Learning from vernacular building practices in achieving disaster resilience: Case study of the coastal island of Sandwip, Bangladesh

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Abstract

Bangladesh is an alluvial delta characterized by its low-lying topography, intricate river networks, towering Himalayas to the north and a funnel-shaped coastal region touching the Bay of Bengal to the south. This geographical makeup exposes the nation to the recurring and devastating impacts of tropical cyclones, marked by their origin at sea, accompanied by torrential rainfall and storm surge. Given these physiographical traits and climatic conditions, the coastal belt faces the most severe consequences of these cyclonic events almost every year. Over the centuries, indigenous communities in these areas have cultivated distinctive cultural identities intertwined with effective survival strategies during cyclones. These strategies manifest in their settlement planning, homestead organization and house construction techniques which are rooted in intuitive protective measures.

The aim of this paper is to explore and comprehend the underlying concepts and principles of vernacular building practices as a means to fortify resilience against cyclones. This exploration is accomplished by a detailed investigation of a cyclone-affected village situated in Sandwip, one of Bangladesh's most vulnerable coastal islands. The insights gleaned from these vernacular adaptations offer substantial prospects for reinforcing the resilience of contemporary societies grappling with similar risks. The paper puts forth an approach dedicated to identifying and valorizing disaster-resilient local building culture.

To realize this aim, the study employs a multidisciplinary approach. After a thorough review of pertinent literature, site observations, ethnographic surveys and in-depth interviews provide a comprehensive understanding of the indigenous communities' perceptions, strategies and adaptations in the face of adversity. Through structured questionnaires, photographic documentation, video recordings and meticulous documentation of vernacular architecture and planning strategies, the study identifies resilient and sustainable design principles interwoven within Sandwip island's local building practices. The paper also endeavors to distill universal principles from vernacular practices by analyzing case studies from global landscapes.

Ultimately, the research's findings underscore the significance of indigenous disaster-resilient construction techniques and coping strategies, which are ingrained in a balance between existing skills, available resources and prevailing risks. These findings hold substantial potential for bolstering local resilience. Moreover, the insights gained from this study serve as a valuable resource for future research endeavors aimed at advancing disaster resilience by leveraging indigenous knowledge and practices.

Keywords: Disaster Resilience, Cyclone, Vernacular Building Practices, Sandwip.

1. Introduction

Bangladesh is a low-lying alluvial delta, criss- crossed by many rivers and their tributaries. It is bounded by India and Myanmar on three sides, with the Himalayas in the North and in the South; the funnel shaped coast touching the Bay of Bengal, resulting to experience catastrophic effects of tropical cyclones, nor westers and floods Bangladesh, currently, is the world's 6th most disaster - prone country (World Risk Report, 2015). Almost every year Bangladesh suffers highly by different kinds of disasters like flood, tropical cyclones, tornados, tidal surges, droughts and largescale river erosion etc. Unfortunately, the situation is further aggravated by climate change. The sea level rise due to global thermal expansion will increase the water depth and the water depth would cause increase in the speed of wave progression and travel distance of cyclone storm surge wave over sea surface. These may cause greater amplification of storm surge and surge height (BUET- BIDS,1993). It has been recognized that during the last fifty years, tropical cyclones hitting Bangladesh far exceeds those in any corresponding period of recorded history (Choudhury, 2009).

Due to its unique physiographical features and climatic condition, the 710 km long coastal areas of Bangladesh is particularly susceptible to sea level rise as 12 out of 19 coastal districts are directly exposed to the sea (Ali, A. 1999 & Akter, T. 2009). As depicted in Figure 1, the coastal region of Bangladesh that touches the Bay, especially the Meghna River, is susceptible to the destruction caused by tidal surges during tropical cyclones. Because of the region's coastline's structure and characteristics, the calamity is particularly severe there. A typical cyclone develops in the deep ocean as it passes over one of the biggest continental shelves off Bangladesh's coast. The energy of the cyclone is forced to approach the beach with a sea surge because to the shallow depth of the continental shelf and is further constrained by the funnel-shaped northern Bay coastline.

If a cyclone and storm surge are present at the same time, the tidal surge can even rise 11 meters above mean sea level and the cyclone's wind speed can reach 225 km/h (BUET, 1995). According to the chance that they may be impacted, the coastal regions of Bangladesh have been categorized into three distinct zones: Wind Risk (WR), Risk Zone (RZ), and High- Risk Area (HRA). It was estimated that about five million people currently live in 'High Risk Areas' along the western, central and south- eastern coasts of Bangladesh. (BUET- BIDS, 1993). Frequent attacks of cyclone will surely bring more adversity to the people living on the coast of Bangladesh.

Nevertheless, despite the challenges, millions of people continue to inhabit coastal regions, relying on traditional indigenous practices to adapt to their evolving surroundings. Unfortunately, the lack of progress in indigenous knowledge and coping strategies in the face of changing climate conditions has left these communities increasingly susceptible. As a result, this study aims to explore several key questions: How do coastal communities endure and coexist with recurrent disasters? What is their perception of disaster risks? What vulnerabilities and strengths characterize these communities? What strategies do they employ to endure, adapt to, and manage disasters? This research primarily examines the physical environmental aspects of vulnerability and resilience. It also delves into the potential of indigenous knowledge when integrated with modern technologies and scientific insights,

paving the way for strategic interventions to develop resilient coastal settlements and built environments.

Figure 1*:* Coastal Area of Bangladesh
Source: United Nations, 2004 (rearranged), Risk areas*:* SPARRSO, Surge heights*:* SMR

2. History of cyclone and its ravages *(casualties):* People-Living with disaster

Bangladesh, a deltaic nation shaped by the vast river system of this subcontinent, experiences tropical monsoons. Because of the atmospheric temperature conditions in April, May, and October, a depression may form in the deep sea. This depression is likely to become a deep depression, and a cyclone storm with a waves surge may impact the continent (BUET, 1995). Bangladesh has a long history of cyclones and storm surges devastation. Six out of nine depressions formed in the Bay of Bengal normally cross the belt of Bangladesh almost every year (Khan and Damen, 2000). During the last hundred years, there have been as many as 181 medium and severe cyclones and tidal surges of a catastrophic nature that have battered the offshore islands and costal belt of Bangladesh.

