



Sea-level rise and mental health among coastal communities: A quantitative survey and conditional process analysis

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ABSTRACT

This is the first large-scale empirical study examining the impact of sea-level rise induced by climate change on mental health outcomes among coastal communities. The study focuses on Bangladesh, a country severely affected by salinity ingress, flood risks, and agricultural damage due to sea-level changes. Participants ($n = 1,200$) randomly selected from three coastal regions each having high, moderate, or low vulnerability to sea-level rise were surveyed during the pre-monsoon season in 2021. The cross-sectional survey included validated measures of psychological distress, depression, anxiety, stress, environmental stressors, resource loss, and demographics. The results indicated significantly higher levels of psychological distress, depression, anxiety, and stress in residents of high-vulnerability areas compared to moderate or low-vulnerability regions. Resource loss served as a mediating variable between environmental stressors and mental health outcomes. Furthermore, demographic analyses showed that older adults and women reported higher levels of psychological distress. These findings align with the Sendai Framework for Disaster Risk Reduction, highlighting urgent need for targeted mental health interventions and sustainable models of care in coastal areas increasingly threatened by sea-level rise.

1. Introduction

Sea-level rise (SLR) is a significant indicator of climate change with far-reaching implications for both environmental and human health. Numerous studies concur that climate change exacerbates mental health challenges, particularly in regions undergoing rapid environmental changes (Becker, Karpitchev, & Hu, 2023; Rakib, Sasaki, Pal, et al., 2019). Vulnerable populations, such as communities that depend extensively on natural resources, face higher risks of negative psychological impacts (Clayton, Manning, Krygsman, & Speiser, 2017; Gibson, Haslam, & Kaplan, 2019). Coastal communities whose survival often hinges on natural resources and who reside in areas most vulnerable to climate induced SLR face elevated risks (Hime et al., 2018).

The pace of SLR is accelerating globally. During the 1990s, the global sea-level increased at an annual rate of 2.5 mm; that rate has now risen to approximately 3.4 mm per year (IPCC, 2022). Projections suggest a SLR of 26–77 cm by the year 2100 due to accelerating climate changes (IPCC, 2022). This presents an imminent threat to nearly 600 million people residing in low-lying coastal zones around the world, notably in Asia where many live in vulnerable mega-deltas like Ganges-Brahmaputra estuary (IPCC, 2022).

Environmental stressors triggered by SLR, including increased salinity, coastal flooding, and agricultural degradation, have negative impacts on people's livelihoods (Ahmed, Ayeb-Karlsson, van der Geest, Huq, & Jordan, 2019). Salinity intrusion, for example, has a domino effect on health and livelihoods as it contaminates water used for

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drinking and cooking (Rakib, Sasaki, Matsuda, & Fukunaga, 2019). Flood events cause loss of resources and decrease agricultural productivity, thus diminishing livelihood opportunities (Yanda, Mabhuve, Johnson, & Mwajombe, 2018). Additionally, SLR results in agricultural damage, which includes reduced crop yields and destruction of properties and infrastructure (Cunsolo & Ellis, 2018; Yanda et al., 2018).

Indirect impacts of SLR, such as changes in food, water, and income security, have the potential to further deteriorate community health and social stability (Cunsolo & Ellis, 2018; Ellis & Albrecht, 2017). These consequences can vary at both community and individual levels (Ahmed et al., 2019; Sattler, Claramita, & Muskavage, 2018). Communities experiencing higher levels of resource loss due to SLR, as well as individuals whose livelihoods are closely tied to natural resources, are at particularly elevated risk (Clayton et al., 2017; Hime et al., 2018).

This study advances a model suggesting that resource loss is a key mechanism through which environmental stressors like SLR impact psychological distress (Fig. 1). Building on the Conservation of Resources (COR) theory, the model posits that the threat or actual loss of resources, as well as a failure to gain them, can lead to psychological distress (Hobfoll, 1989; Hobfoll, 2012). Resources in this context refer to both tangible and intangible assets that have personal, social, or economic value. The risk or actual loss of these resources can result in increased stress and distress.

