

Enhancing Climate Resilience in Rohingya Refugee Camps: A Comprehensive Strategy for Sustainable Disaster Preparedness

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Abstract Over one million refugees fled to Cox's Bazar Rohingya refugee camps after the government of Myanmar carried out ethnic cleansing. It's among the world's largest refugee settlements in an environmentally vulnerable area prone to natural disasters, including cyclones, landslides, and flash flooding. To address environmental hazards and forced migration, it is essential to call for the development and implementation of effective climate-resilient frameworks for Rohingya refugees. This research emphasizes a detailed and analytical study of the environmental situation of the Rohingya camps and is further supplemented with the findings of previous research efforts in the international context. This research combines both quantitative and qualitative methodologies, including a survey targeting camp residents and an analysis of secondary literature on climate resilience strategies. The gaps in disaster risk reduction strategies and weaknesses in infrastructure, health services, community involvement, and economic support are assessed in this context. The results indicate structural deficiencies and underscore the need for community-based and comprehensive approaches. The findings of this research provide concrete suggestions for the Refugee Relief and Repatriation Commission (RRRC), national and international NGOs, policymakers,

and other stakeholders to adopt best practices and effective climate resilience strategies.

Keywords Rohingya Refugees, Forced Migration, Climate Resilience, Environmental Challenges, Disaster Preparedness

1. Introduction

The Rohingya crisis started in 1978 and worsened during 2017-2018 when about a million Rohingya fled Myanmar and sought refuge in Bangladesh. Bangladesh is not a signatory to the international refugee conventions, but gave shelter to the Rohingya for humanitarian reasons, though the numbers have put immense pressure on the country and its resources. Over a million refugees have poured into Cox's Bazar, Bangladesh, but the international dimensions of the Rohingya crisis have also unleashed a slew of dire environmental and humanitarian consequences. Rohingya camps in the hilly terrain (Ukhia & Teknaf) of Bangladesh near the Bay of Bengal are also prone to

cyclones, landslides, and flash flooding, even though many of the camps are large. Since Cox's Bazar is considered to be one of the highest-risk areas on the continent in the event of climate change, the objective is to develop a community disaster-resilient contingency plan with a component on climate change risk for the protection of the refugee camps. This research focused on environmental challenges exposed in the Rohingya camps and how they affect the refugees. There is a lack of disaster preparedness, a low level of awareness, a lack of training participation, and access to early warning systems. Structural vulnerabilities in camp infrastructure — aggravated by repeated exposures to environmental stressors — lead to high risks of potential health (physical and mental) outcomes, including injuries, disease outbreaks, epidemics, psychological stress, etc.

It also evaluates the performance and contribution of community support, local authorities, government administration, and NGOs in disaster response with special reference to coordination and resource distribution from a comprehensive and analytical perspective. The environment has long been an unmeasured complication of refugee livelihoods, creating additional financial precarity regarding weather patterns and ongoing loss of income revenue to assist or train a demographic group. Approximately 5800 hectares of forest area have disappeared after the Rohingya influx of 2017 [1]. In most cases, forcibly displaced migrants or refugees are hosted in developing countries, where they live in ecologically degraded environments and areas susceptible to natural disasters [2]. To achieve the SDG goals of the United Nations (UN), it is essential to ensure that refugee populations reduce disaster vulnerability and protect the environment. With extreme weather events becoming more frequent because of climate change, the research added an injunction for better preparedness plans for the Rohingya camps to respond with more resilient strategies. This research makes evidence-based recommendations regarding infrastructure, disaster preparedness, health services, and economic support systems to improve the well-being and safety of the Rohingya refugee population. The research findings have relevance to the constructive discourses and theoretical frameworks of environmental studies, as well as conservation ecology, particularly with regard to environmental sustainability and resilience in situations of armed conflict. The results illustrate that improving the climate resilience of the Rohingya refugee camps can serve as an exemplar for sustainable human ecology and guide environmental policy frameworks targeting displaced and vulnerable populations.

1.1. Objectives of the Study

The main objectives of this study are –

- Identifying and analyzing the environmental challenges of the Rohingya camps caused by cyclones, landslides, and floods.

- Assessing disaster preparedness, awareness training, and access to early warning systems among refugees.
- Evaluating the existing infrastructure and living conditions in the face of environmental disasters.
- Exploring the health impacts of the environmental hazards on the refugee populations.
- Evaluating and analyzing community support systems and the role of the government, local administrations, NGOs, and humanitarian organizations.
- Investigating the economic impacts of the environmental disasters on Rohingya refugee livelihood.
- Evaluating the climate resilience strategies in the Rohingya refugee camps and proposing evidence-based recommendations.

2. Methodology

This study employed a mixed-method approach to understand the environmental challenges in the Rohingya refugee camps and to assess the effectiveness of the existing environmental resilience strategies. The research combined quantitative and qualitative underpinnings using a sequential explanatory design that allowed statistical trends and the nuances behind these issues. The quantitative study was conducted with a structured questionnaire, where 151 respondents were interviewed, while 165 questionnaires were handed out, focusing on Cyclone and Flood Preparedness, Infrastructure and Living Conditions, Health and Well-being, Community Support and Response, Economic Impact and livelihood, and Community Support in the Camps of Cox's Bazar. The data collection of this study was held from October 9th, 2024, to November 15th, 2024, on a two-field visit to the Rohingya camps. A stratified random sampling technique was used for representation; culturally sensitive research assistants who conducted the face-to-face interviews helped with literacy constraints.

To protect data privacy, anonymity, and confidentiality, each participant was assured that his/her identification and information provided on the survey would be kept confidential. Secondary data was taken from academic literature, and organizational reports were collected to complement the findings. The researcher used SPSS-26 to analyze quantitative trends and utilized descriptive and inferential statistics for data analysis. The value of Cronbach's alpha confirmed the reliability of the survey, and triangulations accessing the multiple data sources strengthened the credibility of the findings. The value of Cronbach's Alpha (0.761) demonstrates a high level of internal consistency, reflecting the coherence of the 50 items in capturing the underlying construct (*See Table 1-Reliability Statistics*). The integrative nature of this approach informed our ability to determine both the

prevalence and specific contextual factors that shaped these key challenges, thus providing a sound basis for assessing the potential relevance of resilience strategies within the Rohingya camps.

