Health and Livelihood Vulnerabilities of the People Migrated to Dhaka City Due to Climate Change Induced Natural Disasters: A Quantitative Study

MSc. Thesis

In order to fulfill the requirements of Master of Science Degree in Climate Change and Development

Submitted by

Md. Al Amin
Department of Environmental Science and Management
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January 2024

LETTER OF TRANSMITTAL

20 January 2024

Dr. Md. Hafizur Rahman

Associate Professor and Chairman
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Subject: Letter of Transmittal for MSc. Thesis on "Health and Livelihood Vulnerabilities of the People Migrated to Dhaka City Due to Climate Change Induced Natural Disasters: A Quantitative Study".

Dear Sir,

With most pleasure, I am **Md. Al Amin** from the Department of Environment Science and Management, would like to present the thesis paper on the topic **"**Health and Livelihood Vulnerabilities of the People Migrated to Dhaka City Due to Climate Change Induced Natural Disasters: A Quantitative Study" as a requirement to complete my Master of Science Program in Climate Change and Development.

This was an immense experience for me, and I have tried my best to complete the project successfully.

I therefore pray and hope that you will encourage my small effort by accepting the thesis.

Sincerely yours,

Md. Al Amin
MSc. Candidate in Climate Change and Development
Department of Environmental Science and Management
Independent University, Bangladesh (IUB)

The thesis paper titled "Health and Livelihood Vulnerabilities of the People Migrated to Dhaka City Due to Climate Change Induced Natural Disasters: A Quantitative Study" has been submitted on 20 January 2024 by Md. Al Amin (ID:2231639) to fulfill the requirement to get the degree of Master of Science in Climate Change and Development from The Department of Environmental Science and Management under the School of Environmental & Life Sciences at the Independent University, Bangladesh.

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Supervisor: Dr. Md. Hafizur Rahman

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Co-supervisor: Dr. SM Manzoor Ahmed Hanifi

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Abbreviations

A	**Assets**
AdCap	Adaptive Capacity
CE	Climate Extremes and Disasters
CF	Contributing Factors
CID	Chronic and Infectious Disease
CRI	Climate Risk Index
CV	Climate Variability
CVI	Climate Vulnerability Index
EH	Environmental Health
EM	The Emergency Preparedness
Exp	Exposure
F	Food
F	Financial Capital
FI	Finance and Income
H	Health
H	Human Capital
HF	Healthcare Facility
HF	Health Financing
HH	Household
HIM	Health Information and Medicine
HL	Housing and Living Conditions
HS	Health Service
HVI	Health Vulnerability Index
HW	Health Workforce
IMPEX	Interstate Migrant Policy Index
IPCC	Intergovernmental Panel on Climate Change
KS	Knowledge and Skills
L	Land
LD	Loss and Damage by Disasters
LG	Leadership and Governance
LS	Livelihood Strategies
LVI	Livelihood Vulnerability Index
Max	Maximum
MC	Major Component
MCH	Maternal and Child Health
Min	Minimum
MLI	Multidimensional Livelihood
N	Natural Capital
P	Physical Capital

PMH	Psychosocial and Mental Health	
S	Social Capital	
SC	Sub-component	
SD	Socio-demographic Profile	
Sen	Sensitivity	
SN	Social Networks and Safety	
SRH	Sexual and Reproductive Health	
SRHR	Sexual and Reproductive Health and Rights	
UH	Universal Health	
UHC	Universal Health Coverage	
UNDRR	United Nations Office for Disaster Risk Reduction	
UNHCR	United Nations High Commissioner for Refugees	
WASH	Water, Sanitation, Hygiene	
WHO	World Health Organization	
WS	Water Sources	

PART ONE: LIVELIHOOD VULNERABILITY

Livelihood Vulnerability of Climate-induced Migrated People: Evidence from Dhaka, Bangladesh

Abstract:

Climate-induced migration, driven by the primary impact of climate change-induced natural disasters, leads to significant livelihood vulnerabilities among affected populations. This study investigates these vulnerabilities among the people who migrated to Dhaka city – a rapidly urbanizing city at the forefront of this crisis and primary destination of climate induced natural disasters affected people. Using the Intergovernmental Panel on Climate Change (IPCC) framework and the Contextualized Livelihood Vulnerability Index (LVI), a quantitative survey was carried out among 393 migrants who faced disasters and relocated to Dhaka city for the livelihoods and well-being. The findings reveal a substantial vulnerability level of 0.522, emphasizing the challenges faced by migrants despite relocation. The component-wise analysis highlights their heightened exposure and sensitivity valuing as 0.679 and 0.641 respectively and limited adaptive capacity (0.392). The disparities between the LVI – IPCC (0.184) and CVI (0.760) highlight the importance of context-specific assessments. Targeted interventions must enhance housing, water access, health services, and livelihood diversification. Investments in education and skills empower migrants. An integrated approach addressing climate adaptation and migration is imperative. This study contributes to understanding the complex livelihood vulnerabilities of climate migrants, emphasizing the need for context-specific policies and interventions. It calls for a multi-pronged approach to build resilience and improve the well-being of vulnerable populations facing ongoing climate change challenges.

Keywords: Vulnerability, Livelihood Vulnerability, Climate Change, Migration, Bangladesh.

1. Introduction

Climate change is indisputably one of the most urgent global challenges of our era. Its impacts are not limited to rising temperatures and unpredictable weather patterns; they also have profound implications for human societies, ecosystems, and economies. Among these multifaceted consequences, the escalating phenomenon of climate-induced migration stands out as particularly distressing [1]. The most significant singular impact of climate change is expected to be human migration. An estimate referenced by the Intergovernmental Panel on Climate Change (IPCC) in 1990 suggests that millions will be displaced due to natural disasters such as floods, river-bank erosion, salinity, and disruptions in agricultural production. Analysts have projected that by 2050, nearly 200 million people will be affected by climate-induced displacement and migration [2]. While these estimates might fluctuate based on social contexts, global agendas, policy frameworks, and significant interventions, the inevitable impact of climate change on humanity is evident. However, the full extent and intensity of climate change's effects remain uncertain and unpredictable.

Climate change has diverse consequences, including, but not limited to, shifts in livelihood patterns and strategies, deteriorating health outcomes, loss of income-generating activities, and damage to crops and agricultural lands [3]. Concurrently, climate-induced migration may exacerbate issues such as rapid urban migration for livelihoods, undernutrition, diminished livelihood opportunities, reduced earning capacities, and compromised human settlements [4]. It might also intensify existing livelihood vulnerabilities and adversely affect education, information dissemination, and socio-economic and cultural events. Reports from the United Nations indicate that in 2021, approximately 59.1 million people migrated internally, with the majority doing so due to climate change-induced natural disasters. This figure surpasses migrations caused by armed conflicts. The United Nations High Commissioner for Refugees (UNHCR) has stated that around 21.5 million people globally will be forcibly displaced annually by sudden climate change impacts like floods and cyclones. In contrast, roughly twice this number will migrate due to slow-onset climate change effects such as salinity, droughts, and sea-level rise [5].

Bangladesh, one of the most disaster-prone countries in the world, was identified by the United Nations Office for Disaster Risk Reduction (UNDRR) in its Climate Risk Index 2019 as one of the nations most affected by climate-induced vulnerabilities. Of the total households in the country, 25% of the poor and 14% of the non-poor are highly exposed to disasters. Given its vast population, Bangladesh is acutely susceptible to climate-induced calamities due to its geographical location, topography, and unsustainable development interventions. The country frequently experiences flooding during the monsoon and pre-monsoon seasons, riverbank erosion, droughts, landslides, salinity, and cyclones. Although Bangladesh contributes only 0.56% of global greenhouse gas emissions, it is ranked as the seventh most climate-vulnerable country according to Germanwatch's 2021 Global Climate Risk Index (CRI). Migration and displacement are increasingly seen as primary strategies to evade the impacts of climate change.

Against this backdrop of global and regional challenges, the importance of our study becomes profoundly clear. The research we present delves into the lived experiences of climate-induced migrants, emphasizing their vulnerabilities and adaptive capacities. Recent literature has underscored the urgency of addressing climate-induced migration. Scholars and experts from various disciplines have examined different aspects of this phenomenon, highlighting the myriad challenges confronting migrants and host communities. While many studies have documented the escalation of climate-induced disasters [5][6], patterns of displacement [7][8], and the shortcomings of current governance structures in managing this crisis [9], there remains a significant gap in understanding the vulnerabilities and adaptive strategies of climate-induced migrants within urban settings, specifically in Dhaka, Bangladesh. As the capital city, Dhaka is a primary destination for climate-induced migrants, attracting a large influx of individuals seeking refuge from the detrimental effects of climate change. However, the rapid population growth raises questions about the city's capacity to adequately and sustainably address the needs of these individuals, particularly in areas like housing, employment, healthcare, and social services. Our research aims to address this critical issue by examining the vulnerabilities of climate migrants in Dhaka and their adaptive capacities.

Through this study, we aspire to offer a comprehensive understanding of the unique challenges they encounter.

In spite of the increasing body of literature on migration driven by climate change, there is a significant study deficiency on the vulnerability of migrants' livelihoods and their ability to adapt in urban environments, specifically within the context of Dhaka, Bangladesh. In order to address this gap in knowledge, we provide the following research inquiries: What are the livelihood vulnerabilities experienced by individuals who have relocated to Dhaka city as a result of natural catastrophes driven by climate change? Through an examination of vulnerabilities within the framework of the IPCC vulnerability index, our objective is to uncover significant insights pertaining to the everyday challenges faced by climate migrants residing in urban settings.

The main aim of this research is to conduct a thorough examination of the vulnerability of climate migrants in Dhaka, Bangladesh, particularly concerning their livelihoods, and to assess their capacity to adapt to these challenges. To accomplish this, we have undertaken a cross-sectional study using a quantitative data collection method. By employing the vulnerability frameworks prescribed by the IPCC, we aim to elucidate the complex interplay of factors that determine vulnerability and resilience among climate migrants. This study stands as a pioneering endeavor to address the research gap, focusing specifically on the vulnerabilities encountered by climate migrants in urban environments, thus providing a fresh perspective on a pressing global issue. The insights derived from this research are expected to inform policymakers, development agencies, and researchers, aiding them in devising evidence-based strategies to bolster the adaptive capacity of climate migrants. Such strategies are crucial for fostering more resilient and inclusive urban communities in the context of climate change. Consequently, it is evident that a comprehensive understanding of the challenges faced by climate migrants, especially in terms of livelihoods in their new urban locales, is essential. This understanding will facilitate better planning, design, and implementation of strategies for governments, societies, and individuals.

2. Methodology

The study employed contextualized livelihood framework to meet its objectives, adopting a cross-sectional study design to identify and explore the vulnerabilities of the population. A quantitative method was employed to detect and measure vulnerabilities based on the established index of the IPCC. The framework, derived from multiple sources and tailored to the country's specific context, aids in deepening the understanding of the phenomenon.

2.1 Study Settings and Population

The primary study location was Dhaka city, a common destination for climate migrants seeking livelihoods, as indicated in previous studies. Climate-induced migrants are predominantly from low- to middle-income communities, typically residing in urban and semi-urban areas surrounding Dhaka. The target population was identified in low- to middle-income settlements, such as urban slums and peri-urban areas, including: Korail Slum, Mollah and Tejgaon, Chand Uddyan, Turag and Beribad, Ekota Housing, and Bosila Slum.

Inclusion criteria for the study population encompassed individuals who had already experienced or were exposed to climate vulnerabilities. This included those affected by any form of climate-induced natural disasters (e.g., Floods, Riverbank Erosion, Cyclones, Droughts, Tidal Surges, Salinity) and who had migrated to Dhaka from any part of Bangladesh for livelihood reasons. The study excluded individuals who had never encountered natural calamities and had not migrated to Dhaka for livelihood purposes.

2.2 Sampling and Data Collection

Given the absence of precise data on the number of individuals migrating to Dhaka due to climate change-induced natural disasters, we employed the Cochrane formula for calculating the sample size for an unknown population using the following formula.

$$n = \frac{P(1-P)\ X\ z^2}{e^2}$$

In the formula, Z represents the 5% (1.96) level of significance, P denotes the expected proportion in the population, estimated at 50%, and the margin of error (e) is set at 0.05. Using this formula, we derived a sample size of n = 384.16, which rounds up to 385. Therefore, a total of 385 individuals exposed to climate change effects needed to be surveyed. However, we surveyed an additional few, resulting in a total of 393 participants included in this study's analysis.

The "snowball sampling technique" was employed to reach survey respondents. Given the anticipated challenges in identifying the target population affected by climate change and who migrated to Dhaka for livelihood reasons, we opted for snowball sampling. This technique is cost-effective, economical, and simplifies the process of identifying individuals based on set criteria. It also reduces the workforce required for data collection, as referrals for subsequent respondents are sought from current participants, potentially enhancing response rates.

Face-to-face interviews were conducted to gather quantitative data based on the established framework. A semi-structured questionnaire was devised to interview climate-induced migrants and gauge their livelihood vulnerabilities. This tool was crafted based on study objectives, thematic areas, indicators, and variables derived from the conceptual/analytical framework rooted in the Livelihood Vulnerability Index prescribed by the IPCC and other literature. Dichotomous questions were incorporated into the tool to assess respondents' vulnerabilities.

2.3 Piloting, Quality Assurance and Ethical Issues

Before the main survey, the tool underwent pre-testing. Approximately 5% of the total estimated sample size was tested in a different region with similar characteristics to minimize potential overlap. This pilot aimed to verify the tool's validity and ensure that respondents could comprehend each question. Feedback from the pilot was integrated into the final tools. During the main survey, data quality was maintained through multiple checkpoints. The quality controller and principal investigator consistently reviewed and validated the data, providing feedback to enumerators as needed.

Ethical considerations were paramount throughout the study. Informed oral consent was obtained from each participant. If a respondent was a minor or adolescent,

permission was sought from their guardian or parent. In the absence of a guardian or parent, data collection from the minor or adolescent was avoided. We prioritized the anonymity of responses and ensured no harm came to participants. Confidentiality of data and information was maintained, and we guaranteed that no personally identifiable information was collected. All data obtained was solely for research purposes.

