

Disability Inclusion in Climate Resilient Infrastructure: A Cross-Sectional Study in Four Coastal Sub-Districts of Bangladesh

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Abstract

Bangladesh's coastal region is extremely vulnerable to hydrometeorological and climatic disasters. A distinct group of marginalized population is disproportionately impacted by a disaster. Regardless of gender, "people with disabilities" (PWDs) face substantial challenges in a disaster scenario. The response mechanisms of people with disabilities are also different in a disaster situation. The purpose of this paper was to investigate the climate-resilient infrastructure of PWDs in Bangladesh's coastal zone during a natural disaster. A cross-sectional survey of 520 participants was conducted in the subdistricts of Khulna: Dacope, Koyra, Paikgacha, and Bagherhat: Mongla. The study found that only 8% of homes are made of concrete and are resistant to strong winds, cyclones, floods, and storm surges, while only 7% of homes are disaster-resilient. Only 5% of respondents indicated that their residences were accessible to PWDs, and there are no accessible WASH facilities. With disaster-resistant infrastructure, the study suggests that accessibility for PWDs should also be addressed.

Keyword: *PWD, Disaster Inclusion, Climate Change, Resilient, Infrastructure*

1. Introduction

Bangladesh is a climate-vulnerable country, and the most vulnerable population is the person with disabilities (PWD) (Nishat et al., 2022). According to Bangladesh's "Persons with Disabilities Rights and Protection Act" of 2013, 2.80% of the population is disabled, with gender-stratified prevalence of 2.322% for women and 3.28% for men. In terms of geography, the prevalence is 2.45% in urban areas and 2.89% in rural areas. In addition, the prevalence rates are broken down by age groups. For example, the rates for children ages 0 to 4 are 0.83%, adults ages 18 to 49 are 2.24%, and those 65 and older have a significantly higher incidence of 9.83%. The district of Khulna, in particular, has the highest prevalence rate of 3.62% (BBS, 2022). Many coastal residents are impoverished, and the population is vulnerable to both natural and man-made disasters (Ahmad, 2019). A significant correlation was found between poverty and the impact of natural disasters on the disabled (Mahmud et al., 2014). Individuals with disabilities are disproportionately affected by inaccessible evacuation, response, and recovery efforts in disaster, emergency, and conflict situations (King et al., 2019). Bangladesh is susceptible to both climate change and natural disasters. The country is ranked seventh globally in terms of extreme risk, according to the global Climate Risk Index of 2021 (Eckstein et al., 2020). According to the 2021 Climate Risk Index, which was developed based on data from 2000 to 2019, Bangladesh suffered substantial damages that were related to climate change. The country suffered 11,450 fatalities and \$3.72 billion in substantial financial

losses during the same period. A total of 185 extreme weather events that were directly linked to climate change occurred in Bangladesh during this time (Al Amin, 2021; Eckstein et al., 2020). Due to insufficient planning and preparation, as well as inaccessible infrastructure, services, and transportation systems, people with disabilities are disproportionately vulnerable to being ignored or marginalized in disaster situations (Mahmud et al., 2014). Problems include disproportionate access to resources, inability to adapt to the built environment, and poor living conditions (King et al., 2019). The inadequacy of communication infrastructure in remote areas makes it more difficult for people with disabilities to mobilise communities during emergencies (Mahmud et al., 2014). Natural disasters (flood/cyclone/lightning) account for 0.46% of the disabled population in Bangladesh as a whole, and 0.67% in the Khulna division (BBS, 2022). Frequently, the extent to which individuals, communities, and countries are vulnerable or resilient is determined by the interactions between various structure-related problems (King et al., 2019). It is not always possible to find gender-friendly shelters because they frequently do not have separate lavatories for men and women (Mahmud et al., 2014). The CEGIS conducted a Comprehensive Disaster Management Programme (CDMP) survey across 10 districts, covering 1,705 cyclone shelters and killas. The survey results highlight serious deficiencies in vital infrastructure. Just 25% of the shelters that were surveyed have water supply infrastructure located in high-risk areas, and only 14% have facilities for storing perishable goods. Moreover, only 26% of these shelters have spaces exclusively reserved for women, and only 33% have separate restrooms that meet the needs of women. The surveyed shelters notably lack provisions for