Table 1. Reliability Statistics

Reliability Statistics	
Cronbach's Alpha	N of Items
.761	50

3. Literature Review

With climate-induced risks triggered by landslides, cyclones, and floods, climate resilience in the Rohingya camps of Cox's Bazar has now become an urgent issue. These camps are located in hilly areas around the Bay of Bengal (Cox's Bazar) and are extremely environmentally vulnerable due to poor infrastructure, density, and deforestation. High demand for fuelwood and deforestation—space has disturbed the soil and increased the hazards of landslides, whereas a poor drainage system has caused widespread floods in monsoons [3]. These compelling factors not only magnify exposure to natural disasters but also threaten the safety and sustainability of the camps [4].

Global research on resilience strategies has identified several effective interventions that could be adopted for the Cox's Bazar Rohingya camps of Bangladesh, which include early warning systems, infrastructure reinforcement, and community involvement in adaptive planning. Although the International Organization for Migration (IOM) and UNHCR have taken several initiatives of landslide-safe zones, improved rainwater drainage, and shelter reinforcement, deforestation and resource limitations challenge the sustainability of these interventions [5]. However, community-based disaster risk reduction has been recognized as the most effective tool for enhancing climate resilience through training the community.

Due to the coastal proximity of the Rohingya camps, cyclones are the most significant threat, while evacuation protocols and cyclone shelters have been established. Limited shelter capacity and the lack of accessibility for vulnerable populations were not recognized, intensifying the severity of the natural disasters [6]. Mitigating the flash floods by improving drainage systems should be the priority task, while planting vegetation on the slope can be implemented to stabilize the soil and reduce landslides. Sustainable ecological disruption is essential for vulnerable sectors like Rohingya camps, and it must be addressed with a long-term goal to reduce the source of the strife in the climate resilience strategy rather than any stopgap solutions [7]. Alam et al. [8] proposed a resolution of merging ecological restoration with social development to ensure a sustainable livelihood for the Rohingya

community and improve climate resilience for the refugee camps' vulnerable residents. Diversifying the climate resilience strategy is an essential step towards addressing stability and making the community less reliant on outside help.

There are also wide-scale land cover changes and forest degradation in the region, which is the environmental impact of the influx of refugees. Sajib et al. [9] underscore how the proliferation of refugee camps has caused environmental degradation, which exacerbates the dangers that Rohingya are exposed to, including wildlife encounters and landslides. The consequences not only endanger the refugees' safety at the moment but also take away the ecological equilibrium that is vital for sustainability in the long term. Thus, prioritizing environmental issues is significant for strengthening the facilities of the camp.

Investments should complement the physical infrastructure, community readiness, and logistics to address the protracted environmental and public health ramifications of the refugee camps. Afroz and Mahbub [10] state that comprehensive policies tailored to the immediate needs of the Rohingya and the environmental impact of their presence are needed jointly from the Bangladesh government and international organizations. Then, access to clean water, sanitation, and health care is needed to keep the population healthy, especially in light of what climate change will do.

The literature also emphasizes the need for integrated disaster risk reduction (DRR) and climate change adaptation (CCA) frameworks to address the cascade of environmental hazards impacting the camps. Neef et al. [11] discuss that Rohingya refugees face complex risks stemming from both conflict and climate-induced disasters, which are further compounded by overcrowding and infrastructural limitations. This duality necessitates the development of policies that do not isolate DRR and CCA measures but instead promote their convergence into a coherent strategy tailored to the unique challenges of refugee settings. The integration of geospatial indices for climatic and environmental exposure, as developed by Owen et al. [12], serves as a practical example of how quantitative methods can underpin such interdisciplinary strategies by providing real-time data that inform adaptive responses in dynamic environments.

Bangladesh has shown bravery by providing shelter to the Rohingya refugees, whose economy is not particularly strong. The Rohingya population has worsened deforestation, produced massive amounts of waste, polluted the air, caused soil erosion, and destroyed wildlife in Cox's Bazar. The findings of this paper will underscore the necessity for a unified international response and policy advocacy for safe repatriation while strengthening environmental resilience to support Rohingya refugees of the camps and host communities in navigating the complex challenge of ecological restoration.

4. Findings and Discussions

4.1. Demographic and Socio-Economic Analysis

Among the respondents of Rohingya refugee camps, 100% have faced floods or cyclones in the last 12 months, which underscores that this study belongs to a community/region heavily impacted by natural disasters (See Figure 1- Experienced flood or cyclone in the past 12 months). In this study, five significant clusters of

environmental factors in Rohingya refugee camps were presented and analyzed, including Disaster Preparedness, Infrastructure and Living Conditions, Health and Well-being, Community Support and Response, and Economic Impact and Livelihood. The discussion effectively ties survey data together with themes from academic literature to provide a holistic view of the generators of climate vulnerability and avenues for improvement in the Rohingya refugee camps.

