The active involvement of women in the Rakhine's DRR practices—particularly in resource management and information dissemination (Azad & Pritchard, 2023)—further illustrates the community's inclusive approach, which may serve as a model for DRR frameworks seeking to enhance resilience through equitable, community-based governance (Islam et al., 2020; Roy et al., 2022; Shiroshita et al., 2024).

By structuring the literature around these four themes identified through Scopus AI, this study establishes a comprehensive framework that situates the Rakhine's DRR practices within the broader landscape of culturally inclusive DRR strategies. This approach not only aligns with international findings on indigenous resilience but also addresses critical gaps in DRR research by emphasizing the value of culturally specific strategies in building sustainable resilience.

3. Methodology

3.1. Population, study context and scope

Historically, the Rakhine migrated from the Arakan region following periods of political upheaval and mass violence, with large waves of refugees resettling in Cox's Bazar and Patuakhali under British administration in the late 18th and early 19th centuries. Early colonial records indicate that between 14,000 and 50,000 Rakhine refugees were rehabilitated in these coastal areas, forming the core of the present-day Rakhine settlements in Bangladesh (Hasan, 2021). Today, Rakhine communities remain concentrated in villages such as *Khuruskul*, *Chowfaldandi*, *Ramu*, and *Kuakata*—areas that reflect their long-standing dependence on coastal resources and their exposure to climate-sensitive ecosystems (Hasan, 2021). Their traditional stilted

houses, distinct linguistic heritage, and temple-centered village structure illustrate a well-preserved cultural identity that shapes both social organization and disaster-related practices (Islam et al., 2020; Parmar et al., 2019). Unlike the majority Muslim population in Bangladesh, the Rakhine practice Theravada Buddhism, with temples serving as cultural and spiritual centers that play an integral role in community governance and social cohesion (Tun, 2015). Their coastal settlements place the Rakhine at high risk of hydro-meteorological hazards, including cyclones, tidal surges, and flooding, which have further exacerbated by the impacts of climate change (Islam et al., 2020).

With livelihoods centered around fishing, agriculture, and small-scale trade, the Rakhine people face severe socio-economic challenges when natural hazards strike (Tun, 2015). These vulnerabilities have led the Rakhine to develop indigenous strategies for disaster preparedness and recovery, which have interwoven with their cultural traditions. For example, they construct “Tong houses,” elevated on stilts to withstand flooding, and employ traditional forecasting methods to anticipate storms (Islam et al., 2020; Rahman et al., 2021). Despite the relevance of these practices, the Rakhine's disaster resilience strategies remain largely undocumented in formal research and have not incorporated into national DRR policies, pointing to a critical gap in understanding their unique contributions to disaster management (Islam et al., 2020).

3.2. Research design and data collection

This investigation has implemented a qualitative research design to investigate the culturally embedded DRR practices of the Rakhine people, in accordance with the study conducted by Sony et al. (2023), which advocates for a qualitative approach to community-based DRR research. Through focus group discussions (FGD), key informant interviews (KII) and field observations, the study seeks to capture the perspectives and experiences of Rakhine community members in managing disaster risks. However, with the help of an FGD guidelines and an open-ended interview guideline the researchers of this study have visited the study are three times between February 2023 and July 2023. And each field visits have lasted four days and five nights. Purposive sample procedures were utilized in the study to choose KII respondents, while simple random sampling was used for FDG participants. The unit of analysis for this study includes individuals from the Rakhine ethnic minority community in the Kuakata of Patuakhali district of the coastal Bangladesh, specifically targeting adults aged 25 and above who possess significant experience in disaster risk management. This demographic encompasses community leaders, elders, and residents with lived experience in disaster response, ensuring insights into both traditional practices and collective strategies used in DRR. This design was well-suited for examining the complexities of community-specific practices and provides rich insights into the socio-cultural underpinnings of Rakhine resilience strategies.

The researcher conducted six FGDs to gather community-level information on disaster preparedness, responses, and coping activities. The study involved 37 participants, mainly farmers, fishermen, small businessman, housewives, and day laborers, with an average age of 41. The sessions were conducted at convenient locations, such as tea stalls and home yards, and participating in the season was voluntary and open. Some participants left immediately after the beginning of sessions, while whole FGD lasted between 45 min and 1 h. Further, by using 9 KIIs, the researcher has some key information about the Rakhine people's disaster management techniques. Religious leaders, community leaders, and senior members of the Rakhine community made up the responders for KII. The researchers will also employ notebooks, pens, and voice recorders in addition to interview guides. For respondents who are unable to understand Bengali, the researcher requested the help of a volunteer to interpret conversation during the data collection process.