Previous research has confirmed the applicability of the COR theory in various contexts. For example, Freedy, Saladin, Kilpatrick, Resnick, and Saunders (1994) found a strong positive correlation between resource loss and psychological distress after Hurricane Hugo, which surpassed the influence of demographic variables and coping strategies. Similarly, Rudolphi, Berg, and Parsaik (2020) found that resource loss was significantly linked to symptoms of anxiety and depression among Midwest USA farmers and ranchers. Extending these findings, this study focuses on applying the COR theory to understand the implications of SLR, which threatens livelihoods and physical infrastructure in coastal communities.

The model also proposes that the psychological impact of environmental stressors varies across demographic groups. Factors such as income level, gender, and age modulate this impact. Specifically, prior evidence identifies older adults, women, and individuals from lower socioeconomic backgrounds as particularly vulnerable to experiencing increased psychological distress because of SLR (Kabir, 2023).

Support for this claim comes from multiple studies. Kumar et al. (2007) found increased rates of depression and trauma-related disorders among individuals who faced income losses after a tsunami. Other literature indicates that climate change and environmental hazards

disproportionately affect women and girls, thereby exacerbating existing gender inequalities and leading to significant mental health impacts (Shahjalal, 2021). Additionally, older individuals may be more vulnerable due to factors such as reduced mobility, dependence on caregivers, and limited evacuation capabilities (Berry, Waite, Dear, Capon, & Murray, 2018; DeVito, Calamia, Roye, Bernstein, & Castagna, 2018).

This research employs COR theory to understand generalized and differentiated psychological distress resulting from SLR. It offers a comprehensive framework for examining mental health implications of SLR in the context of escalating climate change.

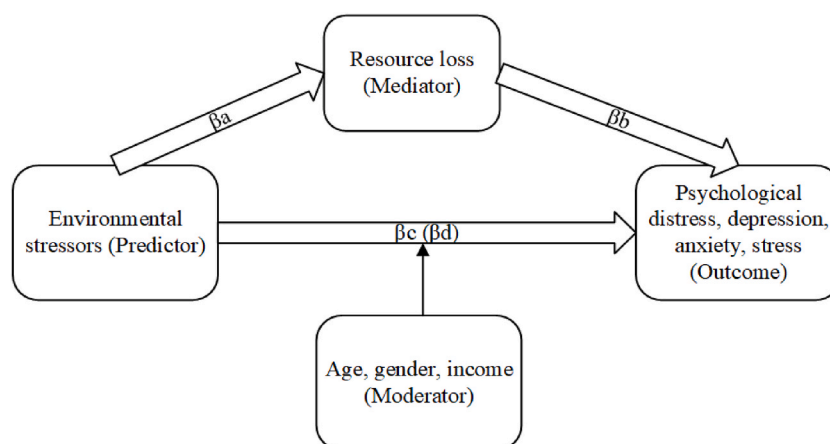
While SLR is a global concern, its ramifications are especially pronounced in the Asia-Pacific region, home to 56% of the world's population and nearly two-thirds of its impoverished citizens (IPCC, 2022). In 2021 alone, Asia accounted for 40% of all global hazard events and affected 66% of people impacted by these events (IPCC, 2022). Given its geographical vulnerabilities, high poverty rates, and reliance on agriculture, Bangladesh serves as a crucial case study for examining the effects of SLR (Rakib, Sasaki, Pal, et al., 2019). Existing research shows that 53% of Bangladesh's coastal areas are affected by salinity, largely due to climate induced SLR (Rakib, Sasaki, Pal, et al., 2019). Annual natural disasters result in loss of life, significant property damage, and disrupted development in these coastal zones (Rakib, Sasaki, Pal, et al., 2019). Coastal communities in Bangladesh are thus at high risk for a range of health issues, including worsening psychological well-being.

The aim of this study is to assess the impact of SLR-induced environmental stressors on mental health, with resource loss acting as a mediating factor and income, gender, and age serving as moderating variables (refer to Fig. 1). Specifically, this study tests several hypotheses. First, it proposes that individuals in coastal communities, who are more exposed to SLR and depend heavily on natural resources, will report higher levels of psychological distress than those living further inland. Second, the study suggests that environmental stressors lead to the loss of resources, which in turn elevates the risk of mental health, including symptoms of distress, depression, anxiety, and stress. Finally, the study anticipates that the most severe mental health impacts will disproportionately affect lower-income individuals, women, and older adults residing in these vulnerable coastal communities.

