Perceiving the Imperceptible: Discerning Household Satisfaction on Cyclone Shelters in the Exposed Coastal Areas of Bangladesh

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ABSTRACT: The Coastal area of Bangladesh remains exceptionally vulnerable to cyclonic disruptions owing to its unique geographical and socio-economic characteristics. The present study evaluates the household-level satisfaction on the accessibility of cyclone shelters at three districts located in the exposed coastal area of the country. Developing a Satisfaction Index (SI) namely, Cyclone Shelter Satisfaction Index (CSSI) on a 5-point rating scale, the level of satisfaction was quantitatively assessed and the qualitative insights were identified by focus group discussions. To derive the satisfaction index, a semi-structured questionnaire survey was completed, taking responses from 162 respondents, ensuring spatial and socio-economic representation throughout the selected administrative unions of the three districts. The overall satisfaction scores of 2.77 out of 5-points suggest a moderate level of community satisfaction on the operational readiness of the cyclone shelters in the area. Amtali Upazila recorded the lowest satisfaction score (i.e. 2.57), whereas Char Fasson Upazila achieved the highest score (i.e. 2.95). The study identified the inter-regional disparities, which highlight the pressing need for targeted infrastructure enhancements, strategic planning, and increased community engagement. To enhance the role of the cyclone shelters on disaster preparedness, this study emphasizes the critical need for infrastructural enhancement, better road networks and increased coverage area of the cyclone shelters. By addressing these critical gaps through evidence-based, resilience-oriented planning on the cyclone shelters, authorities can significantly improve household safety and evacuation efficacy during cyclonic events.

Keywords: Coastal Vulnerability; Disaster Preparedness; Shelter Accessibility; Satisfaction Scale; Spatial Analysis

INTRODUCTION

Bangladesh's coastal zone covers 47,201 km², which is 32% of the country (Ahmad, 2019). The coastal area is home to about 43.8 million people, which is approximately 27% of the national population (BBS, 2022). Bangladesh is globally recognized as one of the most disaster-prone countries, particularly vulnerable to tropical cyclones, storm surges, and flooding due to its geographic location along the Bay of Bengal (UNDRR, 2020). The coastal districts of Barguna, Patuakhali, and Bhola experience frequent cyclonic events that result in extensive socio-economic losses and displacement (Alam and Collins, 2010). After the 1970 Bhola Cyclone, the Government of Bangladesh, in collaboration with development partners, has invested in constructing and upgrading multipurpose cyclone shelters to reduce disaster-related mortality and enhance community resilience (CDMP II, 2014; IFRC, 2021). In recent years, however, cyclone-related deaths have significantly decreased, with fatalities now often in the tens. The lower death rate is attributed to the establishment of dual use Multi-Purpose Cyclone Shelters (MPCSs) and effective early warning systems (EWSs).

A variety of structures, built by multiple organisations, serve as cyclone shelters (ADB, 2012), which makes it difficult in ascertaining the precise number of cyclone shelters in Bangladesh. In 2015, the coastal region of Bangladesh has 3,793 cyclone shelters (Amin et al. 2015). Over the past three decades, the number of cyclone shelters has grown from 400 to 14,000; however, this number remains inadequate (ICCCAD, 2022). According to (Amin et al., 2016) many cyclone shelters operate in Bangladesh, but vulnerable individuals often face access challenges due to long travel distances,

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poor road conditions, and limited transport options in remote areas. Accessibility to cyclone shelter in times of disaster reduces the number of deaths, however studies have shown that many people could not access those shelters easily (Akon and Mia, 2024). Moreover, a total number of 10 coastal districts do not have proper capacity to ensure shelter to the most vulnerable people, and about 81 percent of those shelters do not have any mechanisms for social participation (Mahmood et al., 2014). Furthermore, the general physical condition of existing cyclone shelters in Bangladesh is a matter of concern, with reports indicating that many suffer from inadequate maintenance and have experienced structural instability (Miyaji et al., 2020). About 30 percent of the shelters in Patuakhali district does not have healthy sanitation facilities (Amin et al., 2016), which has serious implications for when many people are occupying the shelter. Low-Lying Coastal Subsidence Zones in Bangladesh, including the districts of Barguna, Patuakhali, and Bhola, are considered to be the most cyclone-prone areas in Bangladesh due to high exposure to the coastal, inadequate adaptation capabilities, and climate change (Salman et al., 2025). Patuakhali and Barguna have also been hard hit by flooding and damage to crops as a result of recent cyclones, in particular Cyclone Remal (Hossen et al., 2025). However, within both upazila areas, localities including Arpangasia, Patharghata, Dakua and Baliatali are found to be highly susceptible socio-economically where Patharghata Union emerges as the most vulnerable one (Mollah et al., 2024). The area of Patharghata in Barguna also holds high levels of socio-economic and ecological vulnerability and is subject to regular and severe cyclones (Rahman et al., 2023). In addition, the infrastructures of cyclone shelters in the two districts of Barguna and Bhola are in general substandard and have less functional adequacy (Siddique et al., 2025). Socio-physical composite indicators revealed that most of Patuakhali, Bhola and Barguna is highly susceptible to cyclones (Hasan et al., 2024) while the prevailing mitigation capacity in Barguna is far from adequate (Hasan et al., 2024). Vulnerable populations in Taltali Upazila and vulnerable groups such as ethnic minorities like the Rakhain are even more at risk from the threat of cyclones (Rahman et al., 2022). High cyclone frequencies and impacts destroy Bhola district and in Bhola Sadar, Tazumuddin and Charfasson Upazilas (Tasnim et al., 2021). In Bhola, the social dynamics and quality of the shelter (especially for women, children and the elderly) influence evacuation decisions rather than the spatial location of the cyclone shelters. However, some shelters are inadequate, and the information and risk perception also impact utilization (Islam & Mallick, 2021). Shelters in Bhola also tend to be inadequately designed, constructed and prepared for disaster, which makes them unreliable in the event of a disaster (Siddique, Riad, & Hore, 2025). Since Barguna is considered to be extremely cyclone-prone, the major part of infrastructure is highly vulnerable to destruction. Only 0.29% of district land is deemed very good for urban-based placement of cyclone shelters, and a large proportion of the people are shelter-dependent owing to insufficient resilient dwelling (Hasan et al., 2024). In Amtali (Barguna), 65% of the respondents revealed that the shelter has inadequate facilities, poor sanitation, and insufficient medical services. Women, in particular, are vulnerable because of mismanagement and the absence of separate toilets. Shelter supervision was deemed unsatisfactory by almost 70%, deterring shelter utilization (Nur, Rahim, & Rasheduzzaman, 2021). A large number of shelters in Barguna are in a very dilapidated condition, the walls are falling down, and the roofs are leaking, while 37% of respondents were dissatisfied with WASH (water, sanitation, hygiene) conditions (Rahman et al., 2023). Shelters are also unevenly spaced along the coastal, with just under 9% of shelters inaccessible during cyclones. Only 19% have community involvement in management and funds for maintenance (Mahmood, Dhakal, & Keast, 2014). The majority of shelters are ill-equipped to cater for the needs of disabled, elderly and other excluded people, and often lack gender sensitive features (Faruk, Ashraf, & Ferdaus, 2018). Distances are long, roads are bad and transportation options are limited, constituting significant barriers particularly in rural areas (Alam, 2023).

Satisfaction, especially for the public services and disaster shelters, is better conceptualized as a perception-based multilevel measure that reflects user's overall experience and evaluation on the service quality, service convenience and sufficiency. Different from single dimension or completely objective measures, satisfaction contains cognitive (e.g., service performance comparing to expectation) and emotional components (e.g., feeling safe, comfortable, or trust toward the service) (Pakurar, Haddad, Nagy, Popp, & Olah, 2019). In public infrastructure and emergency sheltering, satisfaction is more than a service delivery metric; it also predicts on the ground use, adherence, and community. This multi-dimensionality is important

because it helps to explain why people might choose not to use an available service, even if it could benefit them, particularly in the high stakes setting of disaster shelters where issues such as physical access, inclusivity, security, and emotional comfort among others all converge (Mata et al., 2023). Therefore, comprehensive satisfaction evaluation should involve objective service aspects and user individualized perceptions, and is a crucial means to evaluate and enhance the effectiveness of public services. To assess satisfaction levels, several studies have adopted Satisfaction Index (SI) methods, which provide a composite metric of user satisfaction based on multiple qualitative and quantitative indicators (Faruk et al., 2018; Eckstein et al., 2021). The SI methodology provides a systematized and quantifiable measure to assess perceptions related to access, structural firmness, water/sanitary services and administration in the context of shelter. For instance, Roy et al. (2021) applied the satisfaction index to cyclone shelters in India's Odisha coast and found that over 60% of the community were only moderately satisfied, with structural safety and sanitation as major concerns. Similarly, Khatun et al. (2014) used the Satisfaction Index (SI) method in southwestern Bangladesh and highlighted that communities gave lower scores to gender-sensitive features and nighttime security, indicating critical areas for policy intervention. However, the extent to which these shelters fulfill community expectations remains underexplored. While prior research has assessed the structural adequacy and spatial distribution of cyclone shelters (Shamsuddoha et al., 2013; Roy et al., 2021), limited attention has been given to community satisfaction and behavioral responses related to shelter use. User satisfaction shaped by factors such as accessibility, infrastructure, gender-sensitive features, and safety perceptions plays a crucial role in determining whether vulnerable populations actually utilize shelters during emergencies (Dasgupta et al., 2019). Yet, there remains a significant knowledge gap in evaluating satisfaction levels using standardized methods like SI in the exposed coastal zones of Bangladesh, where communities are often repeatedly affected. In terms of disaster-related domains, study was located between disaster resilience and user-oriented evaluation frameworks. User satisfaction with defensive structures is increasingly being considered as a key facet of social resilience, as it represents a system's ability to fulfill the needs of its users in times of crisis. Studies of Bangladesh's coastal communities now highlight how resilience encompasses more than built environment, but also includes the ways people's experiences, indigenous knowledge, and social networks influence recovery and capacity to adapt (Uddin, et al.2021). Moreover, satisfaction evaluation drinks from the cup of index-based assessment which involves objective evaluation of conditions level and subjective evaluation of perception level (Islam et al,2021). By basing the Cyclone Shelter Satisfaction Index (CSSI) on these conceptual and methodological models, this paper advances beyond structural sufficiency to interrogate the day-to-day realities and satisfaction levels of multiple user groupings.