providing physical accessibility for individuals with disabilities (Mahmud et al., 2014). A disaster may exacerbate the conditions of PWD, and they may lose interpersonal support and mobility aides (King et al., 2019). The majority of shelters are located beyond the prescribed reachable territory (Mahmud et al., 2014). Individuals with disabilities often experience disproportionately higher rates of morbidity and mortality during emergencies, making them among the most vulnerable to the lack of emergency support infrastructure (World Bank, 2017).

2. Objectives of the study

This research aims to carry out a comprehensive analysis of the effects of climate change-related disasters on people with disabilities (PWDs) and to assess the current state of climate-resilient infrastructure in Bangladesh's coastal regions during natural disasters. The study aims to

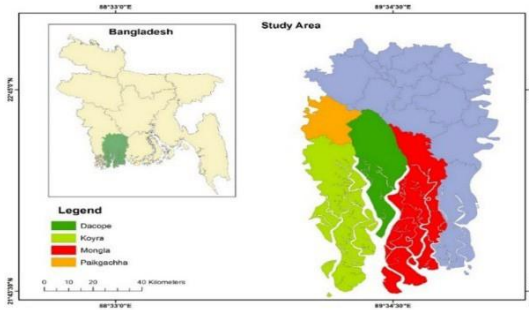
- Examine how the current climate is changing and how that affects people with disabilities.
- Determine how vulnerable people with disabilities are to disasters brought on by climate change.
- Examine how resilient the coastal areas of Bangladesh's infrastructure are to natural disasters for people with disabilities.

3. Methodology

3.1. Study Design

Using a quantitative approach, the study was conducted in one subdistrict in Bagerhat District and three subdistricts in the Khulna District (**Map 1**). To further inform the study, relevant scientific literature was reviewed as secondary desk review. Using primary and secondary sources, the study has adopted a participatory, multidisciplinary methodology that integrates quantitative and qualitative data collection techniques. Key Informant Interviews (KIIs), Focus Group Discussions (FGDs), and the Household Survey (HHS) are the main methods used to collect data. Long-term meteorological and climate data, including rainfall and temperature, as well as data pertaining to disasters, were also examined. In particular, the study used a methodical approach, carefully classifying 520 households (130 per Upazila) in accordance with the Socio-Economic and Demographic (SAAD) framework. Community members participated in sixteen Focus Group Discussions (FGDs), distributing four FGDs in each upazila. Participating in these discussions were 168 PWDs (Persons with Disabilities) and 182 non-PWDs, who were both male and female. Additionally, a total of twelve Key Informant Interviews (KIIs) were carried out, with three interviews taking place in every upazila. Representatives from the Department of Women Affairs, the Department of Social Services, and Project Implementation Officers (PIOs) were among the key informants. Data was analysed with triangulation of the quantitative, qualitative and secondary information.

Map 1: Study area



3.2. Population Distribution in the Study Area

The population of the study area is 730,818 people in total, according to data from the Bangladesh Bureau of Statistics (BBS) from 2011 (BBS, 2011). Among this population, 11,693 individuals are identified as Persons with Disabilities (PWDs). Paikgacha Upazila stands out with the highest number of Persons with Disabilities, totaling 3,968 individuals residing with disabilities.

Table 1 shows the population distribution in the study area broken down by Sex, Age, and Disability (SAAD).

Table 1: Population by SADD in study area.