2. Materials and methods

2.1. Data collection

Participants were selected from the coastal communities of Satkhira and Khulna districts in southwestern Bangladesh, areas known for their



where β_a = Beta coefficient of the predictor \rightarrow mediator, β_b is beta for mediator \rightarrow outcome, β_c is coefficient for predictor when mediator is in equation, and β_d is coefficient for predictor when mediator has not been entered.

Fig. 1. A model of the association between environmental stressor and mental health, mediated by resource loss and moderated by age, gender and income.

vulnerability to sea-level rise, high poverty rates, and reliance on agriculture. Three distinct communities, Gabura (60 km from the coastline), Kamarkhola (93 km), and Naihati (120 km), were chosen based on their varying levels of vulnerability (high, moderate, and low level of vulnerability respectively) as reported by the Bangladesh Bureau of Statistics (BBS, 2019) and verified by a Geographic Information System (GIS). A two-step sampling strategy was used in the study. First, 12 villages were chosen through purposive sampling. Next, 100 individuals from each village were randomly selected from current voter lists. This led to 400 participants from each of the three communities, totaling 1200 participants. This number slightly exceeded the initial estimate of 1224 prospective participants.

Data collection occurred between March 6 and April 5, 2021, conducted by six trained field assistants under expert supervision. Ethical approval was obtained from the relevant Research Ethics Committee prior to commencing fieldwork. The field assistants underwent rigorous training covering the study's objectives, ethical considerations, and data handling procedures, confirmed by a pilot survey. Surveys were administered in Bengali at locations chosen by participants and generally took around 40–45 min to complete. Strict data protection measures were in place throughout the process, and all collected data were reviewed for inconsistencies to ensure reliability and validity.

2.2. Measures

This study utilized four primary scales to capture an array of psychological, environmental, and social factors. The Kessler Psychological Distress Scale (K10) was previously adapted to Bengali following a comprehensive translation process, consistent with existing research affirming its validity and reliability in the Bengali-speaking population (Islam, 2019; Kessler et al., 2002; Khan et al., 2019; TMHC, 2012; Uddin et al., 2018). Alongside the K10, the Bengali version of the Depression Anxiety Stress Scale (DASS-21) was also administered, which has been validated for use in Bangladesh (Sadiq et al., 2019; Sarkar et al., 2018). A custom Environmental Stressor Scale (ESS) was developed for this study, modeled on previous works to measure environmental stressors specifically related to sea-level rise (Hahn, Riederer, & Foster, 2009). Lastly, Resource Loss Scale (RLS), which underwent a comprehensive validation process (refer to Appendix), was utilized to measure loss in multiple resource domains (Hobfoll, 2012; Hobfoll et al., 2015; Mutahara et al., 2016; Sattler et al., 2018).

Demographic variables were also collected, offering further context for the psychological and environmental data. These included open-ended queries about age and number of dependent family members, as well as multiple-choice questions about variables like gender, religion, and marital status. Income categorization extended beyond a simple annual figure to incorporate source-specific income such as agricultural or non-agricultural earnings. The MacArthur Socioeconomic Status Scale was used to assess participants' relative socioeconomic standing both within their community and in the larger context of Bangladesh, as suggested by previous studies that underscore the scale's applicability for contextual socioeconomic assessment (Curhan et al., 2014; Giatti et al., 2012). For additional information regarding the measuring scales, please refer to the appendix attached.

2.3. Data analysis

This study used a multilevel mixed-effects model to analyse a hierarchically structured dataset, where individual responses were nested within specific villages. The two-tier model allowed for three key types of analyses: examining disparities in mental health outcomes across communities with varying levels of vulnerability to environmental stressors, investigating the mediating role of resource loss in the relationship between environmental stressors and mental health, and exploring the moderating effects of demographic variables like age, gender, and income on this relationship (refer to Fig. 1). These analyses

were designed to control for demographic variables, thereby offering insights into the complex interplay between environmental factors and mental health in different contexts.