Public-shelter satisfaction refers to a predominantly positive perception of shelter conditions, characterized by the alignment between actual experiences and desired standards (Mayunga, 2012). In cyclone-prone coastal districts of Bangladesh such as Barguna, Patuakhali, and Bhola, many residents report preferring to take shelter with relatives rather than in public shelters citing concerns about comfort, privacy, and accessibility. While previous studies have contributed valuable insights into shelter infrastructure and management, many fail to address intersectional vulnerabilities and the diverse lived experiences of various demographic groups due to methodological limitations (Dasgupta et al., 2019). Moreover, existing assessments often emphasize structural soundness over user-centric indicators such as emotional safety, perceived adequacy of amenities, and inclusive design. This study responds to these gaps by incorporating a satisfaction index to evaluate community perceptions across multiple dimensions including accessibility, safety, hygiene, and functionality while also recognizing the differing needs of user groups based on gender, age, and socio-economic status. To address this, the present study evaluates community satisfaction to cyclone shelters in Barguna, Patuakhali, and Bhola districts using both perception-based surveys and spatial analysis. Therefore, the objectives of this study were to assess the level of community satisfaction to cyclone shelters in the exposed coastal areas of Bangladesh and to conduct spatial analysis and prepare maps illustrating the geographic distribution of satisfaction levels across the study area. In disaster and cyclone shelter studies, data collection and analysis often consider multiple dimensions encompassing natural, physical, social, economic, and institutional factors. The natural dimension typically includes parameters such as geology, land elevation, inundation, soil type, landform, slope, and environmental pollution

(Sahoo & Bhaskaran, 2018; Rana & Routray, 2018). The physical dimension covers infrastructure, road networks, shelter conditions, utilities, accessibility, and shelter types (Rana & Routray, 2018; Patri et al., 2022; Sahoo & Bhaskaran, 2018). The social dimension incorporates population density, cultural and religious factors, community engagement, mental health, and neighborhood cooperation (Frigerio et al., 2016; Trentin et al., 2023; Patri et al., 2022). The economic dimension focuses on income, post-disaster aid, employment, economic support, and funding for recovery (Noy & Yonson, 2018; Meem et al., 2025; Patri et al., 2022). Finally, the institutional dimension involves awareness campaigns, training, warning systems, governance, and restructuring shelters (Marin et al., 2021; Rana & Routray, 2018; Patri et al., 2022). These dimensions and variables provide a structured framework for assessing vulnerability and resilience in disaster-prone areas and guide the development of composite indices such as the Cyclone Shelter Satisfaction Index (CSSI). It relies on recent findings that infrastructure- and social/subjective factors co-shape resilience in Bangladesh's coastal communities (Uddin et al., 2020). It provides a sound rationale for why a multi-faceted, index-based satisfaction evaluation approach is appropriate, thereby bringing CSSI in line with the prevailing methodological best practices (Islam et al., 2021). Resilience at the community level is strongly affected by local knowledge, social connections, and perceptions of community, as opposed to just material resources (Uddin et al., 2020). Social resilience and contentment in disaster-risk areas have been evaluated more and more through index-based, spatially explicit approaches that include objective and subjective aspects (Islam et al.,2021). The inclusion of these theoretical traditions guarantees that the evaluation of satisfaction is strong, context sensitive, and relevant in terms of policy (Murshed et al., 2024). The findings of this study aim to contribute to improved cyclone risk management strategies by identifying critical gaps in shelter infrastructure and services, ensuring that vulnerable populations can access safe and functional shelters during cyclone.

METHODOLOGY

Study Area

The present study covered three districts such as Barguna, Patuakhali, and Bhola located in the exposed coastal area of Bangladesh. Six Upazilas were selected from these districts (Fig. 1), among them Char Fasson is distinguished as the largest, encompassing approximately 1,106.31 square kilometres, whereas Patharghata is identified as the smallest, with an area of 387.36 square kilometres. In terms of population, Char Fasson is the most populous Upazila, housing 456,437 individuals, while Patharghata is the least populous, with 163,927 inhabitants. These variations significantly influence the number and density of cyclone shelters to be allocated and distributed within each Upazila.

Research Design and Sampling

The present study assessed the level of satisfaction of the coastal community on cyclone shelters by developing a satisfaction index namely, Cyclone Shelter Satisfaction Index (CSSI). The index requires community level responses on different variables under different parameters and dimensions. To make the responses representative to the whole study area, the first task was to identify the representative administrative units from the study area. In the first stage, Amtali, Barguna Sadar, Charfasson, Galachipa, Kalapara, and Patharghata Upazilas were selected based on their exposure to cyclonic disaster by reviewing existing literature. In the second stage, the average household size across all Unions within these Upazilas was calculated. Based on this, a sample size of representative households was determined using a 95% confidence level resulting a sample size of 137.

$$n_o = \frac{Z^2.p(1-p)}{e^2} \text{.....(1)}$$

$$n = \frac{n_o}{1 + \frac{n_o}{N}};\ where\ Z = 1.96, p = 0.5, and\ N = 137$$

However, to ensure a more comprehensive distribution and coverage of the dataset, A reconnaissance survey was carried out before the actual data collection to get an idea about the spatial distribution of the cyclone shelters and socio-economic variations of the study area. Hence, to accommodate for these, the sample size was increased to 162 households, as readers coverage more. This modification facilitated a more uniform and representative distribution 27 households allocated to each Upazila. the final sample size was adjusted to 162 households. This adjustment allowed for a more even representation.

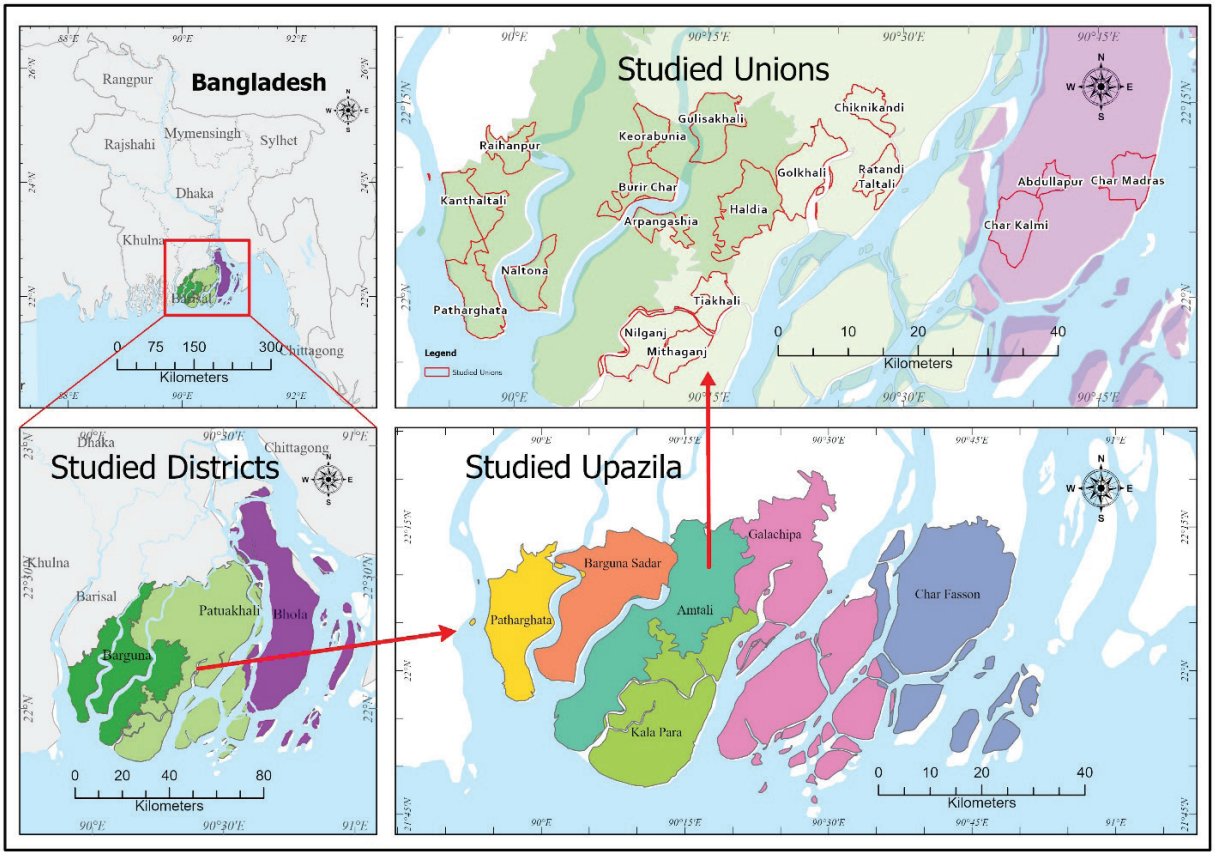

Figure 1: Map of the Study Area at Different Administrative Levels

This sample size was distributed across three Unions in each of the six Upazilas, with each Union being categorized based on economic status and cyclone shelter availability. For instance, in Barguna Sadar Upazila, three Unions were selected: Keorabunia (with the fewest cyclone shelters, household size 175.6), Burirchar (average number of cyclone shelters, household size 300.6), and Naltona (the highest number of cyclone shelters, household size 222.5). Consequently, 18 unions (Abdullapur, Arpangashia, Burir Char, Char Kalmi, Char Madras, Chiknikandi, Golkhali, Gulisakhali, Haldia, Kanthaltali, Keorabunia, Mithaganj, Naltona, Nilganj, Patharghata, Ratandi Taltali, Raihanpur, and Tiakhali.) were selected, spread across three levels of economic condition. This two-tiered sampling approach guided the determination of the number of households to be surveyed in each Upazila. Subsequently, specific Unions and households within those Unions were selected to ensure a representative and comprehensive sample.

Data Collection

A semi-structured questionnaire was used to conduct interviews with 162 households in 2024, capturing a range of views on the access to and satisfaction with cyclone shelters. To ensure spatial representation, nine interviews were conducted in each union. Respondents were selected from both sides of major roads to reflect variations in accessibility that may affect evacuation and shelter use. The data were collected under five dimensions such as natural, social, economic, physical and institutional in which a total number of 08 parameters and 54 variables were used in the study by review of relevant literature, experts' consultation and a reconnaissance survey in the selected unions (Table 1). Field data were collected against each of the variables, which were then processed for each parameter and dimensions for composite scores. Moreover, six Focus Group Discussions (FGD) were conducted in six Upazilas with local stakeholders with a view to correspond the relevant issues of satisfaction on cyclone shelters.

Table 1: Selected Variables Under Different Parameters and Dimension Used in the Study

Dimension	Parameter	Variable
Natural Dimension	Geology	Land Elevation
		Inundation Level
		Soil Characteristics
		Landform
		Slope
		Orientation
	Environment	Water Pollution
		Air Pollution
		Noise Pollution
		Soil Pollution
Physical Dimension	Physical Infrastructure	Road Network
		Proximity to Residents
		Condition of Cyclone Shelters
		Transport Facility
		Travel time
		Mobile Network
	Type of Shelter	Cyclone Shelter- Stand Alone
		School cum shelter
		Monastery cum shelter
		Health cum shelter
		Multipurpose Community Building
	Utilities and Facilities	Availability of cyclone shelters
		Capacity to accommodate
		Separate facility for men and women
		Facility for old and disable people
		Special facility for pregnant women
		Violence or harassment
		Privacy issue
		Crowd
		Security
		Safety measures like fire exit
		Evacuation facility
		Health facility
		Surplus food supply
		Animal Shelter
		Power supply
		Water supply
		Sanitation
		Gas supply
		Garbage disposal

Social Dimension	Cultural/Religious	Separate place for doing religious activity Neighbourhood cooperation Mental Health Support Community engagement
Economic Dimension	Economic Support	Post Disaster Support/aid Funding for restructuring house Recreate work environment Support from NGOs
Institutional Dimension	Local Level	Support from Govt. Awareness campaign Training program Restructuring the cyclone shelters Warning system Special session for women and children

Weighting and Scoring Method

Variables within each parameter were normalized and ranked comparatively, and weights (1–5) were assigned based on their relevance to the site where the interview had been conducted, with higher weights indicating greater importance. Duplicate ranks were prohibited to ensure clarity. Weights were further assigned to parameters themselves, reflecting union-specific priorities (e.g., remote unions prioritized physical accessibility, while areas with low literacy emphasized community engagement). The natural dimension, for instance, evaluates cyclone shelter accessibility through two parameter groups: *Geology* (6 variables) and *Environment* (4 variables). Variables include land elevation, inundation level, soil characteristics, landform, slope, orientation, and pollution metrics (water, air, noise, soil) for Environment. Each variable is rated on a 1–5 Likert scale (1 = lowest satisfaction, 5 = highest satisfaction).

Variable Ranking: Within each parameter group, variables were assigned unique ranks reflecting their relative importance (e.g., Geology variables ranked 1–6, Environment variables 1–4).

$$\text{Score}_{\text{variable}} = \frac{Rating \times Rank}{\sum Ranks\ within\ parameter\ group} \quad \ldots\ldots\ldots\ldots (2)$$

Parameter Group Score: Sum scores of all variables within a parameter group:

$$Score_{Geology} = \sum\left(\frac{Vi \times Ri}{\sum r_{Geology}}\right),$$

$$Score_{Environment} = \sum\left(\frac{Vj \times Rj}{\sum r_{Environment}}\right) \ldots\ldots\ldots\ldots\ldots (3)$$

Natural Dimension Index:

$$\text{Score}_{\text{NaturalDimension}} = \text{Score}_{\text{Geology}} + \text{Score}_{\text{Environment}}$$

In particular, and are the values of individual variables within the groups Geology and Environment, respectively, and and are their assigned ranks according to importance. The system of equations has been rearranged in a more natural order (similar to the order in the Research Design section, then the Sampling and the Data Analysis sections) providing a more detailed, stepwise description of scoring variables, aggregating over parameter groups, and calculating the index at the dimension level.