Upazila	Total population	Men	Women	Persons with Disabilities
Dacope	152316	76291	76025	2437
Koyra	193931	95393	98538	3103
Paikgacha	247983	123900	124083	3968
Mongla	136588	71492	65096	2185
Total	730818	367076	363742	11693

Source: BBS, 2011

3.3. *Quantitative Method*

The study's quantitative methodology is covered in this chapter. To choose participants for a household questionnaire survey, a non-probability sampling technique called convenience sampling was employed. Four areas and 520 participants in total were surveyed. Microsoft Excel's descriptive statistics were used for data analysis.

3.3.1. *Sampling Design*

Numerous sampling strategies, such as convenience, purposive, and non-probability sampling, were used in the study. The researcher used convenience sampling, a type of non-probability sampling, to choose units for the sample based on how easily accessible they were (Rahman et al., 2023). Yamane's formula was used to calculate the sample size (Yamane, 1968):

$$nn = + \frac{NN}{1 + NN (ee^2)}$$

Therefore, following this population and 0.05 error tolerance, the required sample size was around 400. where n = sample size, N = population, e = error tolerance. Therefore, following this population and 0.05 error tolerance, the required sample size was around 400. For better representation of the targeted population, a design effect of 1.3 was implemented. The final sample size with design effect of 1.3 was found to be 520.

3.3.2. *Sample Size and Data Collection*

Homogeneous individual household survey was conducted in all four upazilas (Khulna: Dacope, Koyra, Paikgacha and Bagherhat: Mongla) (**Map 1**) with person with disability, children, men and women, total of 130 from each (**Table 2**).

Table 2: Household survey sample distribution in study area.

Upazila	Men	Women	PWD	Youth	Children	Total sample
Dacope	30	50	20	15	15	130
Koyra	30	50	20	15	15	130
Paikgacha	30	50	20	15	15	130
Mongla	30	50	20	15	15	130
Total	120	200	80	60	60	520

3.4. Qualitative Method

In addition to quantitative methods, the study incorporated qualitative approaches by conducting Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) with pertinent ecosystem actors. Sixteen focus group discussions (FGDs) were held in each of the four Upazilas, with four FGDs held in each location. The participants included both PWDs and non-PWDs. In addition, twelve KIIs were conducted, with three interviews taking place in every Upazila. Those interviewed included representatives from the Department of Womens Affairs, the Department of Social Services (DSS), and development organisations that work in the areas that were targeted.

Table 3: Qualitative Method of Data Collection

Qualitative Method	Respondents	Number
Focus Group Discussions (FGDs)	<ul style="list-style-type: none"> • PWDs • Non-PWDs 	16 (4 in each Upazilas)
Key Informant Interviews (KIIs)	<ul style="list-style-type: none"> • Department of Women Affairs • Department of Social Services (DSS) • Development Organizations 	12 (3 in each Upazilas)

3.5. Data Analysis

With a particular focus on the inclusion of people with disabilities, the research used a participatory and multidisciplinary methodology that integrated quantitative and qualitative data collection techniques to obtain a comprehensive understanding of the context surrounding climate-resilient infrastructure. The study examined the vulnerabilities faced by people with disabilities in the study areas, as well as the risks associated with climate change and natural disasters. The Bangladesh Meteorological Department (BMD) provided long-term disaster data, which were examined to look for patterns in the weather like rainfall and temperature. Microsoft Excel was used to perform a descriptive statistical analysis on household quantitative data.

3.5.1. Quantitative Data Analysis

Using Microsoft Excel, quantitative data from the household questionnaire survey were subjected to descriptive statistical analysis. To summarize and interpret the data, this analysis looked at means, standard deviations, frequencies, and percentages. Additionally, relationships between various variables were investigated using inferential statistical techniques like correlation analysis. The quantitative analysis's conclusions shed important light on the vulnerability of people with disabilities (PWDs) in the study areas as well as the prevalence of climate-resilient infrastructure.

