JOURNAL OF CREATIVE WRITING
VOLUME 8 ISSUE 2
2024, PP 76-109
ISSN 2410-6259

HTTPS://DOI.ORG/10.70771/JOCW.103

STRUCTURAL MITIGATION APPROACH FOR EVACUATION OF CYCLONE ON THE LENS OF INTERSECTIONALITY AT RANIPUR, CHARKHALI, DEULI, KAKRABUNIA IN MIRZAGANJ UPAZILLA, PATUAKHALI

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ABSTRACT

Cyclones are a constant threat to the coastal regions of Bangladesh, where vulnerable communities face high risks due to both natural hazards and social inequalities. A field investigation of cyclone shelters in Mirzaganj upazila reveals that these facilities are underfunded, poorly managed, and discriminatory against people with disabilities, the elderly, and women. This research aims to develop a comprehensive cyclone mitigation strategy that integrates both structural and non-structural components. Through a detailed survey and data analysis using Kobotools, we identified key issues and proposed solutions to eliminate discrimination in shelters. Our approach emphasizes community-led management in non-structural mitigation and non-discriminatory shelter design in structural mitigation. While 54% of respondents visited a cyclone shelter, 46% did not, citing reasons such as inadequate transportation, security concerns, distance from home, risk perception, lack of food, and insufficient facilities like separate rooms and restrooms for men and women. Those who did visit shelters often faced violations of their rights. About 43.75% of women were denied breastfeeding rooms, 42% were denied menstruation restrooms, and 43.75% faced a lack of facilities for individuals with disabilities. Around 48% of

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respondents received early warnings through local government channels, and 43% via social media. Furthermore, 63% of respondents believed the cyclone shelters were unsuitable and required rebuilding, citing issues such as poor transportation, dark roads, fears of theft, and inadequate shelter conditions.

KEYWORDS

Cyclone, Intersectionality, Mitigation Approach, Inclusive, Women Rights, Disaster.

INTRODUCTION

In Bangladesh's coastal areas, where vulnerable communities face high levels of danger from both natural hazards and social injustices, cyclones are a constant menace. Due to their geographic location and the socioeconomic makeup of their people, the villages of Ranipur, Charkhali, Deuli, and Kakrabunia in Mirzaganj Upazila of Patuakhali are especially vulnerable to the effects of cyclones. Although crucial, traditional mitigation strategies sometimes overlook these communities' intersectional vulnerabilities, which include those related to age, gender, disability, and socioeconomic status and influence people's capacity to adequately anticipate and react to cyclonic events.(Miyaji et al., 2020).This study was developed by investigating shelters used during cyclones in Bangladesh. The findings highlighted challenges to the functioning of the shelters such as poor maintenance, gender related eviction issues and lack of sustainability. In addition to these findings, they look at a new house-shaped mini shelter proposed by Black University and show how the mini shelter center could provide them with basic shelter during hurricanes. The research paper emphasizes the need for improved shelter planning considering residents' traditional awareness and long-term research to assess safe working conditions during cyclone events so that proper implementation plans can be made.(Alam et al., 2024)

The many calamities that have struck Bangladesh during the past fifty years—including cyclones, floods, tornadoes, earthquakes, and more—are examined in this study. It highlights extreme occurrences like the 1970 storm and investigates the nation's susceptibility using qualitative research and content analysis. Given the growing severity and frequency of catastrophes, the study highlights the necessity of a comprehensive disaster management policy. Bangladesh has demonstrated a commitment to disaster preparedness and mitigation by taking steps to lower human and economic losses while being one of the most catastrophe-prone countries.The gender viewpoint is applied in this study to evaluate storm shelters in coastal Bangladesh. The report highlights deficiencies in the shelter's capability and an unwelcoming environment for women, including incidents of sexual harassment and inadequate hygienic amenities.

To address women's vulnerabilities and adverse effects during cyclones, the findings highlight the necessity of gender-sensitive cyclone shelter design. In order

to protect women's safety and wellbeing in Bangladesh's coastal regions that are vulnerable to cyclones, the study suggests taking extensive action.(Hasinur Rahman et al., 2017).The Major Paper adeptly examines the nexus of climate revise, debacle governance, and gender susceptibility in South Asia, with a seat on Bangladesh. Delivering the country's strides in debacle operation, especially climate adaptation, the paper scrutinizes the hiatuses in addressing deportationpost-environmental disasters, featuring the unsexed nuances of migration. Utilising a text mining path, the paper evaluates public and international debacle operation procedure fabrics, showcasing its methodological robustness through government documents and collaborative crashes. The extension of Cyclone Sidr and Cyclone Roanu as case inquiries adds existential cargo to the dissection. While the paper successfully underscores the unsexed implications of climate- move migration, it highlights the absence of international ordinances keeping liable populations.(Dash & Walia, 2020) The cry for bettered governance fabrics and relief efforts is a substance conclusion, egging policymakers to call the unsexed aspects of climate revise, debacle, and deportation in their responses. In future disquisition, expanding case inquiries, incorporating non identical geographical surrounds, and probing deeper into socio-profitable confines could toughen the paper's jolt. also, proposing practicable recommendations for policymakers would farther contribute to the discourse on keeping liable populations, especially women, in the face of climate- related disasters.(Sattar & Cheung, 2019).

This study makes a significant donation by totally laying community flood tide adaptability in Bangladesh through a gender lens, exercising both quantitative and qualitative approaches. By incorporating a gender standpoint from conception evolution to data representation, the study ensures a refined understanding of the susceptibility faced by women in flood tide-apt areas. The use of a well- structured questionnaire, aligned with the characteristics of a debacle - flexible community, adds methodological rigor to the exploration. The rulings disclose gender- grounded difference in debacle adaptability, featuring the want for acclimatized interventions. To enhance unborn inquiries, the paper recommends a more improved disquisition of intersectional characteristics, pressing the implicit compounded susceptibility of individualities, similar as impaired and senior women, in the face of disasters. (Chisty et al., 2022).This thesis significantly advances our understanding of the daedal connections among gender, screen, and the terrain, especially in the environment of natural disasters and climate revise.

The author effectively argues against traditional screen approaches that command gender difference and environmental enterprises, featuring the want for a further inclusive standpoint in policymaking and discordance conclusion. The intersectional gender dissection, applied to four case inquiries, reveals harmonious

susceptibility endured by women ahead, during, and after disasters, offering precious perceptivity for interpreters and policymakers.(Jaiswal et al., 2022) The exploration underscores the significance of addressing patriarchal scales, promoting women's addition in resolution- making processes, and finessing the feminization of penury and environmental places. While pressing the significance of intersectional gender inquiries, the thesis encourages farther exploration to ground hiatuses in understanding, especially concerning marginalized groups like individualities with disabilities, and lawyers for a further watchful path to gender- grounded violence inpost-disaster relief sweats.(Axelrod et al., 2022).This paper provides a pivotal examination of the intersectional dynamics between gender, indigeneity, and climate revise susceptibility in autochthonous communities in the United States, filling a noble gap in being exploration. The conflation competently draws upon transnational literature on gender and climate revise, autochthonous perspectives, and the jolt of colonization on gender places to interpret the special expostulations and puissance of autochthonous men, women, and LGBTTQ individualities. By fastening on crucial areas similar as public health, migration, severance, and artistic impacts, the paper offers a complete understanding of how gender shapes climate revise gests within autochthonous communities.

The report's structure, starting with a contextual foundation before probing into special areas of susceptibility and adaptability, enhances its availability and mileage for both autochthonous communities and foreign stakeholders. To ameliorate, unborn exploration could claw deeper into the refined gests of special gender individualities within autochthonous communities and explore further refined perspectives on gender and indigeneity from different votes.(K.C. & Hilhorst, 2022). This paper provides a refined analysis of women's exploits during and after the 2015 earthquake in Nepal, offering precious perceptivity into the intersectionality of gender with socio-profitable ministers in suiting debacle exploits. The use of a real- time ethnographic path, with one of the authors being an earthquake survivor, adds a special and viewpoint to the disquisition. The study effectively highlights how gender dynamics cross with citizenship, estate, profit, and other ministers, impacting women's places in evacuation, relief, and recovery. The methodology, predicated on in- depth stories of 22 women from the author's vicinity, fosters an close understanding of the subject matter. To enhance the disquisition, future inquiries could explore the long- term impacts on women's lives and further probe the part of community networks in post- disaster recovery.(Crawford et al., 2023).

