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RESEARCH ARTICLE

Assessment of existing cyclone shelters in disaster-prone areas of Bangladesh: A case study of Barguna and Bhola

Nadim Siddique[1], Arefin Riad[2], Ripon Hore[3*]

[1] *Graduate Student, University of Alabama, USA*

[2] *Research Associate, University of Alabama, USA*

[3] *Adjunct Faculty, East West University, Bangladesh*

*** Corresponding author:** Ripon Hore, riponhore1984@gmail.com

ABSTRACT

Bangladesh, a low-lying riverine nation in South Asia, faces significant vulnerability to natural disasters due to its geographic position at the confluence of the Ganges (Padma), Brahmaputra (Jamuna), and Meghna Rivers. Its proximity to the Bay of Bengal further heightens the risk of frequent tropical cyclones, particularly during the monsoon season. The increasing severity of these events is compounded by climate change. This study assesses the current state of cyclone shelters in two disaster-prone districts, Barguna and Bhola, focusing on their architectural and structural adequacy. It identifies key challenges related to their functionality, highlights deficiencies in disaster preparedness, and evaluates design and construction aspects. The findings provide insights into existing limitations and propose strategic improvements to enhance the resilience and effectiveness of these shelters. Additionally, the study outlines areas for future research to strengthen disaster management initiatives.

Keywords: cyclone shelter; resilient; climate change; disaster

1. Introduction

Bangladesh has a coastline stretching approximately 580 km (360 mi) along the northern shore of the Bay of Bengal. Since the catastrophic cyclone of 1970, around 2,500 cyclone and multipurpose shelters have been constructed along the 710 km-long coastal region to provide safe refuge for at-risk communities. These shelters, developed by various organizations, vary considerably in terms of funding sources, locations, designs, structural footprints, materials, and construction techniques. Their planning and implementation have historically been influenced by factors such as spatial distribution, structural integrity, catchment area accessibility, and management efficiency.

To mitigate the growing challenges posed by climate change, the Government of Bangladesh introduced the Coastal Zone Policy and the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) in 2009. These policies were further prioritized under the 2010 Strategic Program for Climate Resilience (SPCR), implemented through the Pilot Program for Climate Resilience (PPCR). A key aspect of this initiative is the enhancement of climate-resilient infrastructure, including the construction of new cyclone shelters, the

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rehabilitation of existing ones, and the improvement of critical road networks to ensure better accessibility.

Previous studies have identified significant gaps in cyclone shelter design and functionality. Research by Faruk's research[1] emphasized the lack of inclusivity for vulnerable groups, including the elderly, people with disabilities, and women, as well as the inadequate consideration of local farmers' needs. Furthermore, tropical cyclones bring multiple hazards—strong winds, heavy rainfall, storm surges, and inland flooding—which exacerbate vulnerabilities in coastal regions[2-3]. The impact of these events is often intensified by weak infrastructure and insufficient disaster preparedness measures.

Recent research has contributed further insights into disaster resilience and infrastructure challenges in Bangladesh. Arefin's research[4] investigated the state of water, sanitation, and hygiene (WASH) facilities in rural areas, emphasizing their poor condition. Additionally, Hasan[5] analyzed rainfall-induced landslides in hilly regions, while Hore[6-9] studied dynamic soil properties to support resilient infrastructure development. Advances in numerical modeling for seismic soil-pile-structure interaction (SSPSI) in high-rise buildings, as explored by Hasan[5], demonstrate the growing role of technology in disaster resilience planning. Talukder[10-11] examined soil chemical properties and earthquake preparedness, highlighting crucial aspects of disaster risk reduction. The coastal vulnerability of Bangladesh, particularly in the Bay of Bengal, has been extensively studied due to its exposure to frequent cyclones and tsunamis. The 1991 cyclone's severe impact on Sandwip Island and the high death toll across affected regions reveal critical weaknesses in preparedness and infrastructure[12-14]. Tsunami and cyclone hazard syntheses provide detailed insights into regional risks and past events, emphasizing the need for integrated hazard assessment[15-17]. Recent studies have emphasized earthquake awareness, soil chemical properties, and the application of smart polymeric materials for disaster resilience in Bangladesh[18-20]. Additionally, geological and environmental data from surrounding regions enhance understanding of depositional patterns and storm genesis influencing the coastal hazard profile[21].