3.3. Analytical framework and thematic analysis

Data analysis was guided by the four core themes identified through Scopus AI: local knowledge, community engagement, dynamic adaptation, and governance. These themes provided a structured analytical framework for coding and interpreting the qualitative data from interviews, FGDs, and observations. NVivo software was used to organize the data and facilitate thematic synthesis, ensuring consistency and transparency in the analysis process. To further clarify the study's findings, a Code Summary Table (Table 1) was developed, detailing the frequency and percentage of responses associated with each theme and sub-code. For instance, "indigenous knowledge" was mentioned in 14.24% of responses, supporting the importance of traditional practices within the "local knowledge" theme. The table provides a quantitative overview of the themes, supported by relevant literature, which validates the Rakhine community's contributions to disaster resilience and contextualizes the findings within broader DRR research.

3.4. Ethical standards and confidentiality

Ethical guidelines were strictly observed throughout the study to ensure respect for the rights and dignity of the Rakhine participants. All participants were informed of the study's purpose, the voluntary nature of their participation, and confidentiality measures. Verbal consent was obtained from each participant, who was assured of their right to withdraw at any point in the study. To protect anonymity, personal identifiers were removed from transcripts, and findings have reported in a manner that preserves participant confidentiality.

Table 1
Code summary table of the study and the code supporting literatures

Themes	Codes	Frequency of responses	Percentage of the responses	Code supporting literatures
Local Knowledge	Indigenous knowledge	46	14.241	(Hiwasaki et al., 2014; Lohse et al., 2018; Rahman et al., 2021; Roy et al., 2018)
	Disaster Preparedness	27	8.359	
	Indigenous Technology	5	1.548	
	Technological advancements	16	4.954	
	Traditional forecasting methods	18	5.573	
	Wisdom passed down through generations	25	7.740	
	Change in traditional coping mechanism	11	3.406	
	Community engagement			
	Collaborative action	47	14.551	(Albris et al., 2020; Karki et al., 2022; Roy et al., 2023; Wani et al., 2022)
Dynamic actions	Collective risk analysis	27	8.359	
	Perception of disaster	11	3.406	
	Vulnerability	16	4.954	(Azad & Pritchard, 2023; Timperio et al., 2020)
Governance	Migration	2	0.619	
	Leadership	13	4.025	(Albris et al., 2020; Foster-Sanchez & McGee, 2024; Heim & Charles, 2024)
	Gender roles	11	3.406	
	Resilience	48	14.861	
	Total	323	100	

(Source: Author produces)

3.5. Methodological contributions and innovations

This study's methodology makes notable contributions to DRR research by leveraging Scopus AI to refine the study's thematic framework, offering a data-driven basis for identifying gaps in literature. The AI-driven analysis allowed for a focused literature review that guided theme selection, ensuring that the study's framework was evidence-based and tailored to the unique DRR challenges faced by the Rakhine. Additionally, the qualitative design, combining KIIs, FGDs, and field observations, provides a holistic view of Rakhine DRR practices, capturing the intricate dynamics of individual, communal, and institutional resilience strategies. This comprehensive approach underscores the study's alignment with international calls for culturally inclusive DRR frameworks, demonstrating the potential for indigenous knowledge to inform and strengthen national resilience strategies.

4. Findings: DRR strategies of Rakhine ethnic minorities

The overall findings of this study indicate that Rakhine was a family-driven, kinship-based culture where social interaction patterns were originally formed by collectivism. For instance, the study's code summary (refer to Table 1) notes that indigenous knowledge (14%) was deemed important as well as collaborative actions. With about 15% responses, collaborative action also shown up, highlighting its critical role in catastrophe resilience. Moreover, the examination revealed 8% responses pertaining to "Collective Risk Analysis", highlighting its importance in anticipatory approaches to catastrophe reduction. Resilience and disaster preparedness, two topics linked to governance, attracted a lot of attention 8% and 14% replies, respectively. To effectively address disaster risks and improve resilience in vulnerable communities, it was crucial to harness local knowledge, promote community engagement, and implement proactive leadership strategies. These points have highlighted by the statistical data, which also emphasizes the complex nature of disaster prevention and response. The following subsections present additional details regarding Rakhine's DRR initiatives.