From 1994 to 2013, at least 24,376 people were killed and at least 129 million people were reportedly affected by disasters (IFRC, 2014). From the record it has known that a devastating cyclone accompanying tidal surge of 11meter height hit this land in May 1684, which caused enormous losses. Among all these, the Killer November Cyclone of 1970 alone caused 300,000 deaths and affected 4. 7 million officially. The April 1991 cyclone in Bangladesh is

considered as the Worst Killer Cyclone in Human History, it killed 138,882 people and injured another 139,054. The cyclones *Sidr* of 2007 and *Aila* of 2009 are the two noteworthy events of recent time. While cyclone *Sidr* is climatologically comparable with the 1970 and 1991 events, the consequence in terms of human casualties have been much less. Around 5,000 people died in cyclone *Sidr* which is attributed to the enhanced disaster management practices imparted institutionally over last few decades in Bangladesh. The affected communities have been suffering for prolonged periods and in some cases, in unprecedented ways. Figure 2 shows the destroyed construction by cyclone and helpless people of coastal areas.

5.

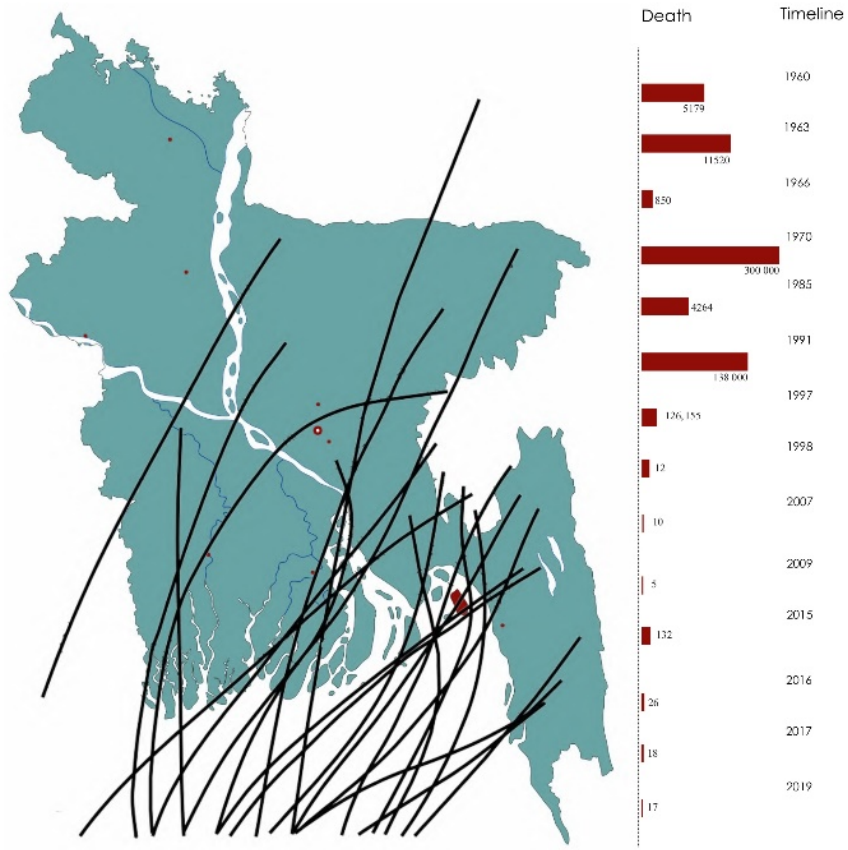

Figure 2*:* Map showing past cyclones and damages in coastal area of Bangladesh
Source*:* http:// www.bdpc.org.bd

3. Government initiatives to reduce the damages by cyclone

The impact of natural disasters not only varies with their type and magnitude, but also critically depends on institutional strength and response to disasters by different branches of the government, as well as community- based organizations. In the past 50 years, Bangladesh has learnt how to adapt to recurrent cyclones and has succeeded in significantly reducing cyclone-related deaths. Both structural and nonstructural approaches are followed in cyclone disaster management since 1961 by government and non-government agencies. Among them, the construction of purpose-built cyclone shelters is very significant. This has been planned since the late 1960s in East Pakistan. Because they saved many lives in the aftermath of the 1991 cyclone, shelter construction became the cornerstone of cyclone damage countermeasures. But study shows that the number of cyclone shelters are still inadequate (Government of Bangladesh, in collaboration with the UNDP and the World Bank). Also, the Inter-ministerial Task Force on Cyclone Shelter Construction guided the initiative titled Multipurpose Cyclone Shelter Program *(*MCSP*)* to ensure the whole year occupancy and maintenance (Rajib, S, Fuad M, Aminul I., 2005). Through 1991 around 475 cyclone shelters and killas (A killa is a heighted earthen mound providing safe ground for livestock during cyclone) were constructed, which have a capacity of around 1500 people per shelter. Due to the population growth, the Government of Bangladesh under the "National Plan for Disaster Management 2010-2015" finds it necessary to construct at least 2,000 disaster shelters and killas in the coastal areas. Figure 3 shows cyclone shelters and killas in the coastal areas.

Cyclone Preparedness Program (CPP) is another on-going process to mitigate the cyclone damage provided by the collaboration of government and nongovernment organizations. Early Cyclone warning system associated with awareness raising programs has continued to operate with the goal of minimizing loss of life and property in cyclonic disasters by strengthening the disaster management capacity of Bangladesh's coastal people.

Figure 3: Cyclone shelters in Azimpur, Sandwip Island
Source: Photo by Author, 2021

4. Aim and Objective

Followings are the objectives of the study:

(i) The main intention of this study is to analyze existing houses and building processes, which are able to withstand frequent cyclones and storm surge.

(ii) To understand public perception of cyclone-resistant house building processes and to gather information about the building techniques for houses able to withstand the wind speed of cyclones.

(iii) To organize and enhance these indigenous building techniques with scientific knowledge to make more cyclone resilient houses.

5. Research Methodology

An interpretive methodology, which deals with explaining meanings and human experience, was adopted in this study as a philosophical framework. The techniques adopted to conduct the survey include observation, Focus Group Discussions (FGDs) and Semi Structured Interviews (SSI) while secondary information was collected from different sources of published data (e.g. research papers, books).

In order to explore how the communities have learnt to live with coastal disasters intensive field survey and study is conducted. Qualitative data has also been collected through conducting interviews. A Non-Participatory Observation (NPO) approach was adopted to conduct interviews on both a one-to-one basis and in the form of a Focus Group Discussion (FGD). Focus Group Discussions (FGDs) and Semi Structured Interviews (SSI) were conducted to unveil the history of community, wealth and wellbeing, profile of past and present natural disasters. Semi Structured Interviews with 10 selected households are conducted are conducted by the author - 3 households from farmer community living in the middle part of the union; 4 from fisherman communities living on the higher land along in the periphery; and 3 from the families living on the embankments in temporary make-shift built form.