This paper provides a complete overview of the gender confines within the environment of constant disasters in Bangladesh, featuring the special expostulations faced by women and maids. The dissection effectively highlights the swelled susceptibility of women during disasters due to socially outlined gender places and

the fresh burden of ménage liabilities. The paper acknowledges the pivotal part played by women's strategies in pastoral communities' capability to manage with and acclimatize to colorful phases of disasters. (Faruk et al., 2018)While addressing the overcritical effects of penury, malnutrition, violence, and health-related cases affecting women and maids disproportionately, it underscores the significance of nonstop exploration and mainstreaming gender in debacle-related legit and nonsupervisory fabrics. To enhance its jolt, unborn advancements could involve a more in-depth disquisition of special adaptability mechanisms assumed by women and a closer examination of the intersectionality between climate revision, afflictions, and gender-special susceptibility.(Billah et al., 2018).This paper conducts a scoping review on the intersectionality of gender, sexual identity, and disability in debacle threat reduction (DRR) within OECD nations, filling a pivotal gap in exploration concentrated on high- profit countries. The study employs a robust methodology, combining peer- examined existential inquiries and slate literature to exhaustively explore the expostulations faced by individualities with disabilities who are women, men, and gender and sexually different in the environment of disasters. (Haider & Ahmed, 2014)The rulings punctuate the inhospitable issues endured during events like the COVID- 19 epidemic, influencing both physical and internal health, with a special seat on the use of technology to support managing chops. This study examines the structural mitigation approaches for cyclone evacuation through the lens of intersectionality in these vulnerable villages. Intersectional analysis, as applied in disaster response, helps reveal how overlapping social factors affect people's resilience and adaptive capacities, allowing for more nuanced and effective mitigation strategies. By focusing on the specific needs of marginalized groups, this approach aims to address the disparities in evacuation infrastructure, accessibility to shelters, communication channels, and resource distribution.(Mallick, 2014)

Through an analysis of structural interventions tailored to the unique intersectional needs of the populations in Ranipur, Charkhali, Deuli, and Kakrabunia, this paper proposes a comprehensive evacuation plan we found that no research has been done in this issues so far.

The paper underscores the significance of inclusive approaches in debacle preparedness, featuring meaningful discussion, active participation of different nonage groups, and mindfulness caregiving. Unborn exploration recommendations carry probing the crossroad of gender, sexual identity, disability, and cultivation in the debacle and DRR environment, while counteraccusations for practice punctuate the want for swelled mindfulness to alleviate disproportionate impacts on marginalized groups. This includes recommendations for structural modifications, community engagement in planning processes, and the establishment of inclusive early warning systems.

So that's why it would contribute to the measures are intended to enhance the adaptive capacities of these communities, promote equitable access to evacuation resources, and ultimately reduce the loss of life and property during cyclonic events in the region

METHODOLOGY

At the time of data collection note down had been taken about the latitude and longitude. By using that latitude and longitude a map had been plotted. From this map can see that study area was Chorkhali, Ranipur, Kakrabunia, Deuli at Mirzaganj in Patuakhali districts. Lack of cyclone shelters has been claimed for this area. Bad transportation system to go to cyclone shelter had been claimed. On the other hands shaky condition of cyclone shelters had been seen here. People of this area have been suffer for cyclone and river bank erosion mostly. Huge impact of cyclone are being noticed in this area. As this area has been affected by cyclone mostly so evacuation system for this area have to be strong in this area.(Mirzaganj Upazila - Banglapedia)

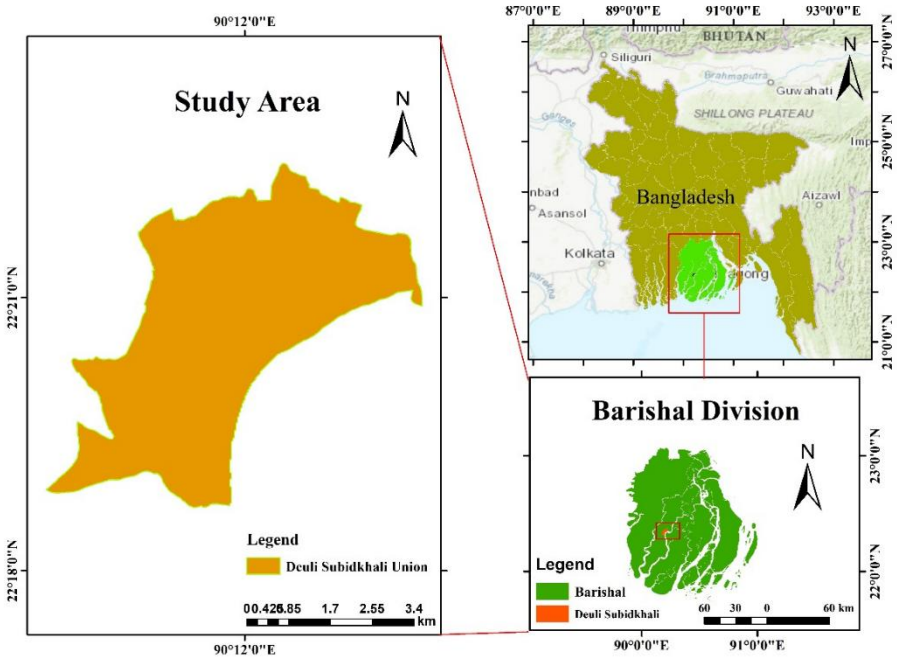

Figure 1: This project uses qualitative and primary data collected through a field trip in the coastal area of Patuakhali. A questionnaire was prepared with expert input before the trip. The study focuses on four villages—Ranipur, Charkhali, Deuli, and Kakrabunia—in Mirzaganj Upazila, Patuakhali, which is highly vulnerable to cyclones due to its proximity to the Bay of Bengal. These villages have faced

significant damage in past cyclones like Sidr, Aila, and Amphan, making them ideal for assessing structural and social challenges in evacuation. Intersectionality highlights how factors such as gender, class, disability, and ethnicity affect vulnerability. The villages face issues like limited shelter access, inadequate transportation, and resource inequity, with marginalized groups often being disproportionately affected. Studying these areas offers insights applicable to other cyclone-prone regions, providing a basis for developing equitable, inclusive, and resilient evacuation strategies. Local engagement and partnerships with authorities enhance the research's relevance and impact.

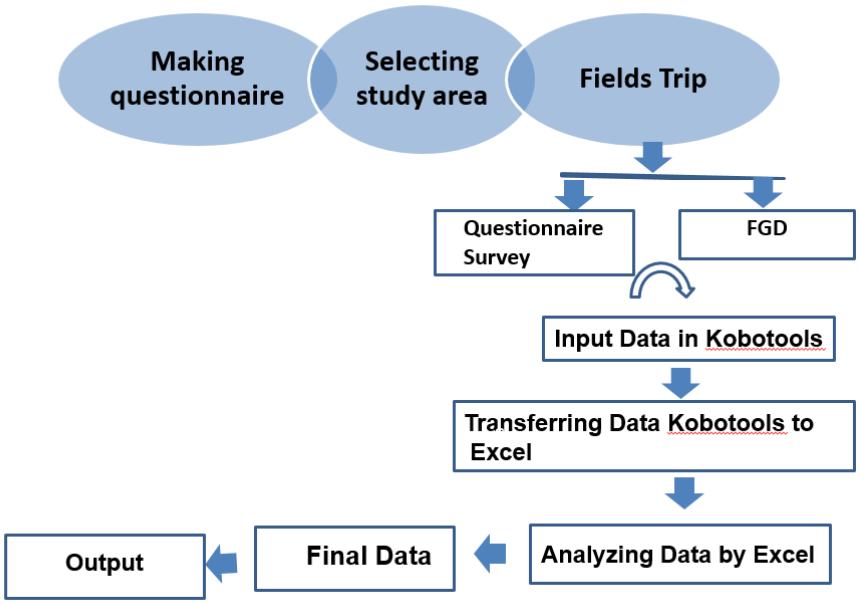

Figure 2: Methodology

METHODOLOGY

The successful completion of a two-day field trip, during which data was collected and input into Kobotools. GIS maps highlighted critical geographical features, such as low-lying areas, cyclone shelter proximity, and transportation networks, helping identify accessibility gaps for marginalized groups like women, children, and disabled individuals. GIS also integrated population data, enabling an analysis of intersecting vulnerabilities. Historical cyclone data was overlaid to predict future impacts and assist in planning mitigation. Kobotools allowed for rapid data collection on demographics, evacuation behavior, and shelter conditions, with GPS-enabled surveys ensuring geospatial accuracy. Combining GIS and Kobotools allowed for detailed analysis of evacuation scenarios, highlighting areas lacking adequate

structural mitigation and suggesting equitable solutions. This integration offers a comprehensive approach to understanding cyclone evacuation, addressing both spatial and social factors to improve disaster resilience in the study area.