The assignment of weights to the multidimensional criteria was influenced by several factors, including the geographical distribution of respondents, their socio-economic backgrounds, and the specific accessibility challenges faced by each union. For instance, unions located farther from main roads or with limited transportation infrastructure were given higher weights for variables related to physical accessibility. Similarly, parameters reflecting community engagement and

awareness were prioritized in unions with lower literacy rates or limited exposure to disaster preparedness programs.

Data Analysis

To quantify community satisfaction with cyclone shelters, this study employs the Weighted Mean Index (WMI) and Aggregate Weighted Mean Index (AWMI) methodologies to calculate the Cyclone Shelter Satisfaction Index (CSSI). These indices are effective for aggregating multiple indicators that contribute differently to overall satisfaction by assigning weights based on their relative importance (Quinn and Mangione, 1973). The WMI enables the calculation of weighted scores for individual parameters, while the AWMI aggregates these into a composite satisfaction score, capturing the multidimensional nature of user experiences (Fornell et al., 1996). The mathematical formulations for these methodologies are presented in the equations 4 and 5.

Firstly, the scores of each variable are calculated using the following equation:

$$Score_{Variables} = \frac{w_1 v_1 + w_2 v_2 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots + w_n v_n}{w_1 + w_2 + \ldots\ldots\ldots w_n} \ldots\ldots\ldots (4)$$

Where,

w_n = assigned weight for variable n;

v_n = rating of variable n

After calculating scores for each variable, the weighted mean score is calculated for each dimension, which is shown in the following equation:

Weighted Mean

$$Score_{Dimensions} = \frac{w_1 i_1 + w_2 i_2 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots + w_n i_n}{w_1 + w_2 + \ldots\ldots\ldots w_n} \ldots\ldots\ldots\ldots\ldots (5)$$

Where,

w_n = assigned weights of parameter n

i_n = scores of variables calculated using equation

The overall score is calculated by averaging the weighted mean scores of all dimensions. The scores are classified on a scale from 1 to 5, where 1 indicates the lowest level of satisfaction and 5 represents the highest level of satisfaction.

Ethical Approval: The clearance of ethics was attained at the Upazila level in the presence of the local administrative authority. Before the commencement of data collection, community members were made aware of the purpose of the study. Informed consent was obtained from all subjects, with the clear message that participation was voluntary. The authors confirm that identifiable information was treated in a confidential manner, that the appropriate data protection procedures were followed and that the privacy of respondents was not violated at any point during the study. The authors also confirm that the continued involvement of the local administrative authorities ensured further ethical adherence and that the authors upheld the confidentiality of the data in its entirety.

RESULTS

The Satisfaction Index assesses community satisfaction across five key dimensions: Natural, Physical, Social, Economic, and Institutional. The index ranges from 1 (Lowest) to 5 (Highest) and is widely utilized in research on climate-induced disasters, including cyclones, floods, heat waves, droughts, and heavy rainfall (Debortoli et al., 2017). The results show a discernible variation in satisfaction levels across all dimensions (Fig. 2).

Satisfaction Status at Union Level

The satisfaction scores for individual unions show variations of cores among each other (Table 2). In the natural dimension, the Keorabunia union recorded the highest score, indicating an excellent level of satisfaction, whereas the Abdullahpur union obtained the lowest score (1.741) of satisfaction. Nevertheless, the overall satisfaction score for this dimension is 3.222 out of 5, reflecting a generally positive perception among the studied unions. Regarding the physical dimension, variation is also evident in the satisfaction scores. The average score of 2.822 denotes an overall average level of satisfaction in the context of this dimension. Notably, Mithaganj (3.624) and Char Madraj (3.607) exhibit the highest satisfaction scores, indicating a favourable perception of the physical aspects in these areas. Conversely, Chiknikandi (1.583) and Tiakhali (1.799) recorded the lowest scores, highlighting potential areas for improvement.

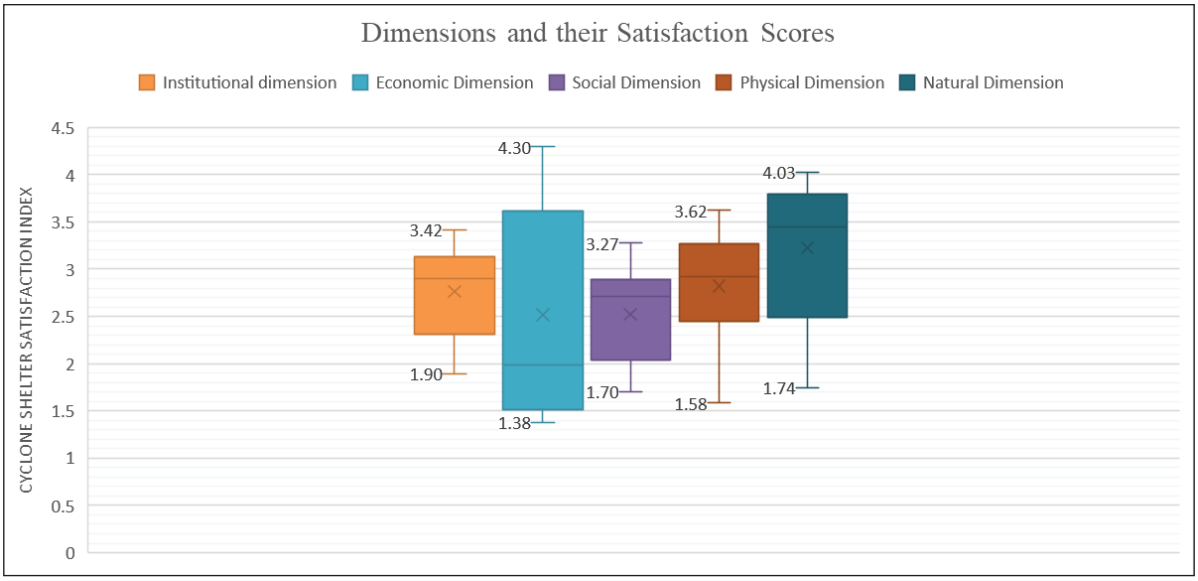

Figure 2: Boxplot of Overall Scores for the Five Dimensions of Satisfaction Index

Likewise, the social dimension scores vary significantly, ranging from a high of 3.274 in Mithaganj to a low of 1.700 in Haldia. In the social dimension, Mithaganj (3.274) and Nilganj (3.044) are notable for their positive perceptions regarding community engagement and religious facilities, whereas Gulisakhali (1.878) and Haldia (1.700) reflect considerably lower levels of satisfaction indicated poor social conditions and community disconnection. It is observed that the majority of the unions (11 out of 18) have scores more than the average of 2.522 out of 5, indicating a general trend towards average satisfaction in the social dimension.

Table 2: Scores of the Studied Unions Categorized on a Relative Scale

Union Names	Natural Dimension	Physical Dimension	Social Dimension	Economic Dimension	Institutional dimension	CSSI
Ratandi Taltoli	3.500	2.303	2.556	2.230	1.955	2.508
Golkhali	3.387	2.192	2.860	3.778	2.637	2.716
Chiknikandi	3.663	1.583	2.713	3.600	2.300	2.771
Tiakhali	1.766	1.799	2.189	3.333	2.320	2.281
Mithaganj	3.983	3.624	3.274	3.141	1.896	3.183
Nilganj	2.189	2.585	3.044	3.822	3.417	3.011
Char Kalmi	2.513	2.795	2.956	3.422	2.903	2.917
Abdullahpur	1.741	2.493	2.785	3.644	2.558	2.644
Char Madraj	2.430	3.607	2.867	4.296	3.269	3.293
Keorabunia	4.026	2.976	2.956	1.407	3.244	2.921
Burir Char	3.669	3.204	2.700	1.451	3.148	2.834
Naltona	3.401	2.824	2.233	1.533	2.903	2.579
Arpangashia	3.374	2.986	2.067	1.704	3.066	2.639
Gulisakhali	3.851	3.305	1.878	1.430	3.118	2.716
Haldia	3.610	2.875	1.700	1.378	2.244	2.361

Patharghata	3.210	3.259	2.711	1.730	2.948	2.770
Kanthaltali	3.778	3.051	1.956	1.615	2.785	2.636
Raihanpur	3.933	3.344	1.967	1.741	3.014	2.799
Overall	3.222	2.822	2.522	2.514	2.762	2.769

The economic dimension also reveals noticeable variation in satisfaction scores across the communities. With an average score of 2.514, the overall satisfaction is moderate; however, the range from 1.378 in Haldia to 4.296 in Char Madraj underscores significant disparities. Char Madraj (4.296) and Nilganj (3.822) stand out due to their residents' positive perception of economic support, while Haldia (1.378) and Keorabunia (1.407) exhibit substantially lower scores. The district of Bhola tends to get a lot more attention and post-disaster support than the district of Barguna. The overall average score was 2.514, highlighting uneven economic resilience and recovery support across unions. In the institutional dimension, Nilganj achieved the highest score (3.417), denoting confidence in governance, awareness campaigns, and early warning systems. On the other hand, Mithaganj shared the lowest score (1.896), signalling dissatisfaction with institutional responsiveness. The overall mean for this dimension was 2.762, reflecting an average institutional performance in disaster preparedness and management. Finally, the overall satisfaction scores across the unions indicate an average level of satisfaction across the surveyed unions, with an average score of 2.769 out of 5. A discernible variation exists among the unions, with scores ranging from a high of 3.293 in Char Madraj to a low of 2.281 in Tiakhali. This variation likely reflects the cumulative impact of the satisfaction levels across the five dimensions natural, physical, social, economic, and institutional. The box plot shows the gamut of the satisfaction between the different dimensions (Figure 2).

Spatial Mapping of Satisfaction at Union Level

Variations and commonalities in the socio-economic and environmental conditions of each union within their respective Upazilas allowed for a more comprehensive investigation into the spatiality of satisfaction (Fig. 3 and 4). To compare the unions, the scores of the unions can be categorized into three groups like the upazilas: Relatively High Satisfaction (more than 2.91), Relatively Moderate Satisfaction (between 2.66 and 2.90), and Relatively Low Satisfaction (less than 2.65). These classes were constructed based on the relative scores; this helps us compare each of the unions with one another as shown in Table 3. Unions falling under the relatively high satisfaction group included Char Madraj, Keorabunia, Char Kalmi, Golkhali, Mithaganj, and Nilganj. These unions reported consistently high scores across most satisfaction dimensions, suggesting robust infrastructure, effective institutional support, and strong community cohesion. However, the moderate satisfaction group comprised Burirchar, Chiknikandi, Patharghata, Raihanpur, and Gulisakhali. These unions demonstrated adequate levels of satisfaction, though specific weaknesses often in institutional or economic support moderated their overall performance. Unions categorized under relatively low satisfaction included Abdullapur, Arpangashia, Haldia, Kanthaltali, Naltona, Ratandi Taltali, and Tiakhali. These areas exhibited deficiencies across multiple dimensions, particularly in physical infrastructure and institutional support, indicating urgent need for targeted intervention and investment.