4.1. Local knowledge

The findings reveal that certain elderly members of Rakhine society, respected for their accumulated wisdom, can anticipate weather patterns based on environmental indicators rooted in long-standing experience. These individuals observe signs such as variations in sky color, shifts in wind direction, and unusual animal behaviors to predict adverse weather. For example, a reddish hue in the western sky before a storm, combined with northeastern winds that abruptly calm, is interpreted as signaling a potential cyclone. Additionally, behavioral anomalies in animals serve as critical signals; on the day before a severe weather event, "Sayori" fish (*Hyporhamphus sajori*) may leap from the water, and foxes along the shoreline are known to bark. Such practices exemplify the Rakhine's reliance on local knowledge to detect and prepare for environmental threats. On this a respondent stated that,

During hazards, we continue to rely on conventional predicting techniques; the way animals behave, the direction of the wind, and the color of the sky direct us, reflecting the knowledge accumulated over many generations. (KII-1, 56 years, Community leader)

Although the young Rakhine people no longer follow this technique, it was a pre-cautionary tactic taught to them by their forefathers. Compared to their archaic methods, they can now foresee hazards with more ease and effectiveness thanks to TV, radio, newspapers, union councilors, and various electronic media. Similar to the common people of Bangladesh, nowadays the Rakhine people use social media, have cautious of news, and follow government warning systems as ways to cope with hazards. On this point a respondent further mentioned that,

Disaster awareness used to be distributed by local elders, but more recently, union parishad warnings, radio, and television have grown more common. These days, chain of command systems have not as closely adhered to. (KII-1, 56 years, Community leader)

According to the majority of respondents, the Rakhine community employs a distinct form of disaster-resilient housing known as “Tong” houses, constructed on poles approximately ten feet above ground level. This elevated structure is an adaptive response to anticipated hazards, offering protection from floods, tidal surges, and wild animals. While Tong houses were traditionally made of wood with roofs crafted from thatch, tin, or *Golpata* (nipa palm leaves), more recent constructions use brick-stone walls and concrete poles to enhance durability. The design also includes open fencing on both sides, allowing airflow during storms, which reduces the risk of total structural collapse. This architectural approach not only serves practical resilience purposes but also preserves the Rakhine community's cultural heritage. For instance, a respondent emphasized,

Standing towering atop concrete poles, our tong homes have an ode to our ancestors' inventiveness and represent centuries of knowledge, protecting us from the fury of storms and floods ... When cyclone hits, we continue to rely on conventional predicting techniques; the way animals behave, the direction of the wind, and the color of the sky direct us, reflecting the knowledge inherited from previous generations ... Pitcher-preserving water and salt-preserving food—we maintain our customs in the face of modernity, fortifying ourselves against hazards with our tried-and-true Nappi cuisine and traditional preservation methods. (KII-3, 49 years, fisherman)

To increase the resilience of their Tong houses against cyclones and other natural hazards, the Rakhine community secures the structural poles by burying them deeply in the ground and reinforcing them with ropes tied to additional support poles. Many households also construct adjacent toilets to address sanitation needs during emergencies, particularly at night. Within their elevated Tong houses, the Rakhine traditionally store essential food grains and seeds in a compartment located beneath the roof, ensuring accessibility for cultivation after a disaster. In the past, women assembled portable, tin-covered stoves within these houses, allowing them to prepare meals during floods or tidal surges. They would gather food grains and cook directly on the Tong house floor using these stoves. As an additional food preservation strategy, they salted and dried fish to extend its shelf life. One staple, *Nappi*—a mixture of prawns and salt—served as a long-lasting source of protein and sustenance during crises. However, with increased access to refrigeration, reliance on these traditional preservation methods has lessened, though they remain an integral part of Rakhine cultural practices. Regarding this issue, another participant stated that,

We preserve our resistance against hazards through treasured traditions like our timeless Nappi cuisine and old preservation techniques, honoring our heritage in the face of modernity as we salt our food and meticulously keep water in pitchers. (FGD-4, 43 years, small businesswomen)