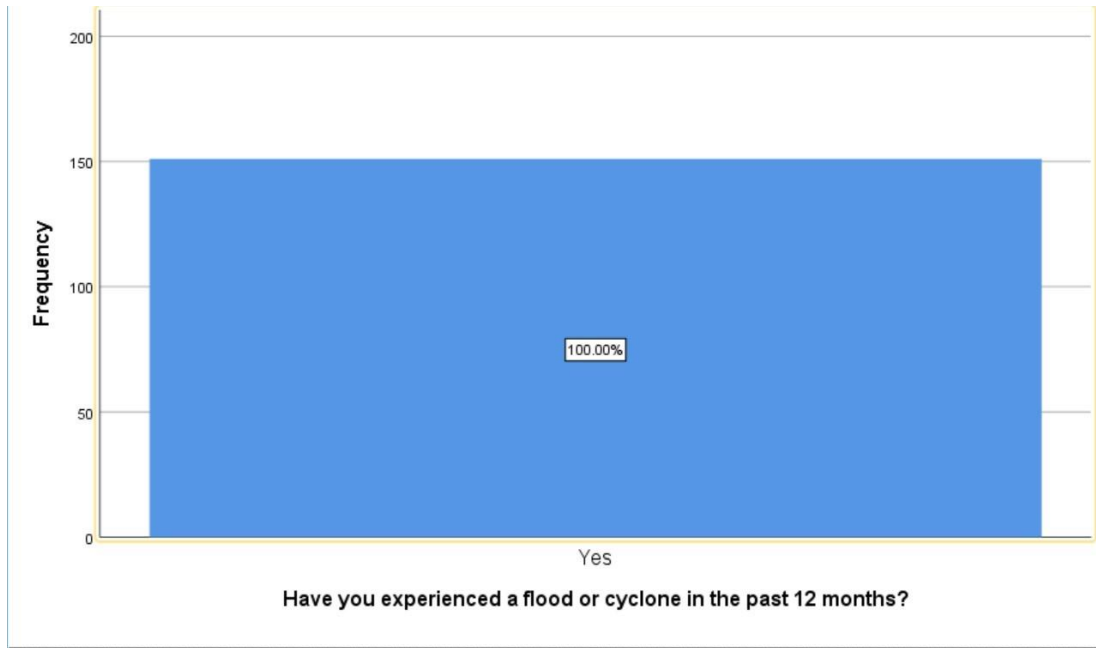


Figure 1. Experienced flood or cyclone in the past 12 months

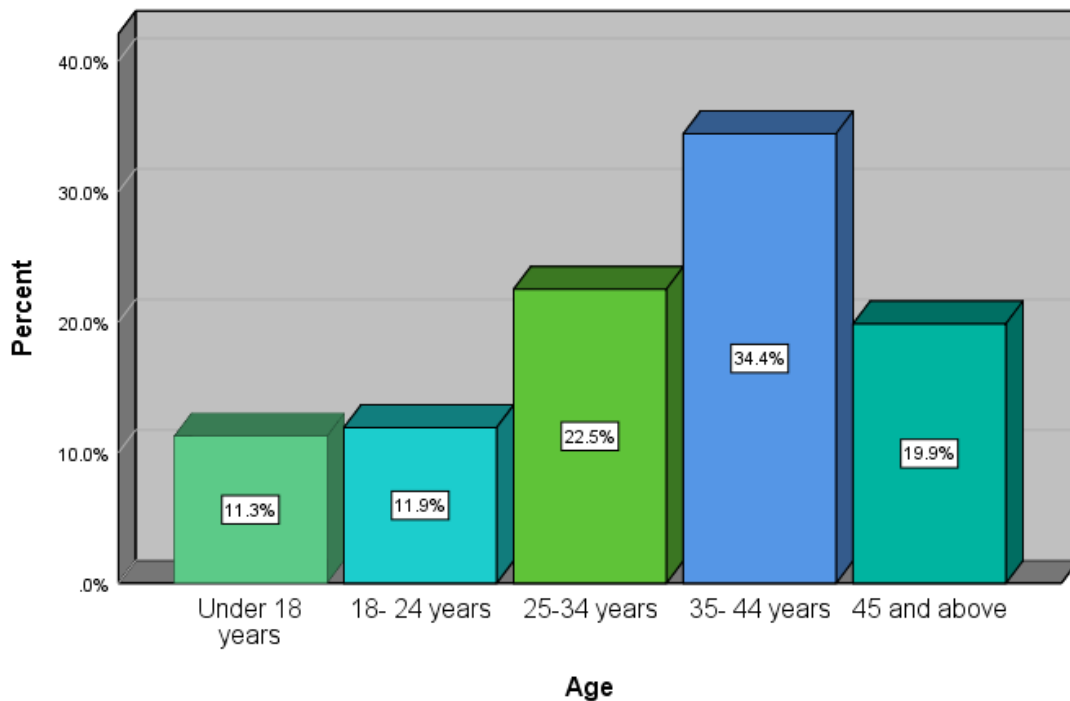


Figure 2. Age

The analysis of the age distribution of respondents reveals that, overall, more than half of the population is middle-aged. The most significant proportion (34.4%) belongs to the 35–44 years age group, showing a mature and potentially economically active cohort. Respondents aged 25–34 years constitute 22.5%, while older adults 45 and above account for 19.9%, and 18-24 years & Under 18 years are 11.9% and 11.26% respectively (See Figure 2- Age). Respondents' gender analysis shows that 56.95% of the respondents are male, while 43.05% are female (See Figure 3- Gender).

The analysis of household size reveals that a significant number of households fall into more moderate sizes. A large portion (82.8%) is made up of families with 4–6 members, indicating a reasonably consistent family structure. Larger households [7–9 members] account for 15.9%, while very large households [10+ members] are very rare, only 0.7% of the total (See Figure 4- Household Size). A smaller average household size indicates a more moderate dependency ratio, potentially easing resource allocation efforts in specific targeted groups.