Table 3: Scores of the Studied Unions Categorized on a Relative Scale

Satisfaction Group	Name of Union	CSSI Score
Relatively High	Char Madraj	3.29
	Mithaganj	3.18
	Nilganj	3.01
	Golkhali	2.96
	Keorabunia	2.92
	Char Kalmi	2.91

	Burir Char	2.83
	Raihanpur	2.79
Relatively Moderate	Chiknikandi	2.77
	Patharghata	2.77
	Gulisakhali	2.71
	Abdullapur	2.64
	Arpangashia	2.63
	Kanthaltali	2.63
Relatively Low	Naltona	2.57
	Ratandi Taltali	2.50
	Haldia	2.36
	Tiakhali	2.28

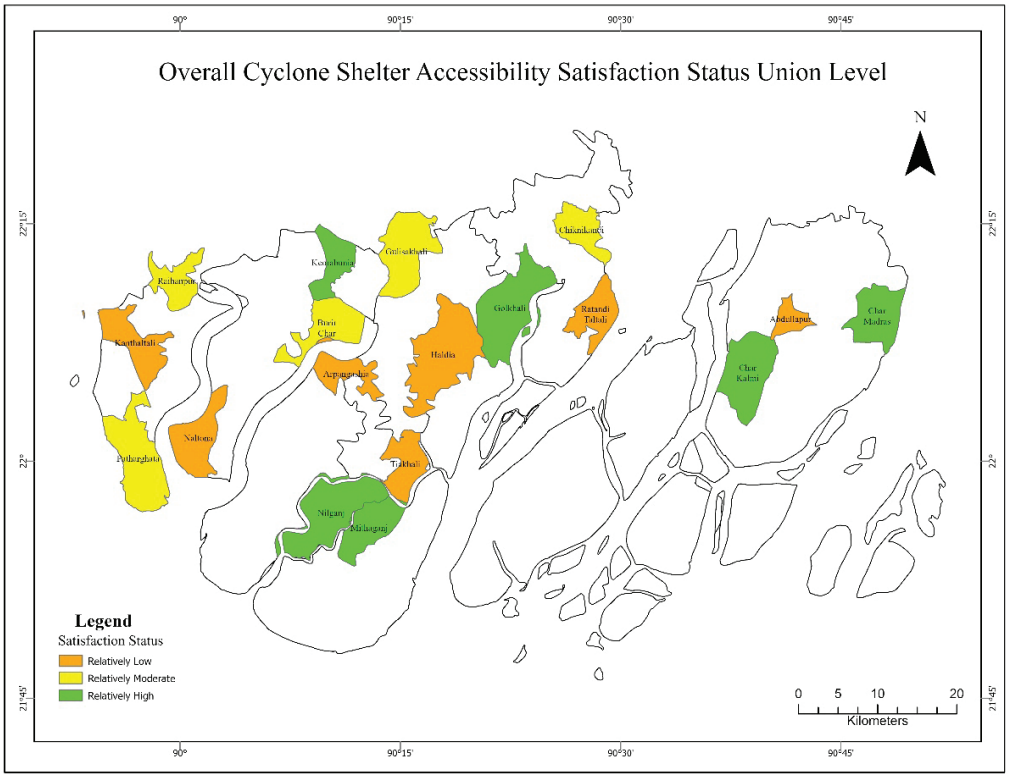

Figure 3: Union Level Overall Satisfaction Status of Cyclone Shelter in the Selected Coastal Districts

In terms of the institutional dimension, Nilganj emerges as the frontrunner, boasting a score of 3.4172, while Mithaganj union languishes at the bottom with a score of 1.8962 out of 5. This dimension highlights the robustness of governance structures and institutional support across the unions during and after the cyclone. From an economic standpoint, Char Madraj reigns supreme with an impressive score of 4.2962, the highest score across all dimensions and unions. Conversely, Haldia union finds itself at the nadir of the economic dimension, with a mere score of 1.3777 out of 5. This stark discrepancy underscores the substantial economic disparities prevailing among the unions at the zenith and nadir of the index. In social dimension, Mithaganj union is at the top, with a score of 3.274 out of 5, whereas Haldia union lags behind with a paltry score of 1.7 out of 5. This disparity illustrates the vulnerability of Haldia union to socio-economic pressures, indicative

of its weakness in coping with post-disaster scenarios. Considering the physical dimension, Mithaganj union stands at top with a score of 3.624, whereas Chiknikandi records the lowest satisfaction levels at 1.582 out of 5. In the natural dimension, Keorabunia claims the title of the best-performing union with a score of 4.0264, while Abdullapur union trails behind with a score of 1.7414 out of 5. A high score in the natural and physical dimensions denotes meticulous maintenance of the environment and cyclone shelter facilities, whereas a lower score suggests discontent among the populace regarding their environment and the cyclone shelters in their vicinity. The following maps depict the scores of the unions across various dimensions, offering insights into their comparative positions concerning the physical accessibility of cyclone shelters and overall satisfaction levels among the populace.

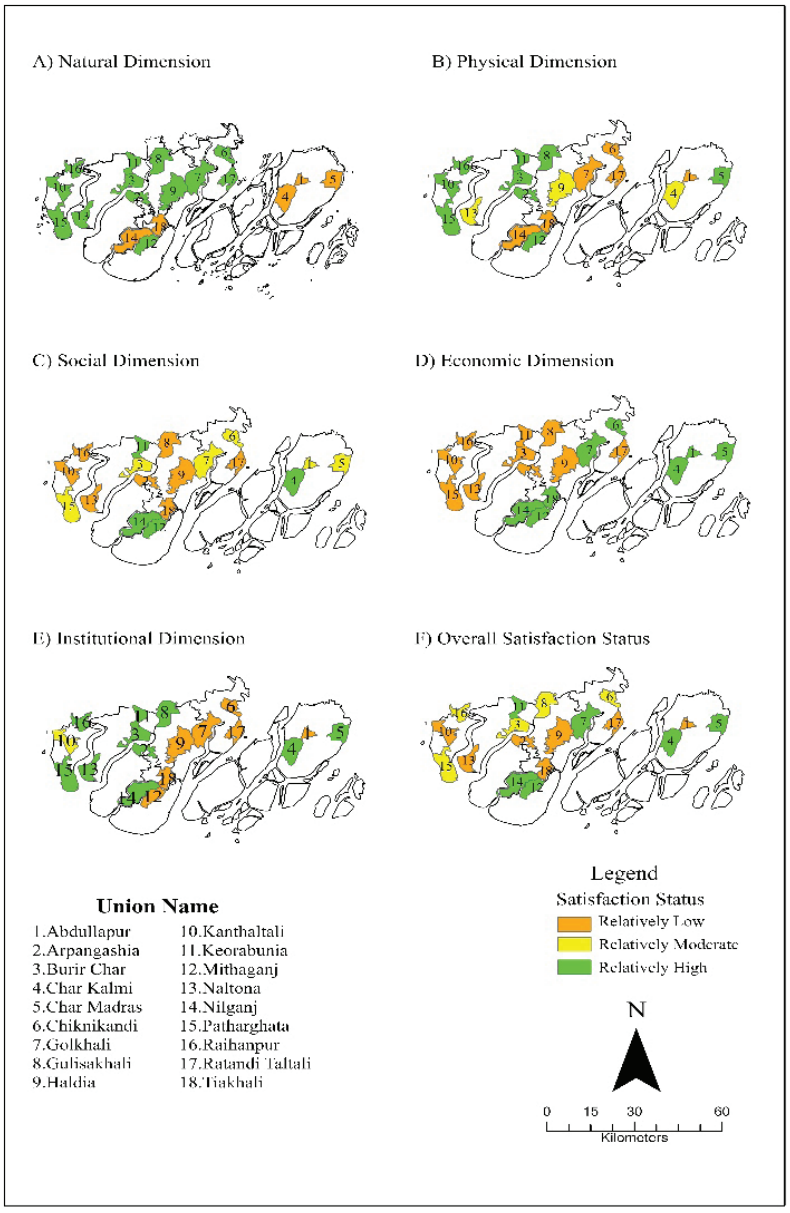

Figure 4: Maps Showing the Satisfaction in the Dimensions; A) Natural Dimension, B) Physical Dimension, C) Social Dimension, D) Economic Dimension, E) Institutional Dimension, and F) Overall Satisfaction Status at the Union Level

Satisfaction Status at Upazila Level

Satisfaction across all dimensions was examined in relation to the locational context of each Upazila, taking into account factors such as land elevation, soil characteristics, landform, slope, orientation, geology, and various environmental conditions, including water, air, noise, and soil pollution. Specifically, four of the six Upazilas Galachipa, Patharghata, Amtali, and Barguna Sadar demonstrated high levels of satisfaction, while Kalapara and Char Fasson Upazilas recorded scores of 2.64 and 2.23, respectively, indicative of a relatively lower level of satisfaction according to the scale presented in figure 5.

In terms of the physical dimension, Patharghata exhibits the highest score (3.22), indicative of a good satisfaction level, while Galachipa records the lowest score (2.02), reflecting relatively lower satisfaction. The average satisfaction score of this dimension is 2.82, which is relatively good. Notably, Patharghata, Amtali, and Barguna Sadar Upazilas demonstrate good satisfaction regarding their shelters, whereas Galachipa, Kalapara, and Char Fasson display only moderate satisfaction.

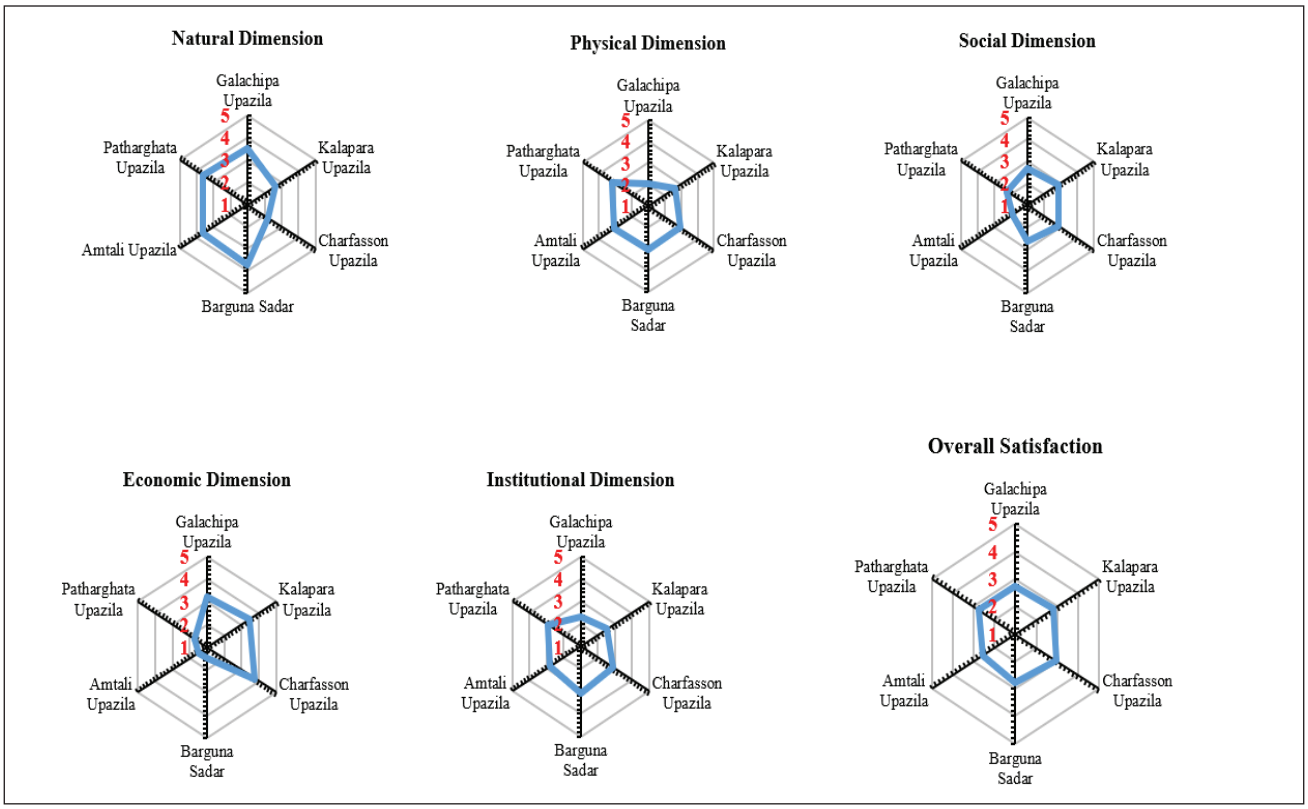

Figure 5: Community Satisfaction with Cyclone Shelter at Upazila Level Under Different Dimensions of Satisfaction Index