3. Results

3.1. Mental health outcomes and environmental vulnerability

This study commenced with the hypothesis that higher levels of psychological distress, depression, anxiety, and stress are prevalent in individuals residing in environmentally vulnerable coastal communities. Fig. 2 details the distribution of mental health outcomes, environmental stressors, and resource loss across coastal areas of varying vulnerability levels (refer to the separately attached file labeled Figure for details). The mean levels of psychological distress were highest in the highly vulnerable Chakbara village ($M = 29.730$, $SD = 4.015$) and lowest in the low-vulnerability Joypur village ($M = 13.800$, $SD = 3.012$). A similar distribution was observed for symptoms of depression, anxiety, and stress (refer to Appendix Table A1).

Table 1 summarizes the findings of the multilevel mixed-effects model. Appendix Table A2 provides a full analysis result that incorporates demographic control variables. Community vulnerability served as the predictor variable, while psychological distress, depression, anxiety, and stress were evaluated as outcome variables.

The results revealed significantly higher levels of psychological distress in moderately and highly vulnerable coastal communities (moderate vulnerability: $b = 7.223$, $p < 0.010$; high vulnerability: $b = 12.739$, $p < 0.010$) compared to low-vulnerability areas. This pattern was consistent across measures of depression, anxiety, and stress, indicating a correlation between higher environmental vulnerability and elevated psychological distress.

Further analysis involving demographic variables (refer to Table A2) identified age as a significant predictor for all assessed mental health outcomes. In the evaluated coastal communities, older age was associated with increased levels of psychological distress, depression, anxiety, and stress. Gender was also significant; higher levels of psychological distress, depression, anxiety, and stress were observed in women compared to men. Variability in mental health outcomes was also noted across religious affiliations.

Additionally, marital status, educational level, and income, were found to affect mental health outcomes. Divorced individuals displayed elevated levels of psychological distress, anxiety, and stress compared to unmarried individuals. Those with some level of formal education exhibited lower levels of distress, anxiety, and depression than those without education. Higher-income households were associated with reduced levels of psychological distress, depression, anxiety, and stress. These findings point to the potential role of socioeconomic factors as mitigators in the relationship between environmental stressors and mental health.

3.2. Mediating role of resource loss

To evaluate second hypothesis that resource loss mediates the relationship between environmental stressors and mental health, a multilevel mediation analysis was conducted to test the mediation model shown in Fig. 1. This analysis utilized STATA version 17's "ml_mediation" command, entering individuals as Level 1 and villages as Level 2, and included a random intercept for villages. Bootstrapping with 500 replications provided estimates for indirect, direct, and total effects (Table 2).

3.3. Moderating effects of demographics on mental health

The third hypothesis examined the moderating role of age, gender, and household income on the relationship between environmental stressors and mental health. Linear mixed model analyses were