Settlement mapping including physical (land use, infrastructure, community services and utilities) and social mapping to identify location and house typologies for fisherman and farmer communities, and environmental mapping to identify natural resource base; study of built form, construction materials and techniques were collected. It also gathered photographic documentations, video recordings, and subsequently documented the traditional building practices

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Once collected, data from both primary and secondary sources were sorted in the line of objectives for the study. Collected data were interpreted and analyzed by SWOT analysis and reflection. Strengths and weakness of indigenous coping strategies are evaluated to assess their level of resilience. Overall, this study has followed the chronological phases outlined in the following methodology chart (Figure 04)

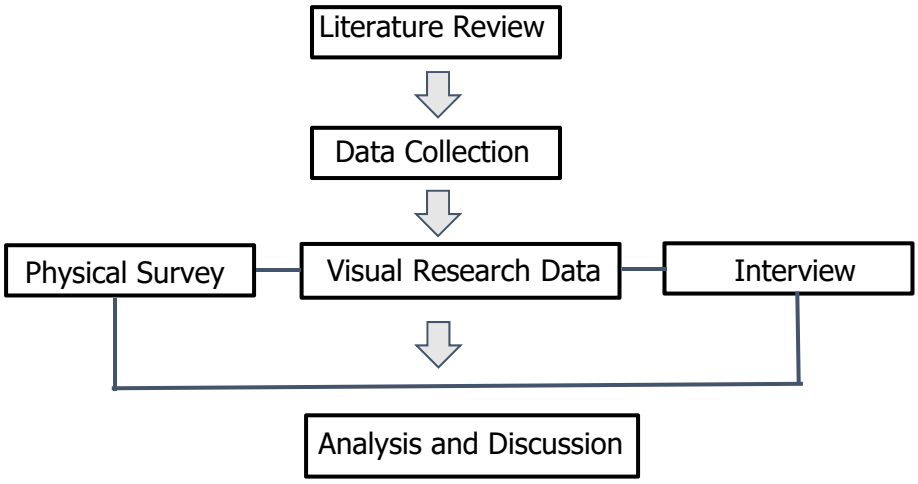

Figure 4: Research Methodology

6. Site Context

Sandwip is an island situated along the southeastern coast of Bangladesh in the Chittagong District. "Sandwip is evidently a very old island, and seems to have been of more importance three hundred years ago than it is now [mid-1800s], because it was one of the chief sources from which Bengal was supplied with salt." "Du Jarric ... tells us that it is opposite Sripur, and that it supplies all Bengal with salt. "(Beveridge, Henry. ,1876). Having a very fertile land feature is one of those reasons. The island is an upazila under Chittagong district with an area of 762.42 sq km and the total population is 4,00,00 (CEGIS, 2003) which is bounded by Bay of Bengal. In total, 34 villages on Sandwip Island. The island is 50 kilometres (31 mi) long and 5–15 kilometres (3.1–9.3 mi) wide. The selected village for detail investigation for this research is Azimpur village. It is located in the western part of Sandwip. Specific reason for the choice was its vulnerability due to natural hazards and being the most affected village of the island. Natural calamities affect much vigorously in the south-western part of Sandwip resulting Azimpur village having only 48% of its area as settlement at present.

It is surrounded by embankment. Since the 1960s, the village's natural sedimentation has been prevented by the embankment, resulting in a region in the center with a lower elevation (below sea level) and an area along the embankment's perimeter with a higher elevation. Fishermen and farmers are two significant occupational groupings that are hereditary professions. Fishermen make up about half of the population, with the other people being small farmers (28%), wage workers (25%), and petty businessmen (2%). Settlement pattern wise, the farmers live in the middle part and the fishermen along the periphery.

Sandwip, a coastal part of active delta of the three mighty river arrangements of the Ganges, Brahmaputra and Meghna locating in the lower Meghna estuary is one of the main offshore Islands. Being positioned in the lower Meghna estuary, it goes through numerous geomorphological changes coastal erosion is one of them. Erosion process is much vigorous

in the south-western part of Sandwip (Irtifa A.N., Nawrid,I. & Nilufa, A. ,2017). A mentionable part of the western part of Sandwip Island has been lost due to coastal erosion. Azimpur which was 2708 acres in 1913 but it became 326 acres only in 2013 due to severe erosion. According to Mukherjee (Mukherjee, R., 2008) "Sandwip lies in the maximum cyclone prone area of Bangladesh". About 41 percent of cyclones travel through this funnel-shaped region each year presently, most hitting Sandwip (Scienze della Terra., 2015). The funnel shaped coast line and particularly the low topography make the coastal area subject to high surge associated with cyclones. The Multipurpose Cyclone Shelter Programme (MCSP) report (BUET-BIDS, 1995) have divided the coastal area of Bangladesh for differentiated risk and Azimpur village is situated on High-Risk area (HRA) for its geographical location and weather condition. Over the past years, several devastating cyclones have already forced the population of Azimpur village to move closer to the inlands leaving their original settlement. And now with furthermore Climate change variability, this village is now more prone to Cyclonic storm and tidal surge. Cyclones annually hit three to five times during pre-monsoon (April- May) and post monsoon (September- November) period. Cyclones occur before Monsoon season (June-September is Monsoon season in Bangladesh), tend to move along the South-Eastern coastal area. Whereas, cyclones after the Monsoon, tend to move along the West side of the Bay of Bengal (PWRI , 2007).

Local communities' indigenous wisdom cannot successfully withstand the unexpected and unanticipated type and degree of environmental catastrophes. However, this does not exhaust the significance of indigenous knowledge; rather, it is necessary to learn from indigenous knowledge and transfer it to higher levels with modern technology and information in order to increase their capacity to not only deal with adversity and unexpected disasters, but also to recover and, in doing so, reach a higher level of functioning (Parvin, A., and Mostafa, A. (2010).