Traditionally, the Rakhine community sourced drinking water from ponds and collected rainwater in earthen pitchers, as these practices predated the introduction of tube wells. To preserve the purity of pond water, strict guidelines were followed: bathing, changing clothes, fishing, discarding waste, allowing animals into the water, or even touching the water with wet hands or feet were prohibited. During floods or tidal surges, the Rakhine would cut down the high walls of their ponds to allow surface salinity to drain out. Recognizing that surface water held a higher salt concentration, they would draw drinking water from deeper sections of the pond where the water remained fresher. Today, the Rakhine store rainwater in large plastic tanks and use tube wells to access drinking water, although these traditional water management practices remain part of their cultural heritage. In a line with this a

respondent mentioned,

Our Rakhine villages depend on nearby ponds and wells for their drinking water needs, so maintaining access to clean water was a major responsibility. We take pride in upholding strict sanitary regulations and making sure that every home has enough restroom facilities to protect the general public's health. The constant fight to safeguard our water supply and sanitation infrastructure was highlighted by the difficulties we confront in regions where our water sources have vulnerable to pollution or outside pressures. (KII-3, 37 years, youth leader)

The study's findings also indicate that while Rakhine community members currently visit hospitals and use prescription medications from modern healthcare providers, they traditionally relied on herbal treatments administered by *Kabirajs*—traditional healers who used natural ingredients for their remedies. During past disease outbreaks, the community would even call upon *Kabirajs* from Cox's Bazar or the Rakhine region in Myanmar. These traditional healers treated common ailments such as fever, cough, cuts, and skin irritations using local herbal preparations. However, the role of *Kabirajs* has significantly diminished as modern medical practices have become more prevalent, and skilled *Kabirajs* are now rare within the community.

Howsoever, many changes have been noted in the customary coping strategies of the Rakhine people. Their personal behavior, attire, and way of thinking have changed significantly as a result of modern technology, knowledge, and communication systems, and their enthusiasm in obtaining an education has grown. Together with the Bengali population, the government has created deep tube wells for fresh water, concrete *Tong* houses, and embankments that lessen the effects of severe calamities. They have also pursued alternative livelihood as a result of the advancement of roads and communication infrastructure. On this issue a respondent strongly stated that,

Rakhine people welcome change with resilience and inventiveness, propelled by a spirit of perseverance and directed by a dedication to advancement. We pave the way for sustainable adaptation by embracing new technology and gender-inclusive strategies, guaranteeing a better future for everybody. (KII-1, 56 years, Community leader)

A majority of those interviewed said that hazards like the cyclone Sidr (hits in 2007) and the cyclone Aila (hits in 2009) had increased their awareness of hazards. They now follow government recommendations and warnings during various hazards, which has decreased the number of people who die and lose property. The Rakhine community was an example of a proactive approach to disease prevention since they heed the advice and warnings given by doctors, government officials, and other authorities on sickness and hazards. People can stay informed on the most important health precautions thanks to their access to information through a range of media, such as the Internet, radio, television, and local government offices.

4.2. Community engagement

The findings indicate that the Rakhine community actively comes together for collective decision-making, often forming organizations aimed at protecting their rights and advocating for their needs. These organizations, primarily temple-based, serve as platforms through which the Rakhine voice their unique cultural and ethnic concerns to government authorities and the media. Typically led by respected elders and educated members, these groups provide guidance on major community issues. Furthermore, Rakhine individuals from various locations—including those living in Cox's Bazar or residing elsewhere for work—participate in these decisions, demonstrating the community's collaborative approach to addressing matters that impact the group. In this regards, a respondent said that,

Though we still have a deep religious commitment, we know that resilience and group effort have necessary for a full recovery. We go to our temples not only for comfort but also as representations of the power and cohesion of our community. (KII-9, 62 years, religious master)

The study's findings reveal a pragmatic approach within the Rakhine community when it comes to disaster preparedness, indicating that they do not rely solely on prayers or religious beliefs to mitigate risks or prepare for calamities. Collective prayers in anticipation of a disaster are rare; instead, most individuals engage in personal prayer within their homes to seek safety. However, during past epidemics, community members would gather with religious priests to pray for relief from illnesses, a tradition that has largely diminished among the younger generation. Today, it is primarily the elderly who occasionally visit the temple alone or in small groups for this purpose. As one respondent noted,

We have never linked religious beliefs to calamities, even if our faith was unwavering. As an alternative, we take comfort in the group prayers held at our Buddhist temples, where we pray for perseverance and fortitude in the face of hardship. We have a particular place in our hearts for our religious rituals, particularly in difficult times. Our faith gives us consolation and hope, whether it was through group prayers or private acts of devotion. (FGD-3, 37 years, housewife)

The findings also reveal that the Rakhine community actively preserves their cultural heritage through various practices. Most respondents continue to weave traditional garments, construct Tong houses, and maintain their native language, which they speak exclusively within the community. Education in their mother tongue holds significant value, with community members either hiring local instructors or designating temple members to teach students. Additionally, the Rakhine sustain elements of their cultural identity and generate income by selling traditional goods imported from Myanmar—such as chocolates, pickles, herbal medicines, clothing, and handicrafts—to tourists. This blend of cultural preservation and economic activity underscores the community's commitment to safeguarding their heritage while adapting to changing socioeconomic contexts.