2.4 Development of the Context Specific Livelihood Vulnerability Index

This research probed into the livelihood vulnerability of individuals who migrated to Dhaka city due to climate change-induced natural disasters in their original locales. Vulnerability refers to the susceptibility of individuals or communities to livelihood disruptions stemming from shifts in socioeconomic and environmental conditions. Vulnerability assessments pinpoint vulnerable populations and the context of natural hazards by scrutinizing socioeconomic processes and environmental outcomes. As defined by the IPCC [10], vulnerability encompasses three dimensions: exposure, sensitivity, and adaptive capacity. Typically, vulnerability correlates positively with a system's exposure and sensitivity but inversely with its adaptive capacity [11]. This study gauged the livelihood vulnerability of individuals displaced by natural disasters using an LVI that emphasized key determinants within the IPCC framework and other pertinent context-specific indicators [12]. The urban contexts, the locations of the individuals, their basic needs, and other circumstances informed the development of the components, sub-components, and their measuring indicators.

The Livelihood Vulnerability Index (LVI), initially conceived by Hahn et al. [13], has found extensive application in climate change impact assessments. Yet, its adaptation to gauge the vulnerability of climate migrants has been explored by a limited number of scholars. Most extant studies employing the LVI have centered on evaluating climate change hazards impacting households reliant on land-based livelihoods [14][15][7][16]. Consequently, this study adapted and contextualized the indicators set by Hahn et al. [13] and other scholars to resonate with the urban milieu and the predicaments of climate migrants. Table 1 offers a synopsis of the primary components and sub-components of the LVI employed in this research.

The IPCC framework integrates three pivotal factors (exposure, sensitivity, and adaptive capacity) to evaluate vulnerability. In this research, an LVI grounded in a composite index was adopted, encapsulating the human, natural, physical, social, and financial capital facets of a livelihood framework to better harmonize with sensitivity and adaptive capacity. This methodological trajectory has also been charted by other researchers. The primary merit of these context-specific livelihood indicators is their capacity to weave sensitivity and adaptive capacity indicators within distinct countries, locales, and contexts. The LVI approach in this research encompasses 13 principal components, replete with primary indicators and sub-indicators grouped under five forms of livelihood capital (human, natural, physical, social, and financial capital). These categories are delineated as follows: under 'Exposure', we have Climate Extremes and Disasters (CE), Land (L), Climate Variability (CV), and Loss and Damage by Disasters (LD); under 'Sensitivity', there's Health (H), Food (F), Water Sources (WS), and Housing and Living Conditions (HL); and for 'Adaptive Capacity', Knowledge and Skills (KS), Livelihood Strategies (LS), Social Networks and Safety (SN), Assets (A), Finance and Income (FI), and Socio-demographic Profile (SD) are incorporated. This context-specific LVI approach adeptly encapsulates the genuine circumstances of livelihood vulnerability stemming from natural disasters.

Table 1. Indicator selection and their expected relationship livelihood vulnerability

Component	Survey Question	Expected relationship	Sources
Climate Extremes and Disasters (CE)	1. Did you face any of the following climate change induced natural disasters? (Over last 10 years?) (Flood, Riverbank Erosion, Drought, Cyclone (Storm), Salinity, Cold wave, Heatwave, Earthquake, Landslide, Lightning, Heavy Rainfall) 2. Did you receive early warning(s) before the disasters?	Positive Negative	[17][18] [11][19]
Land (L)	Having not enough land for food security.	Positive	[20][21]
Climate Variability (CV)	1. Did you notice that the intensity/severity of disasters (marked earlier) have been increased over last 10 years? 2. Did you notice that summer season period expanded, or hot days have been increasing over the last 10 years?	Positive Positive	[21][22] [12][23]
Loss and Damage by Disasters (LD)	1. Did you lose any of your family member in disasters or anybody injured of it? 2. Did you lose any livestock in disasters, or anything injured of it? 3. Was there any loss or damage in your assets due to disaster?	Positive Positive Positive	[24][25] [12] [26]

Component	Survey Question	Expected relationship	Sources
Health (H)	1. Did your health status improve or diminish after migration? 2. Are you proactive about seeking healthcare when you need it? 3. Do you or any family member have any kind of Chronic diseases? (Cardiovascular/Heart disease, cancer, hypertension, diabetes, Asthma) 4. Do you have improved water, sanitation, and hygiene systems at your HH? 5. Did you or any family member get infected with Malaria, Dengue, Chikonguniya, Kalaajar, Cholera or Diarrhea?	Positive Negative Positive Negative Positive	[14][27] [27] [28][29] [7][26] [30][31]
Food (F)	1. Can you or your HH afford three meals a day throughout the year? 2. Did you face struggle or hardship to afford three meals a day anytime in last 12 month? 3. Did you face food crisis/shortage/insecurity in any certain period of time or season? 4. Did you take protein (meat, fish or any non-vegetarian food) and fruits in last month?	Negative Positive Positive Positive	[17][18] [11][19]
Water Sources (WS)	1. Do you have access to uninterrupted water sources? 2. Do you have access to adequate safe and fresh water for cooking, using, and washing? 3. Do you need to buy the water for daily usage? 4. Do you face extra burden to collect the water due to cost or distance or time spent to collect?	Positive Positive Positive Positive	[20][21]
Housing and Living Conditions (HL)	1. What is the status of your HH? 2. What is your is your living condition? 3. What is the status of your currently living house? 4. Do you live in formal/informal settlement? 5. Is your house elevated by low ground and easily inundated by flash floods? 6. Is your house prone to waterlogging?	Positive Positive Positive Positive Positive Positive	[21][22] [12][23]
Knowledge And Skills (KS)	1. Did you receive any training on how to cope up with disasters? 2. Do you or your family member have any technical/mechanical/specialized skills?	Negative Negative	
Livelihood Strategies (LS)	1. Did you attend in any livelihood capacity development program over last one year? 2. What is your employment status? 3. What is the type of your employment? 4. Is your income depended on 'no work no pay'? 5. Approximately from how many sources do you earn? 6. Do any child (below18) at your HH work to earn? 7. Did you miss working/earning due to bad weather condition? 8. Did your occupation changed after migration? 9. What is the status of your current occupation in compared to the previous one?	Negative Negative Negative Negative Negative Negative Negative Negative Negative	[14][27] [27] [28][29] [7][26] [30][31]
Social Networks and Safety (SN)	1. Do you have access to any of the following devices/Services? (TV, Radio, Internet, Smartphone, Computer or Laptop) 2. Do you or any member of your HH have hold a membership/participants of Govt./non-govt. organization? 3. Was any HH member invited to participate in any social or community engagement or services?	Negative Negative Negative Negative Negative Negative	[21][22] [12][23]

Component	Survey Question	Expected relationship	Sources
	4. Did you face any kind of discrimination by any agency due to your migration status? 5. As a migrant, do you feel insecurity? 6. Did you receive any kind of aid or relief (under govt. social safety net programs)?		
Assets (A)	1. Do you have any assets? 2. What is the type of your assets? (Current Assets, Fixed Assets, Operating Assets, Non-operating Assets) 3. Do you have strong network of contacts or well-connected community/friends?	Negative Negative Negative	[24][25] [12] [26]
Finance And Income (FI)	1. What is your HH's average monthly income? 2. Did you face a reduction in income after migration? 3. Do you have any debt or due? 3.1. How much money do you have borrowed from others 4. Do you have any savings or investment? 4.1. How much money do have lent? 5. HH average borrow and lend money ratio (From previous question) 6. Do you afford any emergency expenses for your HH?	 Negative Negative Negative Negative Negative Negative	[14][27] [27] [28][29] [7][26] [30][31]
Socio-demographic Profile (SD)	1. What is the sex of the respondent? 2. What is the age of the respondent? 3. Educational attainment of the respondent? 4. Household headed by? 5. Status of formal/institutional education level of HH Head? 6. Dependent members in the HH? (Working member divided by total members including extreme age groups)	Negative Negative Negative Negative Negative Negative	[17][18] [11][19] [14][27] [27] [28][29] [20][21]

2.5 Vulnerability Analysis

According to IPCC, vulnerability is a function of exposure, sensitivity, and adaptive capacity.

$$\text{Vulnerability} = f \text{ (exposure, sensitivity, adaptive capacity)}$$

Step-1: Standardization by Equation:

As each major component has a few sub-components, they all contributed equally to the index. All components received equal weight. Since specific 'scale' was done for specific components, standardization was done by equation.

$$\text{Index}_{SC_d} = \frac{SC_d - SC_{min}}{SC_{max} - SC_{min}}$$

Here, SC_d denotes the original value for the subcomponent for the area – Dhaka. SC_{min} and SC_{max} are the minimum and maximum value for the subcomponents, consecutively.

Step-2: Average Value of the Subcomponents:

Then, each of the subcomponents were averaged by the following equation.

$$\text{MC}_d = \frac{\sum_{i=1}^{n} Index_{SC_{di}}}{n}$$

Here, MC_d is the value for the major component of area d. $\text{Index}_{SC_{di}}$ is indexed subcomponent value of each major component M_d and n is the total number of subcomponents in each major component.

Step-3: after calculating the value for the major components, all are averaged to obtain the LVI for the area.

$$\text{LVI}_d = \frac{\sum_{i=1}^{14} w_{MC_i} MC_{di}}{n \sum_{i=1}^{14} w_{MC_i}}$$

Where, LVI_d denotes the LVI for area *d* which is the weighted average of the eight majors.

components. Here for livelihood vulnerability, a total of 14 major components were settled under five (05) major components of livelihoods – Human Capital (H), Natural Capital (N), Social Capital (S), Physical Capital (P), and Financial Capital (F).

Step-4: The above equation is directly used for the major components of livelihoods to obtain the values.

$$\text{LVI}_d = \frac{W_H H_V + W_N N_V + W_S S_V + W_P P_V + W_F F_V}{W_H + W_N + W_S + W_P + W_F}$$

Step-5: the above equation can also be represented as the below, where the $W_{CE}, W_L, W_{CV}, W_{LD}, W_H, W_F, W_{WS}, W_{HL} + W_{KS}, W_{LS}, W_{SN}, W_A, W_{FI}, W_{SD}$ denotes weight of Climate Extremes and Disasters (CE), Land (L), Climate Variability (CV), Loss and Damage by Disasters (LD), Health (H), Food (F), Water Sources (WS), Housing and Living Conditions (HL), Knowledge And Skills (KS), Livelihood Strategies (LS), Social Networks and Safety (SN), Assets (A), Finance And Income (FI), and Socio-demographic Profile (SD), respectively. While, $CE_V, L_V, CV_V, LD_V, H_V, F_V, WS_V, HL_V, KS_V, LS_V, SN_V, A_V, FI_V, SD_V$ indicates the total number of indicators under Climate Extremes and Disasters (CE), Land (L), Climate Variability (CV), Loss and Damage by Disasters (LD), Health (H), Food (F), Water Sources (WS), Housing and Living Conditions (HL), Knowledge And Skills (KS), Livelihood Strategies (LS), Social Networks and Safety (SN), Assets (A), Finance And Income (FI), and Socio-demographic Profile (SD) respectively.

$$\text{LVI}_d = \frac{W_{CE}CE_V + W_L L_V + W_{CV}CV_V + W_{LD}LD_V + W_H H_V + W_F F_V + W_{WS}WS_V + W_{HL}HL_V + W_{KS}KS_V + W_{LS}LS_V + W_{SN}SN_V + W_A A_V + W_{FI}FI_V + W_{SD}SD_V}{W_{CE} + W_L + W_{CV} + W_{LD} + W_H + W_F + W_{WS} + W_{HL} + W_{KS} + W_{LS} + W_{SN} + W_A + W_{FI} + W_{SD}}$$

Step-6: then exposure (exp) index is measured by the following equation which includes the four major components: Extremes and Disasters (CE), Land (L), Climate Variability (CV), Loss and Damage by Disasters (LD) where, $W_{\exp 1}CE, W_{\exp 2}L, W_{\exp 3}CV, W_{\exp 4}LD$ indicates the weight of each components respectively.

$$\text{IndexExp} = \frac{W_{exp\,1}CE + W_{exp\,2}L + W_{exp\,3}CV + W_{exp\,4}\,LD}{W_{exp\,1} + W_{exp\,2} + W_{exp\,3} + W_{exp\,4}}$$

Step-7: At this stage, sensitivity (Sen) index is measured by the following equation where, $W_{sen\,1}H, W_{sen\,2}F, W_{sen\,3}WS, W_{sen\,4}\,HL$ refers the weight of each major components of sensitivity: Health (H), Food (F), Water Sources (WS), Housing and Living Conditions (HL).

$$\text{IndexSen} = \frac{W_{sen\,1}H + W_{sen\,2}F + W_{sen\,3}WS + W_{sen\,4}\,HL}{W_{sen\,1} + W_{sen\,2} + W_{sen\,3} + W_{sen\,4}}$$

Step-8: Finally, the adaptive capacity (AdCap) is measured by the equation below. Here, $W_{ad\,1}KS, \; W_{ad\,2}LS, W_{ad\,3}SN, W_{ad\,4}\,A, W_{ad\,5}\,FI, W_{ad\,6}\,SD$ indicates weight of the major components of Adaptive Capacity: Health (H), Food (F), Water Sources (WS), Housing and Living Conditions (HL), Knowledge And Skills (KS), Livelihood Strategies (LS), Social Networks and Safety (SN), Assets (A), Finance And Income (FI), and Socio-demographic.

$$\text{IndexAdCap} = \frac{W_{ad\,1}KS + W_{ad\,2}LS + W_{ad\,3}SN + W_{ad\,4}\,A + W_{ad\,5}\,FI + W_{ad\,6}\,SD}{W_{ad\,1} + W_{ad\,2} + W_{ad\,3} + W_{ad\,4} + W_{ad\,5} + W_{ad\,6}}$$

Step-9: at this stage, contributing factors (CF) is measured for each of three components. Here, w_{MC_i} indicates the weight of each major components and MC_{di} denotes the index of each major components.

$$\text{CF}_d = \frac{\sum_{i=1}^{n} w_{MC_i}\, MC_{di}}{n \sum_{i=1}^{n} w_{MC_i}}$$

Step-10: Finally, the IPCC prescribed LVI-IPCC is derived by a linear function equation portrayed below.

$$\text{LVI} - \text{IPCC}_d = \left(\text{CF}_{d,exp} - \text{CF}_{d,AdCap} \right) * \text{CF}_{d,sen}$$

3. Results

3.1 Livelihood Vulnerability condition

The findings of the livelihood vulnerability of the people who migrated to Dhaka city due to climate change induced natural disasters in Bangladesh is depicted in this part. Livelihood Vulnerability Index (LVI) and component-wise livelihood vulnerability are presented and interpreted also. A total of 14 components that directly influence the major function of livelihood vulnerability are depicted in figure 1 below. It illustrates the values of each component comprised from the sub-components and its indicators which vary depending on the components or sub-components. The result is shown in between the '0' to '1' in three decimal places which where 0 indicates less vulnerable and 1 is highly vulnerable.