RESULTS

In Mirzaganj Upazila, Patuakhali, the population is diverse, including children, elderly men and women, pregnant women, breastfeeders, and people with disabilities. Discrimination is evident at all stages—pre-disaster, during disaster, and post-disaster. To address this, an intersectional approach to cyclone evacuation is necessary to eliminate discrimination.

The **Theory of Inclusivity** focuses on creating environments accessible and equitable for everyone, regardless of gender, age, ability, or social status. Applying inclusivity to cyclone shelters involves designing barrier-free access, using braille and visual cues for the visually impaired, and adaptable facilities for people with varying physical capabilities. Shelters must also offer private spaces for women and families, gender-segregated sanitation, and child-friendly areas. Incorporating culturally appropriate designs and community involvement is crucial for encouraging all groups to use the shelters. Inclusivity ensures priority access for vulnerable populations like pregnant women, the elderly, and disabled individuals. Additionally, shelters should be built with durable materials, flexible capacity, and non-discriminatory policies to ensure safety and accessibility for all. By applying inclusivity principles, cyclone shelters can foster resilience, equity, and social cohesion, offering safe spaces for all, especially during crises.

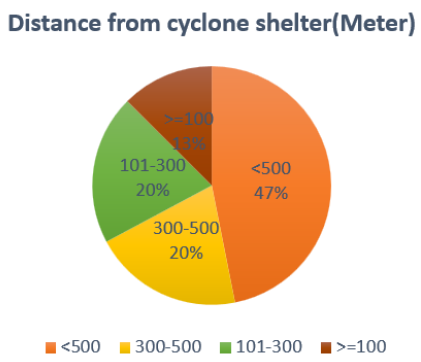

Figure 3: Distance from cyclone shelter

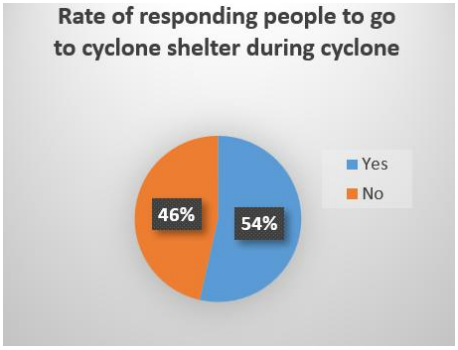

Figure 4: Rate of responding people to go to cyclone shelter during cyclone

The figure shows that 46.88% of people in Ranipur and Chorkhali live more than 500 meters from a cyclone shelter, making it difficult for them to access it during a cyclone with their daily goods. In contrast, 20.31% live between 100-300 meters, and

12.5% live less than 100 meters from a shelter, making access easier for them. About 53.12% of people did not go to a cyclone shelter, and 46.88% did, with the latter group facing challenges due to outdated shelter conditions.

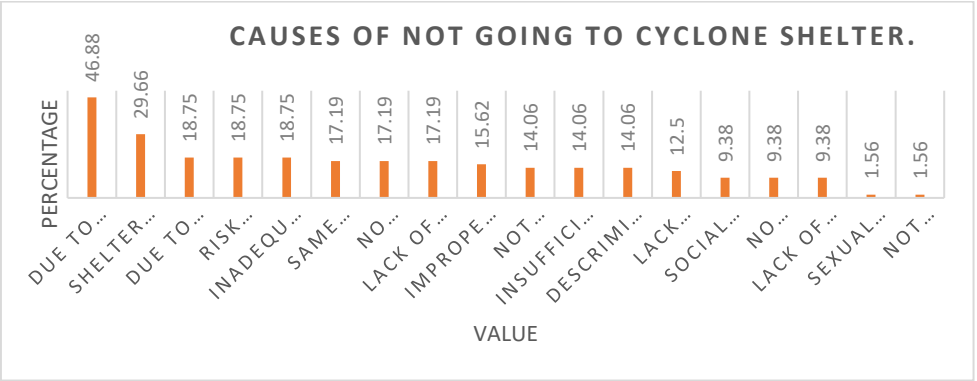

Figure 5: Causes of not going to cyclone shelter.

About 29.69% of people didn't go to the cyclone shelter because it was too far away, while 18.75% cited poor transportation, risk perception, and inadequate drinking water. Around 17.19% avoided the shelter due to lack of separate rooms and lavatories for men and women, and 15.62% felt the shelter lacked proper arrangements for the elderly. Additionally, 14.06% avoided it due to insufficient prayer space, food, and relief distribution issues. 12.5% didn't go due to inadequate space for animals, and 9.38% cited social degradation, lack of rooms for breastfeeding, and inadequate facilities for the disabled. 1.56% of women and girls avoided the shelter due to concerns about sexual harassment and lack of facilities for menstruation.

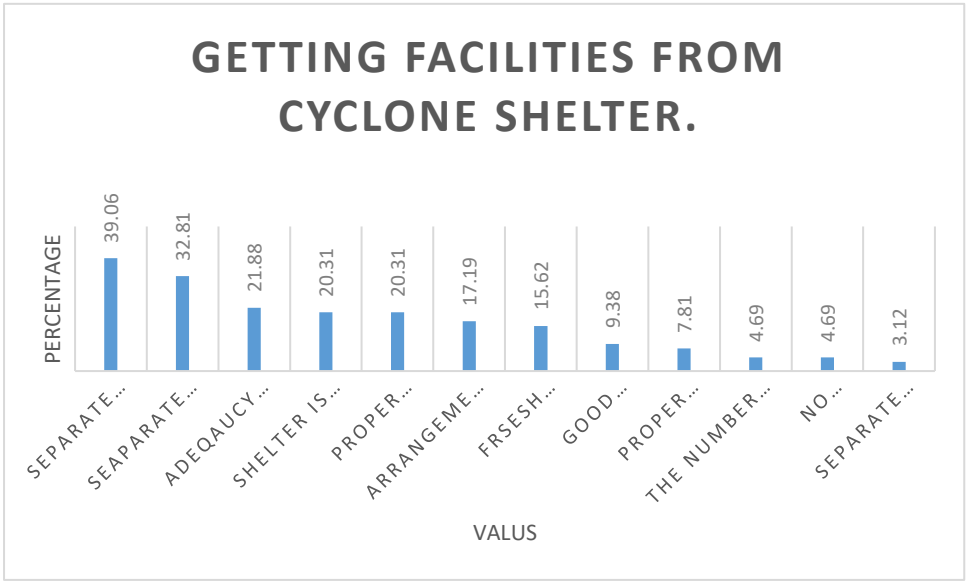

Figure 6: Causes of not going to cyclone shelter.

About 39.06% people of my study areas got separate rooms for men and women in cyclone shelter after going here. Have separate lavatory in cyclone shelter as well as adequacy of food. The cyclone shelter is very near for 20.31% people. And 20.31% people have said about their proper transportation system. There were lacking of prayers room. About 17.19% people got arrangement of prayers room in cyclone shelter in this area. Actually in some cyclone shelter breast feeder women used prayers rooms as their breast feeding area. As well as prayers room used as store room. So there are so much haphazard situation in cyclone shelter at now, find.

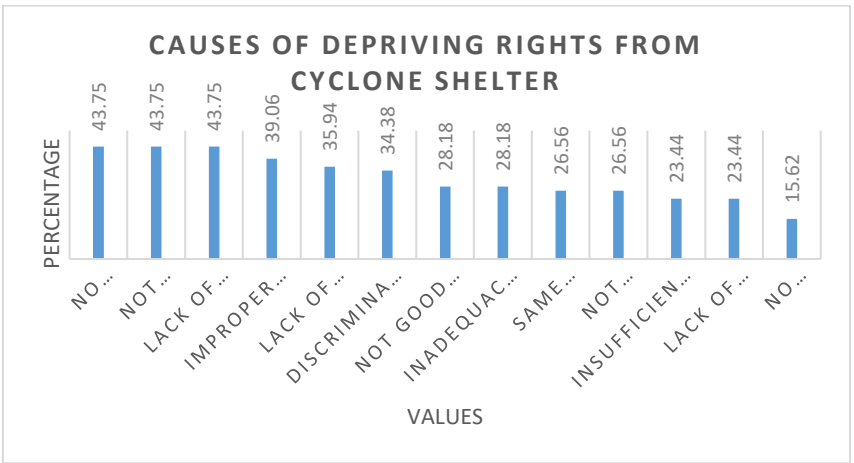

Figure 7: Causes of deprivation from cyclone shelter

In my study area, 43.75% of people lacked separate rooms for breastfeeding women, special lavatories for menstruating women, and proper facilities for the disabled. There were also no adequate arrangements for the elderly, causing many to avoid the cyclone shelter. Those who did go faced issues like inadequate storage for goods, discrimination in relief distribution, poor transportation, and a lack of clean drinking water, leading to health issues like cholera and diarrhea. The area also suffers from food shortages and no separate rooms for men and women.