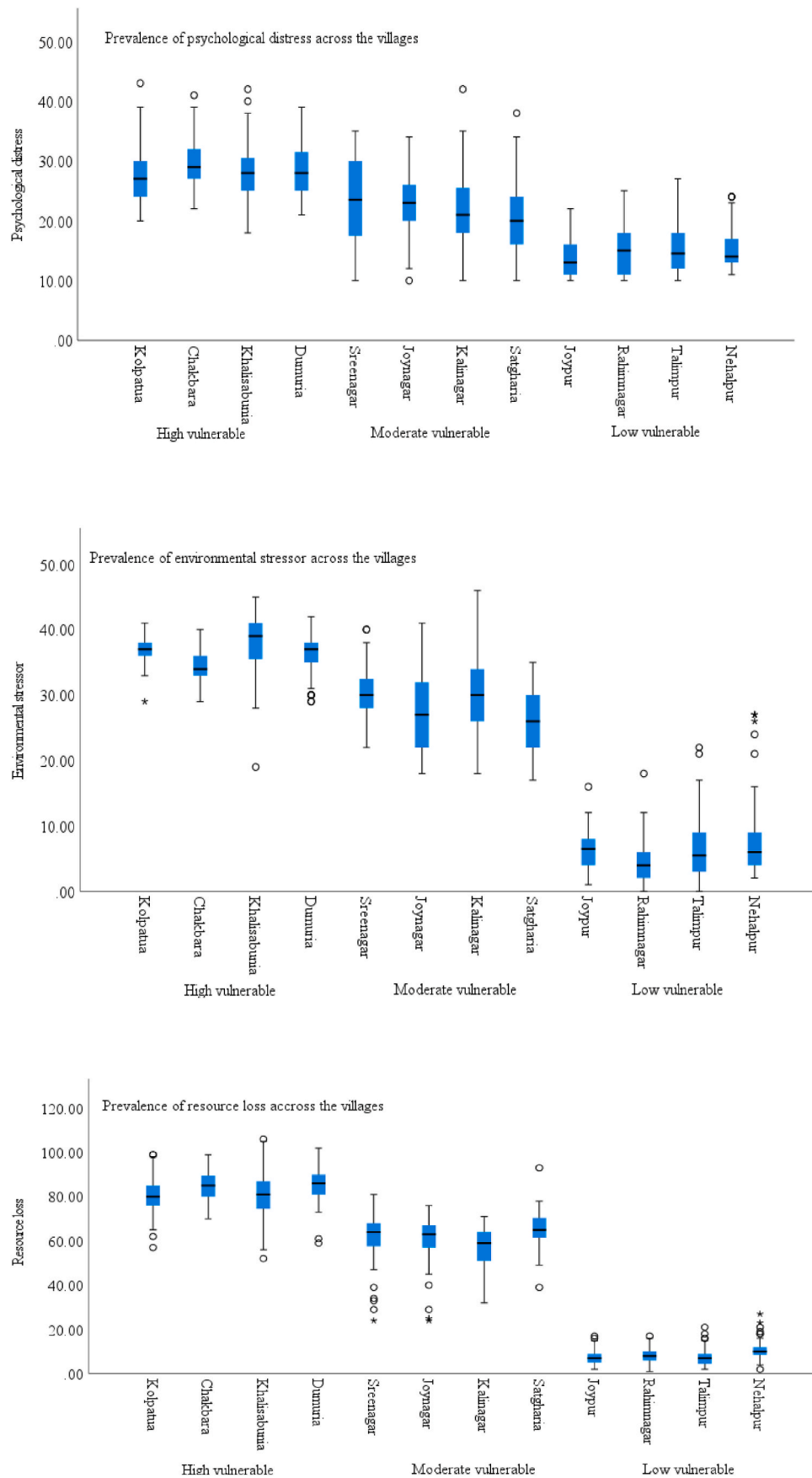


Fig. 2. Psychological distress, environmental stressor, and resource loss across coastal community-level geographical vulnerability in Bangladesh (n = 1200).

Table 1
Prevalence of psychological distress, depression, anxiety, and stress among coastal communities in Bangladesh.

Variable	Psychological distress	Depression	Anxiety	Stress
Vulnerability (Ref: Low)				
Moderate	7.223** (0.969)	11.311** (2.019)	8.993** (2.653)	12.191** (1.647)
High	12.739** (0.946)	18.296** (2.002)	14.773** (2.639)	21.106** (1.628)
Age	0.087** (0.011)	0.068** (0.013)	0.079** (0.014)	0.099** (0.013)
Gender (Ref: Male)				
Female	2.155** (0.549)	4.031** (0.666)	3.868** (0.701)	2.830** (0.644)
Household income (Ref: Low income)				
Lower-middle	-1.321** (0.391)	-1.969** (0.474)	-1.586** (0.499)	-1.837** (0.458)
Middle	-1.884** (0.562)	-2.559** (0.682)	-1.631* (0.719)	-2.901** (0.660)
Upper-middle	-2.359** (0.808)	-3.197** (0.982)	-1.756 (1.034)	-3.063** (0.949)
Constant	23.811** (1.129)	15.150** (1.523)	16.923** (1.730)	18.440** (1.410)
Observations	1200	1200	1200	1200
Number of groups	12	12	12	12

Robust standard errors in parentheses; ** $p < 0.010$, * $p < 0.050$.

employed for this purpose (Table 3).

The data suggest that older individuals and women in coastal communities are more susceptible to the detrimental mental health impacts of environmental stressors specifically for psychological distress (see Fig. 3). Household income did not exhibit a significant moderating influence.

4. Discussion

These findings offer fresh insights into the complex relationship between sea-level rise and mental health, specifically focusing on coastal communities in Bangladesh. The study demonstrated that populations in the areas of elevated environmental vulnerability experience

Table 2
Summary of the mediation analysis.