3.5.2. Qualitative Data Analysis

Thematic analysis was used to examine the qualitative information obtained from Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs). Finding recurrent themes, patterns, and trends in the data was required for this. The FGD and KII transcripts were

meticulously examined and arranged to extract important information about disaster risks, climate-resilient infrastructure, and the inclusion of PWDs in the study areas. The study context was better understood overall thanks to the nuanced perspectives and experiences of stakeholders that were clarified through this qualitative analysis.

3.5.3. Integration of Quantitative and Qualitative Findings

To give a comprehensive picture of the state of climate-resilient infrastructure and the vulnerabilities of PWDs in the study areas, the quantitative and qualitative findings were combined. Deeper investigation of the study questions and objectives was made possible by the more thorough and nuanced analysis that resulted from the integration of both forms of data. The process of identifying potential gaps and opportunities to improve the resilience and inclusivity of infrastructure against natural disasters and climate change was made easier by this integration.

4. Result

Climate Change Vulnerability

Khulna and Mongla, two meteorological stations, encompass the study areas. The last 30 years (1990–2020) of climatic data (temperature and rainfall) from both locations were studied. Khulna and Mongla stations data analysis reveals that total rainfall patterns during this time are nearly the same in both stations. According to the temperature trend analysis of Mongla station, the temperature is increasing 0.0011 degree Celsius per year, whereas Khulna station's temperature per year is increasing 0.0219 degree Celsius (**Figure 3**). With the increase of temperature, both the stations' rainfall also

follows an increasing trend (**Figure 2**). Where analysis shows that Khulna stations' yearly increasing trend was 5.19mm and Mongla stations' rainfall increased 4.82 mm/year.

Figure 2: Total Annual Rainfall of Khulna and Mongla station (1992-2022)

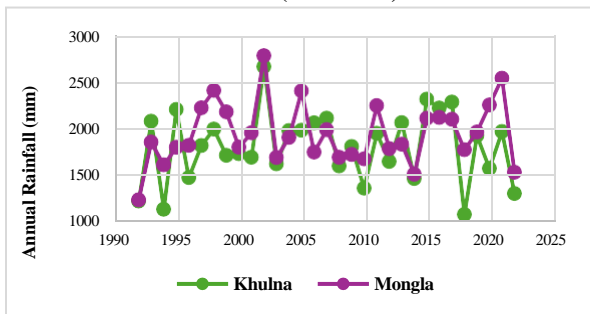
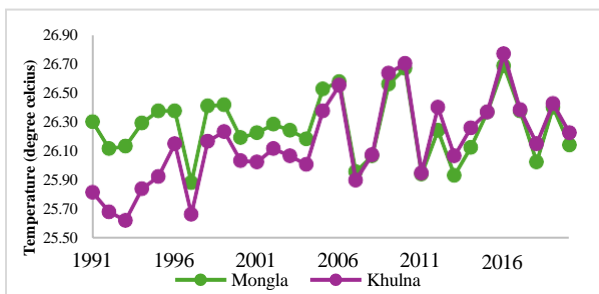


Figure 3: Average Temperature of Khulna and Mongla station (1990-2020)

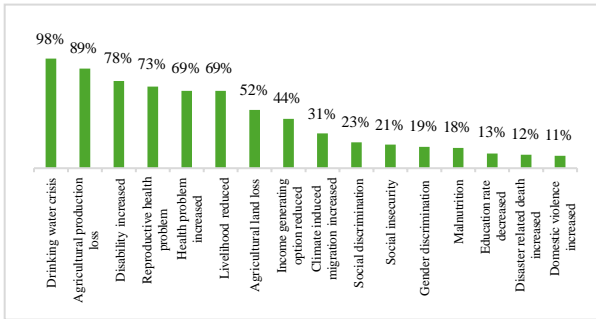


Climate Change and its Impact in the Study Area

Numerous facets of local livelihoods are impacted by the extensive and diverse effects of climate change in the study areas. The local population's life has already undergone tremendous changes because of climate change and disasters brought on by it. Notable inequalities and disturbances were noted in several areas, including water resources, agriculture, health, land use,