Figure 1. Spider Diagram of the major components of the livelihood vulnerability of climate migrants. Source: field survey – 2023

The value of the LVI for the people who migrated to Dhaka city due to climate induced natural disasters is 0.522 – which indicates that their livelihood vulnerability is substantially vulnerable even after relocating for better livelihood. The individual index value of each function also reflects the vulnerability where value for them calculated as 0.679, 0.641, and 0.392 for the exposure, sensitivity, and adaptive capacity respectively. These results also highlight that migrated people suffer from different types of vulnerabilities in accessing and affording better livelihood options.

Table 1. Major component dimensions of livelihoods of the climate migrants

Major Dimensions	Value
Exposure (Climate Extreme - CE, Land, Climate Variability - CV, and Loss and Damage -LD)	0.679
Sensitivity (Health, Food, Water Sources, and Housing and Living)	0.641
Adaptive Capacity (Knowledge and Skills, Livelihood Strategies, Social Networks, Assets, Finance and Income, and Socio-demographic profile)	0.392
Livelihood Vulnerability Index (LVI)	0.522
LVI – IPCC	0.184
Climate Vulnerability Index (CVI)	0.760

Source: Field survey – 2023

3.1.1 Exposure

Exposure refers to the degree to which a population or community is exposed to climate-related hazards and risks. The first major dimension of vulnerability assessed in this study is exposure, which encompasses climate extremes, geographical features of departed lands in the migrants' places of origin, and climate variability over the past decade. These sub-components shed light on the extent to which climate migrants in Dhaka, Bangladesh, have been directly affected by climate-related events and the changing climatic conditions in their regions of origin.

The results [table 2] show that people are highly exposed to climate change risks, with an exposure score of 0.679. It encompasses a diverse range of disasters, including floods, riverbank erosion, droughts, cyclones, salinity, cold waves, heatwaves, earthquakes, landslides, lightning, and heavy rainfall. The major component value for "climate extreme" is 0.715, indicating a substantial level of exposure among climate

migrants. Remarkably, the sub-component "faced climate disasters" attains a value of 1.000, revealing that all of the interviewed migrant population in Dhaka has directly experienced climate-induced disasters over the past decade. This high exposure level underscores the harsh reality faced by climate migrants and their heightened vulnerability to the adverse consequences of these events.

However, the sub-component "received early warnings before the disasters" yielded a lower value of 0.430. This indicates that they received to some extent early warnings from the respective authorities regarding natural disasters. The sub-component "land" explores the geographical features of the lands left behind by climate migrants in their places of origin. It encompasses factors such as whether the departed lands are in high or low-lying areas, coastal regions, floodplain regions, drought-prone regions, or riverbank erosion-prone regions. The major component value for "land" is strikingly high at 0.977, emphasizing the significance of the geographical context which refers a substantial proportion of climate migrants hail from regions characterized by high vulnerability to climate-induced hazards. These regions include low-lying coastal areas, floodplains, and riverbank erosion-prone areas, which are inherently susceptible to the adverse impacts of climate change.

The component "climate variability" assesses changes in climate patterns over the past decade, focusing on the intensity of disasters and shifts in the duration of the summer season. The major component value for it stands at 0.879, signifying that climate variability is a prominent feature of the experiences of climate migrants in Dhaka. Specifically, the sub-component "intensity of the disasters increased over the last 10 years" achieved a value of 0.840, indicating that the severity of climate-related disasters has escalated during this period. Additionally, a value of 0.919 for "summer season period increases over the time being" highlights an extension of the summer season and an increase in hot days, reflecting heightened exposure to heat-related exposures.

3.1.2 Sensitivity

In assessing the vulnerability of climate migrants in Dhaka, the dimension of sensitivity delves into various facets of their livelihoods, including health, food security, water sources, and housing and living conditions. These components illuminate how climate migrants are affected by and respond to the changing dynamics of their environment and living conditions.

The component "health" is a critical aspect of sensitivity and examines the well-being of climate migrants in terms of their health status, healthcare-seeking behavior, chronic disease prevalence, water, sanitation, hygiene (WASH) systems, and the occurrence of vector-borne or waterborne diseases. The major component value for "health" is 0.501, indicating a moderate level of sensitivity. Within this component, several indicators provide insight into the health-related vulnerabilities faced by climate migrants. Notably, "diminished an individual's health status due to migration" scored a value of 0.631, signifying that a significant portion of the migrant population has experienced a decline in their health status since migration. This suggests that the process of migration itself may have adverse health implications. However, "health-seeking behavior" scored lower, with a value of 0.453. The indicator "chronic disease status" achieved a value of 0.483, indicating that a considerable proportion of climate migrants or their family members suffer from chronic diseases such as cardiovascular diseases, cancer, hypertension, diabetes, and asthma. Chronic diseases can exacerbate vulnerability, particularly in resource-constrained settings. "Improved water, sanitation, and hygiene systems in the households (HH)" scored the lowest within this sub-component, with a value of 0.313, implying that there is a need for improvements in WASH infrastructure within migrant households. In contrast, "vector-borne or waterborne diseases," with a value of 0.626, reveals a high incidence of diseases like Malaria, Dengue, Chikungunya, and Kala Azar among climate migrants, signaling their heightened vulnerability to such health risks.

The component "food" delves into the ability of climate migrants to secure adequate and nutritious food for their households throughout the year. It assesses their access to three meals a day, struggles with food affordability, experiences of food insecurity, and the ability to afford protein-rich and non-vegetarian foods. The major component value

for "food" is 0.601, reflecting a moderate level of sensitivity among climate migrants regarding food security. Among the indicators, "HH can afford three meals a day throughout the year" scored a sub-component value of 0.489, indicating that while many households can secure three meals a day, there remains a significant proportion that struggles to do so, especially during certain times of the year, as evidenced by the sub-component "HH struggles to afford three meals a day anytime in a year" with a value of 0.786. Additionally, "food insecurity in a certain period" scored 0.690, underlining periodic challenges in accessing adequate food. "Hardly afford protein, nutritious food, and non-vegetation" achieved a sub-component value of 0.438, indicating that some households find it challenging to afford protein-rich and non-vegetarian foods, which are essential for a balanced diet.

The component "water Sources" assesses the availability and accessibility of water sources for climate migrants. It explores whether households have uninterrupted access to water, adequate safe and fresh water for various purposes, the need to purchase water, and any extra burdens incurred in collecting water. The primary component value associated with "water sources" is 0.651, suggesting a modest degree of sensitivity in relation to the accessibility and availability of water. The score of 0.565 indicates that there is space for development in guaranteeing continuous access to water sources for households (HH). Although many families already have dependable access to water, there is still a need to enhance the continuity of this access. In a similar vein, the metric measuring "access to sufficient, uncontaminated water suitable for culinary purposes, personal hygiene, and domestic use" yielded a score of 0.539. This underscores the existence of homes who lack satisfactory access to safe and unpolluted water for crucial everyday tasks. The sub-component labeled "HH need not purchase water" obtained a value of 0.705, suggesting that a significant majority of individuals who have migrated due to climate-related factors do not have the need to acquire water via monetary means. Nevertheless, the sub-component labeled as "extra burden (attributable to the cost, time spent, and distance) associated with water collection" had the highest score among all sub-components, reaching a value of 0.794. This discovery indicates that a significant proportion of individuals who migrate due to climate-related factors have additional

challenges, including heightened expenses, time constraints, and exertion, in accessing water resources. The aforementioned supplementary obstacles highlight the vulnerability of climate migrants in relation to fluctuations in water supply and accessibility.

The housing and living component examine the living circumstances of individuals who have been displaced due to climate-related factors. This includes an assessment of the quality of residential infrastructure, living conditions, the nature of their tenure (whether they rent or own their homes), the classification of their settlements (whether they are official or informal), and their susceptibility to floods and waterlogging. The primary component value associated with "housing and living" is 0.778, suggesting a modest degree of sensitivity within this particular domain. Within this sub-component, "poor household infrastructure" scored the highest, with a value of 0.931, indicating that a significant proportion of climate migrants live in households with subpar infrastructure, which can exacerbate vulnerability. "Rented house" scored 0.916, implying that a substantial number of migrants need to pay for their house rents, which can confer a degree of instability and insecurity in their living arrangements. Living in informal settlements is a common experience among climate migrants, as indicated by a sub-component value of 0.911. Informal settlements often lack essential services and infrastructure, increasing sensitivity to environmental changes. "Houses elevated by low ground and easily inundated by flash floods" scored 0.483, suggesting that some households are located in low-lying areas prone to flash floods. Additionally, "HH prone to waterlogging" achieved a value of 0.545, signifying that waterlogging is a prevalent issue faced by climate migrants, especially during monsoon seasons.

3.1.3 Adaptive Capacity

In examining the vulnerability of climate migrants in Dhaka, it is crucial to assess their adaptive capacity, which encompasses their knowledge and skills, livelihood strategies, social networks, assets, financial well-being, and socio-demographic profiles.

This dimension provides insights into their ability to cope with and adapt to the challenges posed by their new environment and circumstances.

The component "knowledge and skills" reflects the capacity of climate migrants to acquire the necessary knowledge and skills to adapt to their changing environment. It considers whether household members have received disaster preparedness training and possess technical skills. The major component value for "knowledge and skills" is 0.309, indicating a lower level of adaptive capacity in this domain. However, it is worth noting that there is huge room for improvement in enhancing knowledge and skills to cope with disasters, as indicated by "HH member has training to cope up with disasters" with a sub-component value of 0.242. Additionally, "technical skills of HH member" scored 0.377, suggesting that climate migrants possess limited technical skills that can contribute to their adaptive capacity.

The component "livelihood strategies" examines the various approaches adopted by climate migrants to sustain their livelihoods. It includes participation in livelihood capacity development programs, employment status, employment types, income sources, the presence of child labor, work disruptions due to extreme weather, occupational changes, and shifts from original livelihoods to opportunistic ones. The major component value for "livelihood strategies" is 0.480, indicating a moderate level of adaptive capacity concerning livelihood strategies. Within this sub-component, "employment status (employed/unemployed)" scored notably high, with a sub-component value of 0.850, suggesting that a significant portion of climate migrants is gainfully employed, which can enhance their resilience. In contrast, "participated in livelihood capacity development programs" had a sub-component value of 0.173, indicating that fewer climate migrants have engaged in programs aimed at enhancing their livelihood capacities. Similarly, "income mainly dependent on 'no work no pay'" scored 0.318, reflecting vulnerabilities related to the unpredictability of income sources. The presence of "child labor in HH (below 18-year members)" and "work hampered due to extreme weather" both scored moderately, at 0.756 and 0.382, respectively, highlighting areas where adaptive capacity is limited and can be improved. The sub-component "same occupation before and after

migration or changes in livelihood strategy" scored the lowest, with a value of 0.150, indicating high occupational changes among climate migrants.

The component "social networks" explores the extent to which climate migrants are socially connected and integrated within their new communities. The major component value for "social networks" is 0.425, indicating a lower level of adaptive capacity related to social networks. Within this sub-component, "HH without access to information (TV/Radio/Internet/Smartphone, Computer or Laptop)" scored notably moderate, with a sub-component value of 0.679. This suggests that many climate migrants have access to information through various media, which can contribute to their adaptive capacity. However, "HH member involved in any Govt/Non-Govt Organization as a membership/participant" and "HH member invited to participate in any social/community engagement" scored relatively lower, with values of 0.130 and 0.148, respectively. This indicates potential areas for improvement in terms of social engagement and participation. The sub-component "access to social protection systems (safety net programs)" achieved a value of 0.634, highlighting that climate migrants have some access to social safety nets, which can act as a buffer against vulnerability.

The sub-component "assets" assesses the ownership of tangible assets and intangible assets or social capital among climate migrants. The major component value for "assets" is 0.285, indicating a very lower level of adaptive capacity in terms of asset ownership. "Ownership to any assets" scored 0.387, suggesting that a few climate migrants have tangible assets that can contribute to their adaptive capacity. However, the sub-component "intangible assets or social capital" scored lower, with a value of 0.183, signifying that there is room for improvement in building social capital and intangible assets among climate migrants. The component "finance and income" assesses the financial well-being of climate migrants, including their income levels, income stability, debt levels, savings or investments, and the ability to afford emergency expenses. The major component value for "finance and income" is 0.410, indicating a moderate level of adaptive capacity concerning financial and income-related aspects. Notably, "reduction in income" and "Debt/Due" scored high values of 0.695 and 0.730, respectively, underscoring the financial vulnerabilities faced by some climate migrants. However,

"savings or investment" achieved a lower sub-component value of 0.247, suggesting that there is potential for enhancing financial resilience through increased savings and investment practices.

The component "socio-demographic" considers various demographic factors, including education levels, household headship, formal education of the household head, and dependency ratios. The major component value for "socio-demographic" is 0.217, indicating a very lower level of adaptive capacity concerning socio-demographic factors. Notably, "level of education (Including HH head)" scored relatively high, with a value of 0.641, suggesting that education levels among climate migrants can positively impact their adaptive capacity. In contrast, "female/male/child headed HH" and "HH head have no formal Education" achieved lower sub-component values of 0.069 and 0.150, respectively, indicating potential areas of vulnerability within certain demographic groups.