In social dimension, Char Fasson Upazila registers the highest score (3.86), corresponding to a relatively higher satisfaction level, whereas Amtali Upazila shows the lowest score (1.88), indicating less satisfaction. This is probably because of the social capital that has developed in the district of Bhola compared to the other districts of the study area. Nonetheless, the average social satisfaction across the six Upazilas is 2.52 out of 5, revealing considerable variation in social preparedness and cohesion among the studied regions. However, the economic dimension exhibited significant disparities. Char Fasson Upazila exhibits the highest score (3.79), representing an average level of satisfaction among residents. In contrast, Barguna Sadar Upazila records the lowest score (1.46), suggesting a markedly lower level of satisfaction concerning economic support. The average economic satisfaction across all Upazilas was 2.51, implying moderate performance but underscoring the need for targeted economic interventions, particularly in Amtali and Patharghata, which also

scored poorly (1.50 and 1.70, respectively). Regarding the institutional dimension, Barguna Sadar Upazila exhibits the highest score (3.10), indicating a relatively good level of satisfaction with the effectiveness and responsiveness of local institutions. Char Fasson and Patharghata Upazilas follow closely, with scores of 2.91 and 2.92, respectively, suggesting a generally average satisfaction status. Conversely, Galachipa Upazila presents the lowest score (2.30), highlighting a comparatively lower. Amtali and Kalapara Upazilas record intermediate scores of 2.81 and 2.54 respectively, contributing to an overall institutional satisfaction score of 2.76 across all studied Upazilas. The aggregate satisfaction status across all dimensions reveals an average score (2.77 out of 5). Accessibility satisfaction shows minimal variation among the studied Upazilas, with Char Fasson Upazila attaining the highest score (2.95) and Amtali Upazila the lowest (2.57), both remaining within the average satisfaction range.

Spatial Mapping of Satisfaction at Upazila Level

Each Upazila is evaluated based on five critical dimensions: Natural, Physical, Social, Economic, and Institutional, with overall satisfaction encapsulated in the satisfaction index) score. Firstly, based on the overall scores, the Upazilas can be categorised into three groups: Relatively High Satisfaction (more than 2.85), Relatively Moderate Satisfaction (between 2.7 and 2.84), and Relatively Low Satisfaction (less than 2.69). This scoring criterion was also established on a relative basis so that it is easier to compare the Upazilas to one another; the grouping is as shown in table 4.

Table 4: Satisfaction Scores of the Studied Upazilas Categorised Relative to Each Other

Satisfaction Group	Name of Upazila	CSSI Score
Relatively High	Char Fasson	2.95
Relatively Moderate	Kala Para	2.82
	Barguna Sadar	2.78
	Galachipa	2.75
	Patharghata	2.73
Relatively Low	Amtali	2.57

The comparative analysis reveals that while some Upazilas perform well in certain dimensions, they lag significantly in others, indicating a need for targeted interventions. Galachipa and Kala Para demonstrate moderate satisfaction overall but are notably weak in the physical infrastructure and institutional dimensions indicating a need for improvements in shelter conditions and governance mechanisms. For Char Fasson, the focus should be on environmental improvements, despite its strong economic satisfaction. Barguna Sadar has strong natural and institutional satisfaction but faces significant economic challenges that need urgent attention. Amtali requires substantial improvements in social and economic dimensions to balance its strengths in natural and physical aspects. Patharghata shows high satisfaction in natural and physical dimensions but needs to enhance social and economic conditions.

In the Natural Dimension, Barguna Sadar exhibits the highest satisfaction with a score of 3.699, while Char Fasson records the lowest at 2.228 on a scale of 5. From the Physical Dimension perspective, Patharghata Upazila attains the highest satisfaction at 3.218, contrasting sharply with Galachipa's minimal score of 2.026 out of 5. Regarding the Social Dimension, none of the Upazilas display exceptionally high satisfaction levels; all fall within moderate satisfaction, with Char Fasson leading at 2.869 and Amtali trailing at 1.881 out of 5. The Economic Dimension reveals notable performances across multiple areas, with Char Fasson achieving the highest satisfaction at 3.788, and Barguna Sadar at the lowest with a score of 1.464 out of 5. Lastly, in the Institutional Dimension, Barguna Sadar again ranks highest with a satisfaction score of 3.099, while Galachipa is the lowest at 2.298 out of 5.

DISCUSSIONS

Union-wise Satisfaction Status

The analysis of community satisfaction with cyclone shelters at the union level reveals that satisfaction

scores show a weak correlation with population density, although the relationship offers important insights into service adequacy relative to the population size. As shown in Table 5, the score of satisfaction index varies notably across unions, ranging from 3.293 in Char Madraj to 2.281 in Tiakhali. Char Madraj, with a moderately high population density (1051 inhabitants/km²) and 23 shelters, achieves the highest satisfaction score, reflecting a relatively balanced shelter-to-population ratio. In contrast, Tiakhali exhibits a lower satisfaction score despite having 25 shelters for a population density of 853 inhabitants/km². Notably, Haldia, which has the highest number of cyclone shelters (68), records one of the lowest satisfaction scores, indicating that shelter quantity alone does not ensure community satisfaction. These findings are consistent with previous research emphasizing that the adequacy of disaster shelters is not solely dependent on shelter availability but also on shelter quality, accessibility, and management (Paul and Routray, 2011; Islam et al., 2023). Older infrastructure frequently fails to satisfy the changing demands of vulnerable people when it is not properly maintained and upgraded, which is consistent with the discrepancy between shelter numbers and satisfaction in Haldia (Islam et al., 2023).

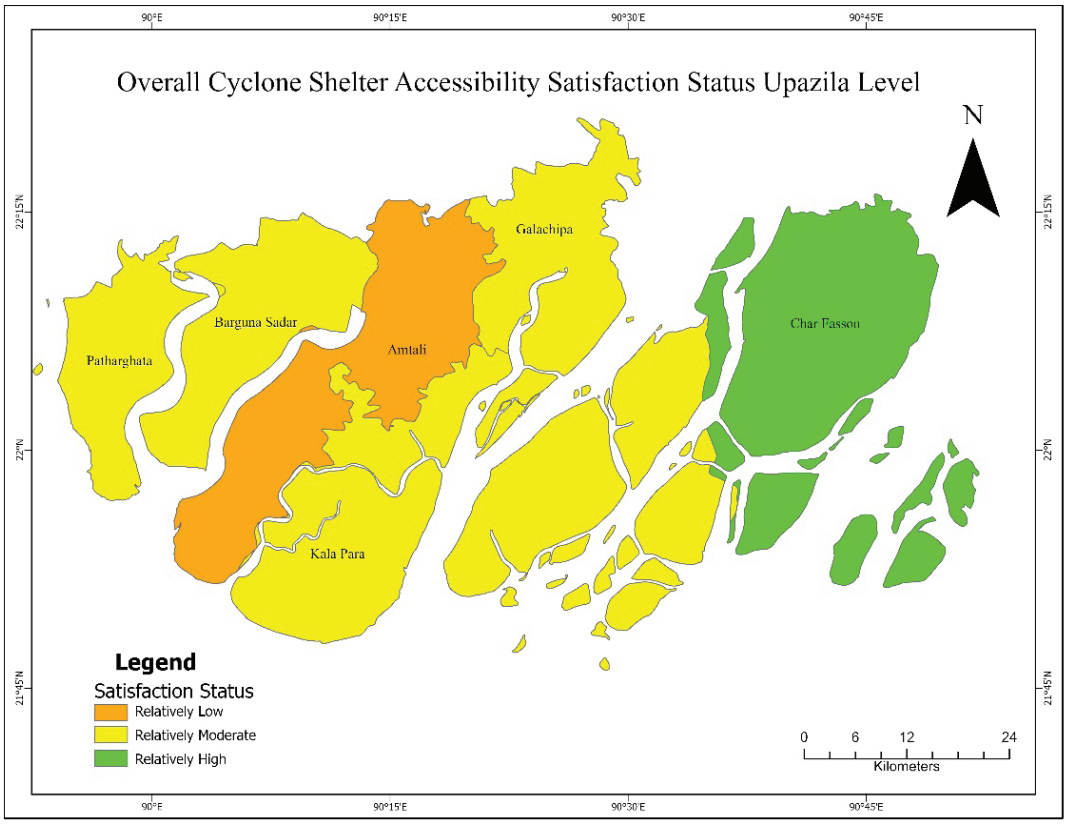

Figure 6: Map of the Status of Overall Cyclone Shelter Satisfaction at Upazila Level

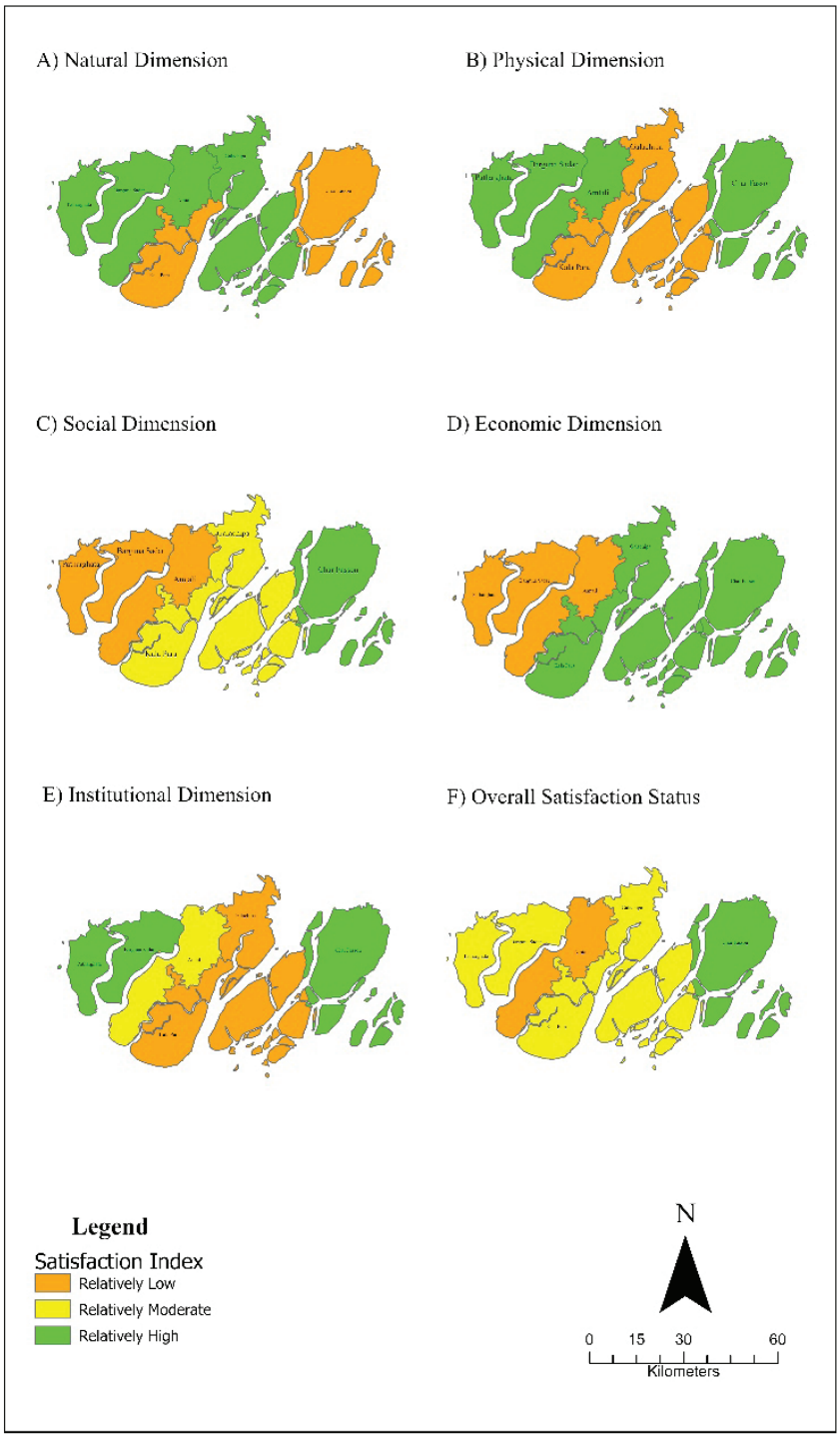

Figure 7: Maps Showing the Status of Satisfaction in the Dimensions; A) Natural Dimension, B) Physical Dimension, C) Social Dimension, D) Economic Dimension, E) Institutional Dimension, and F) Overall Satisfaction at the Upazila Level