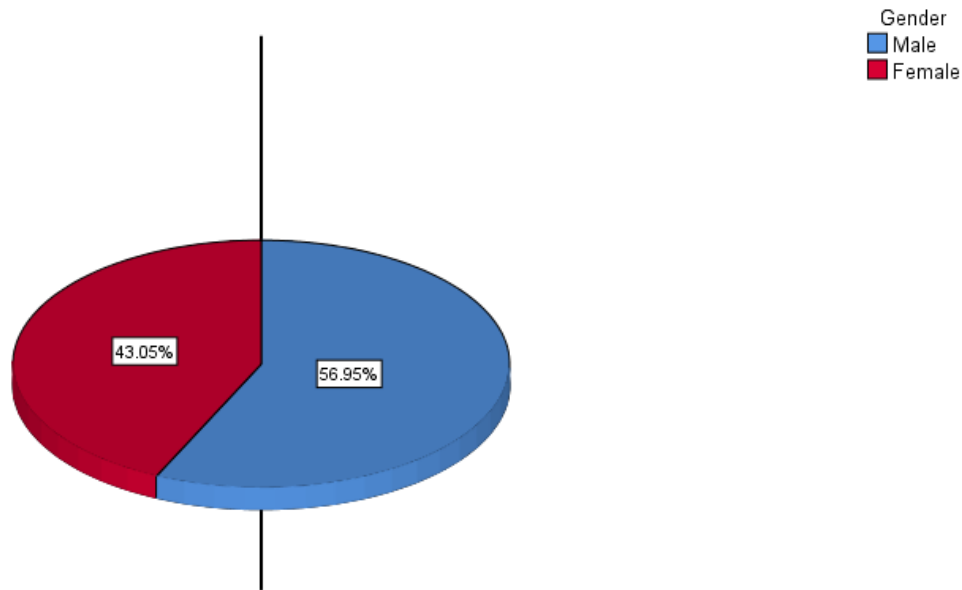


Figure 3. Gender

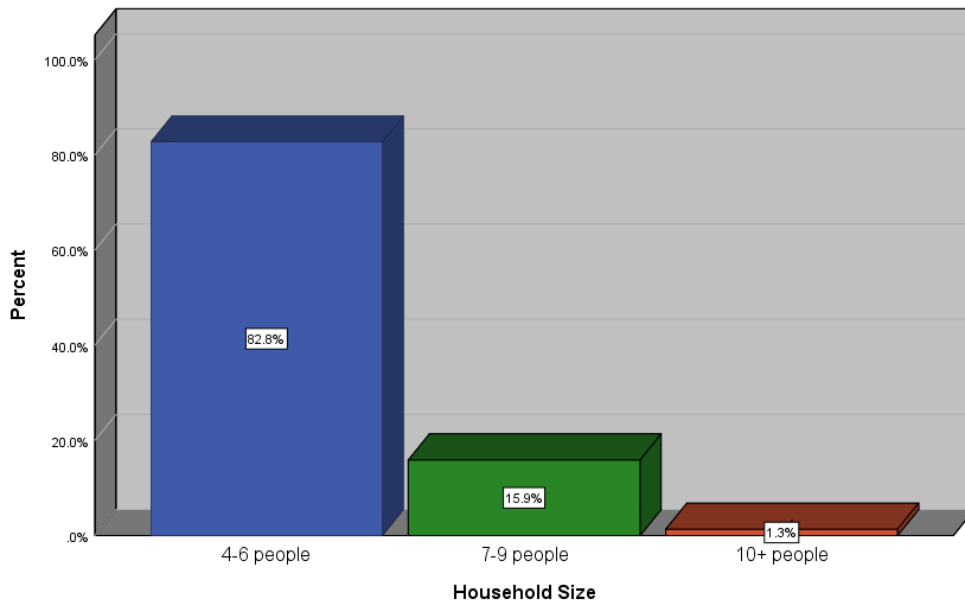


Figure 4. Household Size

Socio-economic vulnerabilities are starkly depicted in occupational data. Unemployment is nearly half the population (46.4%), signaling widespread economic inactivity and dependency on the government's donations and NGO funding. Secondary groups include homemakers (18.5%) and students (13.9%), which reflect non-income-generating activities. Self-employed (2.0%), casual laborers (10.6%), and NGO/Relief workers (4.6%) — active-income generating categories are drastically under-shadowed (*See Figure 5- Occupation*). This occupational profile underscores the urgent need for skills development, job creation, and livelihood interventions to address economic precarity.

The length of stay analysis highlights longer-term displacement. The majority of the population (55.6%) has been living in the camp for more than 6 years, a clear indication of protracted displacement conditions. An additional (36.4%) experience lengths of stay of 4–6 years, highlighting even more the long-term nature of the displacement. Short-term residents ('Less than 6 months' and '6 months to 1 year') represent only 1.4%, suggesting little new inflow over recent years, while the duration of stay in the camps of 1–3 years is 6.6% (*See Figure 6- Duration of Stay in the Camp*). The continued nature of the displaced Rohingya population, as evidenced by this data, highlights the need for sustainable interventions.

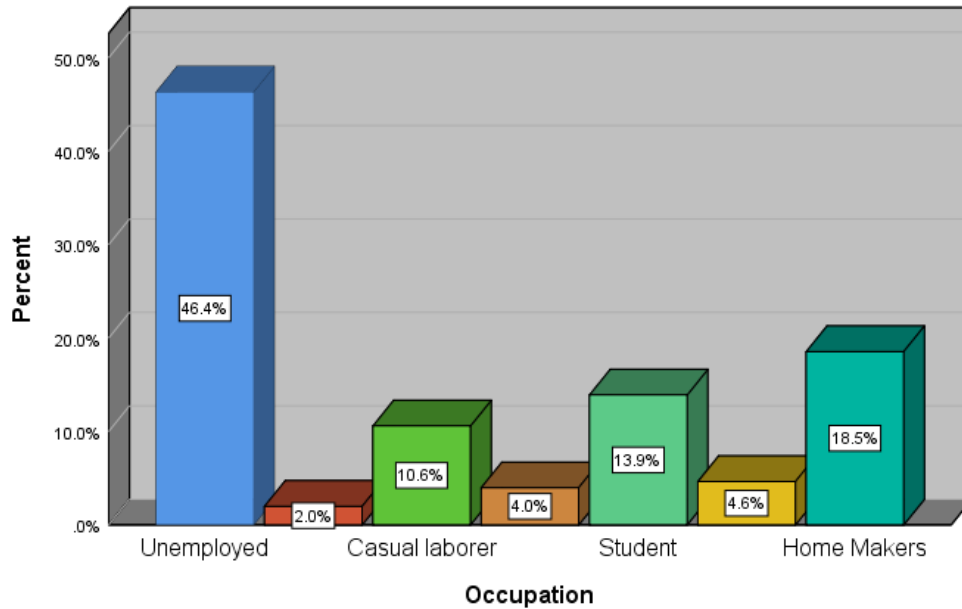


Figure 5. Occupation

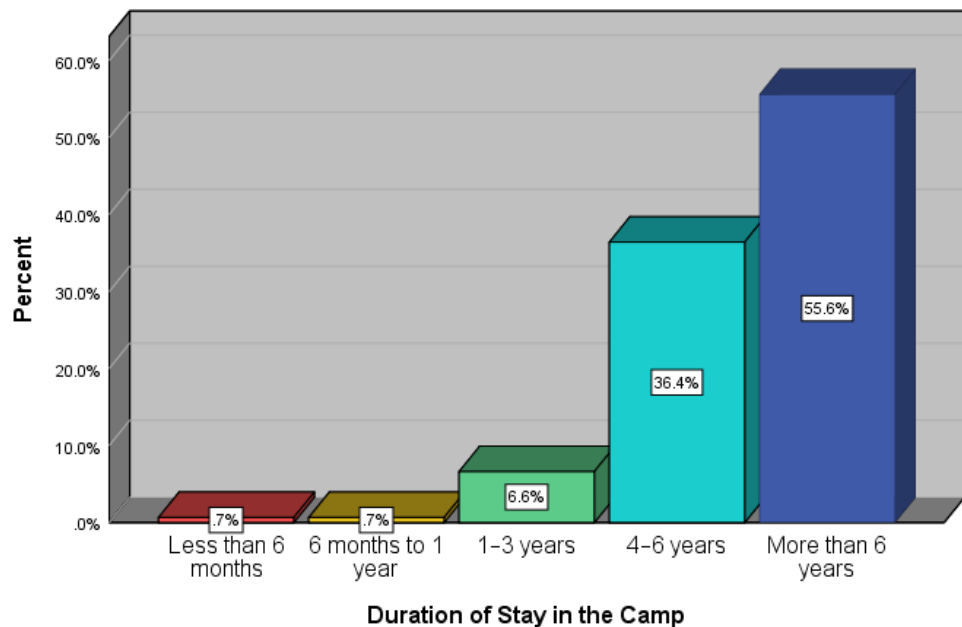


Figure 6. Duration of Stay in the Camp.