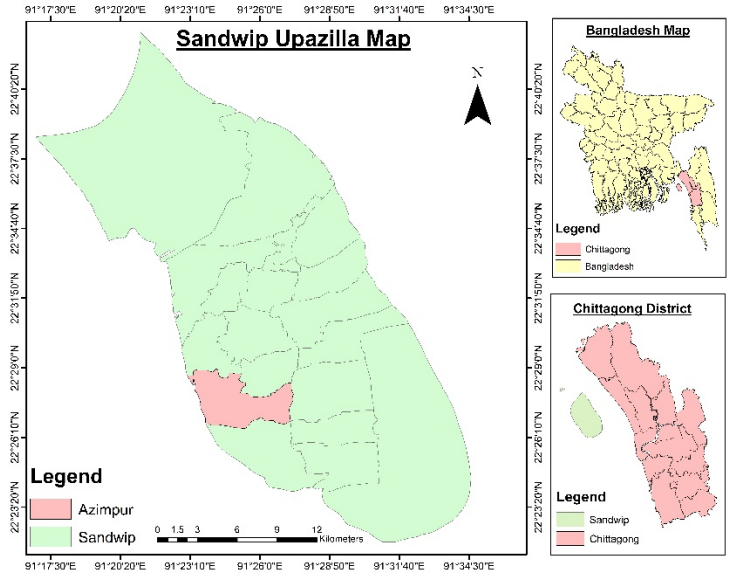

Figure 5: Map of Azimpur, Sandwip Island
Source: Author, 2023

7. Findings

Through interview the study unveiled the physical and non-physical coping strategies used by the communities in disaster situation. The key findings are as follows:

A. Physical Coping Strategies:

Bangladesh's coastline region has faced a number of powerful storms throughout the years that have killed many people and caused extensive property damage. The locals have created a number of survival tactics to defend their homes and other precious property as a result of their experiences with these natural calamities. Indigenous peoples who have a distinctive cultural identity and have long lived in coastal locations are in close contact with nature. It is assumed that they had an indigenous understanding of cyclones and, as a result, had efficient survival techniques. Through the process of socialization, they have internalized the time-tested wisdom of previous generations. The unknown local builders exhibit a special aptitude for integrating their houses into their natural surroundings and practice building techniques from the overall design to the smallest construction details, which is truly amazing. This chapter will accommodate the findings from survey of the selected cyclone affected village about their locally practiced building techniques to resist effects of cyclone. People's adaptation, perception and construction techniques against cyclone attack has been undertaken and observed on three scales:

a) Community Level
b) Homestead Level
c) Household Level

Community Level

The people of Azimpur have special ways of managing their land and crops, as well as their land use plans, fishing methods, home construction methods, and water harvesting methods. The farmer communities have developed suitable practices for early and late cropping, intercropping, kitchen gardens, etc. which reduces the risk of poor harvests by broadening the range of crops grown. They also have intimate knowledge of the quality and classification of soil, water, and the plants and seeds that are resistant to flood and saline water. The seasonal variations in the resources for fishing are well known to the fisherman.
Avoiding low land for building homes is one of the land use techniques. The bazaar and shops are often located along the road inside the settlement, whereas the dwellings are typically built on higher ground along ridges or embankments. The middle area's agricultural land is located in a rather high area. In order to be protected from tidal surge, the settlement has moved inland through time.

At the settlement level, they would not have been able to do much in the pre-disaster period, but they would check for any leaks or breaches in the embankment and take the initiative to repair them right away using local tools and materials like mud blocks, tree trucks, bamboo mats locally referred to as "chatai," tree branches, etc. They take greater initiative at community level to repair damaged embankment, broken communication lines like bridge (locally called 'pole' or 'shako', made of bamboo), which are crucial to maintain minimum communication.