Outcome variable	Indirect effect		Direct effect		Total effect	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Psychological distress	0.350	0.001	0.032	0.258	0.382	0.001
Depression	0.587	0.001	-0.062	0.117	0.525	0.001
Anxiety	0.387	0.001	0.043	0.286	0.430	0.001
Stress	0.626	0.001	-0.004	0.907	0.622	0.001

The indirect effect of environmental stressors on mental health, mediated through resource loss, was significant across all mental health measures (Table 2). The direct effect was non-significant for all measures. The total effect of environmental stressors on mental health was significant. These results suggest that environmental stressors primarily impact mental health through resource loss.

Table 3
Summary of the moderation analysis.

Moderator	Psychological distress			Depression			Anxiety			Stress		
	b (SE)	95% CI	p	b (SE)	95% CI	p	b (SE)	95% CI	p	b (SE)	95% CI	p
Age	0.002 (0.001)	0.001 - 0.004	0.001	0.002 (0.001)	0.001 - 0.004	0.037	0.001 (0.001)	-0.001 - 0.003	0.192	0.002 (0.001)	-0.001 - 0.003	0.054
Gender	0.077 (0.019)	0.040 - 0.114	0.001	0.014 (0.023)	-0.032 - 0.060	0.549	0.042 (0.024)	-0.005 - 0.090	0.080	-0.031 (0.022)	-0.074 - 0.012	0.161
Income	-0.006 (0.013)	-0.033 - 0.020	0.641	0.008 (0.017)	-0.025 - 0.040	0.641	0.017 (0.017)	-0.017 - 0.050	0.339	0.003 (0.016)	-0.028 - 0.034	0.840

Age significantly moderated the effects of environmental stressors on both psychological distress ($b = 0.002, p = 0.001$) and depression ($b = 0.002, p = 0.037$). Gender also emerged as a significant moderator for the effect of environmental stressors on psychological distress ($b = 0.077, p = 0.001$). However, household income did not display significant moderating effects.

significantly higher levels of psychological distress, depression, anxiety, and stress than those in less vulnerable communities.

A significant finding of this study is the identification of resource loss as a pivotal mediating factor that bridges the gap between environmental stressors associated with SLR and mental health outcomes. This aligns with the Conservation of Resources (COR) theory, which posits that loss of valuable resources, whether tangible, such as property and livelihoods, or intangible, such as social networks and a sense of community, directly leads to psychological distress (Hobfoll, 2012). The study illustrates a cascading effect where environmental stressors induced by sea-level rise deplete essential resources, undermining economic stability and health, thereby increasing psychological distress among impacted populations (Freedy et al., 1994; Gibson et al., 2019; Rudolphi et al., 2020).

Further, analysis of moderating factors unveils that age and gender significantly influence vulnerability to environmental stressors. Older adults and women are found to be more susceptible to the psychological effects of environmental changes, a finding that is consistent with previous research highlighting the vulnerability of these demographic groups to environmental stressors (Berry et al., 2018; DeVito et al., 2018). This age-related vulnerability might be attributed to factors such as reduced mobility, limited access to resources, dependence on caregivers, and decreased ability to evacuate during environmental crises (Chen et al., 2020). Likewise, the study revealed that women in these communities were impacted more in terms of their psychological distress from environmental stressors, though the same pattern was not found for depression, anxiety, or stress. This finding is consistent with prior studies that identified gender as a factor in experiencing a range of stressors and associated distress in climate-sensitive and disaster-affected settings (Shahjalal, 2021; Tearne, Guragain, Ghimire, Leaning, & Newnham, 2020). Cultural and societal barriers, such as restricted access to education and property, may exacerbate the vulnerability of women, limiting their adaptive capacity in the face of environmental stressors. Interestingly, contrary to initial hypotheses, household income was not identified as a significant moderating factor influencing the relationship between environmental stressors and mental health outcomes. This suggests a complex socio-economic dynamic in individual responses to environmental challenges, highlighting