Household income data show extreme economic deprivation. 46.4% had no income at all, and 49.7% earned less than 5,000 BDT (Bangladeshi Taka, approximately 41 USD), both demonstrating endemic financial instability. Only 4% of households earn between 5,000–10,000 BDT, and none earn above it (See Figure 7- *Monthly Household Income*). These figures indicate system-wide poverty, requiring detailed income generation and economic inclusion programs in the Rohingya refugee camps. The

review of shelter types suggests tentatively that living arrangements are precarious. Most (84.1%) live in bamboo shelters, which qualify as rudimentary and provisional housing. Moreover, 13.2% live in semi-permanent structures, and 2.6% live in temporary tents (See Figure 8- *Type of Shelter*). The ongoing reliance on temporary shelters highlights the critical need for investments in durable shelter solutions to improve living conditions.

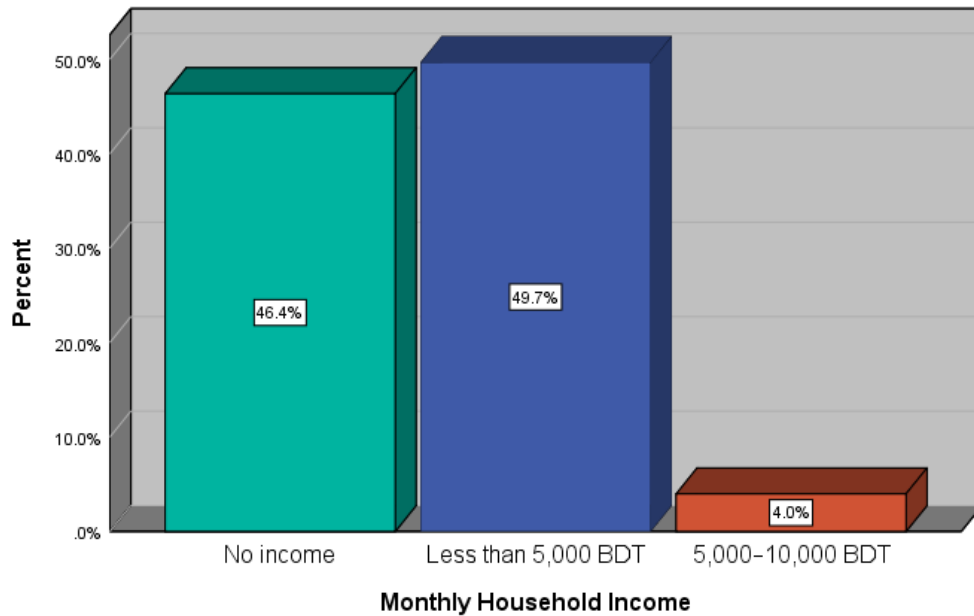


Figure 7. Monthly Household Income

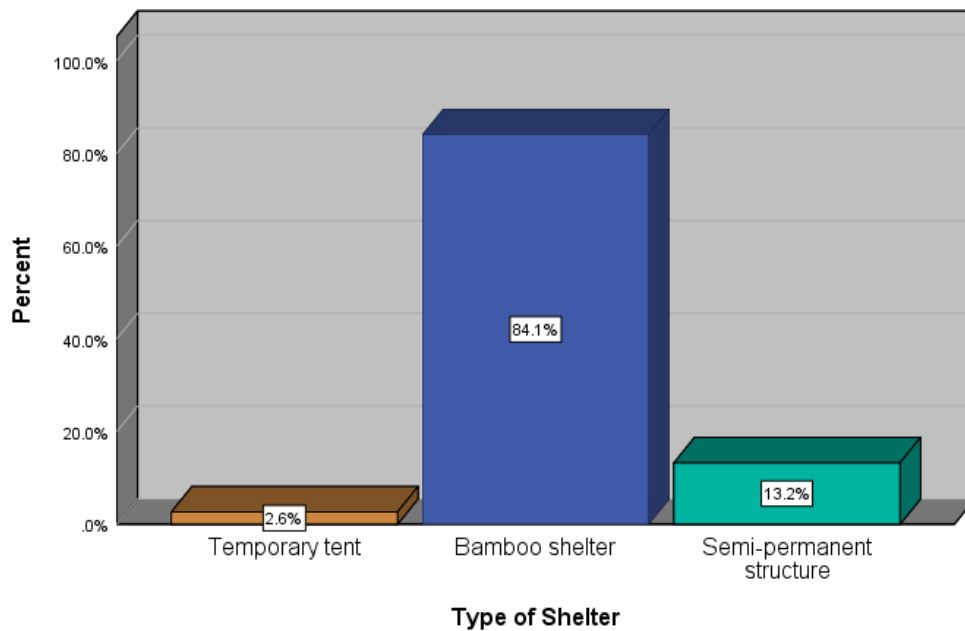


Figure 8. Type of Shelter

4.2. Analytical Summary of Linear Regression Analysis

The linear regression model demonstrated a robust relationship between the predictors and the dependent variable, with an R -value of 0.762, indicating a strong correlation between the predictors and natural disasters affecting the livelihood of the Rohingya refugee camps. The model explains 58.1% of the variance of the participation ($R^2 = 0.581$), indicating that there are considerable underlying factors that the model is picking up. In fact, the Durbin-Watson statistic (1.850), being close to its ideal value of 2, and confirming minimal autocorrelation in residuals further substantiates model reliability and validity (See Table 2- Model Summary).

The study uses the 'Natural disasters affecting the livelihood of the Rohingya refugee camps' as a dependent variable and analyzes 49 independent variables, measuring and prioritizing the most impactful predictors, including disaster preparedness, socio-economic, environmental, and demographic factors that may influence this relationship. This is a holistic model that aims to recognize important predictors and to calculate their impact.

A significant finding of the ANOVA results ($F = 2.860$, $p < 0.001$) establishes statistical significance, meaning that the predictors explained a substantial level of natural disasters affecting the livelihood of the Rohingya refugee camps. Although this highlights the general usefulness of the model, the differing contribution of individual predictors necessitates a closer look to distinguish the most influential factors. Such analysis is critical to help streamline intervention strategies and prioritize resources for disaster preparedness programs (See Table 3- ANOVA).

The analysis uncovers a number of statistically significant predictors of participation, providing detailed insights into drivers of behavior: Disaster preparedness training ($p = 0.042$) and first aid training ($p = 0.011$) are essential enablers, suggesting a need for targeted educational programs. The presence of these programs probably enhances perceived efficacy, motivating a more

proactive attitude toward preparedness. The availability of medical care during and after disasters ($p = 0.010$) raises access to and availability of healthcare services as an important predictor of participants being motivated by health infrastructure. This resonates with theories that highlight the role of perceived resource availability and scarcity in preparedness action.