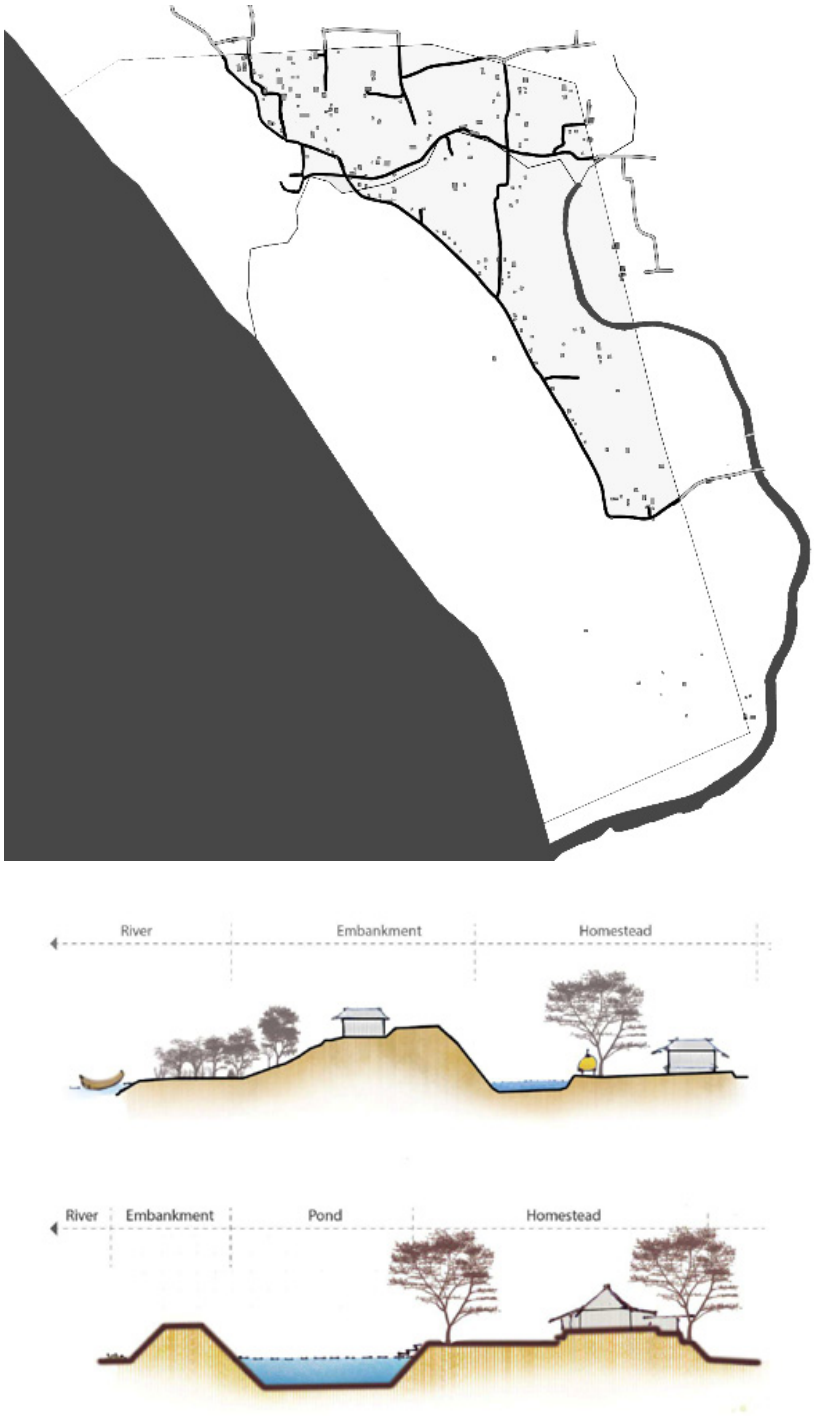

Figure 6: Map of Azimpur showing sections, Sandwip Island
Source: Author, 2023

Homestead Level

a) Physical planning

The traditional builders show talent in positioning the house with surrounding nature to withstand the harsh effects of disasters. They plant heavy vegetation around their house to protect from wind effects on the house, where the peripheral trees absorb the forces of strong winds driven by cyclones. The type of vegetation also depends on the wind direction. Since the cyclones mostly proceed from the south and south-west corner, the selection of trees for those edges are made according to their wind resistance capability. Betel nut, palm, and coconut trees are mostly used for this purpose. Figure 7 shows that trees act as wind breaker during cyclone hit.

They fortify weak areas of houses and restore damaged ones in preparation for an incoming cyclone and storm surge. The immediate tactics at the homestead level include storing some food, a matchbox, a cooker, cooking fuel *(*enough for a couple of days*)*, and other valuables in underground storage, as well as putting poultry and cattle in a higher location or along the roadside and embankment. People tend to stay as long as they can in their home during a crisis. They continue to wait inside the house while watching how high the wave of water becomes. They erect a raised bamboo building called a "macha" to store food, treasures, cattle, and themselves while they temporarily dwell there, especially to protect the young ones from the onslaught of water. They raise the platform's level as the water level rises, even go to the house's roof if necessary. People only seek refuge in a neighboring school, cyclone shelter, or makeshift shelter along a road when all is under water. When traveling long distances, individuals utilize boats, but when moving around their community, they use rafts made of banana trees etc.

b) Distance of Trees

The house is positioned safely apart from the trees that were planted in order to guard against damage from turned-over trees by strong winds. The distance is determined by the average height of the trees. According to the survey, they preferable placing of houses is 7 to 10 meters away from trees, with 70–75 percent of respondents preferring a 10-meter distance. Toppled trees would not significantly harm the houses because the majority of the tree's branches are located between these distances. This distance may vary with the type of planted trees. Practiced house distance from surrounding trees is shown in Figure 7.

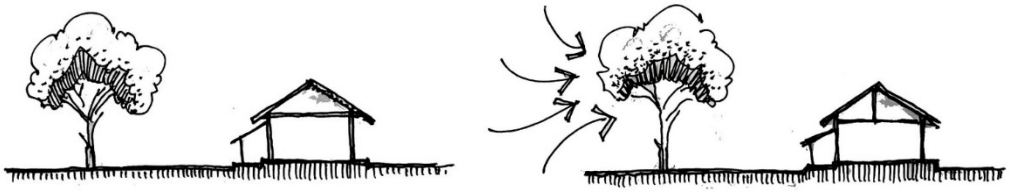

Figure 7*:* Trees act as wind breaker during cyclone hit
Source*:* Author, 2023

c) Rainwater Harvesting

All of the sources of drinking water and sanitary facilities (ponds and tube wells) are damaged by cyclones. All pure water sources are polluted by saltwater water during high tidal surges. Many individuals are forced to drink this contaminated water because they have no other choice, which causes them to contract water-borne illnesses like allergies, skin conditions, cholera, and diarrhea. By collecting rainwater at every home using relatively basic conventional procedures and materials, the communities are able to solve the shortage of drinking water (Figure 8). At the local level, they set up a few ponds as reservoirs to gather and store rainwater for times of need. They constructed a temporary elevated latrine on stilts over water in order to address the sanitation issue. Apart from these traditional technologies, the communities have adapted modern technology like use of solar panel in their houses since last decade.

Figure 8: Traditional techniques of rain water harvesting, protecting roof from wind and use of solar panel.
Source: Author, 2023

Household Level

a) Orientation of House

The house's orientation and design are additional issues for the locals. The house plan is typically rectangular rather than square, with the short arm side typically facing the wind force to prevent it from toppling over. As illustrated in Figure 9, all of the surveyed home owners and builders expressed a desire to position their homes width-wise facing the wind. In these cyclone-affected coastal communities, this traditional knowledge is very commonly used.

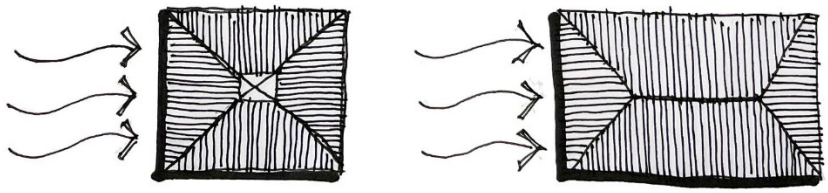

Figure 9: House orientation following wind direction
Source: Author, 2023

b) House Typology

As previously said, locals in cyclone-prone locations give their homes a particular form and shape as a result of years of coping with calamities.They can safely place their "ghar," or main living area, by enclosing it with "pashchati," or a linked lower section. The "ghar" is shielded from wind pressure and water penetration by winds carrying rain water by the surrounding outer layer of "pashchati". Hip roofs are used to construct ghars because they can withstand strong winds. Separate low roofs above the "pashchati" also provide the main space a sense of security. For the safety of the main roof, the roofs of the "ghar" and "pashchati" are constructed independently.

Moreover, minimum roof overhangs and low openings in the front "pashchati" wall prevent roof uplift from wind pressure. Figure 10 shows a single-story indigenous house with surrounded 'pashchati' in the lower part.

Figure 10: House plan with "pashchati" and photo
Source: Author, 2023

c) Size and Position of Opening

Top-hung windows were preferred by almost all respondents *(*nearly 95*%)* because they are safer during cyclones. Some people agreed that top-hung windows are superior to side-hung windows for cyclone safety, as illustrated in Figure 10, even if they also accepted side-hung windows. In light of the wind speed, they were also worried about the location of the aperture.