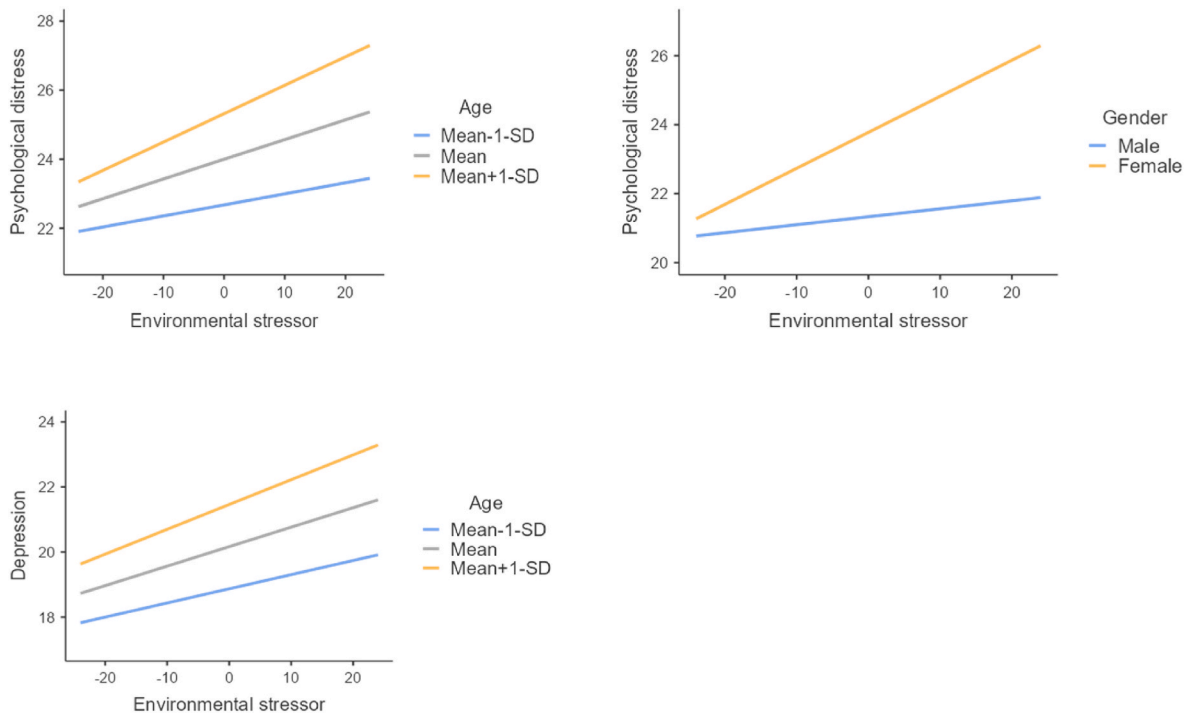


Fig. 3. Simple slope analyses for the significant moderating relationship.

the need for further research to untangle these relationships.

By providing a comprehensive exploration of the pathways linking SLR to mental health outcomes in the coastal communities, this research enriches the academic dialogue on climate change and mental health. It underscores a critical need for integrating mental health considerations into climate adaptation and mitigation strategies (Newnham et al., 2020). Advocating for policies grounded in empirical evidence, the findings call for a nuanced approach to policy and intervention design that is sensitive to the specific vulnerabilities of coastal populations, aiming to mitigate the direct and indirect psychological impacts of environmental changes (Berry et al., 2018; Evans, 2019; Hwong et al., 2022).

This investigation contributes significantly to academic discourse and carries profound implications for policy formulation, risk management, and efforts to mitigate climate change on a global scale. It underscores the critical importance of integrating mental health considerations into hazard risk reduction frameworks, aligning with global initiatives such as the Sendai Framework for Disaster Risk Reduction and the World Health Organization's Thematic Platforms for Health Emergency and Disaster Risk Management (Kayano, Chan, Murray, Abrahams, & Barber, 2019). Furthermore, the research emphasizes the need for multidisciplinary strategies designed to enhance community health resilience in response to the evolving challenges of climate change. It advocates for the development of strategies that are not only cost-effective and culturally sensitive but also specifically attuned to the needs of vulnerable populations, including women and older adults, who are disproportionately affected by the psychological impacts of environmental changes (Ingle & Mikulewicz, 2020; Johns, Power, & MacLachlan, 2018; Newnham, Titov, & McEvoy, 2020).