4.3. Dynamic actions

The findings of this study reveal that the local Rakhine community maintains strong connections to Arakan State (also known as Rakhine State) in Myanmar. Many of their relatives, as well as their ancestors and descendants, still reside in Rakhine State. Most respondents believe that the Rakhine people originally migrated from Arakan (Rakhine State) to Bangladesh, settling in the coastal areas of Patuakhali and Cox's Bazar. However, due to frequent extreme natural events, a significant number of Rakhines who had lived in Bangladesh before the 1960s and 1970s relocated back to Rakhine State. Although migration has decreased following the construction of embankments, many still leave due to persecution by powerful local individuals in Myanmar, who may seize their land or exert other forms of control. Additionally, many Rakhine individuals have temporarily moved to other regions for educational and employment opportunities.

According to participants' accounts, changing economic conditions and limited livelihood opportunities have influenced work patterns within the Rakhine community. Several respondents noted that some men in the community tend to engage less in physically demanding agricultural labor, preferring alternative or less intensive forms of income generation. This perception was often expressed through the phrase, "Rakhine use their brains instead of their bodies," which, as participants explained, reflects a cultural preference for work perceived as strategic or skill-based rather than purely physical. Historically, the Rakhine practiced shifting cultivation—clearing forested land, planting

once, and harvesting multiple times before moving to new plots. However, this practice has become increasingly unsustainable, contributing to growing economic vulnerability and reduced agricultural productivity in recent years. A respondent emphasized associated with this point,

... The Rakhine community's socioeconomic profile shows that most people rely on labor, agriculture, and fishing, with very few running small enterprises ... But there have problems: diminishing agricultural fields from encroachment and problems with land ownership ... With increased preparedness for calamities, migration rates—which were formerly high—have dropped. The community's savings habits have still uneven in spite of advances in education. (KII-5, 57 years old, clan leader)

This study also uncovered additional vulnerabilities within the Rakhine community, such as land grabbing by a few powerful local individuals, which has contributed to their reduced interest in agriculture. Furthermore, it was observed that the Rakhine people generally avoid adopting specialized farming or planting techniques. This tendency is partly influenced by their close-knit social relationships. For instance, if young individuals lose their jobs, their parents typically provide financial support, as elderly family members often retain control over the family's wealth until their death, without relying on the income of their children. The study further found that both joint and nuclear family structures exist within the Rakhine community. However, most respondents noted that, due to career demands, schooling, relocation, and other factors, their families are becoming increasingly nuclear. Moreover, while the community once prioritized their own language and religious education, there has been a noticeable shift toward mainstream education in recent years. On this point a respondent stressed,

Children from Rakhine communities attend school in *Path Sala* [religion-based education center], where local educators teach them both language and religion. Language preservation initiatives continue as the younger generation embraces formal education, with imported books from Myanmar assisting in language acquisition. Academic progress indicates a movement in the community toward modernity. (FGD-1, 39 years, fisherman)

In recent years, the Rakhine community has increasingly sent their children to conventional schools for general education, recognizing that education is key to improving their future prospects. Many individuals leave their the study area to seek employment or continue their education, often relocating to cities or other rural areas for better opportunities. While wealthier older individuals also leave the community in search of greater prospects, the migration rate among younger people has been notably higher. This shift reflects the growing importance placed on education and career advancement, driving many Rakhine individuals to seek opportunities beyond their local area.

4.4. Governance

The governance system within the Rakhine community has undergone significant transformation, reflecting both historical structures and contemporary shifts. Traditionally, governance was centered around the *Matabbar* (the clan heads) who played a critical role in decision-making. These leaders held authority in resolving various issues, including judicial matters, and their decisions were widely accepted by the community. The governance framework was once supported by a clear chain of command; however, this structure has weakened over time. A key finding of the study is the increasing skepticism toward the *Matabbars'* decisions, particularly due to perceived biases in their rulings.