Table 5: A Comparative Status of Population Density (BBS, 2022), Number of Cyclone Shelters Along with Their Satisfaction Scores at Union Level

Name of Union	Population Density (2022) (People/sq.km)	Number of Cyclone Shelter	CSSI Score	Status
Char Madraj	1051	23	3.293	
Mithaganj	471	11	3.183	
Nilganj	677	24	3.011	Relatively High
Golkhali	713	34	2.969	
Keorabunia	904	16	2.921	
Char Kalmi	556	21	2.917	
Burir Char	1018	30	2.834	
Raihanpur	741	23	2.799	
Chiknikandi	877	17	2.771	Relatively Moderate
Patharghata	625	25	2.770	
Gulisakhali	745	25	2.716	
Abdullapur	1966	7	2.644	
Arpangashia	760	13	2.639	
Kanthaltali	689	21	2.636	
Naltona	730	24	2.579	Relatively Low
Ratandi Taltali	970	14	2.508	
Haldia	563	68	2.361	
Tiakhali	853	25	2.281	

Statistical Analysis of Site Differences

A statistical analysis was conducted to evaluate differences among the study areas including Ratandi Taltoli, Golkhali, Chiknikandi and Tiakhali). The result showed some variation, with Golkhali having the highest average value (M= 2.97, Var =0.38) and Ratandi Taltoli the lowest (M= 2.51, Var= 0.35). Still, these differences were not statistically significant, suggesting that the measured factor was quite consistent across the study areas. As a whole, this indicates that the sites share similar environmental and socio-economic conditions, with only slight difference from one place to another

Comparative Analysis and Policy Implications

The results of the current study, reflect a moderate level of overall satisfaction (CSSI = 2.77) with significant variation between-union and within-upazila, is comparable with and critique with the existing body of literature on cyclone shelters in Bangladesh. Our findings corroborate the conclusion that the simple existence of shelters does not necessarily equate with disaster preparedness, a conclusion drawn earlier by Mahmood et al. (2014). This is dramatically illustrated in our findings by Haldia Union, which had the greatest number of cyclone shelters (68) and yet one of the lowest levels of satisfaction (2.361). This incongruity parallels with the findings of Siddique et al. The dissatisfaction in Haldia and other poorly rated unions such as Tiakhali (2.281) and Naltona (2.579) can be explained by already reported factors: quite a few, though they were far from being ideal, lacked good structural repair water, sanitation and hygiene (WASH) provision were insufficient, they were without gender sensitive facilities (Amin et al., 2016; Faruk et al., 2018, Nur et al., 2021). For example, the low scores for the Social Dimension in Haldia (1.700) and Gulisakhali (1. 878) are indicative of a dire privacy and security situation that is particularly troubling for women and is a major factor discouraging them from

seeking shelter as documented by Islam & Mallick (2021) through their research in Bhola. By contrast, the more satisfied unions like Char Madraj (3.293) and Mithaganj (3.183) had existing infrastructure, better administration, and more community consolidation. This reinforces the claim of Uddin et al. (2020) that shelter design has been improved after the 2011 policy amendments. The contrast between the high Economic Dimension score of Char Fasson Upazila (3.79) and the very low scores in the unions of Barguna Sadar (such as 1.41 for Keorabunia) reveals an important insight about satisfaction – it is not even about the shelter itself, but also the post-disaster economic support (perceived) a survivor receives. This indicates a potential inequality in assistance distribution and economic hardiness, implying that districts like Bhola could be brought more in focus, while areas in Barguna linger relatively worse and weaker in the phase of recovery, a difference that must be probed deeper.

Our spatially explicit analysis (Figures 3, 4, 6, and 7) displaying a distinct geography of satisfaction (low satisfaction clustering in some parts of Amtali, Barguna Sadar, and Kalapara), therefore, confirms the particularly high socio-physical vulnerability of these areas captured by Hasan et al. (2024) and Mollah et al. (2024). The poor Physical Dimension results (2. 02) in Galachipa Upazila, for instance, mirror the "poor road networks and limited transport options" as biggest evacuation hindrance stated by Alam (2023). This study provides a numerical basis for these qualitative apprehensions by demonstrating how dismal road conditions and prolonged travel distances culminate in significant user discontent. With the exception of some specific issues, discussed previously in this section, raised by the extreme case study of coastal Bangladesh, the general trends are the same. Studies from other parts of world also support what we have found. For example, dissatisfaction with WASH facilities in Amtali is compatible with the report of Amin et al. (2016), regarding healthy sanitation that 30% shelters i. In addition, the small scale of shelter management, possibly affecting the Institutional Dimension scores, was also identified as a problem in the findings of Mahmood et al. (2014), concluding there was no 'organised' social participation and in approximately 81% of shelters, which had 'become a popular site for political manipulation in the name of community representation.' The moderate level of satisfaction found in our study area is therefore likely to reflect a deeper, bigger problem common across Bangladeshi coastal belt.

The assessment of community satisfaction with cyclone shelters at the union and upazila levels indicates subtle differences impacted by local management strategies, infrastructural coverage, and population density. Broadly speaking however is the year of construction that has significant implications for the difference in satisfaction. Newer shelters are much better in terms of infrastructure and operational capacity as the government code has shifted a lot since the introduction of the Cyclone Shelter Construction, Maintenance and Management Policy of 2011 exhibit superior infrastructure and operational capacity, corroborating findings by Uddin et al. (2020), who reported improvements in shelter design and maintenance following policy reforms. Spatial analysis further reveals pronounced regional disparities in shelter preparedness and accessibility (Fig. 6 and 7). Despite relatively good shelter distribution, many older shelters suffer from structural deficiencies and inadequate amenities, reducing their usability during emergencies. This is exacerbated by limited road infrastructure and poor maintenance, factors known to hinder evacuation efforts and access to shelters in cyclone-prone areas (Alam and Collins, 2010; Paul and Routray, 2011). The case of Haldia underscores this issue; despite the high shelter count, most are outdated and do not conform to modern safety and comfort standards, leading to low satisfaction ratings. This supports the argument made by Uddin et al. (2020) and Hossain and Mullick (2020) that infrastructure longevity without periodic renovation reduces disaster resilience and user confidence. The results of this study offer critical evidence-based guidance that can be used to directly improve, and ultimately bolster, national planning and policy for DRR and CZM. The (CSSI=2.77) and the large disparities among areas revealed by the extraction are not just theoretical; these raise the issue of the gap between policies and their implementation. In this view, the following policy actions for building coastal community resilience toward sustainable development (Goal 4) are proposed:

I. Incorporation of "Shelter Performance and Satisfaction Index" in National Monitoring: The Cyclone Shelter Satisfaction Index (CSSI) established in this study provides a quantitative, reproducible

instrument. The index-based monitoring system should be appropriated by both, Ministry of Disaster Management and Relief (MoDMR) and Disaster Management Bureau (DMB). Instead of merely counting shelters, this would focus on assessing whether they work, are accessible, and are accepted by users. Annual satisfaction assessment to be systematically incorporated in the reporting of the Cyclone Preparedness Programme (CPP) to generate real-time information to pinpoint the poor-performing shelters of unions such as Haldia or Tiakhali for focused attention.

II. Implementing the "Build Back Better" System in Shelter Maintenance: The post disaster recovery process is guided by the government's National Plan for Disaster Management (NPDM) and Standing Orders on Disaster (SOD). The principle needs to be operationalized in shelter maintenance. A separate and ring-fenced budget line for the periodic repair and upgrading of shelters be introduced under the Local Government Engineering Department (LGED). Up-grading of WASH facilities (to address concerns raised in Amtali), introduction of gender sensitive facilities (separate toilets, safe spaces for women) and shelter accessibility for elderly and persons with disabilities (as per the provisions of the Rights and Protection of Persons with Disabilities Act, 2013) should be prioritized.

III. As Shelter Access is Tied to Coastal Infrastructure Development: The low physical access scores, especially for unions such as Chiknikandi and Galachipa highlight a disastrous lack of integrated planning. In fact, both the Bangladesh Delta Plan 2100, but also the Integrated Coastal Zone Management Plan (ICZMP) must priorities linking access to cyclone shelters and coastal infrastructure development projects. Prioritize investments in all-weather rural roads and evacuation routes in shelter catchment areas where connectivity is weakest. This will need concerted efforts from the LGED, Ministry of Road Transport and Bridges and local Union Parishads.

IV. Promoting Local Governance through Community-Based Prime Minister's Shelter Management: The shifting scores in the Dimension of Institutionalist show that there is an absence of local ownership. Policy must require the establishment and capacity development of Community-based Shelter Management Committees at the union level, as articulated under localized risk management plans. Those groups (made-up of local delegates, women, and community heads) could then be vested with modest grants for day-to-day maintenance, and trained to keep shelters functional in times of crisis. This decentralization of authority enhances accountability and responsiveness to the local social fabric, and leads to increased levels of trust and utilization.

V. Integrating Cyclone Shelters in Climate-Resilient Development Planning: Cyclone shelters must not be promoted as isolated emergency buildings but as part of climate resilient coastal infrastructure development. The Mujib Climate Prosperity Plan can also make use of these shelters as multi-use community centers. Additional policies should incentivize use as schools, community centers or clinics year-round for maintenance and community benefit. Moreover, the spatial arrangement for new shelters should be based on a study, such as Hasan et al (2024), to obviate or minimize the challenges of uneven spacing, informed by vulnerability and population density to strike a balance and avoid both "gaps" and clustering.

By this, the Government of Bangladesh can bring the blind empirical findings of this study into the light of meaningful and actionable policy implications. This will allow its huge investments in cyclone shelters to progress from a rudimentary survival approach toward one of long-term resilience and sustainable endurance in an age of escalating climatic change. Figure 8 shows a map of the cyclone shelters in the studied unions with the population density per union to indicate where shelter supply is unevenly distributed and where the most urgent attention ought to be focused (see Fig. 8).

The analysis of shelter capacity to population density shows that there is a large disparity across unions in space availability. Many unions exposed to very high population density (e.g., Kalikhali, Golkhali, Chandipur) have very few shelters, leaving a very high likelihood of overcrowding in these facilities in the event of a disaster. By contrast, some low-density unions have a fair to adequate provision of SA shelters, yet in these cases the generally dispersed settlement pattern may still mean people are cut off in emergencies. These incongruities suggest a greater need to plan strategically and distribute shelters more equitably to achieve efficient cyclone preparedness (Fig. 8).