Table 2. Component and sub-component-wise livelihood vulnerability results

Major Component	Major component value	Sub-component name	Sub-component value
Climate Extreme (CE)	0.715	1. Faced climate disasters	1.000
		2. Received early warnings before the disasters	0.430
Land	0.977	Geographical features of departed lands in origin	0.977
Climate Variability (CV)	0.879	1. Intensity of the Disasters (above) increased over last 10 years.	0.840
		2. Summer season period increases over the time being	0.919
Loss and Damage (LD)	0.423	1. Loss of life and livestock or injured	0.229
		2. Loss of the assets due to disasters	0.372
		3. Damage of the assets	0.669
Health (H)	0.501	1. Diminished an individual's health status due to migration	0.631
		2. Health-seeking behavior	0.453
		3. Chronic disease status	0.483
		4. Improved water, sanitation and hygiene systems in HH	0.313
		5. Vector-borne or waterborne disease: Malaria, Dengue, Chikonguniya, Kalaajar	0.626
Food (F)	0.601	1. HH can afford three meals a day throughout the year	0.489
		2. HH struggles to afford the three meals a day anytime in a year	0.786
		3. Food insecurity in a certain period	0.690
		4. Hardly afford the protein, nutritious food, and non-vegetation	0.438
Water Sources (WS)	0.651	1. HH have access to uninterrupted water sources	0.565
		2. Access to adequate safe and fresh water for cooking, using, and washing	0.539
		3. HH need not to buy the water	0.705
		4. Extra Burden (due to cost/time spent/Distance) to Collect Water.	0.794
Housing and Living (HL)	0.778	1. Poor Household Infrastructure,	0.931
		2. Poor living condition,	0.883

		3. Rented House or own house,	0.916
		4. Living in Informal Settlement,	0.911
		5. Houses elevated by low ground and easily inundated by flash floods,	0.483
		6. HH prone to Waterlogging	0.545
Knowledge and Skills (KS)	0.309	1. HH member has training to cope up with disasters	0.242
		2. Technical skills of HH member	0.377
Livelihood Strategies (LS)	0.480	1. Participated in livelihood capacity development programs,	0.173
		2. Employment Status (employed/unemployed)	0.850
		3. Employment type: informal/casual, formal (permanent/temporary),	0.061
		4. Income mainly dependent on 'no work no pay'	0.318
		5. HH dependent only one income generating source,	0.756
		6. Child Labour in HH (below 18-year members)	0.756
		7. Work hampered due to extreme weather	0.382
		8. Same occupation before and after migration or changes in livelihood strategy	0.150
		9. Original livelihood to opportunistic livelihood	0.560
Social Networks (SN)	0.425	1. HH without access to information (TV/Radio/Internet/Smartphone, Computer or Laptop),	0.679
		2. HH member involved in any Govt/Non-Govt Organization as a membership/ participant	0.130
		3. HH member invited to participate in any social/community engagement (Social Integration and Community Participation or membership)	0.148
		4. Never been discriminated by service provider (by any agency) due to migration	0.453
		5. Feeling any kind of insecurity as a migrant	0.506
		6. Access to social protection systems (safety net programs)	0.634
Assets	0.285	1. Ownership to any assets	0.387
		3. Intangible Assets or Social Capital	0.183
Finance and Income (FI)	0.410	1. Poverty/Income range (socio-economic group)	0.176
		2. Reduction in income,	0.695
		3. Debt/Due	0.730
		4. Savings or Investment	0.247
		6. Emergency Expenses,	0.204
Socio-demographic	0.217	3. Level of Education (Including HH Head),	0.641
		4. Female/Male/Child headed HH,	0.069
		5. HH head have no formal Education,	0.150
		6. Dependency ratio	0.008

Source: field survey – 2023

3.2 Climate Vulnerability Index

Using the specific criteria set by the Intergovernmental Panel on Climate Change (IPCC), the assessment suggests a relatively lower level of vulnerability. This highlights the importance of considering various conceptual frameworks when evaluating vulnerability. The LVI-IPCC score of 0.184 suggests a lower vulnerability concerning livelihood, according to the IPCC's standards. This means that, when assessed based on the IPCC's

specific criteria, climate migrants in Dhaka might display a lower vulnerability compared to other contexts or global benchmarks. However, the criteria employed by the IPCC might not fully capture the unique challenges faced by Dhaka's climate migrants, potentially leading to an underestimation of their true vulnerability.

On the other hand, the Climate Vulnerability Index (CVI) registers a significantly higher value of 0.760, indicating a pronounced susceptibility to climate change among the studied group. These findings emphasize the urgency of targeted interventions and policy measures to enhance the resilience and well-being of individuals displaced by climate factors in Dhaka. Given that the CVI likely encompasses a wider array of local factors and conditions, it suggests a considerably higher vulnerability for the same population. This implies that, when accounting for Dhaka's specific challenges and context, its climate migrants face a significant vulnerability in terms of their livelihoods.

4. Discussion

4.1 Climate-induced migrant's livelihood vulnerability

This study offers a comprehensive analysis of the livelihood vulnerabilities faced by climate migrants who have relocated to Dhaka city due to climate-induced natural disasters in Bangladesh. By evaluating exposure, sensitivity, and adaptive capacity, and subsequently generating the Livelihood Vulnerability Index (LVI), LVI – IPCC, and Climate Vulnerability Index (CVI), we obtain critical insights into the multifaceted challenges encountered by this vulnerable group. These insights have significant implications for policymakers and stakeholders.

The relatively high exposure score of 0.679 underscores the severe climatic risks that climate migrants in Dhaka confront. Their exposure to climate extremes, land-related vulnerabilities, and climate variability intensifies the threats to their livelihoods [33][29]. The exposure dimension of vulnerability paints a stark picture: these migrants have faced a diverse range of climate-induced disasters and come from areas inherently susceptible to the impacts of climate change. Climate variability, characterized by more intense disasters and extended summers, further heightens their vulnerability. To address these

challenges effectively, a holistic approach is needed, encompassing measures such as enhancing early warning system efficiency, fortifying the resilience of vulnerable regions, and adapting to evolving climatic patterns. These findings align with previous research that highlights the vulnerability of individuals migrating to urban centers due to climate-related risks [34].

The sensitivity score of 0.641 indicates that climate migrants are highly vulnerable to health issues, food scarcity, water access challenges, and subpar living conditions. This heightened sensitivity is consistent with past research, which has illustrated how migration can disrupt social and economic networks, leading to adverse health outcomes and restricted access to essential resources [35][36]. A notable observation is the reduced adaptive capacity score of 0.392, which suggests a limited resilience level among individuals migrating because of climate-related reasons.

The adaptive capacity dimension among Dhaka's climate migrants offers a nuanced picture, revealing strengths in areas such as knowledge, skills, social networks, and asset ownership. However, it also underscores challenges related to livelihood strategies, financial well-being, and certain socio-demographic factors. Recognizing these strengths and weaknesses is vital for crafting interventions to enhance the adaptive capacity of those migrating due to climate factors, thereby bolstering their resilience against ongoing environmental shifts. This underscores the importance of enhancing their ability to adapt and effectively navigate environmental challenges. Interventions focused on improving knowledge, fortifying livelihood strategies, and bolstering social networks and assets are essential [37][38].

The LVI, derived from exposure, sensitivity, and adaptive capacity dimensions, indicates a moderate overall vulnerability level of 0.522. While not alarmingly high, it emphasizes the need for interventions tailored to the unique vulnerabilities of climate migrants. Past studies have shown that livelihood vulnerability indices aptly capture the multifaceted nature of climate-induced vulnerabilities [39]. The disparity between the LVI – IPCC

(0.184) and CVI (0.760) underscores the significance of context-specific evaluations. The low LVI – IPCC score might not fully capture the intricacies of climate migration in Dhaka, potentially downplaying their genuine vulnerabilities. Conversely, the high CVI score accentuates the urgency for targeted interventions, taking into account the specific challenges faced by Dhaka's climate migrants [5][40].

These findings emphasize the pressing need for interventions to enhance the adaptive capacity of Dhaka's climate migrants. Priority should be given to improving living conditions, ensuring access to clean water and sanitation, and bolstering health services. Additionally, directing resources towards educational programs and initiatives to broaden employment opportunities could further empower migrants to adapt to evolving situations, thereby reducing their vulnerability [37][41]. While this study provides a comprehensive assessment of livelihood risks, it's essential to note its limitations. The cross-sectional data limits our understanding of vulnerability shifts over time, and the focus on Dhaka might not be fully applicable to other urban settings. Future research could utilize longitudinal data and broaden its scope to explore climate migration in varied urban contexts.

Overall, this study sheds light on the intricate livelihood vulnerabilities of Dhaka's climate migrants. It emphasizes the need for context-specific evaluations and interventions to address their distinct challenges. By enhancing adaptive capacity, minimizing sensitivity, and understanding vulnerability's multifaceted nature, policymakers and stakeholders can better support this vulnerable group amidst climate change challenges.

4.2 Policy Implications

The findings of this study hold significant policy implications for both national and local governments in Bangladesh, international development agencies, and other countries grappling with challenges related to climate-induced migration. Policies should prioritize enhancing food security. Livelihood diversification programs can mitigate sensitivity by providing alternative income sources in both formal and informal sectors. Given the compromised health status of climate migrants, it's crucial for policy

interventions to emphasize improved healthcare access. Strategies such as expanding healthcare facilities, offering affordable healthcare services, and launching health education and awareness campaigns can markedly better health outcomes, especially for vulnerable groups like women, children, and the elderly.

Successfully enacting these policies can greatly enhance the adaptive capacity of individuals compelled to migrate due to climate factors. This could lead to better preparedness for disasters, improved health outcomes, and diversified livelihoods, making individuals more resilient to climate-induced challenges. Boosting adaptive capacity can reduce the propensity for climate-induced migration. The expected benefits include a higher quality of life, reduced health risks, and overall better welfare for the affected population. Policymakers should adopt a holistic strategy addressing the intertwined challenges of climate adaptation and migration. Policies should aim to promote sustainable livelihoods in areas vulnerable to climate-related disasters, thereby alleviating the pressures of migration. Education and skill development programs, especially targeting the youth, can empower migrants to access better job opportunities and contribute significantly to local economies. This, in turn, can reduce their vulnerability to environmental disruptions.

Furthermore, involving communities in disaster risk reduction and local adaptation planning can lead to more effective policies and outcomes. Communities should be at the forefront, both in designing and implementing solutions tailored to their unique needs. In conclusion, addressing the vulnerabilities of climate migrants demands a comprehensive approach that integrates disaster risk reduction, healthcare access, food security, livelihood diversification, and community involvement. Policymakers must act decisively to safeguard the rights and well-being of these vulnerable groups and foster resilience in the face of persistent climate change.

5. Conclusion

This comprehensive study delves into the complex livelihood vulnerabilities faced by climate migrants in Dhaka, unveiling a myriad of challenges. The assessment emphasizes their increased exposure to climate extremes, further intensified by climate variabilities.

Sensitivity analysis highlights significant vulnerabilities in health, food security, water access, and housing, shedding light on the multifaceted nature of their challenges. Conversely, the findings indicate a diminished adaptive capacity among these migrants, signaling an urgent need for intervention. The Livelihood Vulnerability Index (LVI) integrates these dimensions, indicating a moderate to high overall vulnerability level. However, when contrasted with the Climate Vulnerability Index (CVI), the need for context-specific evaluations becomes evident. The CVI reveals a markedly elevated vulnerability tied to local conditions, underscoring the significance of accounting for unique factors.

This study emphasizes the urgency of carefully crafted policy interventions to enhance the adaptive capacity and reduce sensitivity among climate migrants. Achieving this necessitates significant investments in livelihood diversification, healthcare, housing, clean water, sanitation, and education. However, the study has its limitations, including its cross-sectional design and focus solely on Dhaka. As a result, future research should employ longitudinal data and expand its scope to include a variety of urban settings. In conclusion, addressing the unique challenges of climate migrants is crucial for building resilience and ensuring their well-being against the backdrop of intensifying climate change. This calls for dedicated attention from policymakers, governments, development practitioners, and stakeholders.

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Urban Health Vulnerability Index:
Assessing risks for climate-induced migrants

Abstract

Global warming poses serious threats to human settlements, especially those living within urban landscapes that are vulnerable to climate change. Studies tend to focus on individual or groups of migrants' health outcomes and often disregard the many health threats climate-induced migrants face in urban environments. Therefore, this research poses two questions. First is: "What are the particular health risks faced by climate-induced migrants living in urban environments such as Dhaka?" secondly: How can their vulnerability be measured and evaluated systematically? This research develops and validates a new composite index designed specifically to assess climate-related risks to urban migrants. Utilizing both cross-sectional design and study design methods, this research created a Health Vulnerability Index in accordance with IPCC guidelines. This study involved conducting interviews with 393 people living in Dhaka city by employing the snowball sampling technique and semi-structured interviews using an instrument. This research identified moderate or high Health Vulnerability Indexes (HVI = 0.510), which indicate serious health risks to climate-induced migrants due to high exposure levels (0.679), as well as sensitivity (0.560) and inadequate adaptive capacity (0.388). High sensitivity and exposure scores indicate the complex interactions among migrants, climate, environmental risks, health risks and vulnerability risks, respectively. Migration migrants often lack the coping and resilience resources to deal with and overcome risks effectively, thus highlighting the necessity of specific healthcare interventions and responses in urban settings. This study contributes to the field by offering an exhaustive, contextually specific HVI for migrants affected by climate change in urban settings and

emphasizing their need for improved healthcare infrastructure, integrated assessments of health vulnerability for urban planning purposes, and increased adaptive capacity in populations of migrants. Furthermore, the research highlights urgent policies that improve urban health infrastructure while simultaneously increasing the capacity among migrants to adapt.

Keywords: Climate change, urban migrants, health access, index development, urban health, sustainability

1. Introduction

This century has witnessed an unprecedented acceleration of climate change worldwide, with evident impacts across continents. Climate changes ranging from rising sea levels and an increase in cyclones to prolonged dry spells and unpredictable patterns of rainfall have not only had profound impacts on ecosystems but have also presented significant challenges to human settlements [1]. One of the primary responses of humans to environmental changes is migration. While migration can be affected by various variables, evidence shows that adverse climate events play a substantial role in people deciding to relocate frequently [2]. Due to environmental degradation, they leave areas that have become inaccessible or economically unviable due to environmental degradation behind [3].

Climate-prone regions like coastal zones with low elevation and small island nations prone to desertification have experienced massive population displacements as their climate changed drastically [4]. Pacific islands, for instance, face rising sea levels that threaten their very existence; parts of sub-Saharan Africa experience severe drought conditions, which hinder agricultural production and cause shortages in food and water sources [5]. Urban areas in developing nations have increasingly become attractive destinations for climate-sensitive populations due to greater opportunities for economic growth and improved infrastructure. Due to population growth and inadequate housing needs, cities often struggle with an increase in population, which strains existing resources and results in issues like excessive population growth, inadequate housing

availability and an increase in competition for jobs - Dhaka being an example in this regard. Dhaka lies within a deltaic area that is at the forefront of climate change effects, leading to increased populations who seek shelter in rural regions from environmental issues, but urban environments like Dhaka provide little in terms of infrastructure or resources - creating health issues among migrants [6].

The climate-induced phenomenon is more than a mere demographic shift; rather, it involves multiple socio-economic, environmental, and health concerns that are interwoven together in complex patterns of interactions. People and communities that migrate from rural environments into urban settings face various health risks that are compounded by city living [7]. Urban areas present ample opportunity for economic expansion; however, their infrastructure often cannot keep up with sudden surges in population. Unsecure living conditions, limited access to sanitation and clean water services, and strain on healthcare systems could contribute to an increase in infectious illnesses, malnutrition and other health concerns. Additionally, psychological stress caused by relocation and difficulties adjusting to a different environment could result in mental health concerns. Most migrants encounter discrimination, social isolation and economic difficulties that can lead to depression, anxiety and other psychological health concerns. Therefore, it is vitally important that migrants recognize and address health risks. Assuring the wellbeing of migrants is not simply an ethical obligation; it is also an integral component of social cohesion, economic efficiency and overall sustainability in urban environments. When dealing with health issues related to climate change migrants can become resilient urban communities more equipped than ever to face future challenges [8].