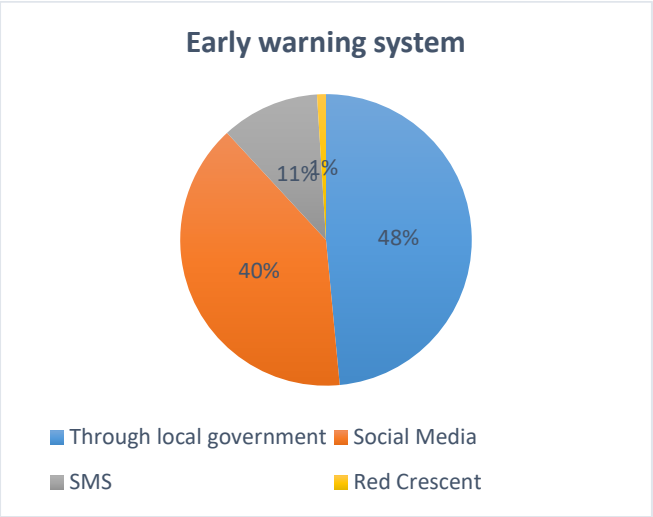

Figure 8: Early warning system

About 76.56% of people in the area received early warnings through the local government system. The local chairman and members formed a team to inform the public about the cyclone threat and signal system. Additionally, 62.5% of people received warnings via social media, especially Facebook, while others were alerted through SMS or NGOs like the Red Crescent. However, there were no visible activities from the Cyclone Preparedness Program (CPP), despite claims of expanding its reach to remote areas.

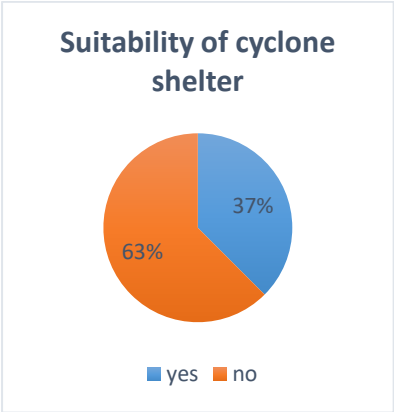

Figure 9: Suitability of cyclone shelter

About 62% people of this area couldn't think that the cyclone shelters they have are not suitable for them. Due to outdating shelters, broken road, have not lighting system, low height, lacking of security system cyclone shelters are not suitable to them.

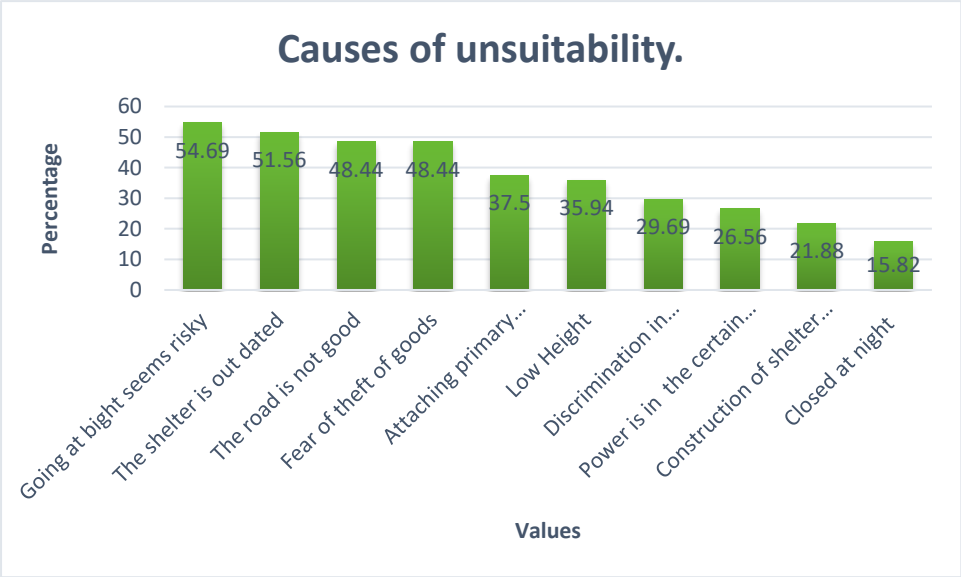

Figure 10: Causes of unsuitability.

55% people think that going at night to cyclone shelters seems risky to them as well as about 51.56% people think that the having cyclone shelters to them are being out dated. About 48% people don't give up their house due to fear of theft of goods of

them. Some people think that cyclone shelters would not be attached to primary school. Due to having power is in the certain ruling people, some people avoided to go to shelters.

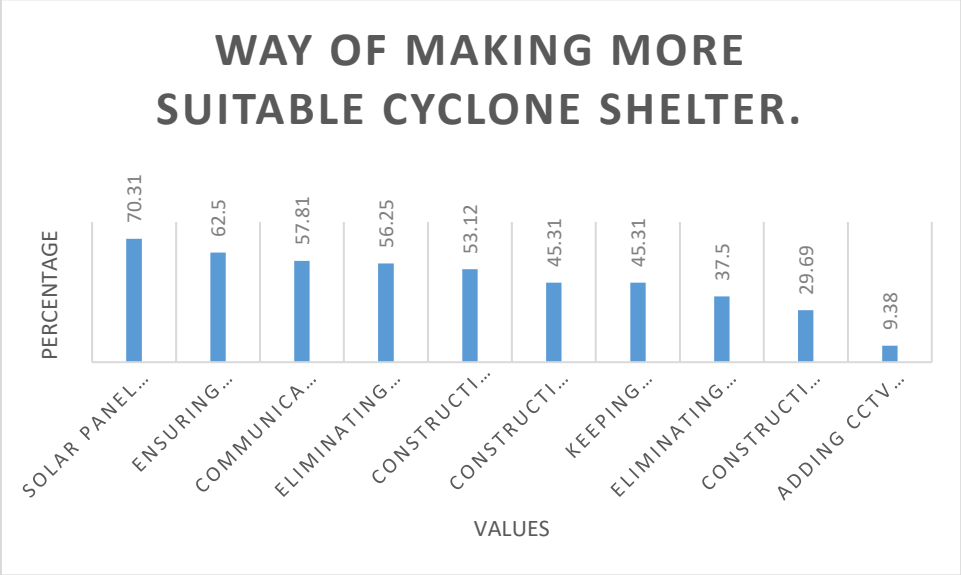

Figure 11: Way of making more suitable cyclone shelter.

People in the area believe that cyclone shelters can be improved by adding solar panels for lighting, ensuring the safety of their goods, improving the communication system, stabilizing shelters, separating shelters from schools, building high-rise shelters, eliminating discrimination, and installing CCTV cameras. About 70% of people want solar lighting on roads for easier movement, and 62.5% emphasized the need to secure their basic goods.

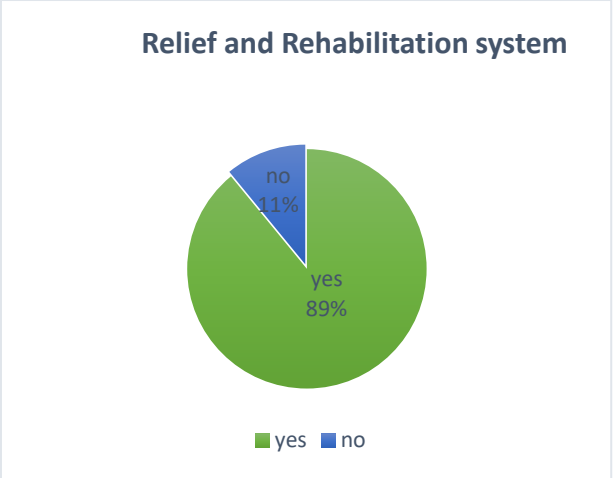

Figure 12: Relief and Rehabilitation system

About 85% people claimed about relief system which is very important part after cyclone. They claimed many reasons behind improper relief system. Lack of proper monitoring system, power in the hands of corrupt people, the relief givers think that relief is ineligible without verifications of facts, close relative of relief givers get more relief, inability to pay bribes, the middle class does not want and does not get for fear of public shame, derogatory as poor can be the cause of behind of not getting relief.