livelihood opportunities, and social dynamics. Reproductive health has become a significant concern because of climate change, especially because of increased salinity levels. About 89% of respondents expressed concern over declining agricultural productivity linked to the effects of climate change, and a significant portion of respondents reported difficulties getting access to drinking water during dry seasons. Furthermore, a sizable fraction of participants, comprising 69%, indicated a rise in health problems linked to climate change, whereas a similar 69% mentioned a reduction in employment prospects. 52% of respondents indicated that they had lost agricultural land because of salinity intrusion and climate change. Furthermore, the study found that there are fewer options for earning money because of climate change, with 31% of respondents mentioning an increase in migration brought on by the phenomenon. Surprisingly, 73% of respondents were women and adolescent girls, who expressed greater concerns about reproductive health disruptions brought on by climate-related disasters like salinity intrusion. Focus group discussions with women in Koyra and Paikgacha clarified a variety of reproductive health concerns linked to disasters caused by climate change. These included leucorrhea, Pelvic Inflammatory Disease (PID), Urinary Tract Infections (UTIs), low birth weight babies, premature delivery, infertility, recurrent pregnancy loss, compromised fertility, abdominal discomfort, obesity, complications during childbirth, and decreased sexual interest. Furthermore, social discrimination was also said to be increasing as a result of climate change, according to some respondents. These included increased gender discrimination, social insecurity, malnourishment, and domestic violence in their communities.

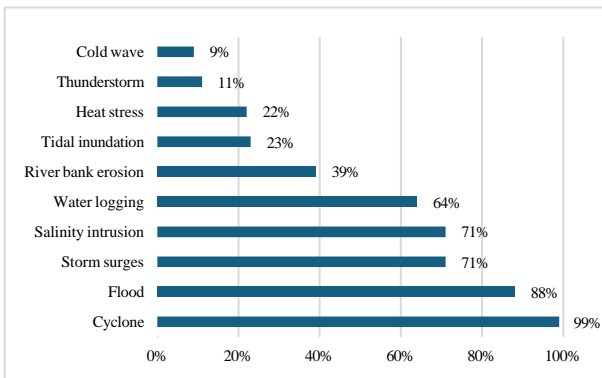
Figure 4: Impact of Climate Change in the Study Area



Climate Effects: Disasters in the Study Area

Cyclones are the most common climate-related disaster that affects their area, according to the vast majority of respondents (99%). Furthermore, flooding is the most prevalent disaster, according to 88% of respondents. Numerous additional climate-related hazards were also identified by the study. Tidal inundation and storm surges are also relatively frequent at 71%. Water logging occurs at a rate of 64%. Less frequent events include riverbank erosion (39%), heat stress (22%), thunderstorms (11%), and cold waves (9%).

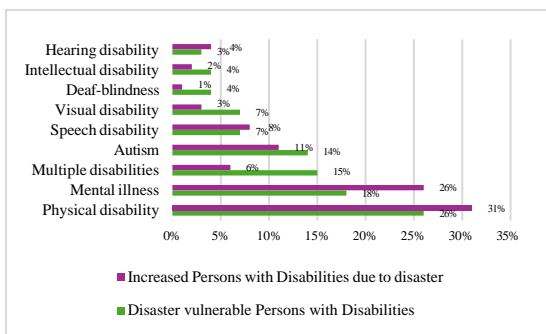
Figure 5: Climate induced disaster in the study area



Assessing Disaster Vulnerability Among Persons with Disabilities

Disasters brought on by climate change not only make people with disabilities more vulnerable, but they also increase the number of people with disabilities overall. Physical disability appears as the main factor linked to the effects of climate change in both cases. Disasters brought on by climate change not only make people with physical disabilities more vulnerable, but they also raise the overall number of people with disabilities in the study area. About two-thirds of respondents said that people with physical disabilities are more vulnerable to the negative impacts of disasters, and another third said that the frequency of physical disabilities is rising because of these events. Furthermore, as noted by 18% and 26% of respondents, respectively, mental illness emerged as the second most prominent type of vulnerability for people with disabilities who are vulnerable to disasters and those whose disabilities are exacerbated by disasters.