As a result, many members of the community, especially newer generations, have begun to seek resolutions through the formal administrative channels rather than relying on traditional clan heads. This shift is attributed to broader societal changes, including advancements in education, greater access to knowledge, and increased familiarity with modern technological tools. Respondents indicated that these

changes have contributed to a redefined approach to governance, where state authorities are now more frequently consulted for judicial and administrative matters. A respondent emphasized,

Our *Matabbars*, selected by popular vote, once led us through hazards with their resolute guidance....Our *Matabbars*' rulings were law at times of distress. However, as education grows, their impact decreases, and we turn to group efforts and official assistance to find answers. (FGD-3, 46 years old, small businessman)

The study also highlights the significant role that gender dynamics play in the Rakhine community's governance and decision-making processes. A key finding is the equitable distribution of wealth and resources between men and women, with no apparent gender-based bias. Both men and women participate equally in decisions regarding household responsibilities, business matters, and broader community issues. In contrast to many other contexts where gender discrimination may be more pronounced, the Rakhine community demonstrates a collaborative approach to decision-making within families. This inclusivity extends to disaster response as well, where, despite the general vulnerability of women and children due to factors such as physical limitations or lack of swimming skills, the Rakhine community has developed mechanisms to ensure all members, regardless of gender, are equally supported. One respondent remarked that in their community, during hazards, both men and women are given equal consideration in terms of safety and assistance, challenging common assumptions about gendered vulnerability. On this point another respondent stated that,

As we prepare for hazards, women—often unrecognized heroes—manage food preservation, water purification, and family safety. But in spite of the times, their achievements have still not fully recognized. (KII-5, 57 years old, clan leader)

The study also found that women in the Rakhine community played a central role in pre-disaster preparations. They were responsible for gathering food and water, cutting tin to build stoves, storing cooking utensils, and ensuring their proper distribution before and after a disaster. While the researcher did not encounter any *Hijras* (individuals of the third gender in Bangladesh) in the Patuakhali Rakhine community, some community members believed a person nearby was likely a *Hijra*. This individual was single, spoke, and moved in a way typically associated with women. However, the community viewed this behavior as a personal matter and did not engage in any discrimination or mistreatment. Importantly, the study found no evidence of gender-based discrimination against women in this community. The overall focus of the community appeared to be on equity, as emphasized by one respondent, who remarked that fairness and equal treatment were core values.

I have personal experience with gender roles in our community during times of tragedy because I am a husband and father. Men have responsible for making sure our families have safe and secure, while women work to maintain food and shelter. (FGD-1, 45 years, businessman)

Besides, the findings indicate a decline in farming and animal husbandry in the Rakhine community, primarily due to the labor-intensive nature of these practices and their limited profitability. As a result, many individuals have shifted toward occupations that are less physically demanding. While farming, fishing, and agriculture were once the main sources of income, people now also participate in various government and private sector jobs, engage in handicrafts, run hotels, and pursue other business ventures. According to most respondents, these diversified income sources have, therefore, enhanced the community's resilience to future challenges. Moreover, the study found that, in the aftermath of hazards, the Rakhine people have traditionally relied on community donations for recovery and reconstruction. In contrast, for longer-term sustainability, they now increasingly access micro-credit loans from NGOs to support new farming practices or business

endeavors. A respondent mentioned that,

Following a natural disaster, our community comes together and works tirelessly to reconstruct what was destroyed. Sometimes, we take loans from Sushilan, Asha, BRAC, Grameen Bank, (popular NGOs who provide micro-credit) and either we reconstruct our house or start a new business. (KII-3, 38 years, entrepreneur)

However, most respondents mentioned that they preferred loans from NGOs over bank loans, as the latter involve complex legal procedures. In addition, the study revealed that certain members of the Rakhine community, particularly those dependent on fishing for their livelihoods, often borrow money from *Mahajans*, traditional moneylenders, to support their sea fishing activities. These loans are repaid with the original loan amount plus 20% interest. Additionally, borrowers are required to give a portion of the fish they catch. Notably, moneylenders also assist fishermen who struggle to catch fish due to various calamities by providing fish and supplying essential goods such as grains, beans, and oil. This situation creates both resilience and vulnerability for the community, as the Rakhine fishing sector is caught in a vicious cycle of debt, making it difficult for many to break free from this dependency.