Academic research recently has focused heavily on the linkages between migration, climate change and the health of people. Clay [9] have highlighted both direct and indirect health impacts associated with climate-induced migration, such as exposure to new infectious diseases or socioeconomic hardships for migrants. Barbieri and Confalonieri [2] examined potential scenarios of vulnerability for populations in Brazil by providing insight into the relationship between climate-related diseases, desertification trends and

potential effects of climate changes on health expenses for cities of major size. Their findings emphasize the necessity of adapting strategies that meet the particular health requirements of urban migrants. Adri [10] conducted an in-depth investigation of Dhaka City and distinguished between climate migrants (climate migrants) and non-climate migrants in terms of health concerns. Their research revealed nuanced differences in health outcomes that were directly attributed to migration motives, underscoring the necessity of targeted health interventions. Bhatta and Pahari [11](2015) examined gender aspects of climate-related migration decisions within South Asia. Their research highlighted the increasing risks to security and health faced by women, compared to when male members relocated due to adverse climate events.

Climate-induced migration presents numerous socio-economic, environmental, and health implications that span multiple fields. When people and communities move due to environmental issues they are met with new sets of problems in their new homes. Urban areas in developing nations are experiencing consequences from an influx of immigrants due to infrastructure development lagging behind population growth, resulting in overcrowded living conditions with potential health hazards, including the spread of infectious diseases or increased pollution levels [12]. These urban areas often lack the resources to handle an ever-increasing population, and healthcare services may become overwhelmed quickly. Lack of access to essential medical services hinders migrants as well as long-term residents, further aggravating health issues [5]. Financially stressed communities pose another serious risk. As the job market evolves and wage cuts become possible, both migrants and host communities could potentially experience economic strain [13]. Migrant communities impacted by climate conditions often face the additional difficulty of social integration. Language, cultural, and socio-economic barriers may contribute to feelings of isolation that could lead to severe health ramifications. Psychological impacts associated with being uprooted, along with adapting to new surroundings, may contribute to mental health problems in many ways. People who move may be at greater risk of experiencing increased depression, anxiety and psychological disorders compared to people living in places without access to appropriate medical

treatment for mental illnesses [2]. One major problem associated with climate-related movements is their insufficient response and response framework in many countries, leaving individuals to manage these challenges alone, often leading to suboptimal results [14].

Recent academic debate has revealed a great deal of interest in the relationship between climate change, migration, and health; however, closer inspection reveals several gaps in our knowledge and methodologies. Research that explores the health issues faced by migrants living in urban environments has become more abundant, yet comprehensive frameworks or tools exist that assess health risks among this population [15]. Most studies focus on individual health outcomes or specific migrant groups, often overlooking broader health risks to which populations within these groups could be exposed [8][16][17]. Although there are tools and indices designed to assess health risks in general populations, not all are tailored specifically to address the unique circumstances and challenges presented by climate-related immigrants [18]. Also, with changing urban landscapes and climate change being such an ever-increasing concern, an adaptable and specialized instrument is necessary. Current approaches rely on static data that doesn't capture the evolving nature of field situations. Additionally, assessment tools often fail to adequately incorporate qualitative data, such as stories and experiences of migrants. Firsthand accounts from migrants provide invaluable perspectives and depth, offering a greater understanding of potential health risks. Under current conditions and given its limitations, an urgently required index that not only captures multiple health risks associated with climate change in urban environments but can also adapt to evolving scenarios and incorporate qualitative data is desperately required. Therefore, this study addresses the following research queries: (a) What do climate-induced migrants face the specific health vulnerabilities in urban settings like Dhaka? And (b) How can these vulnerabilities be quantified and assessed systematically? So, the research develops and validates a novel composite index tailored to assess the health vulnerabilities of climate-induced migrants in urban landscapes. This study offers an innovative approach to quantifying health vulnerabilities through a composite index. By integrating various health

indicators and contextual factors, this index offers a nuanced and comprehensive tool that can inform policy and intervention strategies.

2. Literature Review

2.1 Previous Studies on Health Vulnerabilities of Migrants

Academic research on the health risks facing immigrants and refugees forced to leave due to environmental reasons is growing increasingly relevant. Studies have explored various health challenges this population group faces. McMichael and Barnett [19] conducted a comprehensive investigation that exposed migrants' wide array of health challenges, from infections and mental illness to malnutrition and maltreatment. Their research underscored the fact that those migrating between rural and urban settings, particularly from rural to urban environments, often live in areas prone to illness due to overcrowded living conditions, insufficient sanitation services and limited access to health care. Molla et al. [20] conducted research focused on Dhaka City to examine further the relationship between urbanization, migration and health risks. Climate refugees face specific health issues in urban environments. Adjustment issues coupled with potential socio-economic issues could wreak havoc, leading to physical illnesses as well as mental disorders that impact their quality of life. Bhatta and Pahari [11] highlighted how many factors contribute to health problems, with socio-economic conditions playing a pivotal role in compounded health risks for migrants. Migrants often struggle to secure work which results in financial strain that limits access to healthcare services, nutritious foods and secure housing - further compounding their health concerns.

2.2 Existing Indices or Tools

Numerous studies have explored the health risks associated with migration due to environmental reasons, with various tools and indicators developed to measure migrants' vulnerability, each having their own set of strengths and weaknesses. Aggarwal et al. [21] developed the Interstate Migrant Policy Index (IMPEX), as a crucial metric to assess integration of immigrants from different states and assess health-related risks among this population. Although IMPEX provides a comprehensive system, it is designed for interstate movement only and should not be considered for global or climate-induced

migration scenarios. Acharya and Porwal [22]'s research was significant as they developed an index of vulnerability to assess COVID-19 effects within its movement context. While this index provides useful insight into health vulnerability when pandemics strike, its application may not address all the health challenges affecting migrants. Lyons et al. [23] developed an index of multidimensional livelihood (MLI) to assess risk for Syrian refugees living in Lebanon. While broad in scope, this MLI may only suit particular migrants and may not apply universally across migrant groups. Although indices provide valuable tools, they also have notable limitations. Most instruments used focus on particular groups of migrants or health issues; as such, the need for a broader index has arisen. Such an index would need to adapt to various situations of migrants across many environments while simultaneously meeting any unique challenges posed by urban environments like Dhaka.

Based on these findings, there exists a gap in the literature that calls for an exhaustive index to assess climate-related urban migrant health risks. Such an index must be comprehensive yet flexible enough to respond to unique urban environments like those found in Dhaka.

2.3 The Nexus of Climate Change, Migration, and Health

Studies exploring the interrelation between climate change, migration and human health have become a central focus for countless research studies. Understanding this relationship is of vital importance because each element amplifies its effects. Climate change - which manifests itself through rising temperatures, shifting weather patterns and an increase in extreme events - has become one of the primary drivers behind migration flows worldwide. As regions become unusable due to droughts, floods, or other environmental events, people must relocate for better living conditions elsewhere. McMichael [19]'s illustrates this point well by exploring how climate change alters migration patterns, yet environmental forces also pose risks when causing migration processes to happen. Migrant populations frequently face numerous health concerns ranging from infectious illnesses to mental health concerns. Schwerdtle et al. [8] investigated these health concerns by exploring their link to climate-induced migration

and its attendant health implications in South Asia; Bangladesh is particularly problematic here. Bangladesh, due to its low-lying terrain, is highly vulnerable to climate change impacts that could trigger significant increases in cross-border migration. Barbieri and Confalonieri [2] conducted an in-depth investigation on population vulnerability in Brazil that offers striking parallels with Bangladesh today and highlighted the necessity of regional studies in understanding specific risks and obstacles. While research on individual components of this relationship exists, there has been little done on its integration. Therefore, conducting comprehensive studies is necessary in order to inform policy decisions and actions, protecting those affected by climate change and assuring their wellbeing.

Predictive models and studies have been devised to forecast climate-induced migration patterns and their health implications in South Asia. Research by Maharjan, de Campos, Singh & colleagues (2020) explores this link between climate change and adaptation strategies across South Asia. Their findings underscore the critical need for proactive measures that address the health risks of migrants who migrate into South Asia - with Bangladesh specifically being at greater risk. Bangladesh's geography makes it vulnerable to climate change, leading to significant migration from both outside and within its borders.

2.4 Gaps in the Current Literature

Studies on the relationship between climate, movement, and health changes are vast and wide-ranging, yet certain areas remain understudied or ignored, which require additional investigation and research. One of the primary concerns identified is an absence of comprehensive instruments or indices that capture health risks associated with climate change, particularly within urban settings. Ghosh and Orchiston [24] confirmed this conclusion with their comprehensive review. While there are indicators that assess health vulnerabilities or migration patterns, they don't meet all the challenges posed by urbanization and climate change. They identified an imbalance in existing research on climate migration. Further, while there have been many studies exploring the impacts of climate change on health and mobility separately, few exist that integrate all

three aspects, particularly in urban landscapes like Dhaka. Given the unique challenges cities face - from overcrowded living conditions to inadequate healthcare infrastructure - this development is deeply concerning. Furthermore, while there have been studies that examine the regional or global impacts of climate-induced migration, country-specific studies on South Asia or Bangladesh remain limited in scope.

Furthermore, the unique context that exists for South Asia and Bangladesh specifically often goes unrecognized. Though East Asia is among the regions most vulnerable to climate change impacts, it is surprising to discover there have been no studies that investigate its relationship to migration and health in this area. Due to these limitations and the need for further research, this study seeks to fill a void, providing a complete tool specifically tailored to address urban environments like Dhaka. By doing so, this investigation hopes to offer valuable insights and provide a complete picture of climate change's effects on urban people's health risks.

3. Methodology

The study utilized a framework of contextualized health vulnerability index to achieve the goals of the study, employing the cross-sectional design of the study to discover and analyze the vulnerability of the population. The method employed was quantitative to identify and quantify vulnerabilities using the indicator of IPCC. The framework, drawn from several sources and then adapted to the particular context of each country, aids in improving understanding of the problem.

3.1 Study Settings and Population

The main study site is Dhaka city, which is a frequent location for climate-related migrants looking for jobs, as demonstrated in earlier studies. The majority of climate-induced migrants come from middle- and low-income communities, mostly living in semi-urban and urban regions around Dhaka. The targeted population was discovered in middle- and low-income settlements, including urban slums and periurban regions, such as Korail Slum, Mollah and Tejgaon, Chand Uddyan, Turag and Beribad, Ekota Housing, and Bosila Slum.

The criteria for inclusion in the study population comprised people who have been exposed or had experienced vulnerability to climate change. This included people who were affected by any natural disasters caused by climate (e.g. floods, Riverbank Erosions Cyclones, Droughts Tidal Surges, Salinity) and those who moved to Dhaka from anywhere in Bangladesh in order to earn a living. The study did not include those who had not experienced natural disasters and who did not move to Dhaka to earn a living.

3.2 Sampling and Data Collection

Due to the lack of specific data regarding the amount of people moving to Dhaka due to climate-related natural disasters, our study employed our Cochrane formula [25] to calculate the size of the sample for a population that is not known employing the following formula.

$$n = \frac{P(1 - P) \; X \; z^2}{e^2}$$

In the formula, Z refers to the 5 percent (1.96) degree of significance. The P value is the proportion expected in the population, which is calculated at 50 percent. The Margin of Error (e) can be set to 0.05. With this equation, we came up with an estimate of the number of participants 384.16 that is rounded up to 385. Thus, a total of 385 people who were exposed to the effects of climate change had to be studied. However, we also surveyed another few which resulted in 393 participants that were included in the analysis.

The snowball sampling technique was employed to contact survey respondents. Due to the potential challenges of identifying the people that are affected by climate change and those who moved to Dhaka to work and for other reasons, we decided to employ snowball sampling. This technique is cost-effective and affordable and helps simplify identification of people according to a set of guidelines [Ref]. Also, it reduces the number of staff required to collect data because referrals for the next respondents are sought from existing participants, which could increase responses.

Face-to-face interviews were used to collect quantitative data, based on an established framework. A semi-structured survey was designed to conduct interviews with climate-induced migrants in order to evaluate their vulnerability to loss of livelihood. This

tool was crafted based on study objectives, thematic areas, indicators, and variables derived from the conceptual/analytical framework rooted in the Livelihood Vulnerability Index prescribed by the IPCC and other literature. The tool was based on dichotomous questions. the tool to evaluate the vulnerability of respondents.

3.3 Piloting, Quality Assurance and Ethical Issues

Prior to the survey, the instrument was tested prior to conducting the main survey. About five percent of the estimate of the sample was tested within a separate region that had similar characteristics to reduce the possibility of overlap. This pilot was intended to confirm the validity of the tool and to ensure that respondents were able to comprehend the questions. The pilot's feedback was incorporated into the final tool. In the main survey, the data's quality was ensured by a series of checks. The quality controller, as well as the chief investigators, regularly checked and validated the data and gave feedback to enumerators whenever required.

The ethical considerations were a major factor throughout the research. A written consent form was obtained from all participants. If a person who gave consent was a minor or adolescent was obtained from their guardian or parent. If there were no parents or guardians, the collection of data on the adolescent or minor was not done. We put a premium on anonymity in responses, and ensured that the process hurt nobody. The confidentiality of information and data was ensured. We ensured that no personal information was obtained. The data collected was used solely to be used for research.

3.4 Development of the Context Specific Health Vulnerability Index

This study synthesizes sensitivity, vulnerability and adaptability concepts to assess the likelihood of urban migrants affected by climate change developing illness [26]. HVI serves as a broad indicator that encompasses three dimensions and variables related to health issues affecting this group of population members.

The design of HVI could be informed by previous studies that have looked at similar concepts across various settings. Paul et al. [27] used the Livelihood Vulnerability Index (LVI) in Guwahati city, India provide insight into how climate-related migrants may be more vulnerable to climate changes due to lack of adaptation; this may impact access to water, food and health services, which exacerbates their vulnerability further. Meanwhile,

research conducted into weather migrations in Bangladesh emphasizes female vulnerability as well as adaptation needs and includes social variables in vulnerability assessments.