According to the local responses, it is not safe for a cyclone-resistant house to have an opening in one of the facade corners. According to 80% of respondents, corner openings in houses are not preferred since they increase the risk of cyclone storms and cause structural instability. They recommended, as illustrated in Figure 11, a symmetrical, constrained opening on the windward side of the front facade.

Figure 11*:* Limited and symmetrical opening on the external facades
Source: Author, 2023

d) Architectural and Structural Detail

Foundation

Traditional homesteads generally are constructed on raised earthen mounds *(vita)*; ponds dug to raise the *vita* and create source of sweet water; the height of which is determined by local experience of previous water surge or flood levels (average height 3 feet)(Buckle, P. ,2006*)*

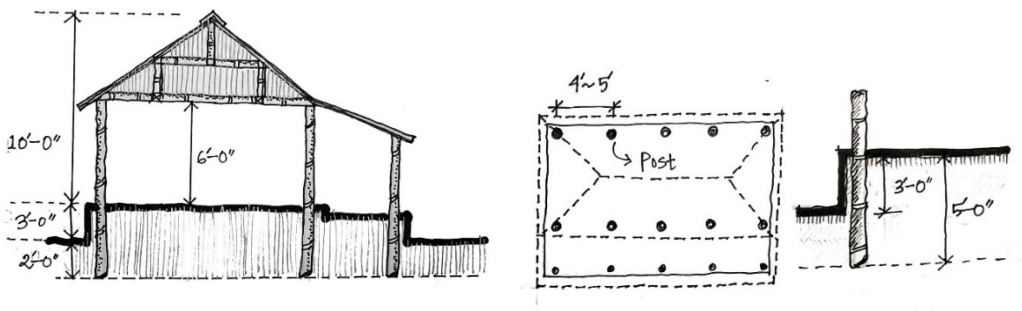

Figure 12: Example of traditional construction techniques.
Source: Author, 2023

Separate Vertical Post

The vertical foundation pillar that is buried straight into the ground has been observed to lose its durability quickly due to weather contact. Because of their financial situation, people are unable to rebuild or replace the structure, which causes houses to lose their structural integrity quickly. To provide more durability, local builders separate the vertical post above the ground from the foundation post. Additionally, this makes it simple to replace each decaying foundation post individually rather than having to replace all of the vertical posts at once. Figure 25 shows the foundation joint detail.

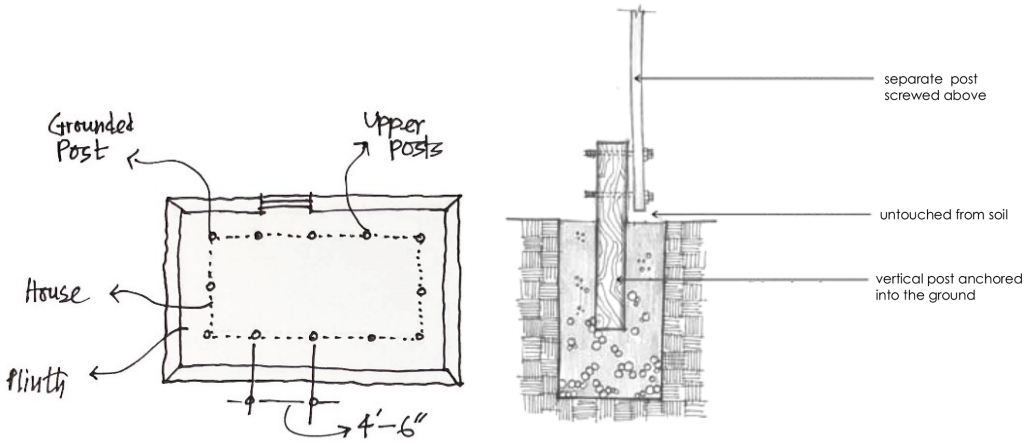

Figure 13: Separate posts prevent massive replacement
Source: Author, 2023.

Walls

Walls in the indigenous houses are usually made of woven bamboo or timber board sheathing attached to the vertical posts. To make the wall sturdy enough to withstand the intense wind pressure which strikes the vertical surface, these walls are strengthened with diagonal bracing, which also prevent houses from collapsing at the corners. This is illustrated in Figure 14.

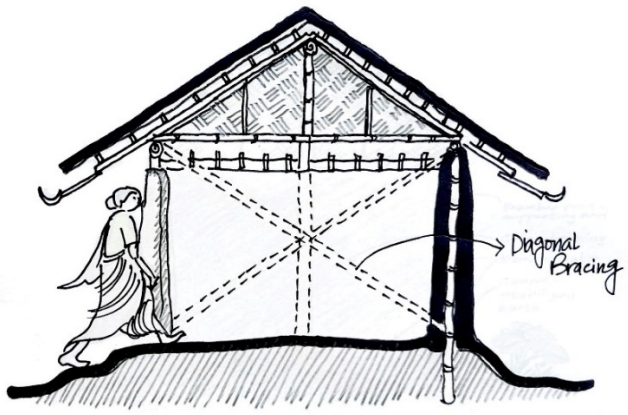

Figure 14: Diagonal bracing in wall
Source: Author, 2023.

Roof *(structure, cladding and joints)*

House damage can result from wind gusts catching the shape of a house's roof. Another type of roof failure can be caused by overhanging roofs, shoddy wall and column foundations, and overextended roofs *(*Haq. B,1999*)*. As seen in Figure 15, the traditional people confidently preferred a hip roof to a high gable roof. According to their observations, homes with hip roofs are less vulnerable to cyclone hits.

One of the common failures in cyclone-affected locales is upheaval of the roof cladding and roof members. Observation in the study areas has shown that if the roof structures are properly secured to the vertical posts, and the roof claddings are tightly attached to the roof structure, then the chance of house damages are significantly reduced. The roof's purlins must be sufficiently strong to support the weight of the roof cladding.

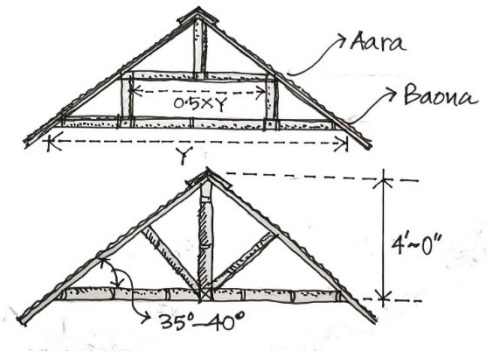

Figure 15: Roof Joint and frame
Source: Author, 2023.