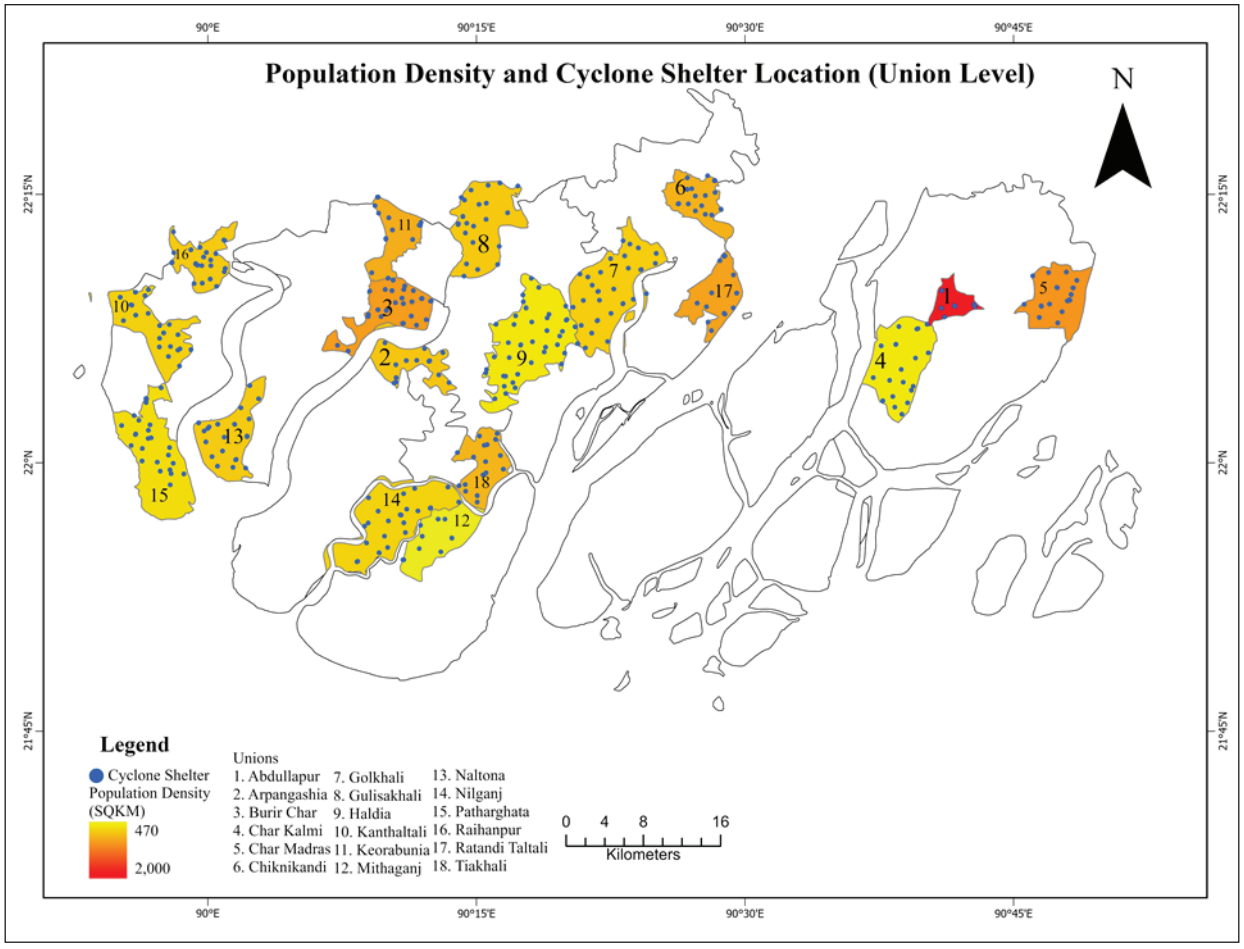

Figure 8: Map Showing the Distribution of the Cyclone Shelters in the Studied Unions Along with the Respective Population Densities

To enhance community satisfaction and resilience, policy interventions must adopt a multi-dimensional approach, which include infrastructural development, economic resilience and institutional strengthening. For infrastructural development it needs to enhance road networks, increasing shelter density, and ensuring adequate transport facilities. For economic resilience, implementing livelihood diversification programs and financial support mechanisms for vulnerable populations would work well for the areas. However, for institutional strengthening, improving governance, increasing disaster management funding, and promoting participatory decision-making are essential for the area.

CONCLUSIONS

The study assessed community satisfaction with cyclone shelters at both the upazila and union levels using the Cyclone Shelter Satisfaction Index (CSSI). The overall CSSI score across the study area was 3.2 out of 5, indicating moderate satisfaction. However, significant disparities were observed between the two levels, with upazila-level respondents reporting a higher average CSSI score of 3.8, while union-level respondents had a lower satisfaction score of 2.7. The analysis showed that 65% of upazila-level respondents found shelters adequately maintained, compared to only 40% of union-level respondents. Accessibility issues were also highlighted, with 70% of union-level respondents indicating difficulties in reaching shelters during emergencies, while the figure was 45% at the upazila level. These findings point to the uneven effectiveness of cyclone shelters and emphasize the need for targeted improvements, particularly in the most vulnerable areas. To improve cyclone shelter efficiency and community satisfaction, several strategic measures should be considered. First, infrastructure upgrades are necessary to enhance

the structural resilience and capacity of shelters, as 35% of surveyed shelters were reported as needing urgent repairs. Second, accessibility improvements, particularly in road connectivity and transportation, are crucial to ensuring timely evacuation, as 60% of respondents cited poor road networks as a significant challenge. Third, regular maintenance schedules should be implemented, and communities should be actively engaged in shelter management, as only 30% of union-level shelters had an active maintenance plan. Additionally, shelters could be utilized for multipurpose activities, such as community events, education, and healthcare services, as only 25% of cyclone shelters were used for non-emergency purposes. This research is the first to develop a multidimensional Cyclone Shelter Satisfaction Index (CSSI) and apply it to assess community satisfaction in the high-risk coastal areas of Bangladesh. In a context where assessments have been mainly traditional (infrastructural), the CSSI is an ordinary user-centric indicator and is able to reflect how different physical, social, economic and institutional factors affect the decision to evacuate and the overall shelter performance.

The most significant result of the study is that simple shelter adequacy along the lines of the National Response Coordination Center (NRC) guidelines do not suggest quite a few answers: moderate and highly spatially variable satisfaction levels are being reported across shelters and crucial question as to whether all shelters, even those deemed socially acceptable, were habitable is raised. This highlights the fact that simply the total number of shelters is not an indication for level of disaster preparedness. The main policy implication emanating from the study is the imperative to realign policy from a supply-side to a performance-based and equity-sensitive approach for cyclone shelter governance. To turn cyclone shelters from last resort structures to trusted, effective and inclusive community resilience building, future action should focus on the following pillars: (1) Specific Infrastructural Investment to upgrade and maintain facilities, particularly for WASH and gender-sensitive features; (2) Improved Physical Connectivity with resilient access and evacuation routes integrated with broader coastal infrastructure plans; and (3) Enhanced Local Governance by entrusting the management and maintenance of shelters to community-based committees. Making regular shelter performance monitoring through tools such as the CSSI a standard practice is important for evidence-based decision-making and for ensuring equitable allocation of resources. Finally, policy interventions should strengthen local governance frameworks to ensure equitable access and efficient resource distribution, as only 50% of respondents believed that resource allocation was fair. The study also had a limited temporal scope, capturing satisfaction levels at a single point in time without considering long-term trends or changes in shelter conditions. Future research should address these limitations by expanding data collection, conducting longitudinal studies, and covering a broader geographic area to provide a more comprehensive understanding of cyclone shelter effectiveness in Bangladesh.

REFERENCES

Ahmad, H., 2019. Bangladesh coastal zone management: Status and future trends. Journal of Coastal Zone Management, 22(1), Article 466. Retrieved February 26, 2025, from https://www.walshmedicalmedia.com/open-access/bangladesh-coastal-zone-management-status-and-future-trends.pdf

Akon, M. S., Mia, M. J., 2024. Performance of JICA-funded cyclone shelters in the coastal areas of Bangladesh: An empirical analysis from Pirojpur district. Progress in Disaster Science 23, 100342. https://doi.org/10.1016/j.pdisas.2024.100342

Alam, E., Collins, A. E., 2010. Cyclone disaster vulnerability and response experiences in coastal Bangladesh. Disasters 34(4), 931–954. https://doi.org/10.1111/j.1467-7717.2010.01176.x

Amin, M. R., Uddin, K., Nishat, A., 2015. Physical accessibility of cyclone shelters in coastal areas of Bangladesh: A study on Kutubdia island. International Journal of Disaster Risk Reduction 12, 222-233. DOI: 10.1016/j.ijdrr.2015.02.004

Alam, E., 2023. Factors of cyclone disaster deaths in coastal Bangladesh. Heliyon 9(7), Article e18417. https://doi.org/10.1016/j.heliyon.2023.e18417

Amin, M. N., Shil, S. C., Hasan, M., 2016. Status of cyclone shelter facilities in south central Bangladesh. Journal of Environmental Science and Natural Resources 9(1), 75–79. https://doi.org/10.3329/jesnr.v9i1.30295

Asian Development Bank (ADB), 2012. Coastal climate-resilient infrastructure project. https://www.adb.org/projects/documents/coastal-climate-resilient-infrastructure-project-tacr

Bangladesh Bureau of Statistics (BBS), 2022. Population and housing census, Bangladesh Bureau of Statistics.

Retrieved from http://www.bbs.gov.bd/site/page/47856ad0-7e1e-4a52-bf88-8329e8e00993/2022-Population-&-Housing-Census

CDMP II, 2014. Comprehensive disaster management programme phase II: Annual report 2014. Ministry of Disaster Management and Relief, Bangladesh. Retrieved from https://erc.undp.org/evaluation/evaluations/detail/8096

Dasgupta, S., Huq, M., Wheeler, D., 2019. Cyclones and shelter behavior: The case of Bangladesh. Environment and Development Economics 24(2), 115–134. https://doi.org/10.1017/S1355770X18000469

Debortoli, N. S., Camarinha, P. I. M., Marengo, J. A., Alves, L. M., 2017. An index of Brazil's vulnerability to expected increases in natural flash flooding and landslide disasters in the context of climate change. Natural Hazards 86, 557–582. https://doi.org/10.1007/s11069-016-2705-2

Eckstein, D., Künzel, V., Schäfer, L., 2021. The global climate risk index 2021. Bonn: Germanwatch. https://doi.org/10.1016/j.ijdrr.2016.08.022

Frigerio, I., Tincani, L., Tullio, D., 2016. Social factors influencing disaster resilience. International Journal of Disaster Risk Reduction 19, 243–254. https://doi.org/10.1016/j.ijdrr.2016.08.022

Faruk, M., Ashraf, S. A., Ferdaus, M., 2018. An analysis of inclusiveness and accessibility of Cyclone Shelters, Bangladesh. Procedia engineering 212, 1099-1106. https://doi.org/10.1016/j.proeng.2018.01.142

Federal Emergency Management Agency (FEMA), (2024). Taking shelter from the storm: Building or installing a safe room for your home (FEMA P-320, 6th ed.). Retrieved from https://www.fema.gov/sites/default/files/documents/fema_p-320-taking-shelter-from-storm-building-installing-safe-room-home.pdf

Fornell, C., Johnson, M.D., Anderson, E.W., Cha, J., Bryant, B.E., 1996. The American customer satisfaction index: Nature, purpose, and findings. Journal of Marketing 60(4), 7–18. https://doi.org/10.2307/1251898

Faruk, M., Ashraf, S. A., Ferdaus, M., 2018. An analysis of inclusiveness and accessibility of cyclone shelters, Bangladesh. Procedia Engineering 212, 1099–1106. https://doi.org/10.1016/j.proeng.2018.01.142

Government of the People's Republic of Bangladesh, 2013. Rights and protection of persons with disabilities Act, 2013. Ministry of Social Welfare.

Hossain, I., Mullick, A. R., 2020. Cyclone and Bangladesh: A historical and environmental overview from 1582 to 2020. International Medical Journal (1994) 25(6):2595-2614.