Figure 6: Climate change and disability nexus



Disaster Vulnerability Corresponding to Housing Structure

Disaster resilience at the household level is greatly influenced by the type of housing structure, especially for

individuals with disabilities who are frequently disproportionately affected by disasters. Houses built with concrete walls and floors tend to be the strongest, but the table shows that people of that region still have a relatively low percentage of concrete, potentially lowering their resilience. Conversely, materials like tin, commonly used in huts, offer little protection. This highlights how the type of materials and construction methods significantly impact how well a house can withstand a disaster. A worrying pattern in the population under study shows that a sizable majority of people with disabilities live in homes that are extremely susceptible to natural disasters. Only 8% of the households surveyed had concrete walls and floors, whereas 4% of the households had tin walls and concrete floors. This means that only a small percentage of homes are furnished with relatively sturdy building materials. On the other hand, it was found that a startling 88% of the households in each of the study area's four Upazilas had housing made of earthen materials or a mix of tin and hut, both of which are extremely prone to damage or destruction during disasters. This data emphasizes how urgent interventions to improve the housing infrastructure's resilience are needed, especially for people with disabilities, in order to lessen the catastrophic effects of disasters on communities that are already at risk.

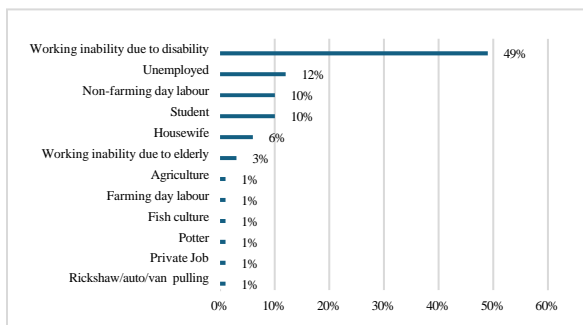
Material	Floor			
	Concrete	Concrete	Earthen	Earthen
Concrete	8%			
Tin	4%			
Tin	34%			
Hut	54%			

Legend	
Low	
Moderate	
High	
Extreme	

Occupation of Person with Disabilities in The Study Area

In terms of occupation as well as employment, persons with disability are unemployed more than non- Persons with Disabilities and the study reveals that only 16% Persons with Disabilities are employed in different sectors including agriculture, fish culture, farming day labor, non-farming day labor, potter, rickshaw pulling and private job. Only 1% Persons with Disabilities is engaged with private job in all four studied upazila. Overall, the chart indicates that a significant portion are unemployed due to challenges related to their disability or age. Since the major focus of this study is to identify disability inclusive development opportunities and livelihood program design in the aftermath, the study team also tried to shed light on occupation or earning potentials for the persons with disability throughout the study locations.

Figure 7: Occupation of Persons with Disabilities

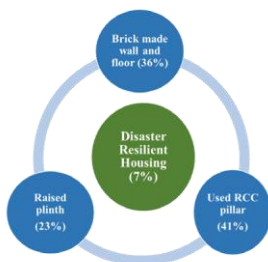


Disaster Resilient Housing

Bangladesh is highly vulnerable to natural disasters which cause widespread damage to infrastructure and homes, displacing people and impacting livelihoods. Disaster-resilient housing in BD incorporates features to minimize damage and ensure the safety of residents