Material

Figure 16 illustrates how local contractors use building supplies like pre-cast concrete posts, steel angles, steel sections, and nylon ropes to strengthen the robustness and endurance of indigenous homes constructed with conventional materials. It is impressive how well-versed they are in corner details, materials for vertical posts, roof joints with vertical posts, and heavier portions of houses. When employing locally weak building materials, builders substitute stronger, more resilient materials, such as nylon rope, to strengthen the structure against cyclone attack. The way they treated and used local materials for the main supports is a sign of their skilled craftsmanship.

Figure 16: Use of innovative materials
Source: Author, 2023

B. Non-physical Coping Strategies

Economic Practices

In Azimpur, alternative income is the main economic approach. During the recovery from a disaster, having multiple sources of income is essential. As a result, people in the villages learn alternative skills including fishing *(*for farmers*)*, boat making, day labor, starting a small business, creating and selling handicrafts, carpentry, and construction work, among others. In certain circumstances, the male family members relocate to towns or cities to work. Most frequently, they end up working as day laborers or richshaw pullers. Families who are vulnerable keep cash reserves, livestock, and food grains for emergencies. They consume less food or food of worse quality when there is a food scarcity. When a crisis is severe, they start to sell their possessions, including their livestock, equipment, seeds, jewelry, and even their land.

Because a large family affords a household additional labor for income earning, having a large family can also be considered as a part of economic strategy. People are typically eager to invest, even with little sums of money, primarily in poultry and cattle husbandry. For investments, they borrow money from friends or moneylenders. However, in times of crisis, acquiring a loan is challenging; instead, because of social ties, individuals assist one another when they need food or temporary housing. Recently, some NGOs have started offering microcredit loans. Although it is not a typical coping strategy, many families have used the microcredit provided by NGO's to recover from post-disaster difficulties.

Social Practices

In Azimpur, social bonds are quite strong. Social structures are based on the idea that people should assist one another when they are in need. the use of kinship networks, mutual aid, and self-help groups as social coping mechanisms. Fishermen or farmers who live close by are the first to offer moral support and financial assistance as they are able. No matter how wealthy or poor they are, relatives and neighbors help those who are experiencing a food crisis. Through love and affection, they support one another psychologically as they work to recover from the loss and shock of a calamity. What noteworthy is most of the time people save others life risking their own. In times of crisis, sharing labor and food is fairly frequent in Azimpur. Community labor in rebuilding and reconstruction is another common social and organizational coping strategy during disasters.

Cultural Practices

The majority of the residents of Sandwip as well as Azimpur village hold steadfast religious convictions, which encourages optimism and bravery as well as a strong faith in God's protection against the adverse effects of calamity. They are able to overcome psychological stress and fear due to their worldviews and religious convictions, and they can live happily even in vulnerable situations. Above all, the tradition of embracing risk and ambiguity transforms each community member become a fighter in their own right.

C. SWOT Analysis

Traditional coping strategies used by the coastal communities in Azimpur are important in coping with disaster. However, in the wake of more intense and frequent disasters, there is an urgent need to understand the strengths and weakness of indigenous building culture and identify what is sustainable and acceptable locally and how people's participation can be solicited to ensure their support for external initiatives. The matrix in Table 01 summarizes the major findings on the SWOT status of vernacular planning and building practices in the coastal island of Sandwip.

Table 1: SWOT analysis of key attributes of vernacular building practices

Attribute No.	Strength	Weakness	Recommendation
Settlement pattern	• Organic morphology in harmony with the natural topography. • Plantation resists the high wind pressure.	• Scattered settlements result in inefficient use of land.	• Integrated strategic and spatial planning • Organized Plantation, i.e. social forestry.
Infrastructure and services	• Non-motorized communication. • Social adaptation of solar panels. • Dedicated cyclone shelter and primary school-cum-cyclone shelter	• Embankment is detrimental to the natural water-coast system. • Poor condition of roads and walkways makes it inaccessible during disaster situation. • Difficult water-way transport system. • No electricity and use of very expensive solar panel.	• Alternative long-term strategy to replace embankment. • Construction of roads with permanent materials, allowing few motorized vehicles for the transportation of goods and services. • Road and waterway connection to surrounding areas and cities. • Electric power supply to support industrial activities. • Cost effective solar panel at neighborhood scale.
Land use	• Agricultural land use and local cropping techniques appropriate for the area. • Optimum spatial distribution of land use regarding accessibility and inter-connections between different related land uses.	• Deforestation in coast line • Residential land use is scattered. • Horizontal growth only.	• Comprehensive land use zoning, with designated zone for coastal forestation, small agro-based industries, and commercial activities • Provide technical support and resource for fishing. • Densification of residential land use.

Housing	• Form, space and order of traditional architecture very much in harmony with physical environment and the way of life. • Use of local construction materials and local craftsman. • Some construction techniques are effective to cope with disaster. • Environmentally friendly and cost-effective rain water harvesting system.	• Use of organic materials *(*clay, wood, bamboo, thatch*)* makes it less durable, and weak. • Some construction techniques make the built form week to withstand disasters. • Singly story houses are less resilient.	• Initiate necessary research to explore the strengths and weakness of local construction materials and techniques, and suggest locally sustainable and durable solutions *(*building upon the traditional practices*)*. • Building compact houses on stilt at least two-story to serve as storage and emergency shelter during disaster.
Economic	• Alternative skills. • Men and women both are very hard working. • Cooperative practices. • Cropping and fishing techniques.	• Acute poverty - more than half are landless households who are the most vulnerable to disaster impact. • Lack of alternative job opportunity during off-season and disaster situation. • Lack of future planning, savings and investment. • No commercial industrial activities except everyday community needs.	• Re-distribution of *'khas' (*land owned by Government*)* land. • Establishing locally acceptable small agro-based industries to create job. • Introduce eco-tourism without disturbing the cultural landscape. • Cooperatives and Banking activities. • Develop Growth Centre with logistics and marketing network to support commercial and industrial activities.
Social	• Strong social ties irrespective of occupation, religion, ethnicity or economic status. • High human values. • Mutual trust. • Cooperating attitude.	• Reluctant to take formal education. • Poor health and nutrition, no physician qualified. • Lack of spirit to change current socio-economic status – socially happy with the way they are. • Does not like to control birth, considers children as earning member.	• Improve educational facilities. • Medical facilities, family planning, health and nutrition program. • Building on the cooperating attitude, motivate to improve socio-economic status for disaster resilience and better life.