5. Discussion

This study has investigated the DRR strategies employed by the Rakhine ethnic minority in coastal Bangladesh, focusing on their indigenous knowledge, community-driven practices, and adaptive approaches. Guided by four core themes identified through Scopus AI—local knowledge, community engagement, dynamic adaptation, and governance—the findings reveal culturally embedded resilience strategies that both align with and diverge from mainstream DRR approaches. Supporting Islam et al. (2020) and Rahman et al. (2022), the findings of this study reveal that the Rakhine community's DRR practices have deeply rooted in indigenous knowledge, community cohesion, and adaptive governance, providing insights that both align with and diverge from mainstream DRR strategies. While many resilience studies emphasize technical and infrastructural approaches (Azad & Pritchard, 2023; Foster-Sanchez & McGee, 2024; Shaw et al., 2021), the Rakhine community relies on culturally specific strategies, demonstrating the potential of indigenous knowledge in complementing formal DRR frameworks. This unique focus on the DRR practices of ethnic minorities in Bangladesh highlights the study's novel contribution, as it addresses a gap in the literature by focusing on the role of culturally embedded DRR practices in enhancing disaster resilience.

One of the study's notable findings was the community's use of traditional environmental indicators, such as the behavior of animals and changes in wind direction, to anticipate cyclones and floods. This early-warning approach, grounded in the observation of natural cues, was similar to practices among indigenous groups in the Philippines (Dayrit et al., 2020; Lawangen & Roberts, 2023) and Zimbabwe (Nyahunda et al., 2024), where communities rely on environmental signs for disaster preparedness. Unlike mainstream DRR strategies that often depend on technological alerts (Khan & Mishra, 2022), the Rakhine's reliance on traditional indicators showcases the value of accessible and cost-effective warning systems that have readily adaptable in remote or resource-limited areas. This finding supports calls for the integration of indigenous early-warning practices within formal DRR frameworks, especially in contexts where conventional systems may not be accessible (Khan & Mishra, 2022; Roy et al., 2022; Sony et al., 2023).

Similarly, community engagement also emerged as a cornerstone of the Rakhine's DRR approach, with temple-based gatherings playing a central role in organizing disaster response. For example, before cyclones, Rakhine community members gather in temples to make collective decisions on evacuation routes, resource-sharing strategies, and post-disaster recovery actions. This approach contrasts with secular, state-led DRR models and reflects the Rakhine's integration of cultural

and religious structures into their disaster resilience framework (Albris et al., 2020; Roy et al., 2023). Studies on disaster-prone regions such as southwest coastal areas of Bangladesh also highlight the importance of community gathering places for mobilizing collective action (Roy et al., 2022, 2023), yet the Rakhine's use of religious spaces emphasizes the significance of culturally specific venues that foster trust and cooperation. These findings suggest that culturally embedded forms of community engagement can provide a model for DRR frameworks seeking to enhance resilience in diverse cultural settings.

Furthermore, the Rakhine's adaptive strategies, such as constructing and maintaining stilted Tong houses to prevent flood damage, further illustrate the community's capacity for dynamic adaptation. While housing adaptation was common in disaster-prone regions, the Rakhine's Tong houses reflect a unique, traditional architectural response that addresses both environmental risks and cultural values (Rahman et al., 2021, 2022). For example, in contrast to flood-resistant houses in Bangladesh's mainstream communities that use modern materials (Azad & Pritchard, 2023), Tong houses utilize indigenous materials and designs, providing resilience without sacrificing cultural identity. Similar to adaptation practices among Pacific Islander communities (Hiwasaki et al., 2014; Weir & Kumar, 2020), who elevate their homes to withstand rising sea levels, the Rakhine's use of Tong houses highlights the potential for integrating traditional architectural adaptations within broader DRR strategies.

Furthermore, the role of governance within the Rakhine community, particularly through local leadership and organized religious institutions, adds a distinctive layer to their DRR practices. Supporting Sony et al. (2023), it was also found that community leaders have often been responsible for coordinating resource distribution and communicating risk information, which strengthens local preparedness and fosters collective resilience. For example, local leaders take charge of coordinating food storage and other resources, ensuring that vulnerable members have access to support during and after hazards. This governance model contrasts with centralized DRR structures, allowing for rapid, flexible responses tailored to community-specific needs (Roy et al., 2022; Shaw et al., 2021; Wang et al., 2019; Wani et al., 2022). Moreover, the active involvement of women in organizing and implementing preparedness tasks—such as food storage, supply management, and emergency communications—demonstrates the adaptability of gender roles within the Rakhine's DRR strategies, an approach that may offer insights for inclusive resilience frameworks in other marginalized communities (Heim & Charles, 2024; Lawangen & Roberts, 2023; Rahman et al., 2022).