Psychological factors- hopefulness caused by support from NGOs and local authorities ($p = 0.018$) can be a powerful motivating force, indicating that trust and optimism have an impact on whether individuals are prone to act; this points to a psychological aspect that enables engagement. The p -value for income reduction in households affected by a disaster as a motivational factor is 0.034, indicating that households experiencing mild stress due to low income are more likely to motivate themselves for preparedness activities. In contrast, loss of primary livelihood due to environmental hazards ($p < 0.001$) is significantly negatively associated with participation, reflecting the decreased capacity of severely economically vulnerable households to prepare proactively. These findings suggest an ambivalent role of economic factors; while moderate economic stress fosters participation, high financial strain acts as a barrier to it. This duality highlights the importance of designing interventions that are tailored based on the specific economic context of each household.

The study identifies several predictors with limited or no significant influence on participation, including Access to clean water ($p = 0.760$), Structural strength of shelters ($p = 0.974$), Community mutual support ($p = 0.590$), Access to emergency supplies ($p = 0.651$), and Proximity to safe communal spaces ($p = 0.730$). Our results indicate that even though these factors are critical for holistic disaster resilience, they may not drive individuals to join preparedness drills. Such weak associations from the higher linguistic contexts suggest a need to consider their role as motivators, as well as a need to consider the periphery of the structural aspects of media-dominated disaster preparedness (See Table 4- Coefficients).

Table 2. Model Summary

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.762 ^a	.581	.378	.922	1.850

a. Predictors: (Constant), All Variables

b. Dependent Variable: Natural disasters affecting the livelihood of the Rohingya refugee camps.

Table 3. ANOVA

ANOVA ^a						
	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	119.050	49	2.430	2.860	.000 ^b
	Residual	85.811	101	.850		
	Total	204.861	150			

a. Dependent Variable: Natural disasters affecting the livelihood of the Rohingya refugee camps.

b. Predictors: (Constant), All Variables.

Table 4. Coefficients

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-4.393	1.927		-2.279	.025
	I am well-informed about the risks of cyclones and floods in my camp.	.106	.178	.052	.595	.553
	Disaster preparedness training has equipped me to handle floods and cyclones better	.266	.129	.174	2.055	.042
	There is sufficient information available about how to protect myself and my family during a flood or cyclone.	-.132	.130	-.084	-1.021	.310
	I feel confident that I know where to find safe shelter during floods or cyclones	.184	.136	.117	1.353	.179
	Our community leaders provide clear guidance on preparing for floods and cyclones.	-.106	.088	-.101	-1.207	.230
	There is a reliable early warning system in place for approaching floods or cyclones.	.197	.126	.135	1.562	.121
	I have received training on first aid and emergency response.	.233	.090	.212	2.577	.011
	I have access to emergency supplies (e.g., food and water) in case of a disaster.	.048	.106	.038	.454	.651
	I know how to secure my shelter to minimize damage during a cyclone.	.174	.098	.160	1.762	.081
	My shelter is structurally strong enough to protect against floods and cyclones.	.003	.102	.003	.033	.974
	The camp's drainage systems effectively prevent water accumulation during heavy rains.	-.174	.094	-.166	-1.848	.068
	Roads and pathways in the camp remain accessible during floods.	-.164	.111	-.133	-1.479	.142
	There are sufficient sanitation facilities that remain operational during floods or cyclones.	.043	.080	.047	.546	.586
	Access to clean water is not disrupted during environmental disasters.	.023	.075	.025	.306	.760
	The camp's infrastructure has improved over time to handle environmental disasters better.	.127	.121	.093	1.050	.296
	I have access to electricity during and after floods or cyclones.	-.083	.090	-.081	-.916	.362
	There are safe communal spaces available during emergencies.	-.040	.115	-.030	-.347	.730
	My shelter is located in an area less prone to flooding.	.057	.076	.068	.758	.450
	I have the necessary materials to reinforce my shelter before a cyclone.	.013	.092	.014	.146	.884
	My household experiences more health problems after floods or cyclones.	-.140	.110	-.096	-1.266	.208
	Medical care is readily accessible during and after environmental disasters.	.318	.121	.226	2.628	.010
	Flooding leads to contamination of water sources in my area.	-.186	.102	-.148	-1.823	.071
	I feel anxious about the possibility of future floods or cyclones.	.139	.081	.136	1.709	.091
	Mental health support is available in the camp when needed.	.144	.100	.114	1.447	.151
	My children have access to education without disruption from environmental disasters	-.106	.107	-.080	-.988	.325
I am concerned about the long-term health impacts of frequent environmental disasters.	.014	.098	.012	.146	.884	
Nutritional support is available for my family during times of crisis.	.016	.099	.013	.157	.876	

Table 4 continued

I have access to clean cooking facilities even during floods or cyclones.	.147	.087	.143	1.685	.095
Community activities help alleviate stress related to environmental risks.	-.040	.093	-.036	-.431	.667
My community provides mutual support during floods or cyclones.	.060	.111	.046	.541	.590
Women and children receive special attention and support during disasters.	-.050	.187	-.023	-.265	.791
Local authorities respond promptly after a disaster to provide assistance.	.207	.144	.122	1.444	.152
Distribution of relief supplies is fair and efficient.	.081	.123	.062	.664	.508
International NGOs are effective in helping us prepare for and recover from disasters.	.122	.110	.102	1.109	.270
Community meetings are held regularly to discuss disaster preparedness.	-.153	.099	-.158	-1.549	.125
I feel that my voice is heard when I raise concerns about environmental risks	.089	.097	.090	.915	.362
There are community programs that teach skills for building resilience.	-.119	.073	-.136	-1.630	.106
I believe that together, our community can overcome the challenges posed by environmental disasters.	-.005	.102	-.005	-.051	.960
I am hopeful about the future due to the support from NGOs and local authorities.	.326	.136	.208	2.394	.018
Environmental disasters have reduced my household income.	.315	.147	.177	2.146	.034
I have lost my primary source of livelihood due to environmental hazards	-.363	.091	-.312	-3.987	.000
I have access to alternative income sources when my main livelihood is disrupted.	.053	.092	.046	.570	.570
Financial assistance is available to me after environmental disasters.	-.032	.120	-.026	-.267	.790
Skills training programs in the camp help me improve my income-generating abilities.	-.121	.101	-.112	-1.201	.233
Cash-for-work programs are accessible to me following environmental events.	.090	.083	.091	1.082	.282
Environmental risks have caused increased competition for limited job opportunities.	.076	.098	.063	.780	.437
Loss of assets (like livestock or tools) due to disasters has affected my livelihood	.125	.118	.083	1.061	.291
Economic programs provided by NGOs or agencies help me recover from disaster impacts.	-.159	.153	-.084	-1.040	.301
Improving environmental conditions would positively impact my livelihood	.199	.264	.061	.752	.454

a. Dependent Variable: Natural disasters affecting the livelihood of the Rohingya refugee camps.