during these events; **houses should be built to withstand disasters (disaster-resilient housing) and come with special features to keep people safe. These features include raising the house up off the ground (elevated foundations) and using stronger materials for the walls and roof, like concrete, reinforced brick, or special materials designed to handle cyclones. This makes the whole house much stronger.** It was found that only 7% houses are disaster resilient in the study area which is aligned with construction materials of houses. Whereas 8% houses are made of total concrete on wall and floor, 7% houses are found disaster resilient. Among these, raised plinth (23%), prepared wall and floor with bricks (36%) and RCC pillar made wall (41%) are found as disaster resilient houses in the study area. During the FGD with the community people of Mongla and Dacope, it was found that the houses which are made of concrete on floor and wall are safe from wind and storm surges as well as flooding.

Figure 8: Disaster resilient housing

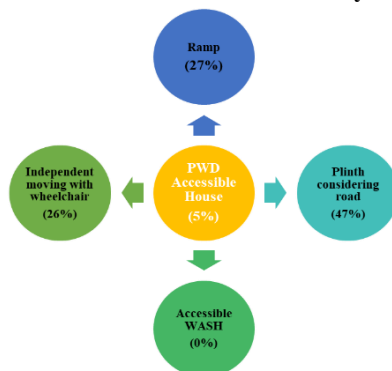


Persons With Disabilities Friendly Housing

The purpose of disability-friendly housing is to lower barriers and encourage self-sufficient living for people with a range of physical, sensory, or other impairments. Housing with features such as ramps, WASH

accessibility, and physical accessibility to allow independent wheelchair movement is adapted or intended to be comfortable and accessible for individuals with disabilities. 5% respondent said that their houses were accessible for People with Disabilities. Out of 5% respondents who have PWD accessible housing, among of them 47% respondents mentioned that they built their house plinth considering the road height. Out of this 5%, 27% respondents said that their houses were accessible for Persons with Disabilities because they had a ramp in their house. 26% of total 5% respondents mentioned that the Persons with Disabilities could independently move with wheelchair. But the main fact is one has the PWD friendly WASH facilitates in their household level (**Figure 9**). For that reason, they thought their houses were accessible for Persons with Disabilities.

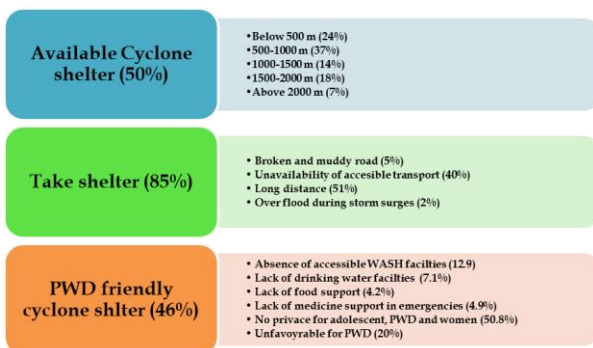
Figure 9: Persons with Disabilities friendly housing



Status of Cyclone Center

It is critical to guarantee that cyclone shelters are handicap accessible in order to give individuals with disabilities appropriate housing and protect their safety during cyclonic events. The study's conclusions, however, point to a troubling dearth of suitable cyclone shelters in the study area that meet the needs of

vulnerable groups, such as people with disabilities. While half of the respondents indicated that there were cyclone shelters in their area where people could go to seek safety during cyclones, it is interesting to note that most of these shelters are located quite a distance away from the communities that are at risk. Due to this geographic difference, it may be difficult or impossible for people with mobility impairments or other disabilities to get to these shelters during an emergency. This presents a serious challenge for people with disabilities. The lack of accessible and well-located cyclone shelters increases the vulnerability of individuals with disabilities during cyclonic events. This highlights the pressing need for focused interventions to close this critical gap in disaster preparedness and response efforts. Only 24% respondents mentioned that they have cyclone center within 500 meters distance and 34% respondents mentions that they have cyclone center more than one-kilometer distance. 85% of respondents out of 50% who have cyclone center take shelter during cyclone center but instead of existence of cyclone center in the locality, 5% people don't take shelter because of broken center and muddy road whereas 40% don't take shelter because of unavailability of accessible transport during cyclone and 51% don't take shelter because of long distance. Most of the people (54%) who take shelter in the nearby cyclone centers mentioned that cyclone centers are not friendly for persons with disability because there are not accessible WASH facilities, lack of drinking water facilities, Persons with Disabilities friendly space, food support during emergency, lack of medicine support in emergencies, no privacy for adolescent, Persons with Disabilities and women