As part of overall wellbeing and health in urban environments, the Climate Vulnerability Index has been used to establish causes of death among urban populations - underscoring its relevance in urban environments. Furthermore, developing the Vulnerability Index using Principal Component Analysis within an urban heat island environment underlined its significance in helping identify and resolve urban health issues that relate to the environment [28].

HVI was developed for this research and uses indicators and contextualization techniques to meet the unique problems presented by climate change in urban environments. It encompasses environmental conditions as well as economic and social considerations that influence health risks.

2.5 Vulnerability Analysis

According to IPCC, vulnerability is a function of exposure, sensitivity, and adaptive capacity [Ref].

$$\text{Vulnerability} = f \text{ (exposure, sensitivity, adaptive capacity)} \tag{1}$$

Step-1: Standardization by Equation:

As each major component has a few sub-components, they all contributed equally to the index. All components received equal weight. Since specific 'scale' was done for specific components, standardization was done by equation.

$$\text{Index}_{SC_d} = \frac{SC_d - SC_{min}}{SC_{max} - SC_{min}} \tag{2}$$

Here, SC_d denotes the original value for the subcomponent in Dhaka. SC_{min} and SC_{max} are the minimum and maximum value for the subcomponents, respectively.

Step-2: Average Value of the Subcomponents:

Then, each of the subcomponents were averaged by the following equation.

$$MC_d = \frac{\sum_{i=1}^{n} Index_{SC_{di}}}{n} \qquad (3)$$

Here, MC_d is the value for the major component of area d. $Index_{SC_{di}}$ is indexed subcomponent value of each major component M_d and n is the total number of subcomponents in each major component.

Step-3: after calculating the value for the major components, all are averaged to obtain the HVI for the area.

$$HVI_d = \frac{\sum_{i=1}^{14} w_{MC_i} MC_{di}}{n \sum_{i=1}^{14} w_{MC_i}} \qquad (4)$$

Where, HVI_d denotes the HVI for area *d* which is the weighted average of the seventeen majors component. Here for health vulnerability, a total of 17 major components were settled under three major dimensions of health vulnerability.

Step-4: The above equation is directly used for the major components of livelihoods to obtain the values.

$$HVI_d = \frac{\begin{array}{c} W_{CE}CE_V + W_{CV}CV_V + W_{EH}EH_V + W_L L_V + W_{LD}LD_V + W_{CID}CID_V + W_{SRH}SRH_V + W_{MC}MC_V + W_{PM}PM_V \\ + W_{HF}HF_V + W_{UH}UH_V + W_{HS}HS_V + W_{HW}HW_V + W_{HIM}HIM_V + W_{HF}HF_V + W_{LG}LG_V + W_{EM}EM_V \end{array}}{\begin{array}{c} W_{CE} + CV_V + W_{EH} + W_L + W_{LD} + W_{CID} + W_{SRH} + W_{MC} + W_{PM} \\ + W_{HF} + W_{UH} + W_{HS} + W_{HW} + W_{HIM} + W_{HF} + W_{LG} + W_{EM} \end{array}}$$

$$(5)$$

Step-5: Calculated by using the components that are associated with climate exposure including Climate Extreme (CE), Climate Variability (CV), Environmental Health (EH), and Land (L). The Exposure Index is the combination of these elements.

$$IndexExp = \frac{W_{exp\,1}CE + W_{exp\,2}CV + W_{exp\,3}EH + W_{exp\,4}\,L}{W_{exp\,1} + W_{exp\,2} + W_{exp\,3} + W_{exp\,4}} \qquad (6)$$

Step-6: At this stage, derived from components that assess the sensitivity of a populace to risks for health, such as loss and Damage (LD) and chronic and infectious (CID) as well as sexual and reproductive health (SRH), maternal and child (MC), and the

psychosocial and mental (PM). It is also known as the Sensitivity Index is the average of the following components.

$$\text{IndexSen} = \frac{W_{sen\,1}LD + W_{sen\,2}CID + W_{sen\,3}SRH + W_{sen\,4}MC + W_{sen\,4}PM}{W_{sen\,1} + W_{sen\,2} + W_{sen\,3} + W_{sen\,4} + W_{sen\,5}} \tag{7}$$

Step-7: Based on components that measure the capacity of the population to adjust to health challenges, such as Healthcare Facility (HF), Universal Health (UH), Health Service (HS), Health Workforce (HW), Health Information and Medicine (HIM), Health Financing (HF), Leadership and Governance (LG) and the Emergency Preparedness (EM). This Adaptive Capacity Index is the combination of the following components.

$$\text{IndexAdCap} = \frac{W_{ad\,1}HF + W_{ad\,2}UH + W_{ad\,3}HS + W_{ad\,4}HW + W_{ad\,5}HIM + W_{ad\,6}HF + W_{ad\,5}LG + W_{ad\,6}EM}{W_{ad\,1} + W_{ad\,2} + W_{ad\,3} + W_{ad\,4} + W_{ad\,5} + W_{ad\,6} + W_{ad\,7} + W_{ad\,8}} \tag{8}$$

In addition to this, WHO prescribed health index also have a number of subcomponents in each of the three dimensions: exposure, sensitivity and then adaptive capacity. Thus, final equation for health vulnerability stands as:

$$\text{HVI} - \text{WHOa} = (\text{Exp} - \text{AdaCap}) \times \text{Sen} \tag{9}$$

Here, HVI – WHOa refers to the health vulnerable index in terms of WHO indicators where the maximum value is 1 that is most vulnerable to health facility and minimum value is – 1 that denotes least vulnerable to health facilities and services.

4. Results

4.1 Health Vulnerability Conditions

In figure 1, the contributing factors that affect the health vulnerability of the migrated people are depicted. It portrays the values of the major components and subcomponents, which vary from indicator to indicator and their major domains. A total of 17 subcomponents comprise the composite indexing for health vulnerability. The result shows three decimal points between '0' and '1', which denotes the less vulnerable and highly vulnerable, respectively.
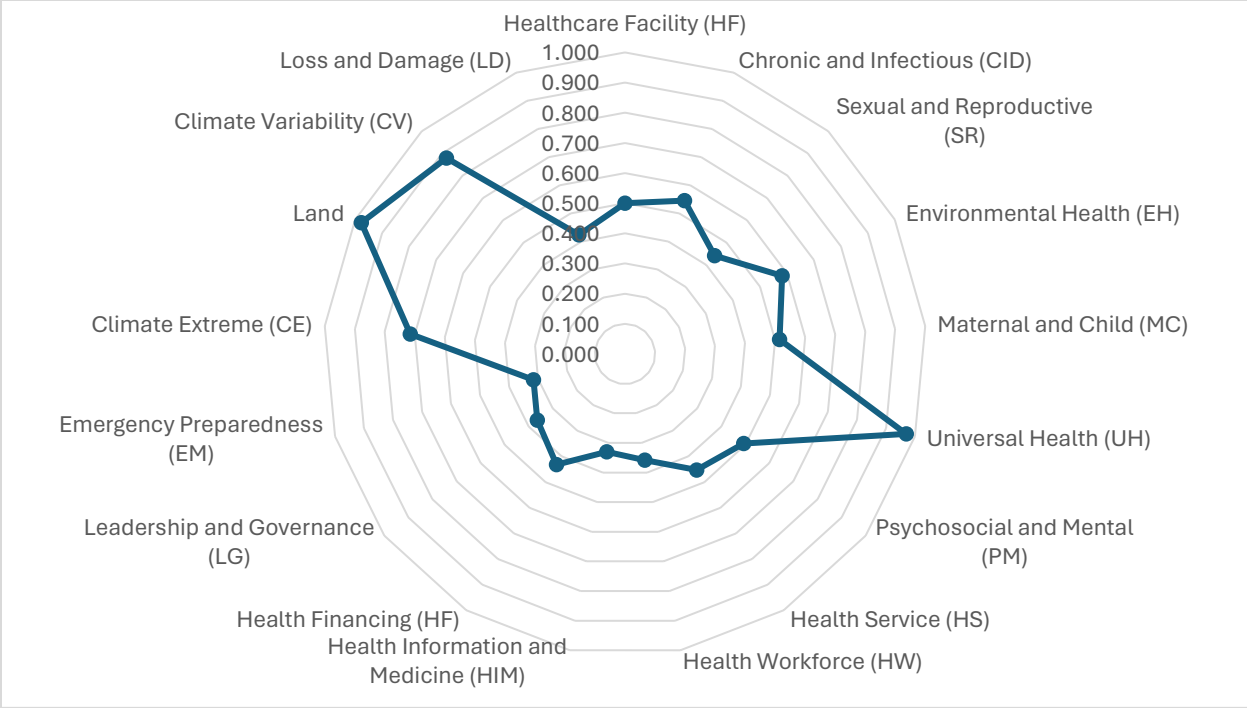
Figure 1. Spider diagram of the major components of the health vulnerability of climate migrants. Source: field survey – 2023

4.1.1 Sensitivity

Sensitivity indicates the degree to which the health of people who migrated and their possessions have the chance to be harmed or deteriorated. It is about the health vulnerability of climate migrants' scale to which their health and health seeking behavior, accessibility, and infrastructure of health outcomes are dependent. The indexing comprised of a total of seven (07) major components like healthcare facility status, chronic and infectious diseases, sexual and reproductive health and rights (SRHR), environmental health conditions, maternal and child health status, universal health coverage (UHC), and psychosocial and mental health conditions of the respondents. The composite value for these major components scored 0.560, which indicates the high sensitivity to the health vulnerability of the climate migrants in Dhaka city.

Among the major components results, universal health coverage scored highest (0.969), referring to lack of health insurance and limited population-wise physicians and hospital beds, followed by environmental health conditions (0.582) contributed by deaths and illnesses from hazardous chemicals and air, water and soil pollution and

contamination, infecting with vector-borne or waterborne diseases, and access to healthy, safe and secure workspace. The chronic and infectious diseases status (0.546), access to healthcare facilities and affordability (0.500), and maternal and child health conditions (0.515) are also indicating the high sensitivity to the health vulnerability of the migrant people (Table 1).

Table 1. Index values of health vulnerability dimensions

Major Dimensions	Value
Sensitivity	0.560
Adaptive Capacity	0.388
Exposure	0.679
Health Vulnerability Index (HVI)	0.510

4.1.2 Adaptive Capacity

The ability to cope with and adjust to the shocks and impacts is called the adaptive capacity [29]. When the adaptive capacity of a community or group of people is high due to climatic adverse events and exposure, it implies that they can adjust with the changing environment and thus reduce the impacts [5]. However, the composite value for the adaptative capacity to health vulnerability of the people who have migrated to Dhaka city due to climate change-induced natural disasters scored very low (0.388) – reflecting their minimum ability to adapt. This value was aggregated from a total of six (06) major components, for instance, health service delivery systems, health workforce and competencies, health information systems and supply of the required medicine, health financing mechanism, leadership and governance of the health systems, and emergency preparedness.

The value for almost all of the major components of the adaptive capacity scored low. Among them, emergency preparedness scored the lowest (0.316), followed by health information and medicine (0.331) – reflecting their limited knowledge of health literacy, lack of awareness and limited accessibility to the required medicine and health workforce (0.359) – representing the inadequate community health clinics and insufficient health workforce, limited health facilities, lack of qualified and well-trained health workforce,

and the lack of quality healthcare. Moreover, leadership and governance of health systems, health financing, and health service delivery scored 0.364, 0.432, and 0.453, respectively. All of these major components' values are resulted from the values of the specific indicators under each of them.

4.1.3 Exposure

Exposure is defined as the level of contact and its intensity towards climatic shocks and events [30]. The exposure to the extreme climate events of the migrant people was indicated by their location of origin from where they migrated to the current city [16]. Since they faced and experienced adverse exposure to climate-related disasters in their district of origin, and thus migrated to Dhaka to adapt to the changing situations, the sensitivity and adaptative capacities were based on the new location, whereas the exposures were on the original place. A total of four (04) major components: climate extreme, land, climate variability, and loss and damage. These are contributing factors for the exposure, the composite value for which scored 0.679 refers to the high exposure to the climate change-induced natural disasters of the migrated people. The values for all of the major components scored very high except the loss and damage (0.423) due to the disasters. The highest scorer component is the land (0.977) due to the nature of the geographical features of the departed land. Secondly, climate variability (0.879) in the newly located city also shown a high score resulting from the intensity and severity of disasters and the period of summer seasons that have had a sternness on their life and health.

3.1.4 Health and Climate Vulnerability Index:

The composite value for the Health Vulnerability Index (HVI) is 0.510, indicating the moderate to high HVI of the climate migrants. This index was measured based on the contributing factors of the three major dimensions: exposure, sensitivity, and adaptive capacity. The HVI reveals a considerable and susceptible health vulnerability of the migrants, which is currently enduring at the newly located city. Alternatively, HVI-IPCC was according to the IPCC prescribed vulnerability indexing method, which shows the value of 0.163 emphasizes the context-specific nature of health vulnerabilities and seeks

further investigation on the particular issues. Moreover, the climate vulnerability index (CVI) at 0.799 highlights climatic shocks and extreme conditions that have been enduring by the migrated people since their relocation till date (Table 2).