5. Recommendations for Enhancing Climate Resilience in Rohingya Refugee Camps

Addressing underlying failings at the system scale through localized socio-technical solutions, these recommendations offer a lens through which to approach improving disaster resilience and sustainability in the camps of Rohingya refugees.

Culturally and Gender-Sensitive Training: In a diverse population such as the Rohingya refugees, it is essential to design linguistically appropriate disaster preparedness programs that also respect cultural practices. Specific attention needs to be paid to ensuring women's engagement in these programs, as women frequently suffer most greatly during disasters. Gender-sensitive disaster management and response programming should also extend to preparedness and response. These initiatives should encompass the social barriers while also being designed to

respond to the specific vulnerabilities of women and children within the camps.

Embrace Participatory Techniques: Engage the community in designing and implementing disaster preparedness programs, as this promotes ownership and ensures that strategies are context-sensitive and aligned with the unique circumstances of the camp. This paper proposes a new model to integrate refugee voices and feedback into organizational disaster management in a way that ensures the sustainability of interventions by placing the onus of engagement work on the organization's internal teams, thus empowering the refugee population to take active roles in their own disaster management and recovery processes. We need to formalize community engagement committees at the local level to make sure the voices of all demographic groups are included.

Adopt Innovative Building Techniques: Refugee camps are highly susceptible to environmental threats, and the embrace of novel construction methodologies is critical. Using resilient, sustainable, and cost-effective materials can significantly help minimize the effects of disasters by utilizing an adequately developed community. Thus, these materials must consider both modern technologies and traditional knowledge in an effort to build not only accommodating shelters but culturally accepted ones. Blending modern styles with conventional Rohingya building techniques, for instance, can result in more substantial, and more disaster-resilient shelters.

Community-Led Construction: Training refugees on sustainable construction practices will enable them to engage within the community with a sense of ownership through development projects and infrastructure. Not only do community members develop skills in the construction and subsequent upkeep and management of their shelters, but they are also more likely to produce structures that meet their needs. It should be in line with international organizations so that it complies with world norms while at the same time giving the refugees and displaced people their own sense of identity and power.

Increase Mobile Health Units: Healthcare services are often limited in refugee camps, and more so during emergencies. This will begin with the expansion of mobile health units to address physical health and mental health needs. Mobile clinics should be able to provide immediate care, respond to emergencies, address infectious disease outbreaks, and offer mental health support to refugees who experience increased trauma. These units should also be linked to the broader health system of the camp in which they are located to provide continuity of care and facilitate access for the most vulnerable populations.

Disease Prevention Measures: The rainy season in a constrained camp environment means people are much more likely to suffer from waterborne diseases, and during a cholera outbreak, significant investment in water, sanitation, and hygiene (WASH) infrastructure may be required. Such measures must comply with internationally recognized standards. Community health workers should

also be trained to carry out awareness campaigns on hygiene and disease prevention.

Empower Women and Marginalized Groups: Resilience is built on inclusivity, and all their programs must be designed to empower marginalized groups, most notably women (associated with the unwelcoming attitude to girls in action), older adults, and those living with disabilities. Camps must also take special care to establish leadership duties for women, giving them space to share their experiences and a seat at the decision-making table. By doing so, you enable girls and women to be less vulnerable in terms of gender and be more resilient in the camps.

Improved Communication Methods: Efficient crisis communication plays a significant role in disaster response. Using multiple different platforms (community radio, social media, and mobile messaging services) can facilitate dissemination among all camp residents, in which safety protocols for fire emergencies can be communicated to those individuals displaced. Such communication channels must also be utilized to continue educating about climate resilience and disaster preparedness with refugees in a two-way dialogue as opposed to a one-way relationship, where refugees receive information with little opportunity to provide input.

Use Cash-Based Interventions: The economic well-being of a household is intimately linked with its ability to absorb risk; cash-based interventions are effective in crisis settings. Unconditional cash transfers provide refugees with flexibility in resource allocation, thus restoring agency and dignity. Refugees can earn a living while giving back to the communities in which they are, for example, through cash-for-work programs that can help improve access to or quality of infrastructure or be used to help provide management of community services, improving resilience in the long term.

Provide Market-Oriented Skills Training: In addition to economic assistance, certain types of skills must be oriented; that is, the skills received are indeed necessary for refugees in the given national and regional employment markets. The relationships with local employers enable the refugees to effectively start engaging with the host population and employment economy as they wait for future employment or reintegration opportunities.

Development of Multi-Stakeholder Platforms: Coordination of activities in camps is often challenging because many stakeholders are involved: the camp administration, NGOs, governments, and the refugees themselves. The identified multi-stakeholder platforms suggest that interventions should be stimulated and coordinated, while the risks of going around in circles increase. This can afford opportunities for partnership and should enhance more systematic and collective approaches to managing camps and to addressing issues related to disasters and disaster risk reduction.

Integrate Climate Resilience into Policy: Policy frameworks for each camp must enshrine climate

adaptation, disaster risk reduction, and priority approaches. This action also calls for the promotion of policies at the national and international levels that support resilience to climate change in refugee contexts and for the use of climate risk assessments at all stages of camp planning and operations. Integrating camp management with climate adaptation and across relevant sectors can achieve critical dual benefits in strengthening disaster-resilient infrastructure and resilient communities.

The implementation of these recommendations will provide greater resilience, sustainability, and preparedness to the Rohingya refugee camps and communities, thus benefiting one of the most vulnerable populations in the world.

6. Limitations of the Study

This study was based on specific camps in Cox's Bazar, limiting generalizability across the density of all Rohingya populations and may introduce possible sampling bias and logistical limitations. Because of the sample size, the findings are not generalizable. Moreover, the study period of the research may overlook the long-term trend of the considered variables and also the fluctuations of seasonal variability. Despite these limitations, this research has provided critical insights into climate resilience strategies for the Rohingya community in Cox's Bazar and underscores the necessity for further comprehensive research, considering the humanitarian context.

7. Conclusions

This research critically evaluates the vulnerabilities of the Cox's Bazar Rohingya camps to enhance climate resilience rather than short-term fixes in the context of social, economic, and infrastructural vulnerability. Research illuminated the complexity of the challenges by leveraging global research and Rohingya camp residents on the ground realities to provide a nuanced understanding. The identified gaps in disaster preparedness, infrastructure resilience, community engagement, healthcare, and economic empowerment highlighted systematic issues for long-term recovery and self-reliance.