By situating these findings within the overarching challenge of climate change and its implications for mental health, the study calls for an inclusive approach to policy and intervention design. Cost-efficient models of care, including task shifting and peer-support models (Markkula et al., 2019), and culturally adapted evidence-based treatments developed for low-resource settings (Newnham et al., 2015; Shidhaye et al., 2019), will enable a scale-up of mental health resources in high-risk settings. Evidence-based, culturally safe, and sustainable

psychological health services are needed, and accessibility for women, older adults, and those in more remote communities must be ensured. The call for global action underscores the interconnectedness of climate change, mental health, and social equity issues, urging stakeholders at all levels to prioritize mental health as a critical component of climate resilience and sustainable development initiatives.

Several limitations should be noted. First, reliance on self-reported data and the exclusion of potential confounding variables, such as community resilience factors, may influence the findings. The absence of measurements for community resilience is particularly notable, as these factors could mediate the effects of environmental stressors on psychological outcomes.

The geographical focus on coastal communities in Bangladesh may limit the generalizability of the results. Given the unique environmental and socio-economic characteristics of these areas, the applicability of the findings to other coastal regions worldwide remains uncertain. This limitation suggests a need for replication of the study in varied geographical and cultural contexts to enhance the universality of the conclusions.

Additionally, the cross-sectional design of the study restricts the ability to establish causality and eliminate alternative explanations for the observed relationships between environmental stressors and mental health outcomes. This highlights the importance of employing longitudinal designs in future research to explore the temporal dynamics and causative pathways among the variables.

To overcome these limitations, future studies should consider longitudinal approaches and expand scope of investigation to include a wide range of variables, such as community resilience factors. This will strengthen the validity of the findings and provide a deeper understanding of the complex interplay between climate change, environmental stressors, and mental health in different settings.

5. Conclusion

This research revealed significant psychological impacts of SLR on coastal communities, particularly highlighting the vulnerability of older adults, women, and those in remote communities at greater risk of

sustaining environmental damage from climate change. By establishing a link between environmental adversities due to SLR and increased resource scarcity, an association with levels of psychological distress, including depression, anxiety, and stress was demonstrated. The findings emphasize the necessity of incorporating psychosocial considerations into hazard risk management and climate change mitigation strategies (Richardson et al., 2023). The study advocates for enhancements in mental health services and formulation of policy recommendations specifically designed to address the mental health challenges faced by coastal communities. There is a significant need for the integration of psychosocial support in disaster risk reduction policy and accessible clinical interventions for communities affected by sea-level rise amidst the growing threat of climate change.

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Ethical approval

Ethical approval was sought and received from both Curtin University's Human Research Ethics Committee (HRE 2020-0645) and Dhaka University Research Ethics Committee (Ref. No. 109/Biol. Scs.), ensuring the process adhered to globally recognized ethical standards.

Ethical statement

- **Ethics in Publishing:** This manuscript adheres to the highest standards of ethics in publishing. All authors have contributed significantly and agree with the content of the manuscript.
- **Declaration of Interests:** We declare that there are no known competing financial interests or personal relationships that could appear to influence the work reported in this paper.
- **Declaration of Generative AI in Scientific Writing:** No generative artificial intelligence (AI) or AI-assisted technologies were used in the writing process of this manuscript.
- **Submission Declaration and Verification:** This manuscript is original, has not been published previously, and is not under consideration for publication elsewhere. Its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out.
- **Use of Inclusive Language:** Throughout the manuscript, we have used inclusive language that acknowledges diversity, conveys respect to all people, and promotes equality. We have avoided making assumptions about the beliefs or commitments of any reader and have refrained from using language that could imply superiority of one individual over another.
- **Author Contributions:** Each author's contribution to this manuscript has been accurately reflected and described, following the CRediT taxonomy.
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CRediT authorship contribution statement

Sajjad Kabir: Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Elizabeth A. Newnham:** Writing – review & editing, Supervision, Resources, Methodology, Conceptualization. **Ashraf Dewan:** Writing – review & editing, Supervision, Resources, Conceptualization. **Md. Monirul Islam:** Validation, Supervision, Resources, Data curation. **Takeshi Hamamura:** Writing – review & editing, Visualization, Validation, Supervision, Software, Resources, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

No competing interests exist among the authors. The research has been solely conducted by the authors and has not been submitted for publication elsewhere, either partially or in full.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2024.101640>.

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