Cultural	• Strong religious belief gives the strength to fight and survive in disaster situation. • Very low gender discrimination; women enjoy relatively high level of freedom in social and economic activities. • Not conservative, very open and receptive to external supports.	• Strong belief in God reduces self-confidence, increase psychological dependency on the savior. • Hardly any cultural activities except celebrating the religious festivals.	• Identify local tangible and intangible cultural components and improve cultural activities. • Preserve and nourish traditional way of life.

Source: Author

8. Conclusion

For generations, diverse communities residing in various disaster- prone regions of Bangladesh have acquired the skills to coexist with, manage, and adapt to disasters by relying on their indigenous knowledge and accumulated experiences. This vast reservoir of knowledge, which has its roots within these communities, is intricately linked to local requirements, climate conditions, and the particular socio- cultural context of each region. These indigenous building practices have played a pivotal role in bolstering community resilience and augmenting their ability to confront disasters *(*Amaratunga, D. and Haigh, R. ,2011*)*. The study indicates that coastal communities lean heavily on their indigenous wisdom throughout the entire disaster cycle, encompassing anticipation, coping, adaptation, and recovery. They make the most of their available resources and skills before seeking assistance from external agencies. Regrettably, this valuable knowledge system has not received the recognition it deserves within policy- making circles or modern disaster management paradigms, which increasingly gravitate toward concepts, tools, and practices that are somewhat disconnected from traditional communities. The influx of purportedly modern, quick-fix solutions has posed a significant threat to the rich repository of indigenous building practices. Consequently, it is imperative to avoid categorizing traditional and scientific knowledge as mutually exclusive domains *(*Flavier, J.M. et al.,1995*)*.

Traditional strategies exhibit a dynamic nature and are continually influenced by internal creativity, experimentation, and interactions with external systems. This ongoing process of experimentation, innovation, and adaptation renders traditional knowledge flexible enough to harmonize with science and technology. Given the evolving disaster landscape, it has become exceedingly important to devise approaches that bridge the gap between the two realms*:* science facilitating the comprehension of traditional knowledge by professionals and traditional knowledge facilitating the translation of scientific concepts into locally comprehensible modes of communication.

As a result, providing structured guidance to enhance these local practices will enhance their effectiveness in mitigating cyclone damage. While such guidelines are essential, it is equally crucial to educate local communities on integrating these guidelines with their existing indigenous knowledge to achieve the desired improvement in cyclone resilience. This dual approach not only empowers the local population but also involves them in developing plans that are no longer imposed externally, leading to a more regionally suitable and environmentally friendly response to potential cyclone-related damage (Haq, B., 1999).

Reference

- World Risk Report. (2015). Bündnis Entwicklung Hilft (Alliance Development Works); United Nations University—Institute for Environment and Human Security (UNU-EHS) Available online: http://www.worldriskreport.org/ (accessed on 20 March 2021)
- IFRC. (2014). World Disasters Report: Focus on Culture and Risk; IFRC (The International Federation of Red Cross and Red Crescent Societies):Geneva, Switzerland.
- IPCC. (2007). Coastal Systems and Low Lying Areas, in Working Group II report "Impacts, Adaptation and Vulnerability", Cambridge University Press, 324, ISBN 978-0521-70597-4.
- Akter, T. (2009). Climate change and flow of environmental displacement in Bangladesh, Unnayan Onneshan, Dhaka, Bangladesh.
- Ali, A. (1999). Ghurnijhar (Cyclone), Bangla Academy, Dhaka. 19PP.
- CEGIS (Center for Environmental and Geographic Information Services). (2003). Integrated Coastal Zone Management Plan Project: Knowledge Portal on Estuary Development (KPED) Working Paper WP017, prepared for: Program Development Office Sponsored by the Government of the Netherlands and the United Kingdom Executed by ARCADIS Euro consult, the Netherlands. Dhaka, Bangladesh.
- Khan, S. R. and Damen. (2000). M. ITC. CYCLONE HAZARD IN BANGLADESH, life incurred on only two occasions, in 1994 (144 people died) and in 1995 (144 people died)
- SMRC. (1998). 'The impact of tropical cyclones on the coastal regions of SAARC countries and their influence in the region'. SAARC Meteorological Research Centre (SMRC), Dhaka.
- BUET- BIDS. (1993) Multipurpose Cyclone Shelter Programme. Government of Bangladesh and UNDP/World Bank.
- Irtifa A. N., Nawrid ,I. & Nilufa, A. (2017). Imperial Journal of Interdisciplinary Research, Vol-3, Issue 10.
- Mukherjee, R. (2008). The struggle for the Bay: The life and times of Sandwip, an almost unknown Portuguese port in the Bay of Bengal in the Sixteenth and Seventeenth Centuries, Historia, p67-68.
- http://www.ifrc.org/world-disastersreport-2014
- Rajib, S, Fuad, M, Aminul, I. (2005). Book: Disaster Risk Reduction Approaches in Bangladesh, Springer Beveridge, Henry. (1876). London: Trübner & Co.
- Scienze della Terra. (2015). PhD Dissertation: Geomorphological Evolution and Vulnerability of LowLying Coasts in Bangladesh: The Case Study of Sandwip Island.
- PWRI 2007.

- Bangladesh Population Census (2001). Bangladesh Bureau of Statistic.
- Parvin, A., and Mostafa, A. (2010). "Re-thinking Disaster-Prone Vernacular Settle ment:A Comprehensive Strategic Planning towards Disaster Adaptive Settlements in Bangladesh", *Proceedings of 5th International Seminar on Vernacular Settlements (ISVS 5), 30-31 July, 2010, Colombo, Sri Lanka.*
- Buckle, P. (2006). "Assessing social resilience", In D. Paton & D. Johnston. *Disaster resilience: An integrated approach (*pp.88-103), Springfield, IL: Charles C. Thomas.
- Amaratunga, D. and Haigh, R. (2011). *Post-Disaster Reconstruction of the Built Environment: Building for Resilience*, Blackwell Publishing Ltd., UK.
- Flavier, J. M. et al. (1995). "The regional program for the promotion of indigenous knowledge in Asia", pp. 479-487 in Warren, D.M., L.J. Slikkerveer and D. Brokensha (eds.) *The cultural dimension ofdevelopment: Indigenous knowledge systems.* London: Intermediate Technology Publications.