Overall, this study's innovative application of Scopus AI technologies to develop a thematic framework—centered on local knowledge, community engagement, dynamic adaptation, and governance—uniquely enriches the understanding of DRR strategies within the Rakhine community. Through AI-supported analysis, the study identified key research gaps and tailored the framework to emphasize underexamined aspects of Rakhine DRR practices, highlighting the essential role of culturally embedded approaches. This thematic organization not only facilitated a comprehensive analysis but also provided a replicable model for future research on indigenous DRR practices. The findings underscore the importance of integrating indigenous and community-specific DRR knowledge into formal disaster management policies, thus promoting a more inclusive and resilient approach to disaster management that respects and harnesses the unique strengths of ethnic minority communities.

5.1. Theoretical contributions and practical implications

This study advances theoretical understanding of DRR by emphasizing the centrality of indigenous knowledge and culturally embedded practices. By examining the Rakhine community's traditional approaches—such as localized early-warning systems, community-led governance, and culturally adapted housing designs—the research challenges conventional DRR models that often prioritize technological

solutions. Additionally, the application of Scopus AI for thematic analysis introduces a novel, data-driven approach to identifying research gaps and structuring conceptual frameworks, offering a replicable method for future qualitative research in DRR and social sciences.

Practically, these findings underscore the need for more inclusive DRR policies that incorporate culturally specific strategies. Policymakers can enhance resilience by integrating traditional knowledge, such as environmental forecasting methods, temple-based community gatherings, and adaptive infrastructure, into national DRR frameworks. Leveraging religious and communal spaces for preparedness activities may strengthen community cohesion and participation, while the active roles of Rakhine women in preparedness and recovery highlight the importance of gender-inclusive approaches. The Rakhine's adaptive housing designs, such as stilted structures and flood-resistant building techniques, suggest valuable insights for construction policies in disaster-prone areas. Together, these insights offer guidance for developing DRR initiatives that respect and utilize the unique strengths of diverse cultural groups.

5.2. Limitations and future research directions

This study, while providing valuable insights into the Rakhine community's DRR practices, has some limitations. The research relied on qualitative data from a specific ethnic minority in coastal Bangladesh, which may limit the generalizability of findings to other cultural or geographic contexts. Additionally, the study's reliance on self-reported data may introduce subjective biases, such as the references to land grabbing, which could not be independently verified within the scope of this research, as participants' accounts are shaped by their personal experiences and perspectives. Future research could benefit from a comparative approach, examining DRR practices across multiple ethnic communities to identify shared and unique resilience strategies. Quantitative methods, such as surveys or longitudinal studies, could also enhance understanding by capturing broader trends and changes in DRR practices over time, providing a more comprehensive perspective on community-driven disaster resilience.

6. Conclusion

This study explores the disaster resilience strategies of the Rakhine ethnic minority in coastal Bangladesh, revealing how indigenous knowledge, community-led governance, and culturally adapted infrastructure contribute to effective DRR. Using Scopus AI for thematic analysis, the research identifies key resilience strategies, including environmental forecasting, temple-centered communal engagement, and adaptive housing designs, that showcase the Rakhine's capacity to manage disaster risks through locally embedded practices. These insights highlight the value of integrating indigenous knowledge into formal DRR frameworks, which often overlook the unique needs and strengths of ethnic minority communities. By recognizing and incorporating such culturally specific practices, policymakers can develop more inclusive and contextually tailored DRR policies that enhance resilience among vulnerable populations. This research ultimately advocates for a DRR approach that values diversity in resilience strategies, offering a model that can strengthen disaster preparedness across diverse cultural settings.

CRediT authorship contribution statement

Tuhin Roy: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **M.M. Abdullah Al Mamun Sony:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Project administration, Methodology, Formal analysis, Conceptualization. **Sheikh Anwar Hossain:** Writing – original draft, Software, Resources, Project administration, Investigation, Funding acquisition, Formal analysis. **Md Mamunur Rashid:**

Visualization, Software, Project administration, Investigation, Formal analysis, Data curation.

Informed consent

An informed oral consent has taken each of respondents involved in this research.

Ethical approval

The research complied with the ethical guidelines of the Khulna University Research Cell (KURC) and involved non-clinical, minimal-risk social science research with no human participants engaged in clinical trials.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ScopusAI in order to analyze literature connectivity. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Tuhin Roy reports administrative support, equipment, drugs, or supplies, statistical analysis, travel, and writing assistance were provided by Khulna University Research and Innovation Centre. M M Abdullah Al Mamun Sony reports article publishing charges was provided by University of Debrecen. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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