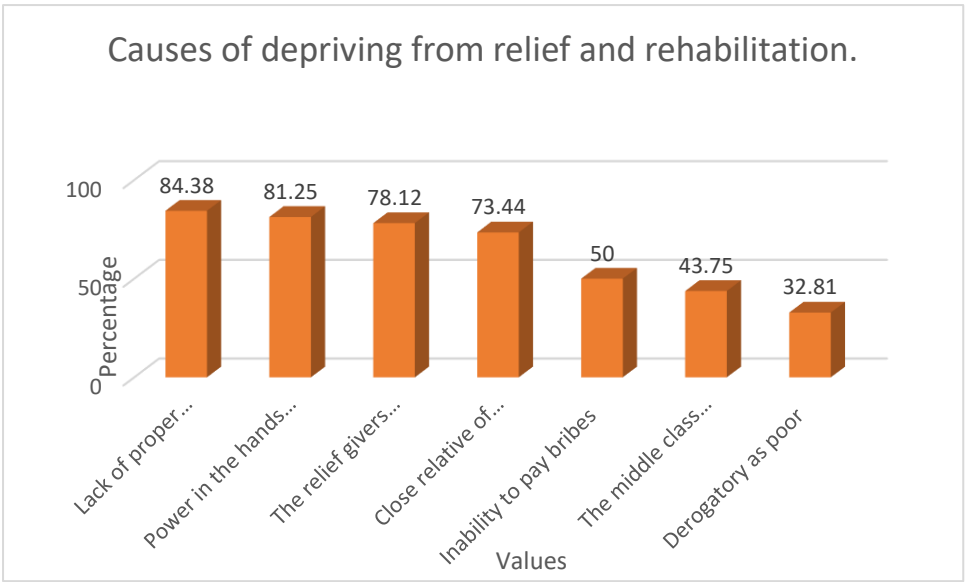

Figure 13: Causes of depriving from relief and rehabilitation.

About 84.38% of people in the area reported not receiving relief due to a lack of proper monitoring. Around 81.25% believe relief distribution is controlled by corrupt

individuals, and 78.12% feel relief is often deemed ineligible without verification. About 73.44% think relief givers favor their close relatives, and 50% believe they didn't receive aid because they couldn't pay bribes. Some middle-class people avoid relief due to fear of public shaming, even though they qualify, while the poor are often excluded due to discrimination.

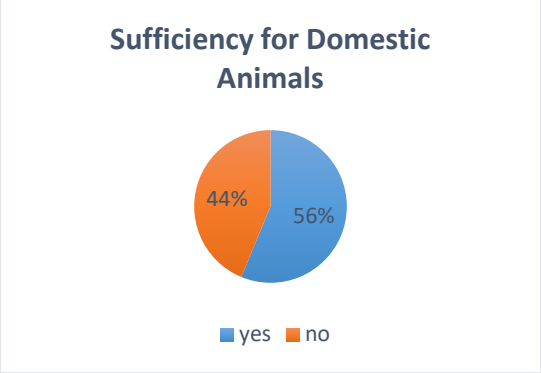

Figure 14: Sufficiency for domestic animals

About 56.25% people think the cyclone shelters are suitable for domestic animals. Due to having enough space for taking domestic animals. Some people avoided to go to shelters during cyclone due to improper situation of cyclone shelters. Basically newly made cyclone shelters are more appropriate to take domestic animals than ago made cyclone shelters. Because of low height, deficiency of domestic animals feed as well as baby animals are prone to infect by various disease people would not like to go to cyclone shelters during cyclone.

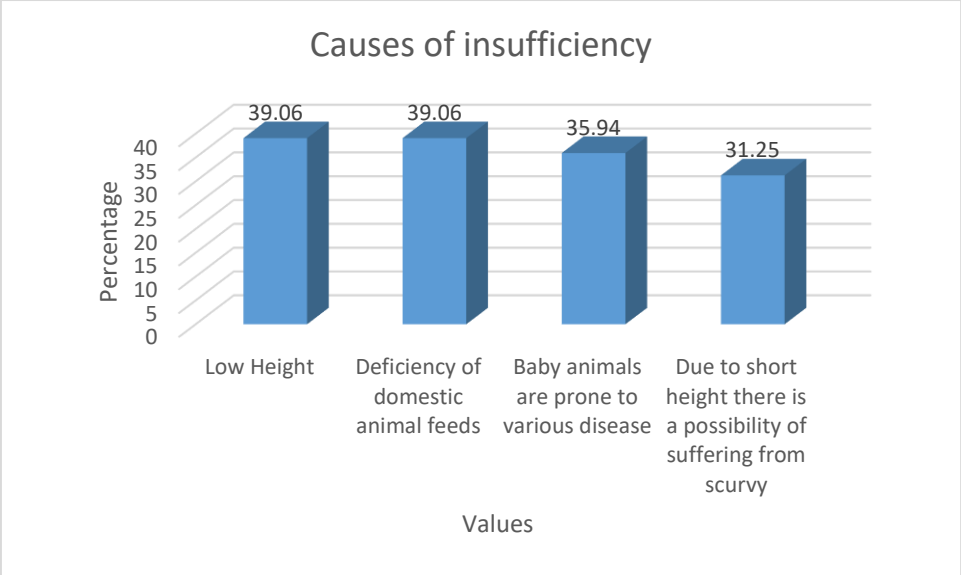

Figure 15: Causes of insufficiency

About 43.75% of people believe the cyclone shelters are unsuitable for bringing domestic animals, and 39.06% feel the shelters are in low-lying areas where their animals are unsafe, causing them to avoid the shelters. Additionally, 39.06% cited a lack of animal feed. A proposed solution is Community Lead Management, where a local team helps people, especially women, children, and the elderly, safely reach cyclone shelters. Many fear going with strangers, particularly women concerned about their decency. However, 95.31% of people are unaware of this idea, which could be an effective non-structural mitigation approach.

Figure 16: Community Lead Management

The analysis reveals several issues: no separate lavatories for menstruating women, no rooms for breastfeeding women, lack of women-friendly spaces, long distances to cyclone shelters, inadequate relief distribution, poor lighting on roads, absence of security and locker systems, shaky shelter conditions, no space for domestic animals, and no provisions for the elderly or disabled. There is corruption in relief distribution, insufficient cyclone preparedness training, and a lack of proper systems for children and pregnant women. Additionally, there is an undeveloped communication system, unhygienic shelters, no disaster assistance teams, no treatment systems, and a lack of building codes, behavioral modification, awareness, and risk perception.

Inferential Statistical Analysis

There are 174 responses in total for causes of not going to cyclone shelter. If the causes were uniformly distributed, the expected frequency for each category would be:

Expected frequency for each cause=Total responsesNumber of causes=17418≈9.67\text{Expected frequency for each cause} = \frac{\text{Total responses}}{\text{Number of causes}} = \frac{174}{18} \approx 9.67Expected frequency for each cause=Number of causesTotal responses=18174 ≈9.67.So, the expected frequency for each of the 18 causes would be approximately 9.67 if they were uniformly distributed.The Chi-square statistic is calculated as:

$\chi^2 = \sum(O_i - E_i)^2/E_i$, where O_i = observed value (actual value) and E_i = expected value.

Table 1: Causes of not going to shelter

Cause of Not Going to Shelter	**Observed Frequency**	**Expected Frequency**
Due to old building	30	9.67
Shelter away	19	9.67
Due to not good transportation system	12	9.67
Risk perception	12	9.67
Inadequacy of clean drinking water	12	9.67
Same toilets for men and women	11	9.67
No separate rooms for men and women	11	9.67
Lack of proper storage of necessary goods	11	9.67
Improper arrangement for sheltering elderly people	10	9.67

Cause of Not Going to Shelter	**Observed Frequency**	**Expected Frequency**
Not having enough space	9	9.67
Insufficiency of food	9	9.67
Discrimination in getting relief	9	9.67
Lack of adequate space for domestic animals	8	9.67
Social degradation	6	9.67
No separate rooms for breast feeders	6	9.67
Lack of proper provision for the disabled	6	9.67
Sexual harassment	1	9.67
Not having separate lavatory for menstrual women	1	9.67

$\chi 2$=47.88+8.47+0.66+0.66+0.66+0.17+0.17+0.17+0.01+0.04+0.04+0.04+0.26+1.39+1.39+1.39+7.49+7.49=77.41\chi^2 = 47.88 + 8.47 + 0.66 + 0.66 + 0.66 + 0.17 + 0.17 + 0.17 + 0.01 + 0.04 + 0.04 + 0.04 + 0.26 + 1.39 + 1.39 + 1.39 + 7.49 + 7.49 = 77.41$\chi 2$=47.88+8.47+0.66+0.66+0.66+0.17+0.17+0.17+0.01+0.04+0.04+0.04+0.26+1.39+1.39+1.39+7.49+7.49=77.41

Chi-square statistic (77.41) with the critical value from the Chi-square distribution table for 17 degrees of freedom (since there are 18 categories minus 1). At a significance level of 0.05, the critical value for 17 degrees of freedom is approximately **27.587**.Since **77.41** is much greater than **27.587**, we reject the null hypothesis.