Table 2. Index values of components and indicators of health vulnerability

Major components	Component's value	Sub-components/ Indicators	Indicator's value
Climate Extreme (CE)	0.715	1. Faced climate disasters 2. Received early warnings before the disasters	1.000 0.430
Climate Variability (CV)	0.879	1. Intensity of the Disasters (above) increased over last 10 years. 2. Summer season period increases over the time being	0.840 0.919
Environmental Health (EH)	0.582	1. Deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination. 2. Vector-borne or waterborne disease: Malaria, Dengue, Chikonguniya, Kalaajar 3. Access to clean air (Air quality) 4. Healthy, safe and secure workspace 5. Access to green space in the locality	0.336 0.626 0.692 0.618 0.639
Land	0.977	Geographical features of departed lands in origin	0.977
Loss and Damage (LD)	0.423	1. Loss of life and livestock or injured 2. Loss of the assets due to disasters 3. Damage of the assets	0.229 0.372 0.669
Chronic and Infectious (CID)	0.546	1. Chronic disease status 2. Infectious disease status	0.483 0.608
Sexual and Reproductive Health (SRH)	0.441	1. Taboo/difficulty in accessing SRH 2. Gender-based violence 3. Contraceptive and family planning 4. Knowledge and awareness about STD/STI	0.369 0.458 0.410 0.529
Maternal and Child (MC)	0.515	1. Maternity care status 2. Access to antenatal care, postpartum and postnatal healthcare 3. Childcare status 4. Malnutrition 5. Premature mortality (under-five mortality) 6. Maternal mortality,	0.593 0.496 0.751 0.562 0.405 0.282
Psychosocial and Mental (PM)	0.493	1. Exposure to traumatic events: 2. Risk of poor mental health because of traumatic or stressful experiences 3. Psychosocial and mental health support	0.293 0.481 0.705
Healthcare Facility (HF)	0.432	1. Proximity (distance) of HF 2. Unequal access to health care 3. Barriers to access to health services 4. Barriers for disables and extreme age groups (below 15 and above 65)	0.366 0.481 0.547 0.524 0.631

		5. Improved or diminished an individual's health status due to migration 6. Health-seeking behaviour	0.453
Universal Health (UH)	0.969	1. UHC (Health insurance) status 2. Population-wise hospital beds in Dhaka 3. Population-wise physicians in Dhaka	
Health Service (HS)	0.453	1. Availability and accessibility of health services, 2. Improved water, sanitation and hygiene systems in HH 3. HH with a sanitary latrine 4. Care for elderly people, disables, children, women and girls 5. Difficult to reach health facility 6. Urban Primary Health Care, community health (Nagar Matri Sadan or Surjer Hashi)	0.448 0.313 0.224 0.634 0.491 0.606
Health Workforce (HW)	0.359	1. Community health workers Community Clinic, Matri Sadan 2. Sufficient health workforce, 3. Well-trained health workforce and resourceful facility 4. Responsiveness of HWF 5. Quality of Health Services	0.585 0.321 0.328 0.303 0.257
Health Information and Medicine (HIM)	0.331	1. Health literacy 2. Health awareness and perception 3. Health information accessibility Availability and Accessibility to essential medicines, medical products, tests, and vaccination, technologies,	0.412 0.341 0.331 0.239
Health Financing (HF)	0.432	1. (High/affordable) user fees, 2. HH members not visiting doctors during illness 3. Can't afford (burden) healthcare expenses 4. Average monthly expenditure for health purpose	0.168 0.705 0.310 0.545
Leadership and Governance (LG)	0.364	1. Discrimination to avail healthcare by the service providers 2. Poor healthcare governance and management	0.372 0.356
Emergency Preparedness (EM)	0.316	1. Emergency preparedness status 2. Pandemic and endemic preparedness status	0.198 0.433

5. Discussion

5.1 Climate-induced migrant's health vulnerability

This study offers insight into the complex health risks climate-induced migrants face in urban environments. To measure and comprehend them, we developed a context specific Health Vulnerability Index (HVI). Our findings indicate a moderate-to-high degree of vulnerability (HVI equals 0.510) due to climate changes posed by climate migration;

especially concerning is the high exposure score (0.679) found here; our findings align closely with results from similar studies on Sagar Island in India [11.]

Our findings about the extreme vulnerability of climate-induced immigrants to health risks is in line with research by Sagar Island in India [31]. Climate-induced migrants were particularly susceptible to the effects of climate change due to insufficient adaptive capacity - an indication of their overall vulnerability regardless of where they resided [32].

Our study's sensitivity component, with scores of 0.560, demonstrates the extent to which these immigrants' health is susceptible to damage from environmental exposure. This is in line with other studies conducted in Bangladesh, where climate change vulnerability was affected by social factors that included gender relationships [32]. Our study's high score for sensitivity indicates a risk of health problems due to migration and environmental exposures that is compounded by other factors, such as lack of access to healthcare and poor living conditions. This study has indicated a high sensitivity score (0.560), suggesting climate-induced migrants in Dhaka are particularly prone to health hazards and should be prioritized when planning urban health and formulating policies. Research has identified gender-specific vulnerabilities and difficulties adapting in contexts where climate-induced migration is occurring [33].

Furthermore, our HVI indicates a serious shortfall of health insurance and resources with its score of high for universal coverage (0.969) with respect to the sensitivity component. This study is evidence of the need for universal health policies that address the specific requirements of climate-related migrants [34], while adding to an expanding body of research on urban health vulnerability due to climate changes [35]. Rouleau et al. [3] analyzes coastal cities' vulnerabilities to climate-related risks, demonstrate the power of composite indices as tools for evaluating urban environmental health issues.

Our research revealed a weak adaptability (0.388) among climate-related immigrants in Dhaka, suggesting they cannot cope with, adapt to and recover from adverse health impacts caused by environmental exposures and sensitivities. This finding is alarming because it exposes gaps in health care system infrastructure necessary for building health resilience among groups. Furthermore, adaptive capacity plays an integral role in overall

health vulnerability, mandating immediate focus from various stakeholders involved [5][35].

5.2 Policy Implications

The findings of this research study have immense ramifications for policy-making, particularly when it comes to urban health management and adaptation strategies for climate change. The Health Vulnerability Index (HVI) gives more nuanced insight into risks caused by climate change impacting urban regions and could serve as a basis for policy actions taken accordingly.

5.2.1 Enhancing Urban Health Infrastructure:

Due to climate-induced migrants' exposure and vulnerability, cities must act quickly to enhance their health infrastructure. Policies should focus on expanding the availability of healthcare facilities and medical services while making sure systems can support an increasing immigrant population. Investment in health infrastructure should include efforts that make its services affordable - particularly among low-income earners who may be most exposed.

5.2.2 Integrating Health Vulnerability into Urban Planning:

Urban planning policies must incorporate assessments of health vulnerability so as to meet the needs of migrants affected by climate change. This includes providing sufficient housing, sanitation and access to clean drinking water, essential elements for good health. Furthermore, environmental health factors like air quality, as well as any exposure hazards, should also be considered when planning urban environments.

5.2.3 Building Adaptive Capacity:

Our researchers observed that to improve adaptive capacity among climate-induced migrants, and policies must focus on increasing resilience through educational and awareness programs that develop health literacy among the community as a whole. Community health programs provide preventative services while offering guidance in accessing healthcare services in their cities.

5.2.4 Targeted Interventions for High-Risk Groups:

Policies should focus on targeting high-risk groups such as children, women and seniors who often face greater health problems. Gender-sensitive strategies are especially crucial due to specific health challenges women and girls may face, such as reproductive health concerns and gender-based violence.

5.2.5 Collaboration and Multi-Sectoral Approaches:

Climate-induced migrants face health risks that require collaboration across various fields - environmental health, urban planning and social services among them. Policymakers must work to establish partnerships among government agencies, non-government organizations and healthcare providers as well as community groups so as to develop holistic responses.

5.2.6 Policy Advocacy and Research:

Studies and advocacy efforts must continue in order to keep climate change's health risks front of mind in policy discussions, including longitudinal studies that track health effects over time and evaluate interventions' efficacy. Policymakers need to be guided by scientifically based studies like our HVI's results to make sound decisions and efficiently allocate resources.

Climate change's health risks to urban landscapes necessitate targeted responses from policymakers that consider exposure, sensitivity and adaptability issues affecting this population. Focusing their attention on such aspects could dramatically improve both health outcomes and overall wellness for this group of individuals.

6. Conclusion

This study offers an in-depth evaluation of the health hazards climate-induced migrants face in urban settings such as Dhaka. Through the development and application of Health Vulnerability Index (HVI), this research offers an exhaustive assessment of how sensitivities, exposures and adaptive capacities interact to determine health risks faced by this population.

Our research has demonstrated that climate-induced urban migrants are particularly prone to the climate and environmental risks they are exposed to due to various socio-economic aspects, and have inadequate capacities for adapting and mitigating them. Their high or moderate HVI scores reflect severe health issues they are currently facing which necessitate immediate interventions and specific strategies.

The study contributes to an overall discussion on urban health vulnerability as a result of climate crisis. Furthermore, it shows the need for policies to strengthen health infrastructure of urban areas by integrating health risks into development planning as well as increasing adaptability among populations who migrate. Furthermore, targeted interventions were recommended for groups at risk as well as multi-sectoral approaches being utilized to tackle such issues.

Overall, this study underlines the significance of addressing health risks to migrants affected by climate change living in cities. The HVI created by this research provides policy makers, healthcare providers, urban planners, and health professionals an effective tool for determining and addressing unique health concerns of this population. Eventually, its findings should lead to effective policies being enacted which foster resilient urban communities capable of better managing climate change's adverse health effects.

7. Limitations and Future Research Directions

This study, while comprehensive in its approach to assessing climate-related migrants' vulnerability to health in urban environments, does have some weaknesses that should help direct future research to provide us with greater insights into this complex issue. These weaknesses should guide future efforts that aim at bettering our understanding.

First, as this study initially concentrated on Dhaka as its primary urban landscape, its findings may be limited when applied to other urban environments. Every city possesses distinctive social, cultural and environmental features which affect residents' health risks differently; future research should seek to apply HVI in different urban settings both inside and outside Bangladesh so as to both confirm and improve it.

Second, cross-sectional studies provide an understanding of the health risks faced by climate-induced migrants at a particular moment in time, but this risk can change over time due to many factors including urban landscape changes, progress of climate change and policies implemented as climate change occurs. Thus long-term studies are essential for monitoring this process over time and understanding more fully its health repercussions on those directly impacted by it.

Thirdly, while this study considers many relevant variables when creating its Health Value Index (HVI), other relevant ones could still exist that were overlooked. Further research should investigate factors that can exacerbate health risk such as social integration, mental health and education access and provide greater insights into climate-induced migrants' health risks.

Finally, this study relied on quantitative methods which were effective at assessing health risks but which failed to reflect the unique perspectives and experiences of people who are displaced. Future research studies might incorporate qualitative methods like in-depth interviews or focus groups as means of better gaining an insight into personal experiences of migrants affected by climate change as well as strategies they use for adapting as well as understanding health-related risks and services they experience firsthand.

While this study made a substantial contribution towards understanding health risks facing urban migrants exposed to climate change environments, future research should address its weaknesses by employing longitudinal studies with other variables integrated qualitative methods for an enriched and complete understanding of this crucial problem.

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Appendix: Survey Tool

Survey Questionnaire

Health and Livelihood Vulnerabilities of the People Migrated to Dhaka City Due to Climate Change Induced Natural Disasters: A Quantitative Study

We are (your name), graduate students of Climate Change and Development at Independent University, Bangladesh. We are here to conduct a study on 'Health and Livelihood Vulnerabilities of the People Migrated to Dhaka City Due to Climate Change Induced Natural Disasters: A Quantitative Study'. The study aims to explore the health and livelihood vulnerabilities, and strategies being adopted to adapt to the vulnerabilities faced by the people who migrated to Dhaka city due to climate change induced natural disasters in Bangladesh.

We need your responses, but you are not obliged to do. There is no right or wrong answer. We need your response on what you had and have been experiencing due to climate change. Your answer will be kept completely confidential and anonymous. Personally identifiable information will never be linked with the report. Only research team will know your responses and nobody else will identify who says what responses. It may take 15-20 minutes to complete the interview. We hope you are willing to respond to our study and we thank you very much for participating.

Are you willing to participate in the interview:

1. Yes   2. No

Thank you for your cooperation.

Date of Interview		Cluster Name	
Name of the Interviewer		Area Code	

Respondent's ID: ▢▢▢▢

Cluster Name/Code: ▢▢▢

Screening Questions:

Did you face any of the following Climate Change Induced Natural Disasters? (Over last 10 years?) (Flood, Riverbank Erosion, Drought, Cyclone (Storm), Salinity, Coldwave, Heatwave, Earthquake, Landslide, Lightning, Heavy Rainfall)	1=Yes 2=No	If both answers are 'Yes', then s/he will be chosen for the interview. If any of the answers is 'No', end the survey here. [End the Survey Note: We appreciate your response. We are seeking to understand the opinions of migrant/displaced persons who faced the climate induced disasters. Thank you for your time.]
Did you migrate from your usual residence to another place due to any of the above-mentioned disasters?	1=Yes 2=No	
Do you know anybody around who migrated here due to Climate induced Disasters?	1=Yes 2=No *If yes, please note down the information of the person right side*	Potential respondent: Name: Mobile Number:

Part A: Respondent's Socio-demographic Information

Questions	Responses and Codes
Sex of the respondent	Male=1, Female=2, Other= 3, Do not want to disclose=4
Age of the respondent	(Write down in completed years):
Educational attainments	(In completed years only):
What is your current occupation? (Main source of HH earnings)	2. Businessperson (Formal/Structural) 3. Informal business (like hawker, or other) 4. Government service 5. Private service 6. Farmers 7. Day laborer/Seasonal Laborer 8. Skilled Worker/Factory Worker 9. Housekeeper 10. Unemployed 11. Student Others, please specify……………………….