Building upon this body of research, this study evaluates the current condition of cyclone shelters and their connecting road networks in the disaster-prone districts of Barguna and Bhola. It focuses on structural, architectural, and management challenges, aiming to propose recommendations for enhancing the design, functionality, and accessibility of these shelters. The study emphasizes the importance of inclusivity, sustainability, and resilience in cyclone shelter development, contributing to a more comprehensive disaster preparedness framework for coastal Bangladesh.

2. Accessibility of cyclone shelters

The coastal belt of Bangladesh has evolved through continuous sedimentation, resulting in extensive low-lying areas that are naturally prone to inundation, even during regular tidal cycles. The region's vulnerability is further heightened by the unique triangular shape of the Bay of Bengal, which amplifies tidal surges during storm events, often leading to severe flooding. When combined with high winds and heavy rainfall, these surges create hazardous conditions for coastal communities. **Figure 1 (a)** illustrates the geographic distribution of cyclone shelters across Bangladesh, highlighting their strategic placement to mitigate disaster risks.

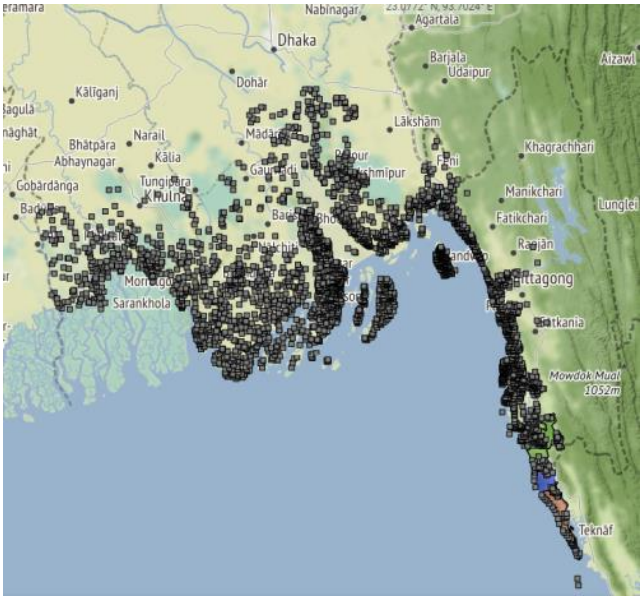

Figure 1 (a). Location of cyclone shelter in southern part of Bangladesh.

This study primarily focuses on the coastal regions of Bangladesh, where cyclone shelters play a crucial role in disaster preparedness. **Figure 1** (Source: Ministry of Disaster Management and Relief, Government of Bangladesh) illustrates the distribution of these shelters across the country. According to the Integrated Coastal Zone Management Plan, nineteen districts bordering the Bay of Bengal are officially designated as coastal areas. Among them, Barguna and Bhola are considered the most vulnerable due to their geographical and hydrological characteristics.

Barguna District is surrounded by several major rivers, including the Paira, Bishkhali, Khakdon, Baleshwar, and Haringhata Rivers. These water bodies collectively cover approximately 160 km², accounting for 22% of the district's total area. Additionally, Barguna contains around 300 natural canals, further influencing its flood dynamics. Bhola, on the other hand, is a deltaic island with the Meghna River bordering its east and north, the Tetulia River to the west, and the Bay of Bengal to the south. These hydrological features contribute to the district's heightened susceptibility to cyclonic events.

Barguna and Bhola experience frequent cyclones, often causing widespread devastation. As shown in Figure 1, cyclone shelters are strategically concentrated in these high-risk coastal regions to provide refuge during extreme weather events. Historically, these shelters have played a vital role in protecting human lives and livestock. During Cyclone Sidr in 2007, approximately 15% of the affected population sought shelter in these facilities (GoB, 2008). **Figure 1 (b)** illustrates a typical cyclone shelter (School Building) in Bangladesh.

Figure 1 (b). A typical cyclone shelter (school building).