Infrastructure resilience is addressed strategically through innovative building techniques that blend modern engineering principles with traditional construction methods. It ensures cultural relevance and enhances the refugee camps' structural durability. For the sustainability and effectiveness of the infrastructure, community-led construction should be promoted by developing the skills of the refugees. Such a community-led participatory approach will meet the sustainable needs for long-term infrastructure development.

The physical and mental health problems of the Rohingya need to be addressed by strengthening the health

service through an integrated approach. Expanding mobile health units tackles both chronic and immediate health concerns. Emphasizing disease prevention through water, sanitation, and hygiene infrastructure is supported by empirical evidence linking it to environmental and public health outcomes. Inclusive community engagement emerges as a cornerstone of effective disaster and climate resilience strategies. The policy should be taken to empower women and marginalized communities in the Rohingya camps to enhance the decision-making process and foster community cohesion.

Economic support and livelihood are connected to household resilience and risk management capacity. Implementing cash-based interventions and providing training on market-oriented skills are needed to reduce dependency on aid and facilitate the economic revitalization of both Rohingya refugees and host communities. Improving policy integration and coordination, as well as establishing a multi-stakeholder platform, is justified for harmonized efforts and efficient resource utilization. In summary, this paper presents a comprehensive strategy for enhancing climate resilience in the Rohingya refugee camps, emphasizing evidence-based, context-specific interventions that address the unique challenges of the Rohingya context. Ultimately, this research demonstrates that incorporating sustainability and ecological restoration into refugee management and climate resilience planning is essential. The study situates humanitarian response within the context of environmental policy and human ecology, offering a framework for achieving sustainable coexistence between displaced populations and fragile ecosystems.

Declarations:

Funding:

No funding body in the public, commercial, or not-for-profit sectors was involved in the design or conduct of this study. The authors conducted this study as part of their commitments to their academic and institutional research agendas. The authors declare that they have no funding, financial sponsorship, or specific resources for this study.

Ethical Approval:

This is not biomedical or clinical research and does not involve any procedures that require formal ethical approval according to the guidelines. The study consisted of non-invasive survey data collection and review of the secondary literature.

Informed Consent:

All respondents received a detailed description of the

study's purpose, methodology, and potential implications for participating before participating. All participants provided both verbal and written informed consent. When respondent literacy levels were low, the consent form was read aloud, and verbal agreement was documented. Participants were assured anonymity, and no personally identifiable information was collected or disclosed. Participation was voluntary, and respondents could refuse at any stage without penalty.

Declaration of Competing Interest:

The authors declare no competing interests with any organization, agency, or stakeholder that has a financial interest in the subject matter.

Data Availability Statement:

The data supporting the results of this study will be made available upon reasonable request. We are unable to share raw data publicly due to confidentiality agreements established with survey participants and ethical constraints involving vulnerable populations. Data will be available on an aggregate and anonymized basis by writing to the corresponding author.

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REFERENCES

- [1] Ahmed, B., Rahman, Md. S., Sammonds, P., Islam, R., & Uddin, K., "Application of geospatial technologies in developing a dynamic landslide early warning system in a humanitarian context: The Rohingya refugee crisis in Cox's Bazar, Bangladesh," *Geomatics, Natural Hazards and Risk*, vol. 11, no. 1, pp. 446–468, 2020. <https://doi.org/10.1080/19475705.2020.1730988>
- [2] Pollock, W., Wartman, J., Abou-Jaoude, G., & Grant, A., "Risk at the margins: A natural hazards perspective on the Syrian refugee crisis in Lebanon," *International Journal of Disaster Risk Reduction*, vol. 36, p. 101037, 2019. <https://doi.org/10.1016/j.ijdrr.2018.11.026>
- [3] Bashar, S., "The Rohingya refugee crisis in Bangladesh: Environmental impacts, policies, and practices," *ScholarsArchive@OSU*, 2021. https://ir.library.oregonstate.edu/concern/graduate_projects/m326m865f
- [4] UNHCR and partners rush support to Rohingya refugees affected by deadly landslides in Bangladesh. UNHCR. (n.d.). <https://www.unhcr.org/news/briefing-notes/unhcr-and-partners-rush-support-rohingya-refugees-affected-deadly-landslides>
- [5] Banerjee, D., "Socio-economic and environmental impact of Rohingya refugee camps in Cox's bazar, Bangladesh," *Brage NMBU*, 1970. <https://nmbu.brage.unit.no/nmbu-xmlui/handle/11250/3151960?show=full>
- [6] Zaman, S., Sammonds, P., Ahmed, B., & Rahman, T., "Disaster risk reduction in conflict contexts: Lessons learned from the lived experiences of Rohingya refugees in Cox's bazar, Bangladesh," *International Journal of Disaster Risk Reduction*, vol. 50, p. 101694, 2020. <https://doi.org/10.1016/j.ijdrr.2020.101694>
- [7] Fao.org. Restoring degraded land in Rohingya refugee camps in Cox's Bazar, Bangladesh | Geospatial information for sustainable food systems | Food and Agriculture Organization of the United Nations. (2022). <https://www.fao.org/geospatial/resources/detail/en/c/1629359/>
- [8] Alam, A., Sammonds, P., & Ahmed, B., "Cyclone risk assessment of the Cox's bazar district and Rohingya refugee camps in southeast Bangladesh," *Science of The Total Environment*, vol. 704, p. 135360, 2020. <https://doi.org/10.1016/j.scitotenv.2019.135360>
- [9] Sadat al Sajib, S. M., Islam, S. A., & Sohad, M. K., "Rohingya influx and socio-environmental crisis in southeastern Bangladesh," *The International Journal of Community and Social Development*, vol. 4, no. 1, pp. 89–103, 2022. <https://doi.org/10.1177/25166026211067604>
- [10] Afroz, T., & Mahbub, M., "Environmental Policy Issues and Public Health Concerns Associated with Rohingya Refugee Population in Bangladesh," *Preprints*, 2022. <https://doi.org/10.31235/osf.io/as8km>
- [11] Neef, K., Jones, E., & Marlowe, J., "The conflict, climate change, and displacement nexus revisited: the protracted rohingya refugee crisis in bangladesh," *Journal of Peacebuilding & Development*, vol. 18, no. 3, pp. 231-247, 2023. <https://doi.org/10.1177/15423166231190040>
- [12] Owen, M., Kruczkiewicz, A., & Hoek, J., "Indexing climatic and environmental exposure of refugee camps with a case study in east africa," *Scientific Reports*, vol. 13, no. 1, 2023. <https://doi.org/10.1038/s41598-023-31140-7>