What was your previous occupation before migrating here?	1. Businessperson (Formal/Structural) 2. Informal business (like hawker) 3. Government service 4. Private service 5. Farmers 6. Day laborer/Seasonal Laborer 7. Skilled Worker/Factory Worker 8. Housekeeper 9. Unemployed 10. Student 11. Others, please specify……………………….
What is your current monthly income? *Probe: daily/weekly wage and convert into monthly*	Write down in BDT:
What was your previous monthly income before migration? *Probe: daily/weekly wage and convert into monthly*	Write down in BDT:
Which disaster forced you to migrate for?	Flood=1 Riverbank Erosion=2 Drought=3 Cyclone (Storm)=4 Salinity=5 Cold Wave=6 Heat Wave=7 Earthquake=8 Landslide=9 Lightning=10 Heavy Rainfall=11 Other (Please specify……………………………)
Which type of migration best relate to you?	Forced/obliged=1 Voluntary=2 Adaptation to climate stressors=3
Did you migrate for livelihood?	Yes=1, No=2
Did you migrate for health and wellbeing?	Yes=1, No=2
Where did you migrate from? Please write in next column:	District: Upazila: Union/Ward:
Where did you move to or where do you currently live in? Please write in next column:	District: Upazila: Union/Ward:
Currently living area	Urban=1 Suburban/Semi-urban=2 Rural=3
When you moved here?	(Write down the year):

Ask the month/year of movement, and then write how long it been here:	
Migrated alone or with family?	Alone=1, With family=2
Number of HH members?	Write down the number:
Total number of earning member	Write down the number:
Is this your temporary or permanent migration?	Temporary=1 Permanent=2
If temporary, then ask, do you plan to move here permanently?	Yes=1 No=2
If temporary, then ask, do you repeat this movement due to repeated climate change stressor(s)?	Yes=1 No=2
If yes, then ask, which month/season do you move here generally?	Month/season

Part B: Livelihood Vulnerabilities:

Component	Survey Question	Score/ Value
Climate Extremes and Disasters	1. This was asked in first screening question. No need to ask again	
	2. Did you received early warning(s) before the disaster?	Yes=1, No=2
Land	What is the main feature of the departed land in your origin?	1. High Land/Mainland 2. Low land 3. Coastal Regions 4. Floodplain Regions 5. Drought Prone Regions 6. Riverbank Erosion Prone Regions. 7. Hill track 8. Others
Climate Variability	1. Did you notice that the intensity/severity of disasters (marked earlier) have been increased over last 10 years?	Yes=1, No=2
	2. Did you notice that summer season period expanded, or hot days have been increasing over the last 10 years?	Yes=1, No=2
Loss and Damage by Disasters	1. Did you lose any of your family member in disasters or anybody injured of it?	Yes=1, No=2
	2. Did you lose any livestock in disasters, or anything injured of it?	Yes=1, No=2
	3. Was there any loss or damage in your assets due to disaster?	Yes=1, No=2

Component	Survey Question	Score/ Value
Health	Health related questions will be asked in Health Vulnerability Part	See the next part
Food	1. Can you or your HH afford three meals a day throughout the year?	Yes=1, No=2
	2. Did you face struggle or hardship to afford three meals a day anytime in last 12 month?	Yes=1, No=2
	3. Did you face food crisis/shortage/insecurity in any certain period of time or season?	Yes=1, No=2
	4. Did you take protein (meat, fish or any non-vegetarian food) and fruits in last month?	Yes=1, No=2
Water Sources	1. Do you have access to uninterrupted water sources?	Yes=1, No=2
	2. Do you have access to adequate safe and fresh water for cooking, using, and washing?	Yes=1, No=2
	3. Do you need to buy the water for daily usage?	Yes=1, No=2
	4. Do you face extra burden to collect the water due to cost or distance or time spent to collect?	Yes=1, No=2
Housing and Living Conditions	1. What is the status of your HH?	Poor=1, Solid/Standard=2
	2. What is your is your living condition?	Poor=1, Standard=2
	3. What is the status of your currently living house?	Own=1, Rented=2
	4. Do you live in formal/informal settlement?	Formal=1, Informal=2
	5. Is your house elevated by low ground and easily inundated by flash floods?	Yes=1, No=2
	6. Is your house prone to waterlogging?	Yes=1, No=2
Knowledge And Skill	1. Did you receive any training on how to cope up with disasters?	Yes=1, No=2
	2. Do you or your family member have any technical/mechanical/specialized skills?	Yes=1, No=2
Livelihood Strategies	1. Did you attend in any livelihood capacity development program over last one year?	Yes=1, No=2
	2. What is your current employment status?	Employed=1, Unemployed=2
	3. What is the type of your employment?	Formal=1, Informal/casual=2, Permanent=3, temporary=4
	4. Is your income depended on 'no work no pay'?	Yes=1, No=2
	5. Approximately from how many sources do you earn?	Number of sources
	6. Do any child (below18) at your HH work to earn?	Yes=1, No=2

Component	Survey Question	Score/ Value
	7. Did you miss working/earning due to bad weather condition?	Yes=1, No=2
	8. Did your occupation changed after migration?	Yes=1, No=2
	9. What is the status of your current occupation in compared to the previous one?	Opportunistic=1, Worse=2
Social Networks and Safety	1. Do you have access to any of the following devices/Services? (TV, Radio, Internet, Smartphone, Computer or Laptop)	Yes=1, No=2
	2. Do you or any member of your HH have hold a membership/participants of Govt./non-govt. organization?	Yes=1, No=2
	3. Was any HH member invited to participate in any social or community engagement or services?	Yes=1, No=2
	4. Did you face any kind of discrimination by any agency due to your migration status?	Yes=1, No=2
	5. As a migrant, do you feel insecurity?	Yes=1, No=2
	6. Did you receive any kind of aid or relief (under govt. social safety net programs)?	Yes=1, No=2
Assets (A)	1. Do you have any assets?	Yes=1, No=2
	2. What is the type of your assets?	Current Assets=1, Fixed Assets=2, Operating Assets=3 Non-operating Assets=4
	3. Do you have strong network of contacts or well-connected community/friends?	Yes=1, No=2
Finance And Income	1. What is your HH's average monthly income?	Average monthly income
	2. Did you face a reduction in income after migration?	Yes=1, No=2
	3. Do you have any debt or due?	Yes=1, No=2
	3.1. How much money do you have borrowed from others	Write in BDT
	4. Do you have any savings or investment?	Yes=1, No=2
	4.1. How much money do have lent?	Write in BDT
	5. HH average borrow: lend money ratio (From previous question)	Yes=1, No=2
	6. Do you afford any emergency expenses for your HH?	Yes=1, No=2
	1. What is the sex of the respondent? (Asked earlier, no need to ask here)	Male=1, Female=2
	2. What is the age of the respondent?	Age in number

Component	Survey Question	Score/ Value
Socio-demographic Profile	(Asked earlier, no need to ask here)	
	3. Educational attainment of the respondent? (Asked earlier, no need to ask here)	Completed schooling year
	4. Household headed by?	Male=1, Female=2, Child=3
	5. Status of formal/institutional education level of HH Head?	Yes=1, No=2
	6. Dependent members in the HH? (Working member divided by total members including extreme age groups)	Number of members

Part C: Health Vulnerabilities:

Component	Survey Question	Score/Value
Healthcare Facility	1. Do you feel healthcare facilities are proximate to you?	Yes=1, No=2
	2. Do you think healthcare service is equal to all?	Yes=1, No=2
	3. Do you face any barrier in accessing healthcare services?	Yes=1, No=2
	4. Is there any family member under 15 or above 65 who need frequent healthcare?	Yes=1, No=2
	5. Did your health status improve or diminish after migration?	Yes=1, No=2
	6. Are you proactive about seeking healthcare when you need it?	Yes=1, No=2
Chronic and NCD	Do you or any family member have any kind of Chronic diseases? (Cardiovascular/Heart disease, cancer, hypertension, diabetes, Asthma)	Yes=1, No=2
Infectious Diseases	Do you or your family member have faced any infectious disease? (HIV/AIDS, TB, Hepatitis, Covid-19, Influenza)	Yes=1, No=2
Sexual and reproductive health	1. Are there any cultural or religious beliefs in your community that make it difficult to access sexual and reproductive health services?	Yes=1, No=2
	2. Have you or any family member ever experienced any form of violence or abuse based on gender or sexual orientation?	Yes=1, No=2
	3. Have you ever had difficulty accessing contraception or family planning services?	Yes=1, No=2

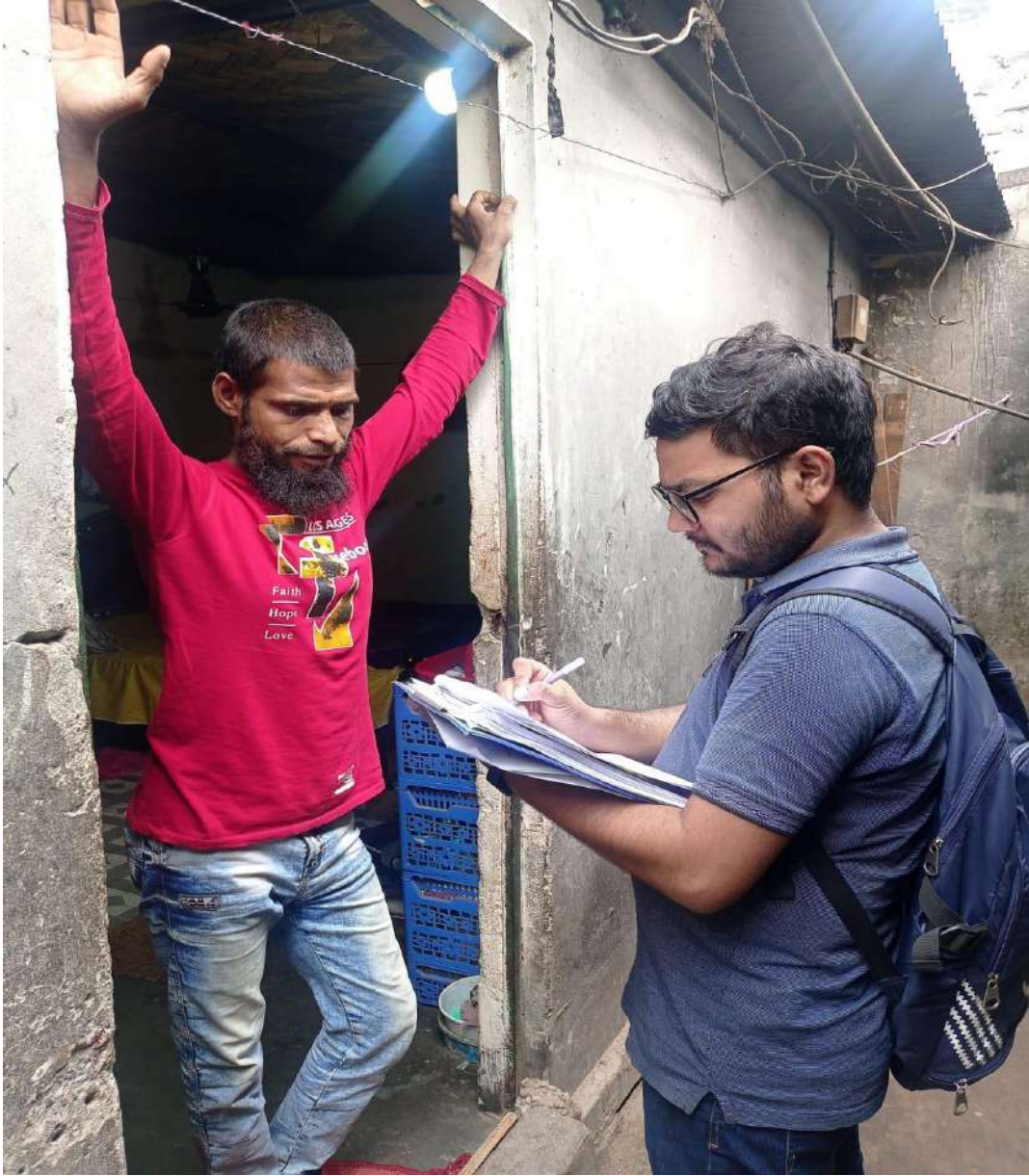|		
	4. Do you think you have enough knowledge and awareness about Sexually Transmitted Disease or Infection?	Yes=1, No=2
Environmental Health	1. Did any of your family member become ill from hazardous chemicals and air, water and soil pollution and contamination?	Yes=1, No=2
	2. Did you or any family member get infected with Malaria, Dengue, Chikonguniya, Kalaajar, Cholera or Diarrhea?	Yes=1, No=2
	3. Do you think you breathe in clean and quality air?	Yes=1, No=2
	4. Do you have (working member) a healthy, safe, and secure workspace?	Yes=1, No=2
	5. Do you have accessibility to green space in your locality?	Yes=1, No=2
Maternal and Childcare	1. Did you or family member access to maternity care during the pregnancy?	Yes=1, No=2
	2. Did you or your family member face any difficulty in accessing antenatal care, postpartum and postnatal healthcare?	Yes=1, No=2
	3. Did you access to childcare facility if you had any kid?	Yes=1, No=2
	4. Has anyone in your family experienced difficulty in accessing adequate nutrition?	Yes=1, No=2
	5. Was there any child died before s/he become five-year-old?	Yes=1, No=2
	6. Has anyone in your family experienced pregnancy-related complications or died during pregnancy or childbirth?	Yes=1, No=2
Universal Health Coverage	1. Do you possess any health insurance?	Yes=1, No=2
	2. Hospital Beds vs Population Ratio (To be collected from secondary data)	
	3. Physicians vs Population Ratio (To be collected from secondary data)	
Psychosocial and Mental Health	1. Did you or your family member ever experience any kind exposure to traumatic events like physical/psychological trauma, injury, or deprivation, depression, post-traumatic stress disorder?	Yes=1, No=2
	2. Did you face any risk of poor mental health because of traumatic or stressful experiences: anxiety and sadness, hopelessness, difficulty sleeping, fatigue, irritability, anger or aches and pains, depression, anxiety, and post-traumatic stress disorder (PTSD)?	Yes=1, No=2

	3. Did you ever took psychosocial and mental health support from any healthcare?	Yes=1, No=2
Improved Health Service Delivery (Level and Equity)	1. Do you have accessibility and availability of healthcare services?	Yes=1, No=2
	2. Do you have improved water, sanitation, and hygiene systems at your HH?	Yes=1, No=2
	3. Do you or your HH have a sanitary latrine that is used by only you or you HH member?	Yes=1, No=2
	4. Does any of your HH member need special cares due to old age complications, childhood, disability?	Yes=1, No=2
	5. Do you feel difficulty to reach health facilities?	Yes=1, No=2
	6. Do you access to urban primary healthcare centers?	Yes=1, No=2
Health workforce	1. Did you ever visit community clinics or Nagar Matri Sadan for healthcare?	Yes=1, No=2
	2. Do you think healthcare facilities have sufficient workforce?	Yes=1, No=2
	3. Do you think healthcare facilities have well-trained workforce and resourceful facilities?	Yes=1, No=2
	4. Do you think that HCW are responsive to the patients and attendants?	Yes=1, No=2
	5. Do you find the health services as a quality?	Yes=1, No=2
Health Information Systems	1. Are you familiar with health-related information?	Yes=1, No=2
	2. Do you feel you are able to understand and use it to make informed decisions about your health?	Yes=1, No=2
	3. Do you have easy access to health information when you need it?	Yes=1, No=2
Access to Essential Medicines and Vaccines	1. Do you find the essential medicines. Medical products, tests, and vaccines available and accessible at your convenience?	Yes=1, No=2
Health Financing	1. How do you find your healthcare service user fee, affordable or expensive?	Affordable=1, Expensive=2
	2. Did you visit doctor when you/your family get sick?	Yes=1, No=2
	3. Do you find it burden to afford the healthcare expense?	Yes=1, No=2
	4. How much do you expend monthly in average? Monthly average expenditure for healthcare	Write in BDT
	5. Did you have to pay for your health expenses out of pocket?	Yes=1, No=2
Leadership and Governance	1. Did you or your family member ever face discrimination to avail the healthcare by the service providers?	Yes=1, No=2

	2. Did you ever experience negative effects of poor healthcare governance and management?	Yes=1, No=2
Emergency Preparedness	1. Are you capable to bear the expense for emergency healthcare?	Yes=1, No=2
	2. Do you think the preparedness for pandemic and endemic is good enough?	Yes=1, No=2

Thank you so much for your valuable time!

Appendix: Glimpse from the Field Survey

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