Figure 10: Overview of Cyclone shelter

5. Discussion

In the context of Bangladesh's coastal zones, the study's findings highlight the connections between the effects of climate change, disaster vulnerability, and disability inclusion. Data from meteorological stations in Khulna and Mongla show trends in temperature and rainfall caused by climate change, which shows a pattern of rising temperatures accompanied by rising precipitation levels, indicating the region's susceptibility to climate-related hazards. Significant effects of these climate shifts have been seen on local livelihoods, with disruptions seen in several areas, such as agriculture, health, and water resources. Notably, reproductive health became a major issue that was made worse by higher salinity levels, affecting not only people with disabilities but also the general public. The study also emphasizes how people with disabilities are disproportionately affected by climate-related disasters, with physical disabilities being recognized as a key vulnerability factor. It was discovered that the housing units occupied by individuals with disabilities were especially vulnerable to natural calamities, underscoring the pressing necessity for resilient infrastructure. Even though there are cyclone

shelters, people with disabilities still face significant challenges during emergencies due to their remote location and lack of accessibility, which highlights a critical gap in disaster preparedness and response efforts. The study furthermore highlights the heightened vulnerability of people with disabilities (PWDs) to climate-induced disasters. Their limited mobility and dependence on specific assistive technologies can be significantly impacted by damaged infrastructure during events like floods or cyclones. The lack of disability-friendly features in housing and public infrastructure are concerning. This creates additional barriers for PWDs during everyday life and further hinders their ability to evacuate or access support during disasters. The consideration of plinth height, ramp, accessible WASH, wheelchair movement independence in housing design demonstrates the community's awareness of disaster risks. Integrating such considerations into broader infrastructure planning, from shelters to evacuation routes, is crucial. Building climate-resilient infrastructure in Bangladesh cannot be achieved without ensuring its inclusivity for PWDs. By integrating their needs into every step of the planning and construction process, we can create safer and more dignified living environments for all coastal communities, fostering a more resilient future in the face of climate change. Promoting neighborhood-based projects to construct handicapped-accessible cyclone shelters is advised as a solution to these problems, highlighting the significance of inclusive infrastructure development in boosting resilience and guaranteeing the safety and inclusion of all community members, especially those with disabilities, in the event of disasters brought on by climate change.

6. Conclusion

In conclusion, this study clarifies the intricate intersections between the effects of climate change, the susceptibility of coastal Bangladesh to disasters, and the inclusion of people with disabilities. The study clarifies the growing susceptibility of nearby communities to climate-related hazards like floods and cyclones through an examination of climatic trends. In addition, the fact that people with disabilities are disproportionately affected by these disasters emphasizes how urgent it is to develop inclusive infrastructure. As the study's results demonstrate, infrastructure accessibility for people with disabilities is still a major challenge in Bangladesh, despite the country's development progress. People with disabilities are more vulnerable during disasters because they frequently lack resilient housing and sufficient infrastructural support. The study recommends the adoption of disability-friendly policies and strict oversight of their implementation to address these issues. Additionally, it highlights how crucial community-based projects are to the construction of handicapped-accessible cyclone shelters, guaranteeing the security and inclusion of every member of the community. Going forward, coordinated efforts are required to close the gap that exists between policy intentions and practical implementation, fostering resilient and inclusive infrastructure that meets the various needs of every person—including those who have disabilities.

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