At present, Bangladesh has 3,791 operational cyclone shelters, many of which feature elevated spaces for livestock and overhead water storage, enhancing their functionality during emergencies. A significant portion of these shelters was constructed following the catastrophic cyclone of 1991. Between 1991 and 2007, the Local Government Engineering Department (LGED) led the construction of most cyclone shelters, ensuring widespread coverage in disaster-prone areas. During non-emergency periods, these shelters serve multiple community functions, including use as schools, healthcare centers, community halls, and office buildings. After Cyclone Sidr, the World Bank supported the construction of additional shelters across coastal districts to further strengthen disaster resilience.

The existing cyclone shelter which are needed for rehabilitation as well as the new proposed cyclone shelters are included in this paper. **Table 1** and **Table 2** shows the Cyclone shelter of Barguna and Bhola district.

Table 1. Cyclone shelter of Barguna district.

Name of the cyclone shelter	Sub District	Capacity (Person)
Mitthalobongola GPS	Barguna Sadar	50
Hazar bigha	Barguna Sadar	70
Bistabak	Barguna Sadar	90
Tafalbari	Patharghata	130
Moddo bainchotki aziz sikdar	Patharghata	120
Horidra	Patharghata	70
Ruhuta	Patharghata	80
Padma	Patharghata	80

Table 2. Cyclone shelter of Bhola district.

Name of the cyclone shelter	Sub District	Capacity (Person)
Meajanpara	Char Fassion	60
Ayeshabag	Char Fassion	70
Mukharbanda	Char Fassion	80
Char Jamuna	Char Fassion	85
G.M. Bazar	Lalmohon	90
South Char Vuta	Lalmohon	95
South Chachra	Tajumuddin	100
Borhangong	Borhanuddin	130
Howla	Doulotkhan	120
Shukdev	Doulotkhan	100

3. Existing condition of the cyclone shelter

This section presents an assessment of the current state of cyclone shelters and their connecting roads. While the overall physical condition of most cyclone shelters is relatively good, significant issues persist in terms of drainage and road accessibility. In many cases, the existing drainage systems and road networks are inadequate, limiting the effectiveness of these shelters during emergencies.

One of the primary structural concerns is the design of the shelters' roofs. Most cyclone shelters feature flat roofs, similar to standard residential buildings. However, improper slope maintenance has led to water accumulation in various areas. This stagnant water damages the protective layer of the roof, causing efflorescence on the ceiling. Due to the high salinity in coastal regions, this efflorescence accelerates the deterioration of the concrete cover, exposing the reinforcement and compromising structural integrity. As a result, many cyclone shelters experience roof leaks during extreme weather events, disrupting their functionality and making it difficult for evacuees to meet their basic needs.

Accessibility is another critical factor in cyclone shelter effectiveness. Ideally, cyclone shelters should be easily reachable from all directions, and boundary walls should be avoided to ensure unrestricted access. However, a major challenge is the poor condition of the connecting roads. Many of these roads are narrow, unpaved, and structurally weak, with sections frequently eroded due to the presence of polders. The lack of proper road construction, including inadequate widening and paving, makes evacuation difficult during cyclones. As a result, people often face life-threatening situations while trying to reach safety. Addressing these issues through improved drainage systems, better road infrastructure, and structural enhancements is essential to ensure that cyclone shelters serve their intended purpose effectively.

4. Conclusion

This study assessed the current condition of cyclone shelters and their associated road infrastructure in disaster-prone coastal regions of Bangladesh. While the majority of cyclone shelters remain structurally stable and capable of providing emergency refuge, significant deficiencies in the surrounding infrastructure—particularly inadequate drainage systems and deteriorated access roads—pose serious challenges to timely evacuation and effective disaster response.

To improve the overall resilience and utility of cyclone shelters, urgent attention must be directed toward upgrading drainage and access road networks. These improvements should be strategically

incorporated into national and local development plans, emphasizing long-term maintenance and climate-resilient design. Strengthening these critical infrastructure components will not only enhance accessibility during emergencies but also contribute to a more robust and inclusive disaster management system. In doing so, Bangladesh can better protect vulnerable coastal populations and build greater resilience against future climate-induced hazards.

Conflict of interest

The authors declare no conflict of interest.

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