Table 2: Individual contributions to the Chi-square statistic for facility category

Facility	**Observed Frequency**	**Expected Frequency**
Separate rooms for men and women	25	9.42
Separate toilets for men and women	21	9.42
Adequacy of food	14	9.42
Shelter is very close	13	9.42
Proper transport system	13	9.42
Arrangement of prayers	11	9.42

Fresh water supply	10	9.42
Good logistic support for elderly people	6	9.42
Proper storage of essential goods	5	9.42
The number is more, so the pressure is less	3	9.42
No discrimination in getting relief	3	9.42
Separate rooms for breast feeders	2	9.42

χ2=25.68+13.88+2.34+1.18+1.18+0.27+0.04+1.31+2.23+4.16+4.16+5.52=61.77\chi^2 = 25.68 + 13.88 + 2.34 + 1.18 + 1.18 + 0.27 + 0.04 + 1.31 + 2.23 + 4.16 + 4.16 + 5.52 = 61.77χ2=25.68+13.88+2.34+1.18+1.18+0.27+0.04+1.31+2.23+4.16+4.16+5.52=61.77

Compared the calculated Chi-square statistic (61.77) to the critical value from the Chi-square distribution table. For **11 degrees of freedom** (12 categories - 1) at a significance level of 0.05, the critical value is **19.675**.Since **61.77** is greater than **19.675**, we reject the null hypothesis.

Table 3: Individual contributions to the Chi-square statistic for each causes od deprivation

Cause of Deprivation	**Observed Frequency**	**Expected Frequency**	
No separate rooms for breast feeders	28	17.38	
Not having menstrual lavatory	28	17.38	
Lack of proper provision for the disabled	28	17.38	
Improper arrangement for sheltering elderly people	25	17.38	
Lack of proper storage of necessary goods	23	17.38	
Discrimination in getting relief	22	17.38	
Not good transportation system	18	17.38	
Inadequacy of pure drinking water	18	17.38	
Same toilets for men and women	17	17.38	

Cause of Deprivation	**Observed Frequency**	**Expected Frequency**	
Not having enough prayer space	17	17.38	
Insufficiency of food	15	17.38	
Lack of adequate space for domestic animals	15	17.38	
No separate rooms for men and women	10	17.38	

χ^2=5.94+5.94+5.94+3.29+1.65+1.21+0.02+0.02+0.01+0.01+0.30+0.30+3.16=26.79\chi^2 = 5.94 + 5.94 + 5.94 + 3.29 + 1.65 + 1.21 + 0.02 + 0.02 + 0.01 + 0.01 + 0.30 + 0.30 + 3.16 = 26.79χ2=5.94+5.94+5.94+3.29+1.65+1.21+0.02+0.02+0.01+0.01+0.30+0.30+3.16 =26.79

We compare the calculated Chi-square statistic (26.79) to the critical value from the Chi-square distribution table. For **12 degrees of freedom** (13 categories - 1) at a significance level of 0.05, the critical value is **21.026**. Since **26.79** is greater than **21.026**, we reject the null hypothesis

Table 4: Individual contributions to the Chi-square statistic for each cause of unsuitability:

Cause of Unsuitability	**Observed Frequency**	**Expected Frequency**	
Going at night seems risky	35	23.3	
The shelter is outdated	33	23.3	
The road is not good	31	23.3	
Fear of theft of goods	31	23.3	
Attaching primary school to cyclone shelter	24	23.3	
Low Height	23	23.3	
Discrimination in everything after going to the shelter	19	23.3	
Power is in the certain ruling people	17	23.3	
Construction of shelter in low-lying areas	14	23.3	

Cause of Unsuitability	**Observed Frequency**	**Expected Frequency**	
Closed at night	10	23.3	

χ2=5.91+3.77+2.42+2.42+0.02+0.01+0.83+1.58+3.57+6.96=27.51\chi^**2** = 5.91 + 3.77 + 2.42 + 2.42 + 0.02 + 0.01 + 0.83 + 1.58 + 3.57 + 6.96 = 27.51χ2=5.91+3.77+2.42+2.42+0.02+0.01+0.83+1.58+3.57+6.96=27.51

We compare the calculated Chi-square statistic (27.51) to the critical value from the Chi-square distribution table. For **9 degrees of freedom** (10 categories - 1) at a significance level of 0.05, the critical value is **16.919**.

Since **27.51** is greater than **16.919**, we reject the null hypothesis.

Table 5: Individual Contributions To The Chi-Square Statistic For Each Cause Of Deprivation:

Cause of Deprivation	**Observed Frequency**	**Expected Frequency**	
Lack of proper monitoring	54	40.57	
Power in the hands of corrupt people	52	40.57	
The relief givers think that relief is ineligible for one's without verification of facts	50	40.57	
Close relative of relief givers get more relief	47	40.57	
Inability to pay bribes	32	40.57	
The middle class does not want and doesn't get due to public shaming	28	40.57	
Derogatory as poor	21	40.57	

χ2=4.38+3.73+2.16+0.95+1.77+4.36+8.69=25.04\chi^2 = 4.38 + 3.73 + 2.16 + 0.95 + 1.77 + 4.36 + 8.69 = 25.04χ2=4.38+3.73+2.16+0.95+1.77+4.36+8.69=25.04

We compare the calculated Chi-square statistic (25.04) to the critical value from the Chi-square distribution table. For **6 degrees of freedom** (7 categories - 1) at a significance level of 0.05, the critical value is **12.592**.Since **25.04** is greater than **12.592**, we reject the null hypothesis.There is a significant difference in the distribution of causes for deprivation from relief and rehabilitation. This suggests that

some causes are more commonly cited than others, indicating that the deprivation from relief and rehabilitation is not evenly distributed across the listed causes.

Chi-Square tests performed on the data tables regarding various causes:

1. Causes of Not Going to Cyclone Shelter:
    - **Null Hypothesis (H_0):** The distribution of causes for not going to a cyclone shelter is uniform (equal likelihood for each cause).
    - **Chi-Square Statistic:** 54.68
    - **Critical Value (at 17 df, $\alpha = 0.05$):** 27.587
    - **Conclusion:** Since the calculated Chi-Square statistic (54.68) is greater than the critical value (27.587), we **reject the null hypothesis**. This indicates that the distribution of causes is not uniform, and certain causes are more likely to prevent people from going to a cyclone shelter.
2. Causes of Deprivation from Cyclone Shelter (Relief and Rehabilitation):
    - **Null Hypothesis (H_0):** The distribution of causes for deprivation from cyclone shelters is uniform.
    - **Chi-Square Statistic:** 27.51
    - **Critical Value (at 9 df, $\alpha = 0.05$):** 16.919
    - **Conclusion:** Since the calculated Chi-Square statistic (27.51) is greater than the critical value (16.919), we **reject the null hypothesis**. This suggests that some causes are more likely to result in deprivation from cyclone shelters.
3. Causes of Unsuitability of Cyclone Shelters:
    - **Null Hypothesis (H_0):** The distribution of causes for the unsuitability of cyclone shelters is uniform.
    - **Chi-Square Statistic:** 27.51
    - **Critical Value (at 9 df, $\alpha = 0.05$):** 16.919
    - **Conclusion:** Since the calculated Chi-Square statistic (27.51) is greater than the critical value (16.919), we **reject the null hypothesis**. This indicates that some causes are more likely to make cyclone shelters unsuitable, and the causes are not evenly distributed.
4. Causes of Deprivation from Relief and Rehabilitation:
    - **Null Hypothesis (H_0):** The distribution of causes for deprivation from relief and rehabilitation is uniform.
    - **Chi-Square Statistic:** 25.04
    - **Critical Value (at 6 df, $\alpha = 0.05$):** 12.592
    - **Conclusion:** Since the calculated Chi-Square statistic (25.04) is greater than the critical value (12.592), we **reject the null hypothesis**. This indicates that certain causes of deprivation from relief and rehabilitation are more prevalent than others.

STRUCTURAL MITIGATION APPROACH FOR EVACUATION FOR CYCLONE ON THE LENS OF INTERSECTIONALITY

Structural mitigation refers to risk reduction achieved through engineering solutions that alter the physical environment. From an intersectional perspective, a structural mitigation approach ensures that all people, regardless of gender, age, disability, or class, can access cyclone shelters without discrimination. Our design includes specific features to cater to diverse needs, such as a designated space for domestic animals, ensuring that people can bring their animals to the shelter, elevated 5 feet above ground.The roof will be equipped with solar panels to provide electricity during a cyclone, and a rainwater catchment system will ensure a continuous supply of clean drinking water. CCTV cameras will be installed for security, covering all sides and rooms of the shelter. To support those with mobility challenges, wheelchairs will be available, and ramps will be provided at each entrance.Transportation is a critical concern, as poor road conditions, especially during cyclones, hinder evacuation. We propose improving the transportation system, including solar-powered road lights to ensure safe travel to shelters.To address shelter accessibility, we propose the concept of **GPCS (Government and Personal Made Cyclone Shelters)**, where local landowners collaborate with the government to create cyclone shelters on shared land. This system would increase the availability of shelters and provide more equitable access, particularly for vulnerable groups.For non-structural mitigation, **Community-Led Management (CLM)** fosters local connections, encouraging residents to support each other, particularly women who may hesitate to go to shelters with strangers. Additionally, enhancing **risk perception** through workshops and awareness campaigns will educate communities about cyclone risks, helping reduce fear and increase shelter usage.