Hasan, I., Faruk, M. O., Katha, Z. T., Goni, M. O., Islam, M. S., Chakraborty, T. R., Sowrav, S. F. F., & Hossain, M. S. (2024). Geo-spatial based cyclone shelter suitability assessment using analytical hierarchy process (AHP) in the coastal region of Bangladesh. Heliyon, 10(21), e39831. https://doi.org/10.1016/j.heliyon.2024.e39831

Hasan, M., Rahman, M. H., Islam, M. S., 2024. A GIS-based integrated study assessing the socio-physical vulnerability of the south-central and south-western coastal regions of Bangladesh. International Journal of Disaster Risk Reduction 105, 104392. https://doi.org/10.1016/j.ijdrr.2024.104392

Hossen, M. A., Ayon, M. A. G., Jubayer, R., 2025. Assessment of tropical cyclone Remal induced inundation in Patuakhali and Barguna districts of Bangladesh using Sentinel satellite images. Remote Sensing Applications: Society and Environment 31, 101045. https://doi.org/10.1016/j.rsase.2025.101045

Hasan, I., Faruk, M. O., Katha, Z. T., Goni, M. O., Islam, M. S., Chakraborty, T. R., Sowrav, S. F. F., Hossain, M. S., 2024. Geo-spatial based cyclone shelter suitability assessment using analytical hierarchy process (AHP) in the coastal region of Bangladesh. Heliyon 10(21), Article e39831. https://doi.org/10.1016/j.heliyon.2024.e39831

IFRC, 2021. Bangladesh: Cyclone preparedness and disaster risk reduction. International federation of red cross and red crescent societies. Retrieved from https://www.ifrc.org/sites/default/files/2021-12/Bangladesh-Cyclone-Preparedness-Disaster-Risk-Reduction-2021.pdf

International Centre for Climate Change and Development (ICCCAD), 2022. 50 years of cyclone preparedness: Success in saving lives but not livelihood. Retrieved from https://icccad.net/the-business-standard/50-years-of-cyclone-preparedness-success-in-saving-lives-but-not-livelihood-over-the-past-30-years-the-number-of-cyclone-shelters-have-increased-from-400-to-14000-but-it-is-still-insufficient-for/

Islam, M., Islam, A. F., Bahar, S., Rahman, S. M. A., Sharif, N. H., Hadi, T., 2023. A risk-based approach to assessing cyclone shelter locational needs in the coastal region of Bangladesh. In I. Pal, R. Shaw, T. Ichinose, O. Yonariza, & T. Oda (Eds.), Proceedings of the 2nd International Symposium on Disaster Resilience and Sustainable Development (Vol. 283). Lecture Notes in Civil Engineering. Springer. https://doi.org/10.1007/978-981-19-4715-5_7

Islam, M. A., Paull, D. J., Griffin, A. L., Murshed, S., 2021. Spatio-temporal assessment of social resilience to tropical cyclones in coastal Bangladesh. Natural Hazards 107(1), 279–309. https://doi.org/10.1080/19475705.2020.1870169

Islam, N. N., Mallick, B., 2021. What influence evacuation decisions at cyclone shelters? Empirical evidence from Bangladesh. In G. M. M. Alam, M. O. Erdiaw-Kwasie, G. J. Nagy, & W. Leal Filho (Eds.), Climate vulnerability and resilience in the Global South (Climate Change Management, pp. 175–192). Springer, Cham. https://doi.org/10.1007/978-3-030-77259-8_10

Khatun, M.F., Hossain, M.K., Hossain, K.A., Rahman, M.M., 2014. Participation potential of rural women in different homestead farm activities. The Agriculturists 12(1): 57-67. https://doi.org/10.3329/agric.v12i1.19866

Mahmood, N., Prasad, M., Dhakal, S., Keast, Robyn, R., 2014. The state of multi-purpose cyclone shelters in Bangladesh. Facilities 32(9/10), 522-532. https://doi.org/10.1108/F-10-2012-0082

Mayunga, J. S., 2012. Assessment of public shelter users' satisfaction: Lessons learned from south-central Texas flood. Natural Hazards Review 13(1), 1-8. https://doi.org/10.1061/(ASCE)NH.1527-6996.0000055

Mollah, A. H., Shovon, H. H., Roy, A., 2024. Assessing socioeconomic vulnerability of cyclone Remal-affected coastal communities in Bangladesh. Progress in Disaster Science 22, 100321. https://doi.org/10.1016/j.pdisas.2024.100321

Miyaji, M., Okazaki, K., Ochiai, C., 2020. A study on the use of cyclone shelters in Bangladesh. Japan Architectural Review 3(4), 590-600. DOI: 10.1002/2475-8876.12177.

Marin, A., Schneider, P., Delgado, C., 2021. Institutional preparedness and governance in disaster management. Journal of Risk Research 24(8), 1025–1042. https://doi.org/10.1080/13669877.2021.1906145

Meem, R. M., Uddin, M. R., Alam, S., 2025. Economic recovery and aid distribution post-cyclone events in Bangladesh. Disaster Prevention and Management 34(2), 115–132. https://doi.org/10.1108/DPM-08-2024-0250

Murshed, S., Griffin, A. L., Islam, M. A., Oliver, T., Wang, X. H., Paull, D. J., 2024. A framework for appraising the status of disaster resilience within the multi-hazard environment of coastal Bangladesh. International Journal of Disaster Risk Reduction 113, 104832. https://doi.org/10.1016/j.ijdrr.2024.104832

Mata, P., Cullano, R. A., Tiu, A. M., Gonzales, G., Selerio Jr., E., Maturan, F., Evangelista, S. S., Burdeos, A., Yamagishi, K., Ocampo, L., 2023. Public satisfaction with the government's disaster response during Typhoon Odette (Rai). International Journal of Disaster Risk Reduction 84, 103483. https://doi.org/10.1016/j.ijdrr.2022.103483

Mahmood, M. N., Dhakal, S. P., Keast, R., 2014. The state of multi-purpose cyclone shelters in Bangladesh. Facilities 32(9–10), 522–532. https://doi.org/10.1108/F-10-2012-0082

Nur, M. N. B., Rahim, M. A., Rasheduzzaman, M., 2021. Identifying cyclone shelter facilities and limitations for enhancing community resiliency in coastal areas of Bangladesh. Asian Journal of Social Sciences and Legal Studies 3(4), 107–118. https://doi.org/10.34104/ajssls.021.01070118

Noy, I., Yonson, R., 2018. Economic impacts of natural hazards on vulnerable communities. Natural Hazards 90(1), 123–141. https://doi.org/10.1007/s11069-017-3054-5

Paul, S.K., Routray, J.K., 2011. Household response to cyclone and induced surge in coastal Bangladesh: coping strategies and explanatory variables. Nat Hazards 57, 477–499. https://doi.org/10.1007/s11069-010-9631-5

Patri, S., Rana, R., Trentin, G., 2022. Multidimensional assessment of disaster resilience in coastal regions. International Journal of Disaster Risk Science 13, 678–695. https://doi.org/10.1007/s13753-022-00433-2

Pakurar, M., Haddad, H., Nagy, J., Popp, J., Olah, J., 2019. The service quality dimensions that affect customer satisfaction in the Jordanian banking sector. Sustainability 11(4), 1113. https://doi.org/10.3390/su11041113

Quinn, R. P., Mangione, T. W., 1973. Evaluating weighted models of measuring job satisfaction: A cinderella story. Organizational Behavior and Human Performance 10(1), 1–23. https://doi.org/10.3390/ijerph14080831

Roy, K., Bhuiyan, M. A. H., Khatun, M. A., 2021. Spatial analysis of cyclone shelters in coastal Bangladesh: A case study on preparedness. Natural Hazards 108(1), 415–437. https://doi.org/10.1007/s11069-021-04687-9

Rahman, M. M., Arif, M. I., Hossain, M. T., Almohamad, H., Al Dughairi, A. A., Al-Mutiry, M., Abdo, H. G., 2023. Households' vulnerability assessment: empirical evidence from cyclone-prone area of Bangladesh. Geoscience Letters 10(1), 26. https://doi.org/10.1186/s40562-023-00280-z

Rahman, M. M., Arif, M. S. I., Mahdi, I., Rafi, M. A., Chisty, M. A., Khan, S. J., 2022. Cyclone vulnerability in ethnic

minority: A case study among Rakhain community of Bangladesh. International Journal of Disaster Risk Reduction 83, 103449. https://doi.org/10.1016/j.ijdrr.2022.103449

Rana, R., Routray, J. K., 2018. Physical and environmental determinants of disaster vulnerability. International Journal of Disaster Risk Reduction 31, 589–601. https://doi.org/10.1016/j.ijdrr.2018.06.016

Rahman, M. M., Arif, M. S. I., Hossain, M. T., Almohamad, H., Al Dughairi, A. A., Al-Mutiry, M., Abdo, H. G., 2023. Households' vulnerability assessment: Empirical evidence from cyclone-prone area of Bangladesh. Geoscience Letters 10, Article 26. https://doi.org/10.1186/s40562-023-00257-3

Salman, M. A., Rakib, M. H., Saha, S. C., Haque, M. E., Hossen, M. S., 2025. Cyclone vulnerability assessment of the central coast of Bangladesh: A comprehensive study utilizing FAHP and geospatial techniques. Heliyon 11(3), e45678. https://doi.org/10.1016/j.heliyon.2025.e45678

Siddique, N., Riad, A., Hore, R., 2025. Assessment of existing cyclone shelters in disaster-prone areas of Bangladesh: A case study of Barguna and Bhola. Earthquake 3(1), Article 9051. https://doi.org/10.59429/ear.v3i1.9051

Shamsuddoha, M., Rahman, M., Khan, S.M.M.H., 2013. Disaster resilient housing in coastal Bangladesh: The case for community-based approaches. ActionAid Bangladesh. Retrieved fromhttps://www.actionaid.org/sites/default/files/disaster_resilient_housing_in_coastal_bangladesg.pdf

Sahoo, S., Bhaskaran, R., 2018. Integrating natural and physical parameters in cyclone risk assessment. Natural Hazards 92(3), 1517–1535. https://doi.org/10.1007/s11069-018-3367-z

Siddique, N., Riad, A., Hore, R., 2025. Assessment of existing cyclone shelters in disaster-prone areas of Bangladesh: A case study of Barguna and Bhola. Earthquake 3(1), Article 9051. https://doi.org/10.59429/ear.v3i1.9051

Tasnim, F., Md. Hossain, S., Elahi, K. M., 2021. Vulnerability to natural hazards and climate resilient socio-economic development in Bhola. Journal of Coastal Zone Management 24(2), 1–15. https://doi.org/10.1016/j.envc.2021.100262

Trentin, G., Patri, S., Frigerio, I., 2023. Community engagement and social resilience in disaster management. International Journal of Disaster Risk Science 14(1), 45–62. https://doi.org/10.1007/s13753-023-00478-x

Uddin, M.S., C.E. Haque, D. Walker, M.-U.-I. Choudhury, 2020. Community resilience to cyclone and storm surge disasters: evidence from coastal communities of Bangladesh. Journal of Environmental Management. 264. Article number: 110457. https://doi.org/10.1016/j.jenvman.2020.110457

United Nations Office for Disaster Risk Reduction (UNDRR), 2020. Annual report, United Nations office for disaster risk reduction. Retrieved October 26, 2024, from https://www.undrr.org/annual-report-2020

Uddin, M. S., Haque, C. E., Walker, D., Choudhury, M.-U.-I., 2021. Community resilience to cyclone and storm surge disasters: Evidence from coastal communities of Bangladesh. Journal of Environmental Management 278, 110457. https://doi.org/10.1016/j.jenvman.2020.110457

Uddin, M. S., Haque, C. E., Walker, D., Choudhury, M.-U.-I., 2020. Community resilience to cyclone and storm surge disasters: Evidence from coastal communities of Bangladesh. Journal of Environmental Management 264, 110457. https://doi.org/10.1016/j.jenvman.2020.110457

Zhang, J., Chen, W., Petrovsky, N., Walker, R. M., 2021. The expectancy-disconfirmation model and citizen satisfaction with public services: A meta-analysis and an agenda for best practice. Public Administration Review 81(2), 214–230. https://doi.org/10.1111/puar.13368