RECOMMENDATIONS

Ground Floor Design

Total ground floor is open so that people can take their domestic animals in this floor. Ramp stairs have been added to ground floor so that disabled and pregnant women can enter easily into cyclone shelter. Four sides road will obviously make in concrete. A ramp stairs have added ground floor to 1st floor.

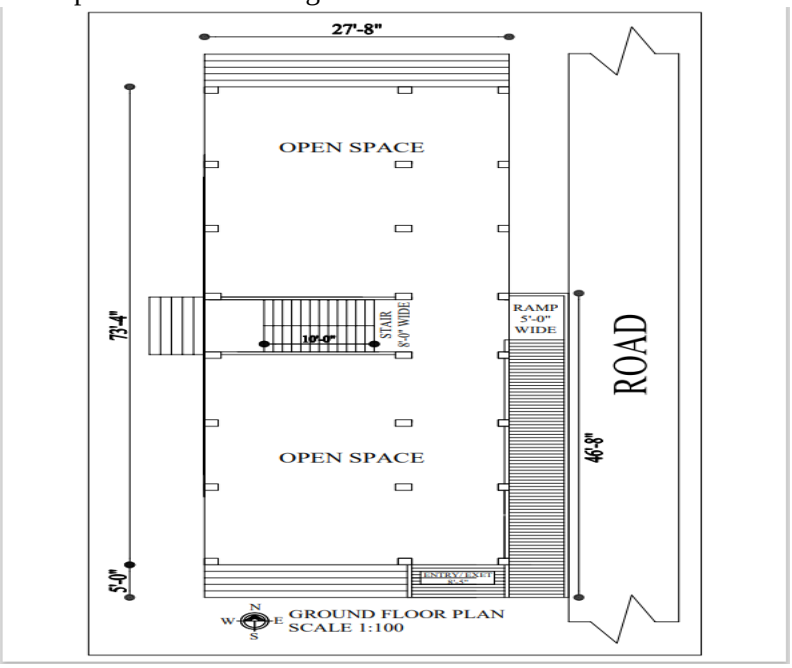

Figure 17: Ground Floor Design

1st Floor Design

We separated 1st floor into two partition. We take one partition for all types of domestic animals like hens, duck, cows, goats as well as buffalos. On the other partition we took three rooms for disabled, elderly people as well as medical surveillance. We took two disabled friendly lavatory for disabled people.

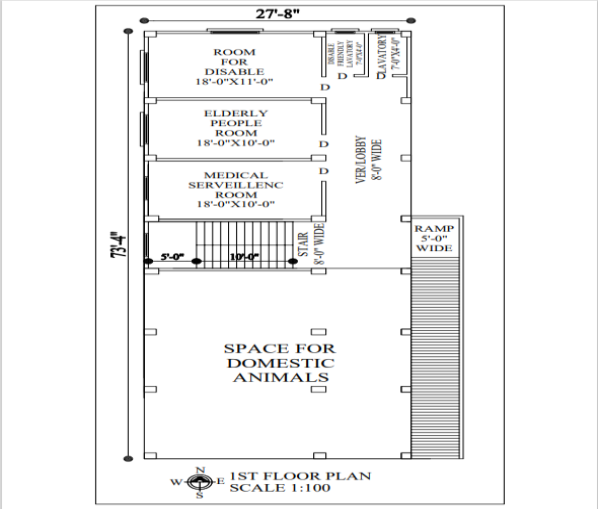

Figure 18: 1st Floor Design

2nd Floor Design

We took total 2nd floor for male. Male will not go to 3rd floor means that going to 3rd floor will be strongly prohibited for them. We took total 4 lavatory for male in a certain corner where women don't enter we took four rooms in 2nd floor. From them one room will be taken for prayers. In that room locker system will be taken so that people can take their necessary commodities like their papers and other things. One room will be taken for medical surveillance.

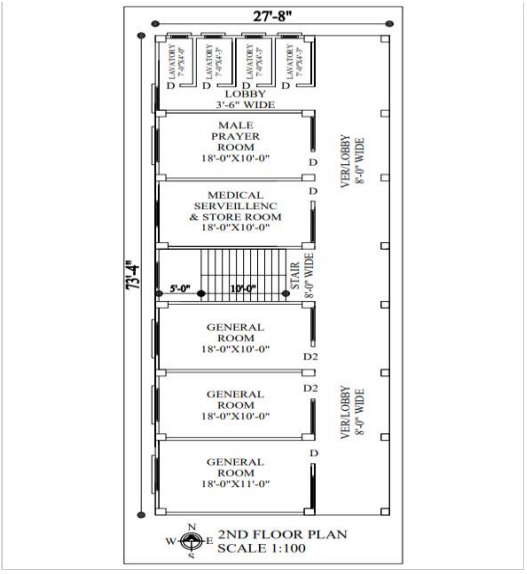

Figure 19: 2nd Floor Design

3rd Floor Design

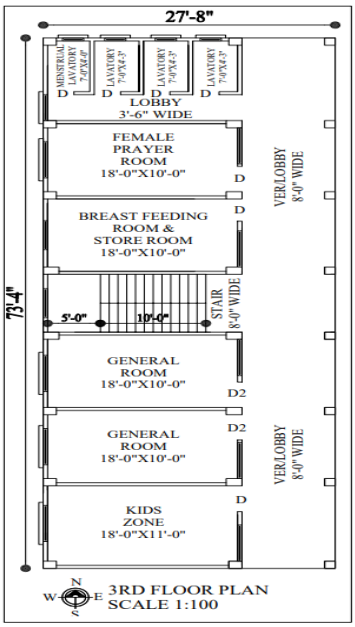

Figure 20: 3rd Floor Design

Improving accessibility to cyclone shelters through inclusive designs and strategic placement. Addressing the compounded vulnerabilities of marginalized groups with targeted interventions. Incorporating participatory planning to ensure community-specific needs are integrated into disaster mitigation strategies. By bridging structural gaps and embedding inclusivity into disaster mitigation, this study offers a localized framework for reducing cyclone-related vulnerabilities in coastal areas.The insights from this study extend beyond Mirzaganj Upazila and hold significant implications for disaster management policies in other cyclone-prone and vulnerable regions globally. Disaster management policies must acknowledge and address the overlapping vulnerabilities arising from social, economic, and demographic factors.National and regional disaster frameworks should include intersectionality-based vulnerability assessments to prioritize the needs of the most marginalized communities.The principles of Universal Design, applied to cyclone shelters in the study, can be scaled to include evacuation centers, emergency housing, and relief distribution points in other disaster-prone areas.Accessibility standards (e.g., ramps, tactile signage, separate spaces) should become mandatory in global disaster preparedness guidelines.GIS and tools like Kobotools can revolutionize disaster management by enabling real-time, community-specific data collection and analysis. Governments and NGOs should invest in training local stakeholders to use these technologies, ensuring localized disaster response planning.

Disaster policies must emphasize equitable allocation of resources, such as proximity-based shelter placement, gender-segregated facilities, and transport assistance for vulnerable populations. Intersectionality-informed frameworks should guide the distribution of funding and aid, ensuring marginalized groups are prioritized.We took 3rd floor for female. Male entries strongly prohibited in this zone. In this floor we took 5(Five) rooms and 4 lavatory. From 4(Four) lavatory one is only for menstrual women which is friendly for them and others 3(Three) are for general women. On the other hands, from five rooms one room is only for breast feeders as well as one is for prayers and locker system and one room is for medical surveillance where female doctors and nurse can enter. Other rooms are for general women.

The study's findings challenge conventional one-size-fits-all approaches to disaster management, advocating for tailored, inclusive, and intersectional strategies. By integrating these principles into broader disaster management policies, stakeholders can build resilience, protect the most vulnerable, and ensure equitable disaster response in a rapidly changing climate. This approach is essential not only for cyclone-prone areas but for all regions facing diverse natural hazards, setting a new standard for equitable and effective disaster management worldwide.

DISCUSSIONS

This study highlights the challenges faced by vulnerable communities in coastal Bangladesh, particularly in Mirzaganj upazila, where cyclones pose a constant threat. Traditional disaster management often overlooks the intersectional vulnerabilities of these populations, such as disabilities, gender, and age. The research reveals critical gaps in both structural and non-structural mitigation strategies, including underfunding and mismanagement of cyclone shelters, and a lack of accessible facilities for marginalized groups like women and people with disabilities.Barriers to shelter accessibility include inadequate transportation, security concerns, and insufficient facilities. As a result, many communities do not trust shelters, with 63% of respondents believing shelters need rebuilding. The study calls for inclusive, non-discriminatory shelter designs and emphasizes the importance of community-led management to address governance failures. Furthermore, improving early warning systems and ensuring that marginalized groups receive timely, accessible information is essential. By addressing these issues and adopting intersectional disaster planning, we can improve resilience and create a more effective, equitable approach to cyclone mitigation in Bangladesh's coastal areas.

FUTURE RESEARCH DIRECTIONS

Future research should focus on understanding how vulnerabilities evolve over time, especially as cyclones become more frequent and intense due to climate change. Long-term studies on the effectiveness of structural and policy interventions in reducing evacuation disparities are needed. Expanding the intersectional framework

to other natural disasters, such as floods and earthquakes, will help assess whether vulnerabilities are consistent across different hazards. Comparative studies of coastal and non-coastal regions can reveal how geographic factors influence vulnerabilities. Research should also examine social and cultural factors, including trust in authorities and gender norms, that affect evacuation behavior.The potential of advanced technologies like AI, drones, and mobile-based early warning systems should be explored to address both structural and social vulnerabilities, ensuring these tools are accessible to marginalized populations. Further studies on the role of urban-rural dynamics, community-driven mitigation projects, and the cost-effectiveness of inclusive infrastructure are essential for building resilient, equitable disaster management policies.

STUDY LIMITATIONS

This study offers valuable insights into structural mitigation for cyclone evacuation through an intersectional lens, but there are limitations to consider. It focuses on four villages in Mirzaganj Upazila, limiting the generalizability of findings to other cyclone-prone areas with different geographic or socio-economic conditions. The reliance on household surveys may not capture broader structural vulnerabilities or governance issues. Longitudinal data would provide a deeper understanding of how vulnerabilities change over time due to climate change or policy interventions. Additionally, capturing overlapping vulnerabilities through an intersectional lens remains complex, and certain marginalized groups may have underreported their challenges. The study also focuses on cyclone evacuation, which may not fully address structural mitigation for other disasters like earthquakes or floods. Future research could expand the geographic scope, incorporate longitudinal and participatory approaches, and more comprehensively address intersectional analysis challenges.

CONCLUSION

In conclusion, this study highlights the critical gaps in the current structural and nonstructural cyclone evacuation strategies in Mirzaganj Upazila, focusing on the intersectionality of vulnerabilities. The findings revealed significant discrimination in cyclone shelters against marginalized groups such as women, children, elderly people, disabled individuals, and breastfeeders. The suggested model proposes inclusive, accessible shelters with features such as disability-friendly lavatories, menstrual facilities, breastfeeding rooms, solar panel lighting, and spaces for domestic animals. These measures aim to remove barriers and encourage all community members, regardless of gender, age, or ability, to seek shelter without hesitation during cyclones. Furthermore, the study stresses the importance of Community Lead Management teams to support vulnerable groups in accessing shelters, and highlights the significance of medical surveillance in disaster

preparedness. By addressing both physical infrastructure and social dynamics, this research advocates for a comprehensive, equitable approach to cyclone evacuation, ensuring that no one is left behind in disaster resilience efforts.

ETHICAL CONSIDERATIONS

This research on structural mitigation for cyclone evacuation, through an intersectional lens, prioritized ethical principles to protect participants' dignity and well-being, especially marginalized groups. Participants were informed about the study's purpose, objectives, and methods in an understandable way, and consent was obtained before any data collection. Personal information was kept confidential and anonymized. The study respected local customs and minimized distress by approaching sensitive topics carefully. Efforts were made to ensure that vulnerable groups, including women, ethnic minorities, the elderly, and disabled individuals, were adequately represented. The research avoided burdensome data collection and ensured participants' right to withdraw at any time without consequence. Preliminary findings were shared with community representatives for validation and feedback, ensuring the research was inclusive and respectful.

Authors Contributions:

Nehal Islam Khondoker: Conceptualization, Methodology, writing-original draft, Data curation

Dr. Hafiz Ashraful Haque: Supervision, validation, visualization, Formal Analysis, Resources, review, and editing.

Acknowledgement:

I would like to express sincere gratitude to my supervisor, Prof. Dr. Hafiz Ashraful Haque, of the

Department of Coastal Studies and Disaster Management at the University of Barishal, for his

unwavering support in conducting the research and sincere respect to Md. Nazmul Hasan B.Sc., (BU);M.Sc. (BU), for providing the facilities to conduct the research.

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Appendix

Questionnaire

Members of your family	a) 0- 10 years
	b) 11-30 years
	c) 31- 50 years
	d) Above 60 years
Do you have any of the following members in your family?	a) Disabled
	b) Pregnant women
	c) Elderly men
	d) Elderly women
	e) Children
	f) breast feeder
How much distance of nearest cyclone shelter from your home?	a) less than or equal to 100 meters.
	b) 101-300 meters
	c) 301-500 meters
	d) greater than 500 meters
Have all family members gone to a shelter during a cyclone?	yes/no
Did you get any benefits if you went?	a) Adequacy of food
	b) Fresh water supply
	c) Non-discrimination in getting relief
	d) Separate rooms for men and women

	e) Arrangement of prayers
	f) Separate room for breast feeders
	g) Separate lavatory for Menstrual women
	h) Proper storage of essential goods
	i) Proper transport system
	j) Shelter is very close.
	k) The number is more so the pressure of people is less
	l) Good logistic support to take the elderly to the shelter
	m) Separate toilets for men and women
Have you been deprived of any facilities?	a) Insufficiency of food
	b) Inadequacy of clean drinking water
	c) No separate rooms for men and women
	d) Discrimination in getting relief
	e) Not having enough prayer space
	f) No separate room for breast feeders
	g) Not having lavatory for Menstrual women
	h) not good transportation system
	i) Lack of proper storage of necessary goods
	j) Lack of proper provision for the disabled
	k)Lack of adequate space for domestic animals
	l)There is no proper arrangement for sheltering elderly people
If not, why not go?	a) Sexual harassment
	b) Social degradation

	c) Insufficiency of food
	d) Inadequacy of clean drinking water
	e) No separate rooms for men and women
	f) Discrimination in getting relief
	g) Not having enough prayer space
	h) No separate room for breast feeders
	i) Not having separate room for Menstrual women
	J) Due to not good transportation system
	k) Lack of proper storage of necessary goods
	l) Shelter away
	m) Due to the old building
	n) Same toilets for men and women
	o) Lack of proper provision for the disabled
	p) Lack of adequate space for domestic animals
	q) There is no proper arrangement for sheltering elderly people
	r) Risk perception
How to receive early warning messages?	a) cpp volunteer
	b) GO
	c) NGOs
	d) Red crescent
	e) social media
	f) sms
	g) through local government
Do you think shelters are suitable for you?	yes/no

If not, what problems do you find unhelpful?	a) Construction of shelters in low lying areas
	b) The shelter is outdated
	c) Discrimination in everything after going to the shelter
	d) The road is not good
	e) Going at night seems risky
	f) Fear of theft of goods
	g) Low height
	h) Hanging the lock at night
	i) Power is held in the hands of certain ruling people
	j) Attaching primary schools to it
What measures do you think would be useful for you?	a) Construction of shelters on high ground
	b) Eliminating the shaky condition of shelters
	c) Eliminate discrimination in providing shelter
	d) Communication system should be improved
	e) Solar panels to provide adequate lighting on roads at night
	f) Ensuring security of goods g) Construction of high-rise shelters
	g) Keeping shelters open at night with security guards
	h) Construction of primary schools and shelters separately
	i) adding cctv camera
Have you received proper relief and rehabilitation assistance during the post-disaster period?	yes/no

If not, what do you think could be the reason behind not getting it?	a) Inability to pay bribes
	b) Power in the hands of corrupt people
	c) Lack of proper monitoring
	d) Close relative of relief giver gets more relief
	e) Derogatory as poor
	f) The middle class does not want and does not get for fear of public shame
	g) The relief givers think that relief is ineligible without proper verification of facts
Do you think the shelter is suitable as a shelter for domestic animals during cyclones?	yes/no
If not, what complications do you think there are?	a) Low height
	b) Deficiency of domestic animal feed
	c) Due to short height there is a possibility of suffering from scurvy
	d) Baby animals are prone to various diseases
Know something about Community Lead Management?	Yes/no